Refining a Laboratory Procedure to Characterize Change in Hot-Mix Asphalt Surface Friction

by

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Abstract

The surface of asphalt pavements gradually lose friction resistance as a result of changes in surface texture and aggregate polishing with repeated traffic application. The loss of pavement friction is a major safety concern. The purpose of this study is to develop a laboratory testing protocol that can rapidly predict the rate and degree of Hot-Mix Asphalt (HMA) surface friction loss by conditioning the surface of HMA slabs and measuring friction and texture. The results of the laboratory conditioning are further correlated to actual change of friction in the field. HMA slabs compacted in the laboratory are conditioned using Three Wheel Polishing Device (TWPD) developed by National center for Asphalt Technology (NCAT). The surface friction loss and change in surface texture are measured using Dynamic Friction Tester (DFT) and Circular Texture Meter (CTM) respectively. The research was carried out in two phases. In Phase I, two Stone Matrix Asphalt (SMA) mixtures for six combinations of TWPD load and speed were tested. The combination with the lowest load (91 lbs.) and highest speed (60 rpm) was found to wear the HMA surface more than other combinations. In Phase II, the rate of friction change was evaluated by varying the amount of friction aggregate in a mixture. Two dense graded mixtures with three blends for each mixture were prepared and tested. The DFT results showed that the friction values decreases as the amount of friction aggregate in a mixture is decreased. A correlation was found between the DFT_{60} values measured in laboratory and SN64 values from NCAT test track measured using skid trailer. The results showed a high correlation between laboratory and test track friction data for three mixtures used in this study.

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List of Abbreviations

ANOVA   Analysis of Variance

ASTM   American Society for Testing and Materials

CTM   Circular Texture Meter

DFT   Dynamic Friction Tester

DFT_{40} Dynamic Friction Tester coefficient at a slip speed of 40 km/h

DFT_{60} Dynamic Friction Tester coefficient at a slip speed of 60 km/h

GLM   General Linear Model

GRN   Granite

HMA   Hot-Mix Asphalt

LMS   Limestone

LWST   Locked Wheel Skid Trailer

MPD   Mean Profile Depth

NCAT   National Center for Asphalt Technology

PG   Performance Grade

PVC   Polyvinyl chloride

RMS   Root Mean Square

SMA   Stone Matrix Asphalt

SN_{40} LWST Skid Number at a slip speed of 40 mi/h

TWPD   Three Wheel Polishing Device

CHAPTER 1. INTRODUCTION

1.1 Background

Pavement friction (skid resistance) is one of the important factors in the construction of asphalt pavements. The surface of asphalt pavement loses its friction by abrasion under the constant wear of the traffic. The loss of pavement friction is a major safety concern for the vehicles travelling at high speeds. Pavement friction not only plays an important role in stopping the vehicle but also gives the ability to maneuver, accelerate and corner safely. In recognition of the importance of the providing adequate skid resistance, most of the state highway agencies routinely monitor the skid resistance of the pavement surface and make sure it meets the minimum criteria set forth by the state agencies to safely maneuver the vehicle. Locked Wheel Skid Trailer (LWST) is the most commonly used device to measure the skid resistance on the field (WSDOT). Once the measured skid resistance is less than the minimum standards set by the state agencies, corrective measures are taken by providing a surface treatment or resurfacing the pavement. However, the costs associated with maintenance and regular monitoring is high, hence there is a need for rapid evaluation of friction characteristics of Hot-Mix Asphalt (HMA) wearing course during the mix design process. By doing so, the state highway agencies can confidently optimize the amount and proportions of aggregate in the final mix design to provide sufficient skid resistance over the life span of the pavement. This research paper concentrates on further developing a laboratory testing protocol for Three Wheel Polishing Device (TWPD) developed by National Center for Asphalt Technology (NCAT) to rapidly evaluate the friction loss of HMA wearing course by conditioning of HMA slabs and measuring the friction and

texture. The results of the laboratory conditioning and testing are further correlated to the field data measured on the NCAT test track.

1.2 Objectives of the Study

The main objective of the study to rapidly evaluate the friction loss of the HMA wearing course as a function of polishing effect by using TWPD and measuring friction and texture of HMA slabs. The study consists of two phases; the specific objectives of each phase are outlined below:

1. The objective of the Phase I was to further develop a laboratory testing protocol for TWPD by determining the optimum load on the slab, speed of the wheel carriage and the number of conditioning cycles. The Phase I will improve the TWPD to better study the polishing and friction characteristics of the HMA surface. Finally, analyze the results to determine the conditioning protocol that best correlates with the field friction history.

2. The objective of the Phase II is to evaluate the friction characteristics of HMA surface by varying the amount of friction aggregate in the mixture and develop a correlation between laboratory and field friction data.

1.3 Scope of Work

The research involved conditioning of HMA surface slabs using TWPD developed by NCAT and measuring friction and texture. The friction and texture of the HMA surface is measured using Dynamic Friction Tester (DFT) and Circular Texture Meter (CTM) in accordance with ASTM E-1911 and ASTM E-2157, respectively. The research work was conducted in two phases. In Phase I, three loads (91, 107and 122 lbs.) and two speeds (40 and 60

rpm) were evaluated. Two SMA mixes are selected for Phase I study (Tennessee hard mix and

Alabama soft mix) with good and poor friction performance at the NCAT Test Track

respectively. Three replicate slabs were prepared and tested for each set of conditioning speed;

load and mixture evaluated i.e. a total of 36 slabs (3 loads×2 speed×2 mixes×3 replicates=36

slabs). The friction and texture are measured at intervals of 0, 0.5, 1, 2, 4, 8, 16, 32, 64 and 128

thousands cycles. The results were analyzed to determine the test protocol i.e. optimum load,

speed and conditioning cycles of the TWPD that best correlates with field friction history. In

Phase II the optimum load and speed combination determined in the Phase I was used. Two

dense graded mixes were selected for the Phase II of this study (Alabama hard mix and South

Carolina soft mix) with good and poor friction performance at the NCAT Test Track

respectively. Three aggregates blends were prepared for each mix by proportionately combining

high and low polishing aggregates to determine the influence of friction aggregate. Three

replicate slabs were prepared for each blend of the two mixes (2 mixes*3 blends*3 replicates=18

slabs). Finally, the laboratory friction data at different intervals of conditioning cycles was

correlated with field friction data measured at the NCAT test track.

In this chapter the definitions of friction, texture and factors affecting the frictional

properties of pavement surface are discussed. The chapter also discusses the different laboratory

polishing devices, friction and texture measurement devices.

2.1 Pavement Friction

According to Hall et al. (2006), pavement friction is defined as "the force that resists the

relative motion between the vehicle tire and pavement surface." The friction force (F) in Figure

2.1 is developed when a tire slides or rolls over the pavement surface (Hall et al., 2006).
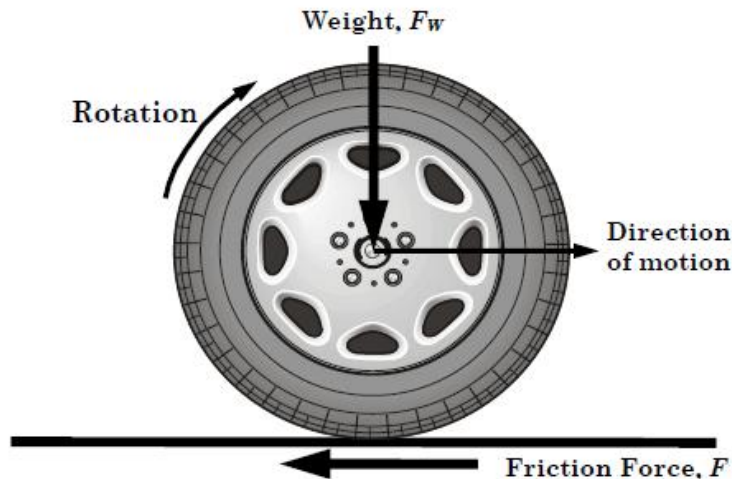
Figure 2.1 Simplified diagram of forces acting on a rotating wheel (Hall et al., 2006)

The friction coefficient (μ) is the ratio of the horizontal friction force (F) to the vertical

load (F_w) and is computed using the equation 1.

$$\mu = F/Fw$$
<div align="right">Eq. 1</div>

Pavement friction is an important factor in road safety as it is critical in maintaining the control of the vehicle and stopping the vehicle in case of emergency braking situation. The terms pavement friction and skid resistance are used interchangeably in the literature. Generally, higher the friction value greater is the control the driver has on the vehicle. The friction force developed between the tire and the pavement surface consists of two components (*a*) Adhesion (F_A) and (*b*) Hysteresis (F_H) as shown in Figure 2.2. (Choubane et al., 2004)
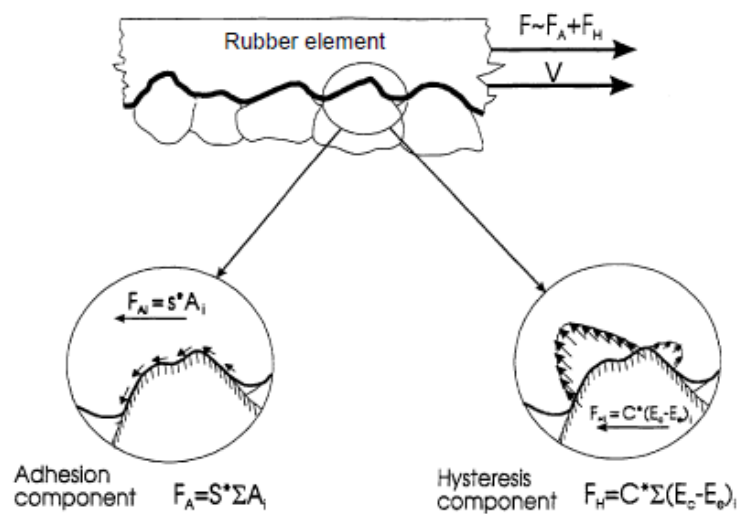
Figure 2.2 Components of pavement-tire interaction (Choubane et al., 2004).

Adhesion is the friction component relates to the contact area at the pavement-tire interaction as well as function of the interface shear strength. The hysteresis component of frictional force is outcome of the energy loss due to bulk deformation of the vehicle tire (Choubane et al., 2004).

Thus the frictional force is sum of the adhesion and hysteresis force components. These components mainly depend on the pavement surface characteristics and characteristics of the tire.

2.2 Factors Effecting Pavement Friction

There are many factors affecting the friction between rubber tires and a pavement surface such as texture of the pavement, vehicle speed, and the presence of water. The characteristics of the construction materials and techniques also influence pavement friction (Dewey et al., 2001). Wilson and Dunn (2005) categorized these factors into following four categories

- Vehicle Factors: vehicle speed, angle of tire to the direction of moving vehicle, slip ratio, tire thread depth and tire characteristics.

- Pavement Surface Aggregate Factors: surface texture, type of surface and geological properties of surfacing aggregate.

- Load Factors: Age of surface, pavement geometry, traffic flow and loading conditions.

- Environmental Factors: temperature, surface contamination, rainfall intensity and duration.

2.3 Pavement Texture

Pavement texture represents the irregularities in the pavement surface and the aggregate particles. Safety, efficiency and friction-related properties of a pavement depend on its surface texture properties. These surface texture characteristics can be classified into Macrotexture and Microtexture (Kummer and Meyer, 1963).

Macrotecture refers to the larger irregularities in the road surface. The irregularities greater than 0.5 mm (0.02 inch) in height are classified as macrotexture (Dewey et al., 2001). The magnitude of this component depends on the size, shape, nominal maximum aggregate size and distribution of coarse aggregates (Noyce et al., 2005; National Asphalt Pavement

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Association (NAPA), 1996). Adequate macrotexture is required for the dispersion of water, to prevent hydroplaning.

Microtexture refers to the irregularities in the surfaces of the aggregate particles. The irregularities less than 0.5 mm (0.02 inch) in height are classified as microtexture (Dewey et al., 2001). Microtexture helps in maintaining the tire-pavement contact by penetrating into the thin water film. The drainage of the water film between tire and pavement is a function of amplitude and number of these micro-irregularities. The smoothness or the roughness of the aggregates depends on these irregularities. The magnitude of the microtexture depends on the initial roughness on the aggregate surface and its ability to retain roughness against the polishing action of traffic and environmental factors (Noyce et al., 2005; Jayawickrama et al., 1996). Microtexture defines the magnitude of skid resistance, and macrotexture controls the slope of skid resistance as speed increases. At low speeds, macrotexture has little effect on friction level while microtexture defines the level of friction at low speeds.

2.4 Overview of Existing Laboratory Polishing Devices

There are four types of polishing devices which are capable of polishing the aggregate and HMA samples. A brief review of the existing devices is as follows.

2.4.1 Michigan Indoor Wear Track

Michigan Department of Transportation (MDOT) uses wear track to determine the performance of individual coarse aggregate specimens by polishing them using the full scale smooth tire in accordance with ASTM 524. According to Dewey et al. (2001), the test specimens are trapezoidal in shape casted in molds and clamped along the circular wear track. The wear

track consists of two wheels pivoted around the center. An electric motor is used to drive the wheels which are loaded by a vertical force of 550 pounds each. The specimens are then individually tested using a laboratory friction tester at specified intervals of 500,000 cycles until 4 million passes. The friction tester consists of freewheeling tire powered by motor; the wheel is drooped on to the specimen after a speed of 40mph is reached. The test specimens are made using coarse aggregates samples passing 9.5 mm sieve and retained on No.3 sieve. The aggregates are placed in the steel molds with binding cement mortar, and then the specimens are cured in water for fourteen days before testing. This method is not only arduous but also time-consuming.

(a) Laboratory Wear Track   **(b) Laboratory Friction Tester with Specimen**
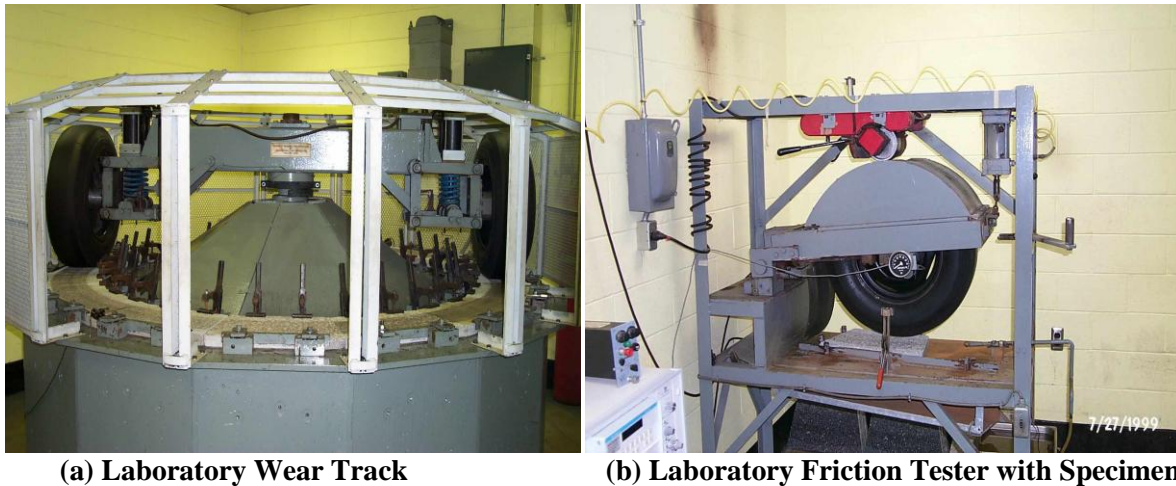
Figure 2.3 Michigan Indoor Wear Track (Dewey et al., 2001)

2.4.2 North Carolina State University Wear and Polishing Machine

The NCSU wear and polishing machine consists of circular track which is used to polish aggregate and asphalt specimens. The test specimens are prepared in accordance with ASTM C 192. The device consists of four individually mounted, free rolling wheels pivoted about a central shaft driven by an electric motor. Pneumatic rubber tires are used for polishing asphalt specimens with tire pressure maintained at 20 psi and constant wheel load of 70 lb. For concrete

specimens, steel wheels are used to accelerate the polishing action during the middle portion and pneumatic tires are used during initial and final testing process. The diameter of wear track is 36 in. to the center of wheel path and holds 12 equally spaced specimens. The duration of polishing is about 8 hours. The friction tests are performed on the specimens at specified intervals during polishing using British Pendulum tester (BPT) or NCSU Variable Speed Friction Tester. The device polishes the specimens in fairly short period of time and does not use slurry or water during operation. The test method is covered in ASTM E 660-90.
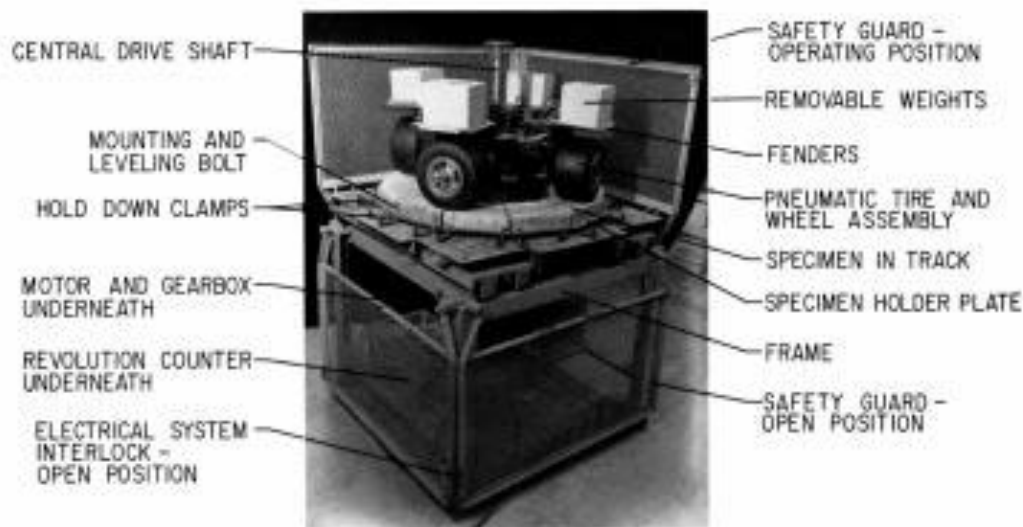
Figure 2.4 NCSU Wear and Polishing Machine (Ref. ASTM E 660)

2.4.3 Wehner/Schulze Polishing Machine:

The Wehner/Schulze polishing machine was developed in Germany 30 years ago (Do et al., 2007). It is comprised of two heads to assist polishing and friction measurement, respectively. Specimens are cores with the diameter of 22.6 cm. They can be taken from asphalt pavement or laboratory-prepared slabs (aggregate or asphalt specimens). Just after the road construction (less than 1-month traffic), 10 cores of 22.5 cm diameter are taken from the road edge. One specimen is stored in the laboratory as a reference. The other specimens are used for

polishing tests. The polishing action is achieved by means of three rubber cones mounted on a

rotary disc, which rolls on the specimen surface. The rotation frequency is 500 rpm, giving a

linear speed of (17 km/h) 10.6 mph. The contact pressure between the cones and the specimen

surface is 58.0 psi. The slip between the cone and the specimen surface is between 0.5% and 1%,

which is roughly the slip between rolling tires and roads. A mix of water with quartz powder is

sprayed on the specimen surface during the polishing action. The surface is polished on a ring of

roughly 16 cm in diameter and 6 cm in width. The machine stops after a given number of

revolutions, at each stop, water is sprayed on the specimen surface and 500 rotations are

performed using the cones to wash all debris before it is moved the friction measuring head. This

machine is not designed to handle typical specimen size compacted from the gyratory compactor.
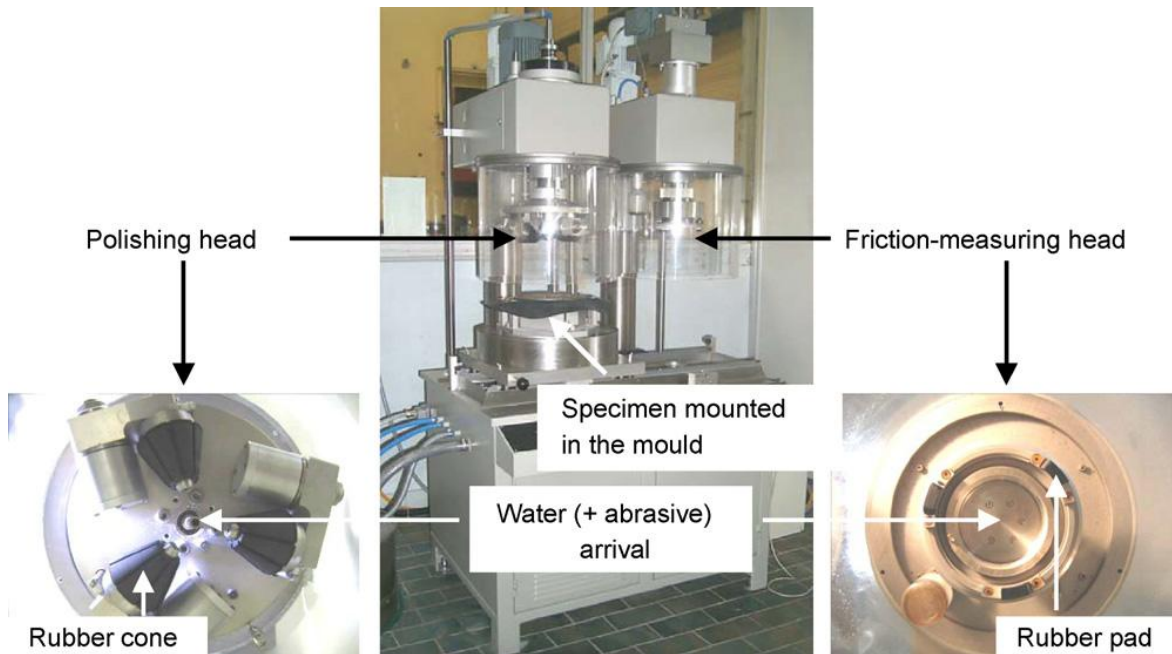
Figure 2.5 Wehner/Schulze Polishing Machine (Do et al., 2007)

2.4.4 Penn State Reciprocating Polishing Machine

The Penn State Reciprocating Polishing Machine used to polish the aggregate and mixture samples in the laboratory was developed by the Pennsylvania Transportation Institute (PTI) and Pennsylvania State University (PSU). The apparatus consists of rubber pad which is oscillated back and forth on the specimen surface to be polished while slurry of water and abrasive are sprayed which prevents the overheating of the rubber surface (Nitta et al., 1990). The specimens are cast as an aggregate panel on which specimens were securely attached. After polishing, the friction properties of the specimen are measured using British Pendulum Tester (BPT). For polishing the specimen, 5000 passes of rubber pad are found to be sufficient to achieve stable surface friction. The extent of polishing was determined based on the measured BPN_{5000} value (BPN after 5000 passes). The test time for polishing is less than half an hour (Nitta et al., 1990).

2.5 Polishing Devices for Aggregates

The British Polishing Wheel is used for polishing aggregates in the laboratory. The Los Angeles Abrasion Test and Micro Deval Device are for measuring toughness and abrasion resistance of aggregates.

2.5.1 Los Angeles (LA) Abrasion Test

The LA Abrasion test is used to characterize the toughness and abrasion of coarse aggregate. The sample of aggregate retained on 1.70 mm sieve is placed in a rotating drum along with specified number of steel spheres and rotated for 500 revolutions at 30-33 rpm. The sample is then removed from the rotating drum and sieved using 1.70 mm sieve. The difference between

the retained and passed material is reported as percent loss. The standard test for LA Abrasion is in ASTM C 535.

2.5.2 British Polishing Wheel

The device is used to characterize the coarse aggregate based on their ability to resist to polishing action. The device consists of a cylindrical wheel assembly with flat surface periphery on which coarse aggregate specimens are clamped to form a continuous strip of aggregate particles. The aggregate specimens consist of curved shape mold in which coarse aggregate particles are held in place by means of a bonding material (epoxy resin). The cylindrical wheel is rotated against a pneumatic-tired wheel that provides polishing action. To accelerate the polishing, Silicon Carbide Grit No. 150 and water fed at the rate of 6 ± 2 g/min and 50 - 75 ml/min respectively for the desired testing time. The friction values of the aggregate specimen are measured using British Pendulum Tester (BPT) according to ASTM E303. The limitation of British polishing wheel is that it can be used for polishing only aggregate specimens; it does not have the ability to polish HMA specimens. Moreover, the procedure used to prepare the aggregate specimen is tedious and time consuming. The test procedure for British Polishing wheel can be found in ASTM D3319.

2.5.3 Micro-Deval Device

The Micro-Deval Test is a measure of abrasion resistance and durability of mineral aggregates resulting from a combination of actions including abrasion and grinding with steel balls in the presence of water. A sample with standard grading is initially soaked in water for not less than one hour. The sample is then placed in a jar mill with 2.0 L of water and an abrasive

charge consisting of 5000 g of 9.5-mm diameter steel balls. The jar, aggregate, water, and charge are revolved at 100 rpm for up to 2 h, depending on the particle size. The sample is then washed and oven dried. The loss is the amount of material passing the 1.18-mm sieve expressed as a percent by mass of the original sample.

2.6 Friction Testing Devices

2.6.1 British Pendulum Tester

The most common device for laboratory testing of friction is the British pendulum tester (BPT). The manually operated BPT provides an indicator of friction through the swinging of a pendulum-based rubber slider and its contact with the pavement surface. The elevation to which the pendulum swings after contact provides the basis for the friction indicator, termed British Pendulum Number (*BPN*). The BPT is a portable device and can be used both for both laboratory and field measurements. BPT is used for measuring the friction characteristics of pavement surface at low speeds (Satio et al., 1996).The test method for measuring friction using BPT is specified in ASTM E303.

Figure 2.6 British Pendulum Tester (BPT)

2.6.2 Dynamic Friction Tester

The Dynamic Friction Tester as described by ASTM E 1911 consists of three rubber

sliders and a motor that reaches to 100 km/h tangential speed. The rubber sliders are attached to a

350 mm circular disk by spring-like supports that facilitate the bounce back of the rubber sliders

from the pavement surface. The DFT system can be used to measure friction characteristics of

laboratory manufactured samples that are at least 450 by 450 mm (17.75 by 17.75 inches). The

test is started while the rotating disk is suspended over the pavement and driven by a motor to a

particular tangential speed.

Water is sprayed on the rubber pad and pavement interface through surrounding pipes to

simulate wet weather friction. Now the disk is lowered and the motor is disengaged. By

measuring the traction force in each rubber slider the coefficient of friction of the surface is

determined. DFT measures a continuous spectrum of dynamic coefficient of friction of pavement

surface over the range of 0 to 80 km/h with good reproducibility (Vollor and Hanson, 2006).

2.6.3 Locked Wheel Skid Tester (LWST)

Locked wheel testers (ASTM E-274) are the most commonly used device in the U.S.

(Henry, 2000). In this method, the relative velocity between the surface of the tire and the

pavement surface is equal to the vehicle speed. Usually the left wheel path in the travel lane is

tested. The operator applies the brakes and measures the torque for one second after the tire is

fully locked then computing the correspondent friction value. According to Davis (2001), the

measurement of skid resistance using LSWT is affected by several factors including pavement

surface texture, age of the pavement, and tire used. The friction measurement with LWST can be

performed using ribbed tire (ASTM E 501) or smooth tire (ASTM E 524). In 2005, Li and

Noureldin found that friction measurement using ribbed tire is sensitive to micro-texture and insensitive to macro-texture. In U.S., the use of a ribbed tire (ASTM E 501) predominates but the use of the smooth tire (ASTM E 524) has been increasing recently. Ribbed tires are preferred by some because they are less sensitive to water film thickness than the smooth tire.

In 2008, Khasawneh studied the friction characteristics of pavement surfaces using the Locked Wheel Skid Trailer (LWST), Dynamic Friction Tester and Circular Texture Meter. Four existing pavement sections were selected for the study. The results were analyzed using regression analysis; Skid numbers measured using LWST are correlated to friction numbers measured using the DFT at different speeds. SN(64)R was found significantly correlated to DFT64, but not to MPD which was attributed to the use of ribbed tire LSWT which is insensitive to macro-texture (Khasawneh et. al., 2008)

2.7 Texture Measuring Devices

The friction-related properties of a pavement depend on its surface texture characteristics. These characteristics, as previously stated, are known as macro-texture and micro-texture. The pavement surface should have adequate macro-texture for the quick drainage of water accumulated on the surface of the pavement to prevent hydroplaning. Macro-texture of the pavements could be estimated by simulating the percentage of contact points within the area of a tire footprint on the pavement surface (Forster, 1989). The section presents some of methods of measuring pavement texture.

2.7.1 Volumetric Method

Macro texture measurements of a surface are generally measured using volumetric techniques. Basically, this method consists of spreading a known volume of a material (sand or glass beads) onto the pavement surface and measuring the resulting area as specified in ASTM E 965. There are different types of volumetric methods depending on the material used. Sand patch method is most commonly used to measure macro-texture. The method involves spreading specified volume of Ottawa sand retained on No. 100 sieve and passing No. 50 sieve. The sand is then spread on the measurement surface in circular shape using a spreading tool. The diameter of the circle gives the area. Dividing the volume of sand by the area gives Mean Texture Depth (MTD) (Ergun et al., 2005). In current practice, glass beads are used instead of sand because glass spheres are uniform in shape compared to sand.

Another method of macro-texture measurement called grease patch method is used by National Aeronautics and Space Administration (NASA). This method is similar to sand patch method, but instead of sand, a known volume of grease is spread over the measurement surface between two parallel strips of masking tape (Jayawickrama et al., 1996).

2.7.2 Outflow Meter Test (OFT)

The Outflow Meter Test (OFT) is another method used to measure the macro-texture of the pavement surface. The test uses the concept of rate of flow of water to determine the macro-texture. The method consists of a transparent vertical cylinder which rests on rubber ring placed on pavement surface. Water is filled in the vertical cylinder with the valve closed at the bottom of the cylinder. When the valve is opened, the time required for known volume of water to pass under the rubber ring into the pavements is measured using a stop watch. This time is reported as

outflow time, which indicates the ability of the pavement surface to drain water. High outflow time indicates smooth macro-texture and low outflow time indicates a rough micro-texture. The OFT is highly correlated with MPD and MTD of nonporous pavements.

2.7.3 Laser Devices

Due to the significant advances made in laser technology several devices which can measure the macro-texture at traffic speeds are now available. The profiles produced by these devices can be used to compute various profile statistics such as the Mean Profile Depth (MPD), the overall Root Mean Square (RMS) of the profile height and other parameters that reduce the profile to a single parameter (Abe et al., 2000). The Mini-Texture-Meter developed by British Transport and Road Research Laboratory, Selcom Laser System developed by researchers at the University of Texas at Arlington and the noncontact high speed optical scanning technique developed by the researchers at Pennsylvania State University are examples of the latest equipment that can collect data from a vehicle moving at normal highway speeds (Jayawickrama et al., 1996).

2.7.4 Circular Texture Meter (CTM)

The CTM is a laser-based device used to measure the MPD of a pavement surface. The CTM can be used in the laboratory as well as in the field. It uses a charged coupled device (CCD) laser to trace the profile of a circle 11.2 inch in diameter. The profile traces of the pavement surface obtained from the laser are stored on a portable computer. The profile is divided into eight segments and the texture depth of the surface is reported as the average profile depth of these eight segments. This test procedure for measuring macro-texture using CTM is

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presented in ASTM E 2157. Hanson and Prowell (2004) indicated that CTM results are

comparable to results from sand patch test.

Figure 2.7 Circular Texture Meter

In addition to the MPD, the analysis software supplied with the CTM produces a root

mean square (RMS) value for the profile of the circular track. The RMS is a statistical value,

which offers one measure of how much the actual data (measured profile) deviates from a best-

fit (modeled profile) of the data. By reviewing both statistics together (the MPD and RMS), it is

possible to make a judgment relating to the kinds of features supplying the texture i.e., negative,

positive or neutral textured (McGhee and Flintsch, 2003).

2.8 Earlier studies on Three Wheel Polishing Device (TWPD)

A laboratory study was conducted by NCAT to investigate the use of the E-Krete product

as a pavement surface using the NCAT Three Polishing Device (Tran and Powell, 2008).The

study focused on friction and noise characteristics of E-Krete product under heavy traffic over

time. This project was conducted in two phases. The friction and surface characteristics of E-Krete product were evaluated by comparing it to a new HMA surface before and after they were polished using the TWPD. The friction and texture measurements are taken using Dynamic Friction tester and Circular Texture Meter according to the ASTM E1911 and ASTM E2157 respectively. The DFT results showed that there is an initial spike in friction values due to removal of binder from the surface. The DFT friction values of the E-Krete increased after initial polishing and then stabilized throughout the laboratory testing. The DFT and CTM results of both the HMA surface and E-Krete treated surface gave similar results after 64,000 polishing cycles. The E-Krete surface showed little wear after 132,000 polishing cycles which agreed with the previous (Engineer Research and Development Center (ERDC) study that E-Krete product exhibited good wear resistance.

A 2006 laboratory study by Vollor and Hanson showed that the friction values rapidly decreases during initial polishing. The friction values continue to decrease on further polishing and finally reach a terminal condition. The reason for decrease in friction values may be due to polishing of sharper edges of exposed aggregates and as these aggregates are reoriented the friction values decreases.

Another Study was conducted by the North Central Superpave Center (NCSC) to evaluate the influence of asphalt mix composition on frictional characteristics of HMA. Different variables were studied including gradations, NMAS, percent of friction aggregate and aggregate types. A total of 46 slabs were prepared and polished using Three Wheel Polishing Device developed by NCSC. The friction and texture measurements are taken using Dynamic Friction Tester and Circular Texture Meter according to the ASTM E1911 and ASTM E2157 respectively. The friction and texture measurements were taken at the beginning and after

specific cumulative number of wheel passes from 1500 to 165000 cycles. The results showed that increasing friction aggregate content improves friction properties and also that the type of friction aggregate influences polishing rate and terminal friction.

CHAPTER 3. NCAT THREE WHEEL POLISHING DEVICE

3.1 Description

The NCAT Three Wheel Polishing Device (TWPD) is an automated slab polisher that consists of three pneumatic rubber tires attached to the turntable. The wheels rotate around a circle with diameter of 11.2 in, same as that of DFT and CTM devices to study the polishing effect of HMA slabs. The turntable is attached to a vertical shaft which is driven by a motor. The motor is controlled by a speed controller which is used to set desired speed. The weight on the wheels can be varied by adding or subtracting circular steel plates. The wheel load setup is enclosed in a wire mesh frame with a front hinged door for safety.
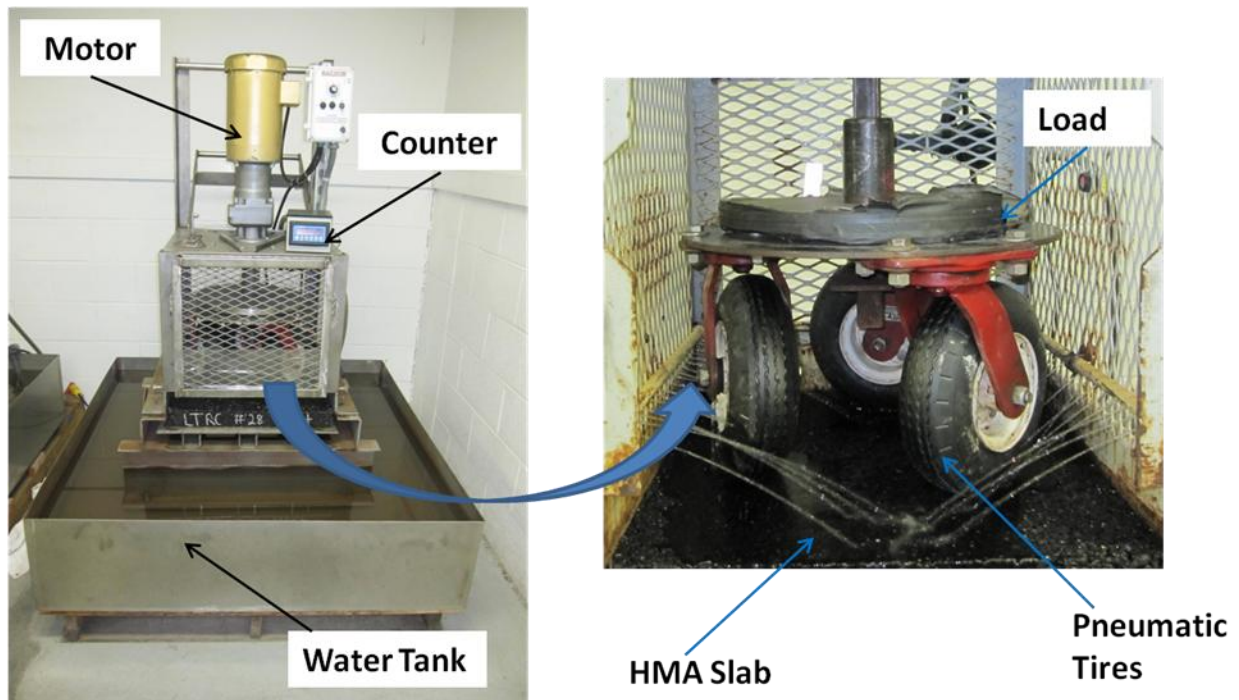
Figure 3.1 NCAT Three Wheel Polishing Device (TWPD)

An Omega digital counter with laser pick-up light is used to count the number of rotations of the turntable. The Omega counter is designed to turn off the motor when desired

revolutions are obtained. A water spray system is provided inside the wire mesh frame to wash the abraded particles from the surface being polished. The spray system consists of three PVC tubes with small holes on three sides of the frame. The entire setup is supported over a water tank from which water is re-circulated through the spray system.

3.2 Test Protocol

1. **Equipment Preparation**

The inflation pressure on tires is set to 50 psi. The tires on the polisher are checked for tread depth at the beginning of every set of six slabs conditioning and polishing cycle. The slab is placed on a stainless-steel pallet and remains for the duration of the test to maintain constant slab conditions and avoid damage.

2. **Initial Testing**

Prior to TWPD conditioning, the texture and friction properties of the slabs are measured using circular texture meter (CTM) and dynamic friction tester (DFT) in accordance with ASTM E 1911 and ASTM E 2157, respectively.

3. **Conditioning**

The test slab is carefully lifted with the help of manual fork lift and inserted into the frame of TWPD. The TWPD polishing tires are lowered onto slab by lowering the load frame with the help of small hydraulic jack. The front hinged door is closed and the motor is turned on. The speed controller is set to desired speed and the counter is used to input desired number of revolutions. The power switch is flipped to start both the tires and water spray system. The motor and water pump turns off automatically after it has run through the set number of revolutions.

The front hinged door is opened, turntable is raised and the slab is taken out on the steel pallet using the fork lift.

4. Post Conditioning Testing

The slab is placed on a cart and DFT reading are taken immediately when the slab is wet. When the slab is surface dried the CTM readings are taken. The procedure is repeated for each conditioning cycle at cumulative intervals of (500, 1000, 2000, 4000, 8000, 16000, 32000, 64000 and 128000) cycles on TWPD. The entire testing process takes three days to complete.

3.3 Data Collection

The laboratory prepared HMA slabs are subjected to accelerated polishing using NCAT TWPD. After polishing, tests with DFT and CTM were performed at the same location on the HMA slabs at pre-defined intervals of conditioning cycles. Two TWPD devices were used for conditioning of HMA slabs. The location of the wheel-path was offset differently for both TWPDs. Each HMA slab is conditioned on the same TWPD throughout the testing. To ensure that the tests are performed at the same location at different intervals of conditioning cycles, four wooden templates were built for DFT and CTM two for each TWPD used for testing. After the specified number of conditioning cycles the HMA slab is taken out of the TWPD and placed on a cart. The DFT wooden template corresponding to particular TWPD is placed around the HMA slab. Now, the DFT is fitted into the space inside the template and friction measurements are taken in accordance with ASTM E1911. After the slab is air dried, the CTM wooden template for the particular polisher is placed around the slab. The CTM is now placed into the space inside the

template and texture measurements are taken according to ASTM E2157. The HMA slab is now

ready for the next set of conditioning cycles.

Circular Texture Meter (CTM)   **Dynamic Friction Tester (DFT)**

Figure 3.2 Laboratory Testing of Friction and Texture Properties of HMA Slabs

CHAPTER 4. PHASE I – RESEARCH TEST PLAN

4.1 Introduction

The mixtures selected for the Phase I testing consists of two SMA mixtures from Tennessee and Alabama with good and poor friction performance at the NCAT Test Track, respectively. The Tennessee mix was paved on test track section E1 in 2003 and the AL mix was paved on section W7 in 2000. They are designated as E1 mix and W7 mix, respectively.

4.2 Aggregate Properties

Both mixtures contained limestone as the primary aggregate source. For the E1 mix, limestone aggregates were obtained from Rinker Materials South Central Inc located in Knoxville, TN and Danley Quarry near Nashville, TN. For the W7 mix, limestone aggregate was obtained from Calera in Alabama located south of Birmingham. A stockpile of this source was locally available at East Alabama Paving Company Inc. located in Opelika, AL. The aggregates used in the E1 mix were: (i) Rinker Limestone 7s, (ii) Danley Limestone 8s, (iii) Rinker Limestone Screenings 10s, and (iv) Boral Fly Ash. The materials used in the W7mix were: (i) Calera Limestone 7s, (ii) Calera Limestone 821, and (iii) Fly Ash. Tables 4.1 and 4.2 give the summary of aggregate properties of E1 mix and W7mix respectively.

Table 4.1 Aggregate Properties of E1 Mix

Stockpile	Specific Gravities		Absorption, %
	Bulk (G_{sb})	Apparent (G_{sa})	
Rinker Limestone 7s	2.581	2.704	1.8
Danley Limestone 8s	2.689	2.723	0.5
Rinker Limestone Screenings 10s	2.283	2.682	6.5

Table 4.2 Aggregate Properties of W7 Mix

Stockpile	Specific Gravities		Absorption, %
	Bulk (G$_{sb}$)	Apparent (G$_{sa}$)	
Calera Limestone 7s	2.739	2.766	0.4
Calera Limestone 821	2.648	2.757	1.5

4.3 Binder Properties

The binder grade used for both Phase I mixtures was PG 76-22, and the optimum binder contents was 6.5% for E1 mix and 6.0% for W7 mix. Table 4.3 gives the summary of binder characteristics.

Table 4.3 Binder Properties

Mix	Mix Type	Binder Grade	Asphalt Content (%)
E1	SMA	76-22	6.5
W7	SMA	76-22	6.0

4.4 Laboratory Preparation of Sample and HMA Slabs

First, the aggregates were separated by dry sieving into desired sizes using a mechanical shaker. The screened aggregates were weighed and re-blended together according to the target gradation for each mixture. The blended aggregates were placed in 5 gallon cans and heated to obtain a uniform temperature in a 350°F oven overnight. The heated aggregate was transferred into a mixing bowl and mixed with target amount of asphalt binder until a uniform mixture was obtained. Asphalt binder was heated in an oven to 310°F for four hours before mixing. The mix was weighed and divided into four parts and heated to 350°F. The loose mix was compacted using laboratory slab compactor into (20 in. x 20 in. x 2 in.) slab specimen. The slabs were prepared on need basis as the project progresses. Refer to Appendix A for the slab preparation protocol.

4.5 Testing Program for Phase I

Only one conditioning load (105 lb) and speed (40 rpm) were used in the initial test development of TWPD done by Vollor and Hanson in 2006. In the Phase I study, different load and speed combinations are used to determine its influence on friction and polishing of the HMA surface. Three conditioning loads (91 lbs., 107 lbs. and 122 lbs.) and two conditioning speeds (40 and 60 rpm) are evaluated. Three replicate slabs are tested for each set of conditioning load, speed and mixture evaluated. A total of 36 HMA slabs with 18 slabs for each of the two mixtures are prepared and tested in the Phase I of this study. Each test group consisted of 6 slabs representing 2 sets of 3 replicates for each combination of load and speed. The conditioning of HMA slabs is done on two TWPD in the NCAT laboratory. Table 4.4 shows the testing order for all 36 slabs in Phase I.

Table 4.4 Testing Order of HMA Slabs in Phase I

Mixture	Slab Group	Slab number	Load, lb.	Speed, rpm	TWPD
E1mix	Group 1	1, 2, 3	107	40	Old
		4, 5, 6		60	
	Group 2	7, 8, 9	91	40	New
		10, 11, 12		60	
	Group 3	13, 14, 15	122	40	Old
		16, 17, 18		60	
W7 mix	Group 4	1, 2, 3	107	40	New
		4, 5, 6		60	
	Group 5	7, 8, 9	122	40	Old
		10, 11, 12		60	
	Group 6	13, 14, 15	91	40	New
		16, 17, 18		60	

Two TWPD are used simultaneously for conditioning slabs in groups of six. A two week gap was provided between the start of each polisher due to early high frequency testing. Testing and conditioning of Phase I started in November 2009 and ended in May 2010. Table 4.5 gives a summary of TWPD conditioning cycles for Group 1.

Table 4.5 TWPD Conditioning Cycles for Group 1 at 107 lbs. Wheel Load

Conditioning cycles		0	500	500	1000	2000	4000	8000	16000	32000	64000
Accumulated cycles		0	500	1000	2000	4000	8000	16000	32000	64000	128000
Speed (rpm)	Slab #										
40	1										
40	2										
40	3										
60	4										
60	5										
60	6										

After each set of conditioning cycles the slabs were tested with DFT and CTM in accordance with ASTM 1911 and ASTM 2157, respectively. According to ASTM 1911 the pads of the DFT need to be replaced every 12 drops. After some preliminary testing it was observed that the DFT pads did not show measurable wearing until after 54 drops on the HMA surface. So the ASTM 1911 protocol was modified and the pads were changed for every 54 drops for effective usage and cost reduction. The DFT pads are checked for consistent measurement by using a calibration plate after every set of six drops. The TWPD tires are replaced at the beginning of each set of 6 slabs. Due to high binder content in the SMA mixes the asphalt binder buildup on the TWPD tires was scraped out by using a spatula during the initial 5000 conditioning cycles.

CHAPTER 5. PHASE I RESULTS AND DATA ANALYSIS

5.1 Introduction

This section presents results and analysis of measurements performed on asphalt mixtures. In the first analysis, the results of the DFT and CTM of the two different mixes selected for Phase I are statistically analyzed and discussed. This analysis was used to develop an optimized test protocol for TWPD by providing an optimum wheel speed and wheel load combination to be used for further testing in Phase II.

5.2 Data Quality

The testing for Phase I consisted of 36 HMA slabs, 18 slabs of each of the two SMA mixtures. The friction and texture properties of each HMA slab are measured by DFT and CTM at specified intervals of polishing. Each test with DFT consists of three replicate measurements made on the surface of the slab. For each replicate test, the DFT measures and records the friction value at five different speeds (0, 20, 40, 60, and 80 km/h). To verify the quality of the data the DFT friction values were analyzed statistically with respect to range, standard deviation and coefficient of variation for each group of three replicate tests. These three values are computed for each slab at five speeds and ten intervals of polishing cycles. This produces 50 sets of 3 computed values for a comprehensive data analysis for each slab.

The outliers for the computed values were identified by the formula (average$\pm 3*$standard deviation). The values that fell outside this range were marked as potential outliers. Of the 900 data points (10 intervals of polishing cycles*5 DFT speeds*18 slabs ==900 data points) there were a total of 84 potential outliers found in the DFT data for E1 mix. Of these 84 outliers, 75

came from the DFT data at 0 and 80 km/h (320 data points), 5 from data at 20 km/h and 2 from data at 40km/h and 3 from data at 60km/h. W7 mix has 77 potential outliers found out of 900 data points. Of the total outliers, 65 came from data at 0 and 80 km/h, 8 from data at 20 km/h and 2 from data at 40 and 60 km/h each. The test results at 0 and 80 km/h showed a large variation due to dynamic conditions of DFT at the beginning and end of each test. Hence the computed values at these extreme speeds were not used for data analysis. The DFT data at 20, 40 and 60 km/h did not have exhibit a large variation with standard deviation values ranging from 0.029 to 0.040. These values met the ASTM E1911 standard's precision statement which states, "The standard deviation of eight measurements on the same test surface ranged from 0.044 at 30 km/h to 0.038 at 60 km/h." Of the measured friction values at 20, 40 and 60 km/h the data at DFT speed of 40 km/h (DFT_{40}) were used for data analysis due to consistency of test results.

5.3 Analysis of DFT Friction Results

Three replicate slabs are tested for each set of conditioning speed and load of the wheel carriage to establish repeatability of test results. There are six different combinations of load and speed for each of the two mixes. A relative analysis is conducted by using the average friction value of three replicate slabs at ten intervals of TWPD conditioning cycles. Figures 5.1 and 5.2 show the comparisons of average friction values (DFT_{40}) at polishing speed of 40 rpm and three levels of load for the E1 mix and W7 mix respectively.
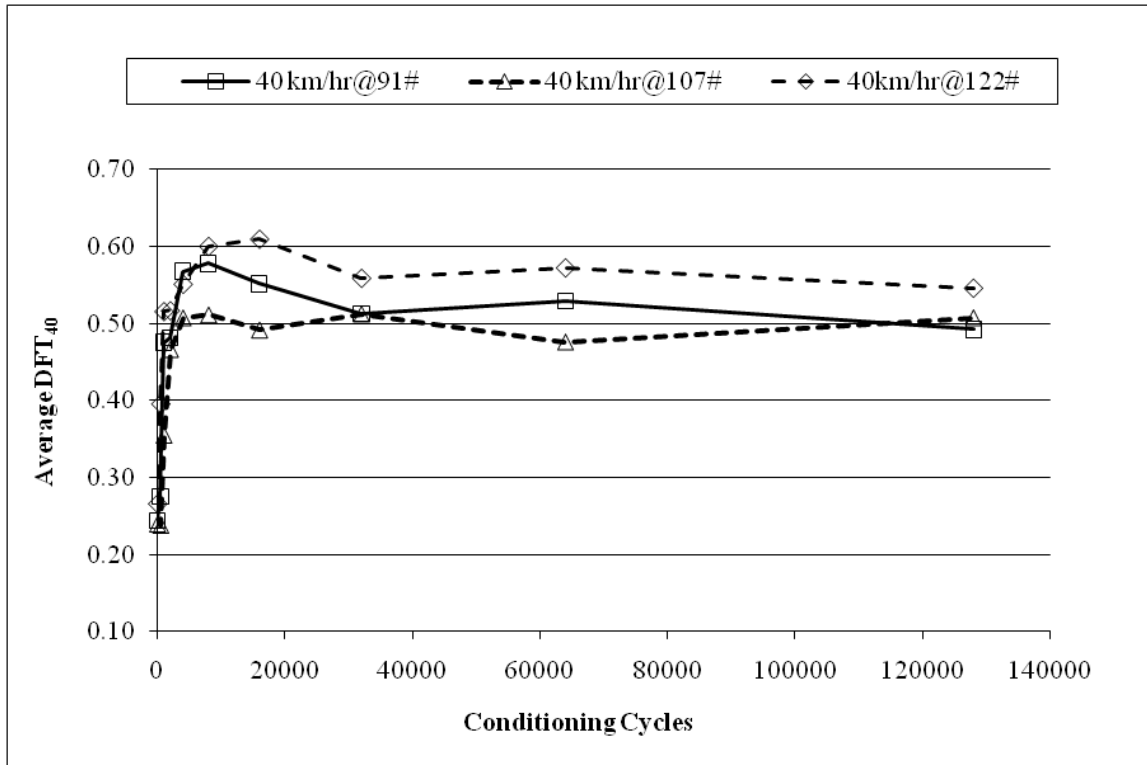
Figure 5.1 Average DFT$_{40}$ vs. Conditioning Cycles for E1 Mix at Polishing Speed of 40 rpm
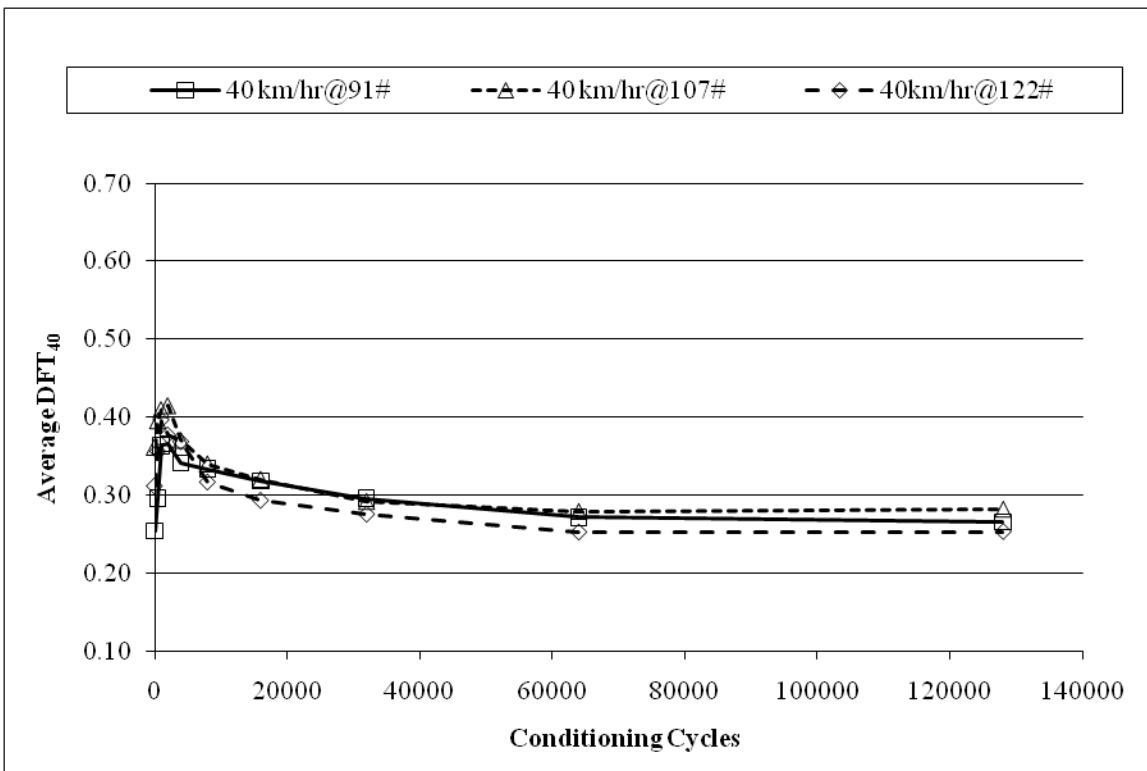
Figure 5.2 Average DFT$_{40}$ vs. Conditioning Cycles for W7 Mix at Polishing Speed of 40 rpm

In Figures 5.1 and 5.2, each point on the graph represents average DFT_{40} of three replicate slabs. Figure 5.1 shows that there is an initial increase in friction values until 8,000-16,000 polishing cycles due to the removal of binder from the surface of the slab. After that there is a gradual decline in the friction values due to aggregate polishing. It is clear that after 64,000 cycles there is relatively little change in the friction values for the E1 mix indicating that it has reached a terminal condition. The terminal friction values for E1 mix are at or above 0.50 for all the three wheel load combinations. This shows that the mix exhibits good skid resistance even after 128,000 cycles.

On the other hand, W7 mix showed much lower DFT results. There was an initial increase in the friction values until 1000 cycles. After that, the W7 mix showed a rapid decrease in the friction values while E1 mix remained almost constant during the polishing. This indicates that the W7 mix is not able to maintain its frictional properties when subjected to polishing. The terminal friction values for the W7 mix are in the range of 0.25 - 0.30 for different load combinations. The E1 mix has higher terminal friction values than the W7 mix. Figures 5.1 and 5.2 indicate that the E1 mix had superior performance when compared to W7 mix. These results are in agreement with the NCAT Test Track results which determined the E1 mix has superior frictional properties.

It was expected that the friction values would decrease as the wheel load from the TWPD was increased, but no trend was observed for DFT_{40} values for either mix when the wheel load was increased. For the E1 mix, the terminal friction value (DFT_{40}) for the 122 lbs. wheel load was higher indicating lower amount of polishing followed by the 91 lbs. and 107 lbs. wheel load both having nearly same terminal friction value. On the other hand, the terminal friction value

(DFT$_{40}$) for W7 mix at 122 lbs. was lower indicating higher amount of polishing followed by 91

lbs. and 107 lbs. respectively.

Figures 5.3 and 5.4 show the DFT$_{40}$ results at polishing speed of 60 rpm for both mixes,

respectively. These figures indicate a similar trend of polishing when compared to slabs polished

at 40 rpm. The terminal friction values for slabs polished at 60 rpm speed are slightly lower than

those at 40 rpm speed indicating higher amount of polishing. The friction values remain stable

after 64,000 cycles for both the mixes indicating that it has reached terminal condition. The

terminal friction values are around 0.5 and 0.25 for E1 mix and W7 mix respectively. The E1

mix performs better than W7 mix under the same speed and load combination. Since the 60 rpm

speed is more time-efficient in polishing the slabs, it was used for further testing in Phase II.

However, as the graphical analysis was not sufficient to determine the optimum load

combination, a statistical analysis was performed. Tables 5.1 and 5.2 summarize the test results

for E1 mix and W7 mix at DFT test speed of 40km/h.
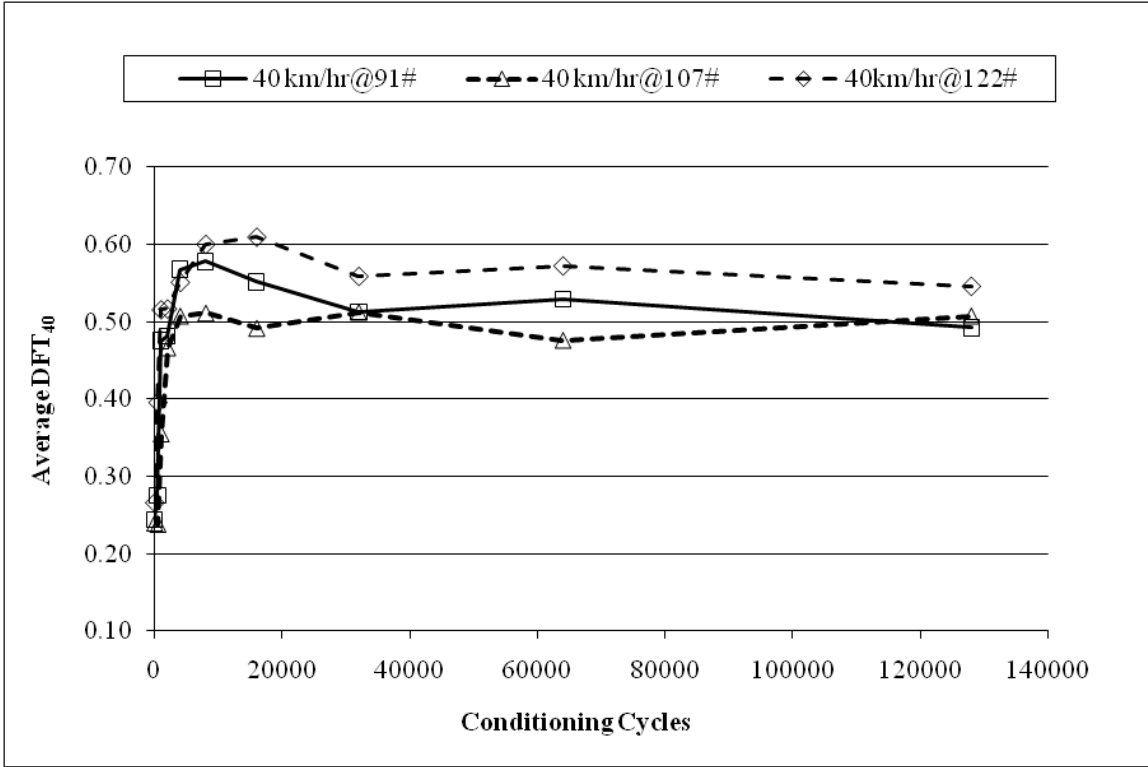
Figure 5.3 Average DFT$_{40}$ vs. Conditioning Cycles for E1 Mix at Polishing Speed of 60 rpm
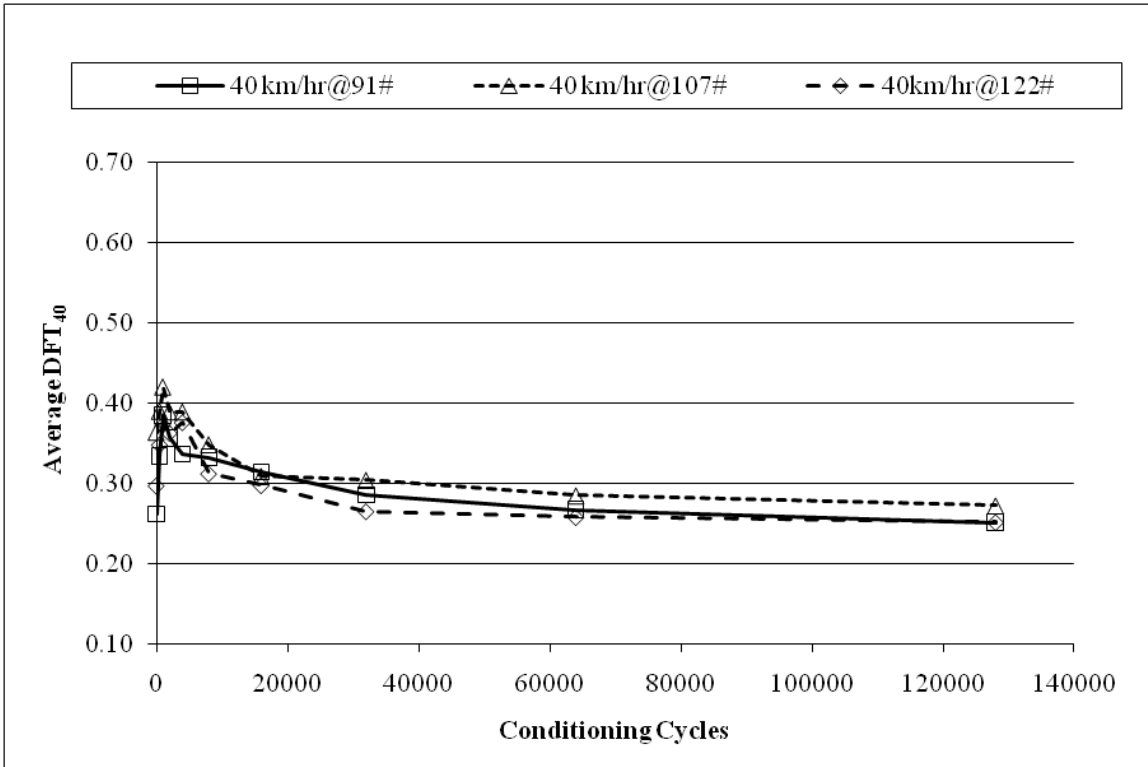
Figure 5.4 Average DFT$_{40}$ vs. Conditioning Cycles for W7 Mix at Polishing Speed of 60 rpm

Table 5.1 Summary of Average DFT40 Values for E1 Mix

Old polisher , Load 91 lbs., Speed 40 rpm				Old polisher , Load 91 lbs., Speed 60 rpm			
Cycles	Slab 7	Slab 8	Slab 9	DFT_{40} Avg.	Slab 10	Slab 11	Slab 12	DFT_{40} Avg.
0	0.230	0.283	0.218	0.244	0.239	0.228	0.231	0.232
500	0.267	0.287	0.271	0.275	0.344	0.339	0.287	0.324
1000	0.461	0.448	0.517	0.475	0.540	0.462	0.434	0.479
2000	0.497	0.419	0.527	0.481	0.551	0.492	0.468	0.503
4000	0.557	0.573	0.573	0.568	0.573	0.510	0.474	0.519
8000	0.552	0.602	0.58	0.578	0.581	0.543	0.522	0.549
16000	0.506	0.592	0.558	0.552	0.551	0.544	0.514	0.536
32000	0.510	0.503	0.525	0.513	0.542	0.538	0.533	0.538
64000	0.506	0.500	0.582	0.529	0.566	0.521	0.501	0.529
128000	0.491	0.516	0.469	0.492	0.488	0.503	0.482	0.491

Old polisher , Load 107 lbs., Speed 40 rpm				Old polisher , Load 107 lbs., Speed 60 rpm			
Cycles	Slab 1	Slab 2	Slab 3	DFT_{40} Avg.	Slab 4	Slab 5	Slab 6	DFT_{40} Avg.
0	0.244	0.208	0.265	0.239	0.197	0.227	0.152	0.192
500	0.191	0.199	0.323	0.238	0.262	0.253	0.296	0.270
1000	0.329	0.343	0.392	0.355	0.334	0.343	0.331	0.336
2000	0.464	0.443	0.492	0.466	0.389	0.400	0.400	0.396
4000	0.511	0.487	0.524	0.507	0.473	0.439	0.432	0.448
8000	0.507	0.490	0.536	0.511	0.509	0.484	0.492	0.495
16000	0.492	0.484	0.498	0.492	0.504	0.501	0.384	0.463
32000	0.514	0.502	0.520	0.512	0.511	0.473	0.484	0.489
64000	0.461	0.482	0.485	0.476	0.484	0.489	0.426	0.466
128000	0.494	0.516	0.512	0.508	0.505	0.510	0.461	0.492

New polisher , Load 122 lbs., Speed 40 rpm				New polisher , Load 122 lbs., Speed 60 rpm			
Cycles	Slab 16	Slab 17	Slab 18	DFT_{40} Avg.	Slab 16	Slab 17	Slab 18	DFT_{40} Avg.
0	0.273	0.264	0.261	0.266	0.210	0.347	0.209	0.255
500	0.460	0.451	0.276	0.396	0.399	0.392	0.242	0.344
1000	0.520	0.517	0.511	0.516	0.392	0.505	0.475	0.458
2000	0.509	0.515	0.527	0.517	0.452	0.529	0.516	0.499
4000	0.577	0.536	0.542	0.551	0.485	0.565	0.524	0.525
8000	0.636	0.593	0.573	0.601	0.570	0.611	0.596	0.592
16000	0.636	0.593	0.601	0.610	0.593	0.606	0.601	0.600
32000	0.557	0.573	0.548	0.559	0.556	0.546	0.552	0.551
64000	0.564	0.574	0.58	0.573	0.469	0.549	0.533	0.517
128000	0.564	0.537	0.538	0.546	0.506	0.531	0.490	0.509

Table 5.2 Summary of Average DFT$_{40}$ Values for W7 Mix

New polisher, Load 91 lbs., Speed 40 rpm				New polisher, Load 91 lbs., Speed 60 rpm			
Cycles	Slab 16	Slab 17	Slab 18	DFT$_{40}$ Avg.	Slab 16	Slab 17	Slab 18	DFT$_{40}$ Avg.
0	0.262	0.246	0.255	0.254	0.209	0.295	0.281	0.262
500	0.302	0.287	0.300	0.296	0.296	0.390	0.317	0.334
1000	0.372	0.360	0.358	0.364	0.372	0.416	0.367	0.385
2000	0.361	0.378	0.359	0.366	0.338	0.375	0.356	0.356
4000	0.336	0.356	0.332	0.341	0.328	0.339	0.341	0.336
8000	0.336	0.352	0.312	0.333	0.333	0.342	0.321	0.332
16000	0.313	0.345	0.297	0.318	0.318	0.314	0.310	0.314
32000	0.306	0.305	0.276	0.296	0.292	0.288	0.277	0.286
64000	0.258	0.271	0.286	0.272	0.260	0.262	0.280	0.267
128000	0.265	0.269	0.264	0.266	0.244	0.250	0.260	0.251

New polisher, Load 107 lbs., Speed 40 rpm				New polisher, Load 107 lbs., Speed 60 rpm			
Cycles	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.	Slab 4	Slab 5	Slab 6	DFT$_{40}$ Avg.
0	0.365	0.346	0.373	0.361	0.365	0.368	0.357	0.363
500	0.399	0.393	0.395	0.396	0.398	0.391	0.380	0.390
1000	0.450	0.376	0.403	0.410	0.440	0.431	0.387	0.420
2000	0.430	0.405	0.410	0.415	0.407	0.390	0.369	0.389
4000	0.377	0.368	0.365	0.370	0.389	0.363	0.414	0.389
8000	0.349	0.341	0.330	0.340	0.348	0.327	0.369	0.348
16000	0.326	0.316	0.319	0.320	0.319	0.295	0.313	0.309
32000	0.302	0.288	0.285	0.292	0.303	0.305	0.305	0.304
64000	0.285	0.291	0.261	0.279	0.293	0.278	0.284	0.285
128000	0.294	0.289	0.262	0.281	0.278	0.253	0.266	0.266

Old polisher, Load 122 lbs., Speed 40 rpm				Old polisher, Load 122 lbs., Speed 60 rpm			
Cycles	Slab 7	Slab 8	Slab 9	DFT$_{40}$ Avg.	Slab 10	Slab 11	Slab 12	DFT$_{40}$ Avg.
0	0.359	0.321	0.254	0.311	0.253	0.405	0.232	0.297
500	0.398	0.321	0.350	0.356	0.316	0.380	0.314	0.337
1000	0.421	0.409	0.359	0.397	0.340	0.413	0.345	0.366
2000	0.402	0.376	0.354	0.377	0.329	0.375	0.359	0.354
4000	0.382	0.361	0.363	0.369	0.301	0.403	0.361	0.355
8000	0.328	0.337	0.285	0.317	0.283	0.347	0.304	0.311
16000	0.300	0.301	0.278	0.293	0.278	0.329	0.286	0.298
32000	0.281	0.279	0.265	0.275	0.238	0.279	0.251	0.256
64000	0.250	0.263	0.244	0.252	0.220	0.269	0.261	0.250
128000	0.255	0.262	0.242	0.253	0.220	0.272	0.242	0.245

5.4 Statistical Analysis of Friction Results

A statistical analysis was performed to evaluate the effect of several variables (cycles, load and rpm) on the measured (DFT_{40}) friction values for different mixes. Minitab's General Linear Model (GLM) procedure was used to conduct Analysis of Variance (ANOVA).

ANOVA is a powerful statistical tool to separate weak and strong effects. GLM procedure was used to conduct ANOVA because it can handle both balanced and unbalanced designs. The values under each factor are called levels of the factor. There are two types of factors fixed and random. In this analysis, all factors were fixed. For fixed factors, ANOVA examines whether the means at each factor level were statistically different. The F-distribution is used to investigate the significance of each effect. If the test indicates significance, the null hypothesis that there is no significant effect is rejected, and the alternative hypothesis is accepted. Table 5.3 gives the information about the factors involved in the analysis, number of levels and type of factors.

Table 5.3 ANOVA Factor Table

Factor	Type	Levels	Values
Cycles	fixed	4	16000, 32000, 64000, 128000
Load	fixed	3	91, 107, 122
Rpm	fixed	2	40,60

Table 5.3 shows that four intervals of polishing cycles were considered in the ANOVA analysis. Generally, these DFT_{40} values form a linear trend. The DFT_{40} values for the initial polishing cycles (0, 500, 1000, 2000, 4000 and 8000) were not considered in the analysis due to initial increase in friction values due to binder removal and followed by a rapid decrease due initial aggregate polishing. The load and rpm have 3 levels and 2 levels, respectively. Minitab also gives an ANOVA table and Tukey's multiple comparison confidence intervals for pairwise

comparisons of different loads. Table 5.4 and 5.5 summarize the results ANOVA analysis at 5

percent level of significance for E1 mix and W7 mix, respectively.

Table 5.4 ANOVA Results for the Effect of Load, Cycles and Rpm for E1 Mix

Source	DF	F-statistic	P-value	Significant
Cycles	3	35.82	0.000	Yes
Load	2	149.85	0.000	Yes
Rpm	1	11.13	0.001	Yes
Cycles*load	6	13.46	0.000	Yes
Cycles*rpm	3	1.77	0.154	No
Load*rpm	2	9.68	0.000	Yes
Cycles*load*rpm	6	4.43	0.000	Yes
Error	186			
Total	209			
R-Sq = 75.25%		R-Sq(adj.) = 72.19%		

Table 5.5 ANOVA Results for the Effect of Load, Cycles and Rpm for W7 Mix

Source	DF	F-statistic	P-value	Significant
Cycles	3	111.89	0.000	Yes
Load	2	60.27	0.000	Yes
Rpm	1	7.50	0.007	Yes
Cycles*load	6	1.74	0.113	No
Cycles*rpm	3	1.74	0.160	No
Load*rpm	2	0.77	0.465	No
Cycles*load*rpm	6	2.22	0.043	Yes
Error	192			
Total	215			
R-Sq = 72.02%		R-Sq(adj.) = 68.67%		

The R-squared value from Table 5.4 shows that the model explains 75.25% of the

variability in the DFT_{40} data for the E1 mix. If *P-value* is less than or equal to 0.05, then the

effect for the term is significant at the 5% level. If *P-value* is larger than 0.05, the effect is not

statistically significant. The *P-value* for the load factor was 0.000 indicating that load was a

significant factor affecting the friction value. The *P-value* for the cycle's factor is also 0.000

indicating that it is significant at the 0.05 level. In other words, the DFT_{40} value varies as the

number of cycle's increases. The *P-value* for the rpm and interaction terms are significant from

statistical standpoint but they do not have practical importance because the *F-statistic* is small

relative to individual factors, load and cycles.

From Table 5.5, the same conclusions were reached for the W7 mix. In the W7 mix the cycle's factor seems to be more significant than the load factor, since the *F-statistic* is lower for the load factor. The rpm factor and a three-way interaction term are significant at the 5% level but they do not have practical importance because of small *F-statistic*. The R-squared value for W7 mix is slightly lower when compared to E1 mix and accounts for 72% of variability in DFT_{40} data. Further analysis was performed to examine the other factors affecting the DFT_{40} value. ANOVA was conducted by considering difference between the individual slabs as one of the factors affecting the DFT_{40} value. The results gave an R-squared value of 81.5% for the E1 mix and 86% for the W7 mix. These results indicate that variation in preparation of slabs accounted for 6% and 14% variability in the E1 mix and W7 mix, respectively.

A pairwise comparison is performed among levels of load for E1 mix and W7 mix to determine the source of variation within each group. Tukey's method compares all possible pairs of level means for the specified factors. Table 5.6 gives the confidence intervals for two mixes generated by the Tukey's method to determine whether two means are different. If an interval contains all positive numbers or all negative numbers then the difference between the corresponding means is statistically significant. If a confidence interval contains zero then the difference between the corresponding means is not statistically significant.

Table 5.6 Tukey's 95.0% Simultaneous Confidence Interval

Mix type	Load	Lower	Upper
	91 subtracted from:		
	107	-0.03650	-0.01911
E1 Mix	122	0.02716	0.04404
	107 subtracted from:		
	122	0.05470	0.07210
	91 subtracted from:		
	107	0.00232	0.01409
W7 Mix	122	-0.02439	-0.01261
	107 subtracted from:		
	122	-0.02359	-0.02082

There are three levels of load; this resulted in three pairwise comparisons. The confidence intervals for the comparisons indicate that the mean of DFT_{40} data of all the three loads are statistically different from each other for both mixes. In E1 mix the mean of DFT_{40} data for load 122 is significantly higher than the loads 91 and 107. Furthermore, the load 107 has the lowest mean of all the three loads. On the other hand, W7 mix has the highest mean for load 107 and lowest mean for load 122. However, the results do not illustrate a clear trend on how the mixes performed as the load in the polisher is increased.
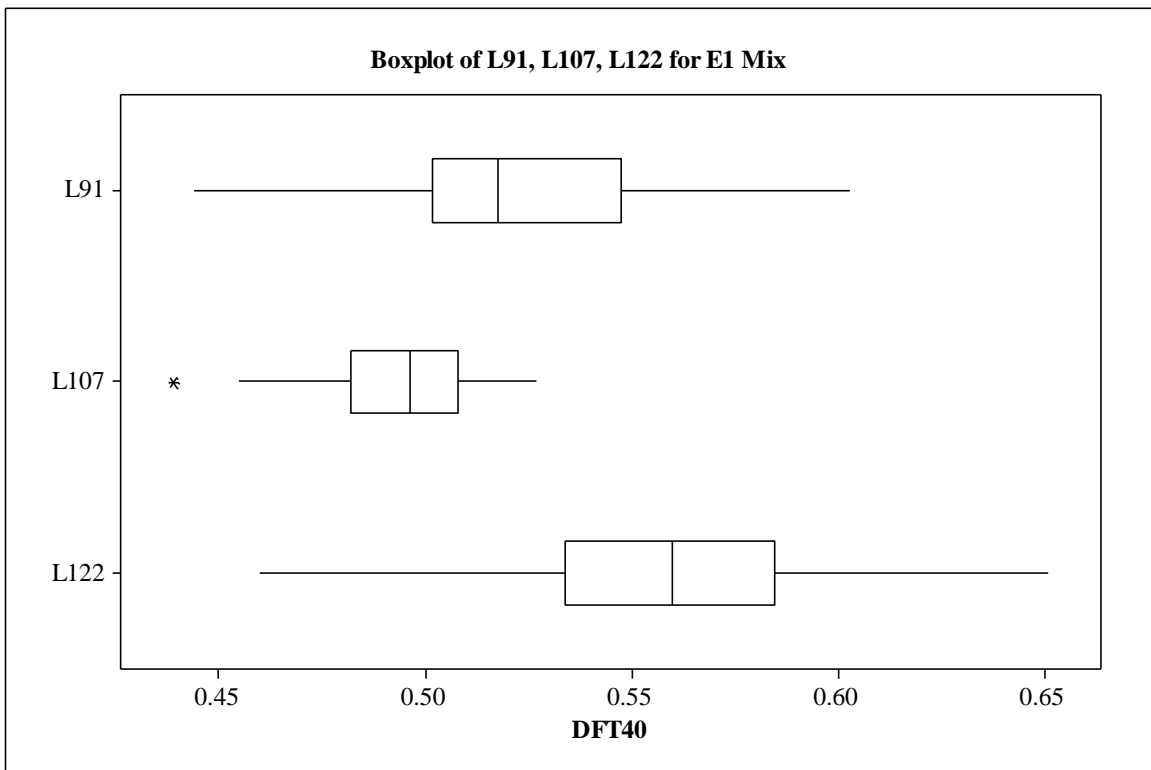
Figure 5.5 Box Plot of DFT_{40} Data for E1 Mix at different Levels of Load
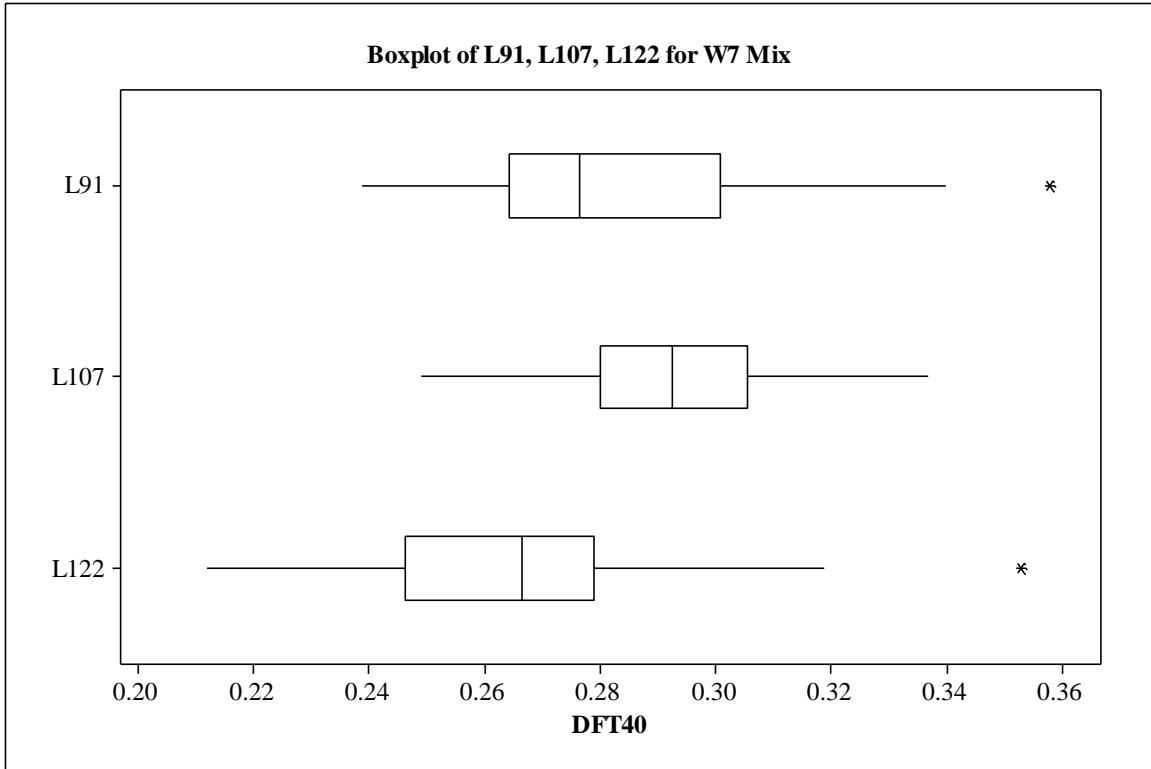
Figure 5.6 Box Plot of DFT Data for W7 Mix at different Levels of Load

Figures 5.5 and 5.6 show the box plots at 3 levels of load for E1 mix and W7 mix respectively. The plot summarizes the spread, the 25th, 50th and 75th percentiles of the data. The extreme values are suspect outliers represented by asterisks . The line drawn through the center of the box represents the median of the data. The left edge of box represents first quartile (Q_1) and right edge represents the third quartile (Q_3). Figure 5.5 and 5.6 do not illustrate a clear trend as to which load provides higher amount of polishing.

For the factors that are significant in the ANOVA table, the Minitab software plots the response means for each factor level with a reference line indicating the overall mean. This plot is called the main effect plot which shows if there is a change in means across the different levels of a factor. The greater the deviation of mean response from horizontal, higher is its significance.
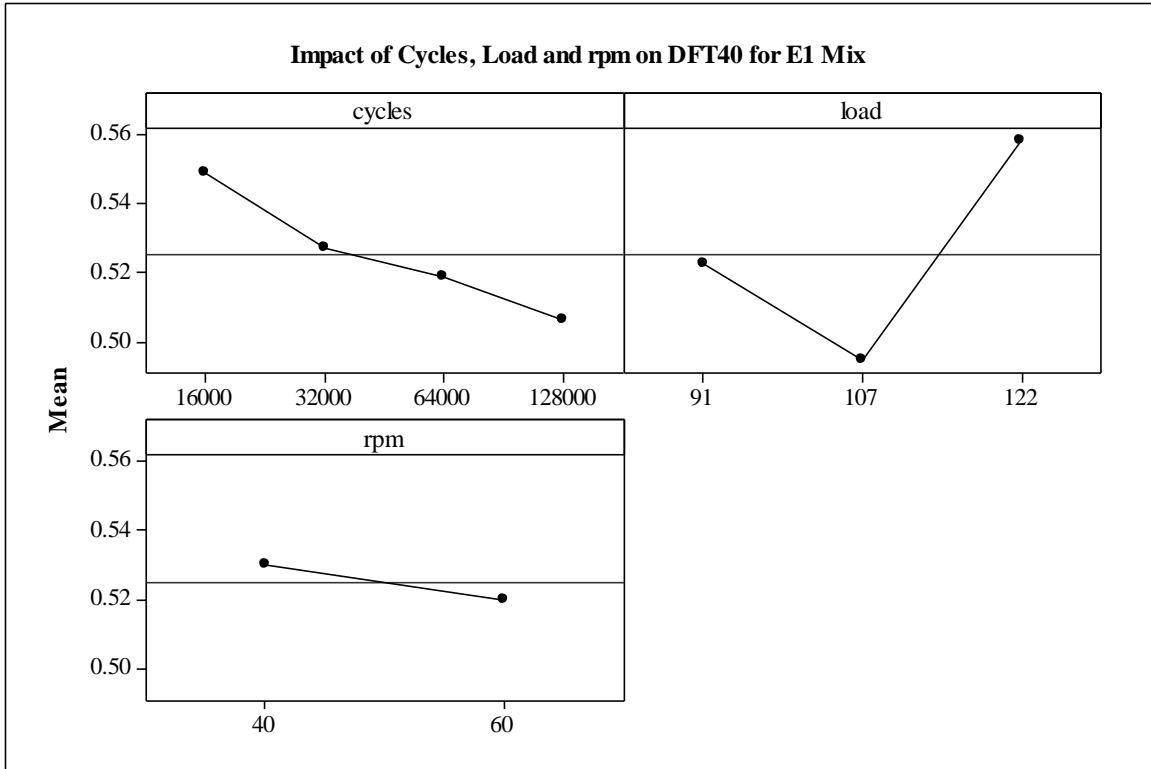
Figure 5.7 Main Effects Plot for E1 Mix
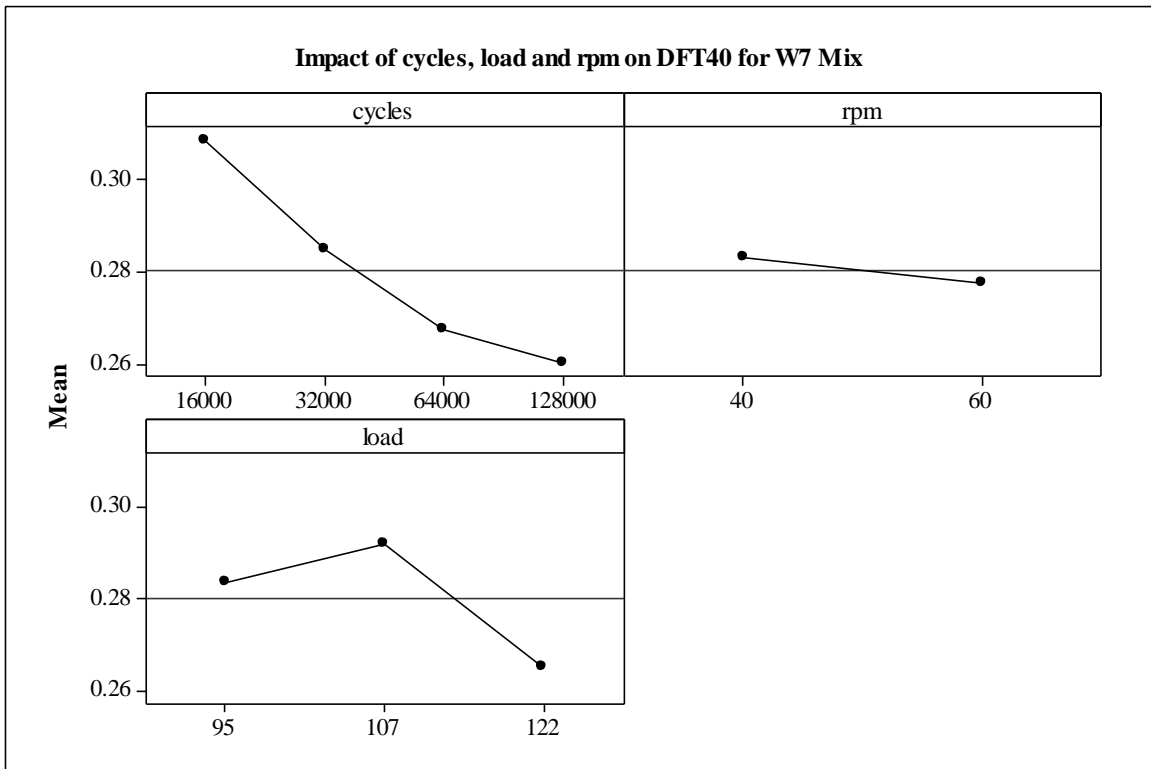
Figure 5.8 Main Effects Plot for W7 Mix

Figures 5.7 and 5.8 show main effects plot for E1 mix and W7 mix, respectively. The main effects plot indicates that the DFT_{40} decreases as the number of cycles increases. The DFT_{40} shows a small decrease when the speed of TWPD is changed from 40 rpm to 60 rpm. These plots show that load also has a significant effect on the DFT_{40}, but they did not follow any particular trend as the load on the polisher is increased from 91 lbs. to 122 lbs..

5.5 Calculation of Adjustment Factor for DFT_{40}

To estimate the difference in polishing characteristics of two TWPD's a comparison was made using E1 and W7 sets of slabs polished on different units with same conditions. Table 5.8 gives a review of the testing order of the different slab groups on two TWPD's. Comparison can be made between the two TWPD's for slab groups at 107 lbs. load.

Table 5.7 Testing Order for different Slab Groups

TWPD1 (old)	TWPD2 (new)
E1 mix @107 lbs.	E1 mix @91 lbs.
E1 mix @122 lbs.	W7 mix @91 lbs.
W7 mix @122 lbs.	W7 mix@107 lbs.

 The adjustment factor due to mix variability is determined by following steps:

First Step: The adjustment factor (Δ) due to mix type is determined by taking average of correction factors Δ_1 and Δ_2, where

Δ_1= mean of DFT_{40} for E1 mix @122 lbs. - mean of DFT_{40} for AL mix @122 lbs.

Δ_1= 0.558-0.265= 0.293

Δ_2= mean of DFT_{40} for E1 mix @91 lbs. - mean of DFT_{40} for AL mix @91 lbs.

Δ_2= 0.523-0.284= 0.239

$\Delta= (\Delta_1+\Delta_2)/2$

$\Delta= 0.266$

Second Step: The data for the E1 mix @107 lbs. is adjusted to account for mix type by subtracting the adjustment factor (Δ).

Adj. DFT_{40} data at 107 lbs. (E1 mix) = DFT_{40} data at 107 lbs. (E1 mix) - Δ

Third Step: Now, any difference between the adjusted data for E1 mix @ 107 lbs. and W7 mix @ 107 lbs. is due to the variability between the two TWPD's. The difference is found by conducting the two sample t-test.

Table 5.8 Two-Sample t-Test Results for DFT_{40} Adjustment Factor

Unit	N	Mean	Std. Dev	SE Mean
DFT_{40} (E1 mix)	72	0.2280	0.0188	0.0022
Adj. DFT_{40} (W7mix)	72	0.2919	0.0203	0.0024

Difference = mean (DFT_{40} W7 mix) - mean (Adj. DFT_{40} E1 mix)

Estimate for difference: **0.06392**

95% CI for difference: (0.07036, 0.05748)

T-Test of difference = 0 (vs. not =): T-Value = 19.62, P-Value = 0.000, DF = 142

Both use Pooled Std. Dev = 0.0195

From the above results it can noticed that the slabs polished on TWPD2 gave higher DFT_{40} values than those polished on TWPD1. DFT_{40} values for the slabs polished on TWPD2 were adjusted by subtracting the estimated difference.
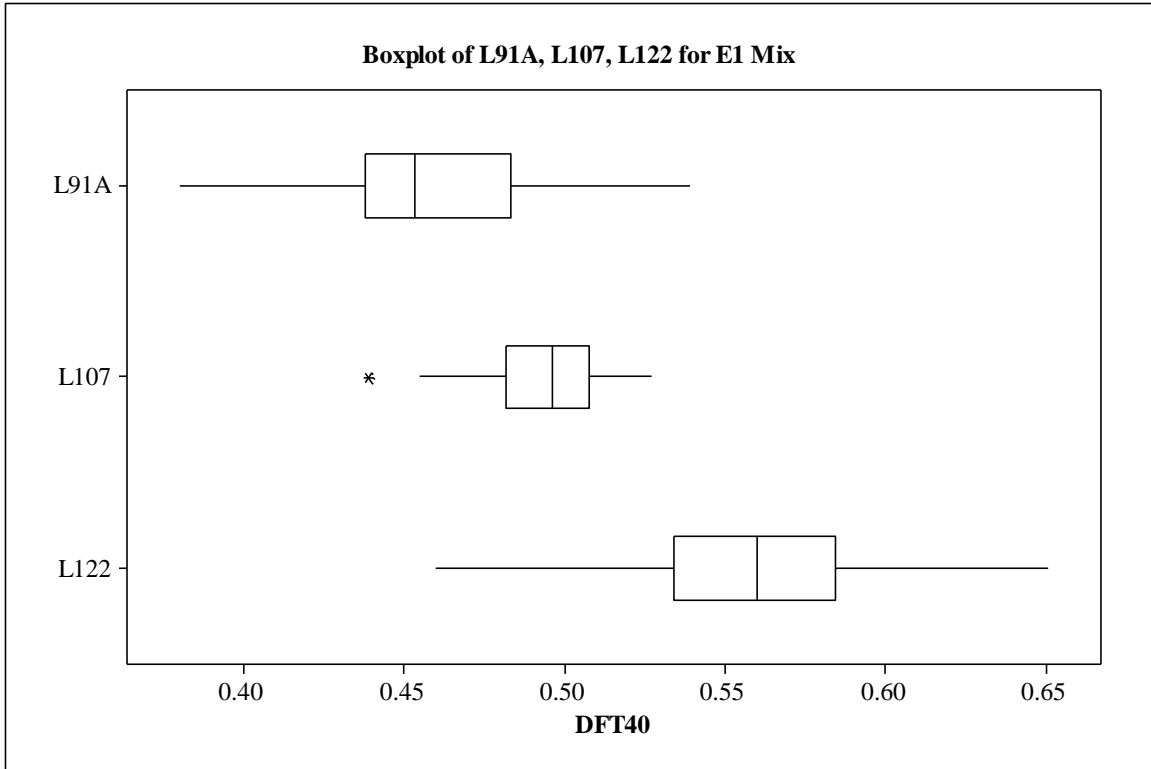
Figure 5.9 Adjusted Box Plots for E1 Mix
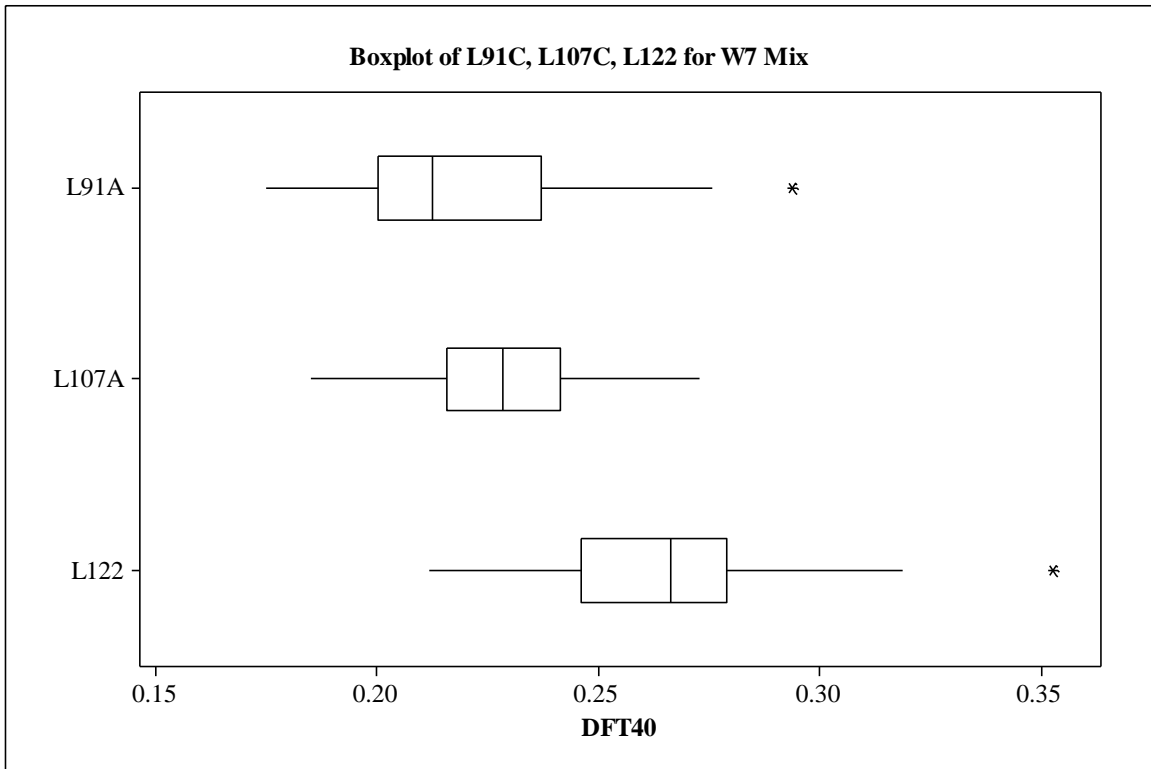
Figure 5.10 Adjusted Box Plots for W7 Mix

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The box plots in Figures 5.9 and 5.10 with the adjusted data show a clear trend. The plots show that as load increases from 91 lbs. to 122 lbs. the friction values are increased. This indicates that the HMA slabs conditioned with lower loads polished more (had lower DFT_{40}) than slabs conditioned with higher loads, which is opposite of the expected trend. The reason for this behavior could be attributed to the fact that at higher load less slip is provided between the tire and HMA surface resulting in less amount of polishing. Given the results of this analysis in Phase I, the combination of 91 lbs. load and 60 rpm speed was used as standard test protocol of TWPD for conditioning HMA slabs in Phase II. The number of conditioning cycles for Phase II was reduced from 128000 to 100000 based on the observation that the friction values remained constant after 64000 cycles.

5.6 Analysis of CTM Texture Results

The texture properties of HMA slabs are measured by using CTM in accordance with ASTM E2157. Five replicate measurements are made for each test and the average MPD is plotted against polishing cycles. The average and standard deviation for each set of five replicate measurements at all intervals of conditioning cycles was computed to check the data quality. The test quality specified according to ASTM E 2157 is an eight- replicate standard deviation of 0.03. Only 2 measurements from E1 mix (18 slabs*10 sets= 180 measurements) and 6 measurements from W7 mix did not meet the standard criteria. The values that did not meet the standard are determined to be outliers and removed from data analysis.
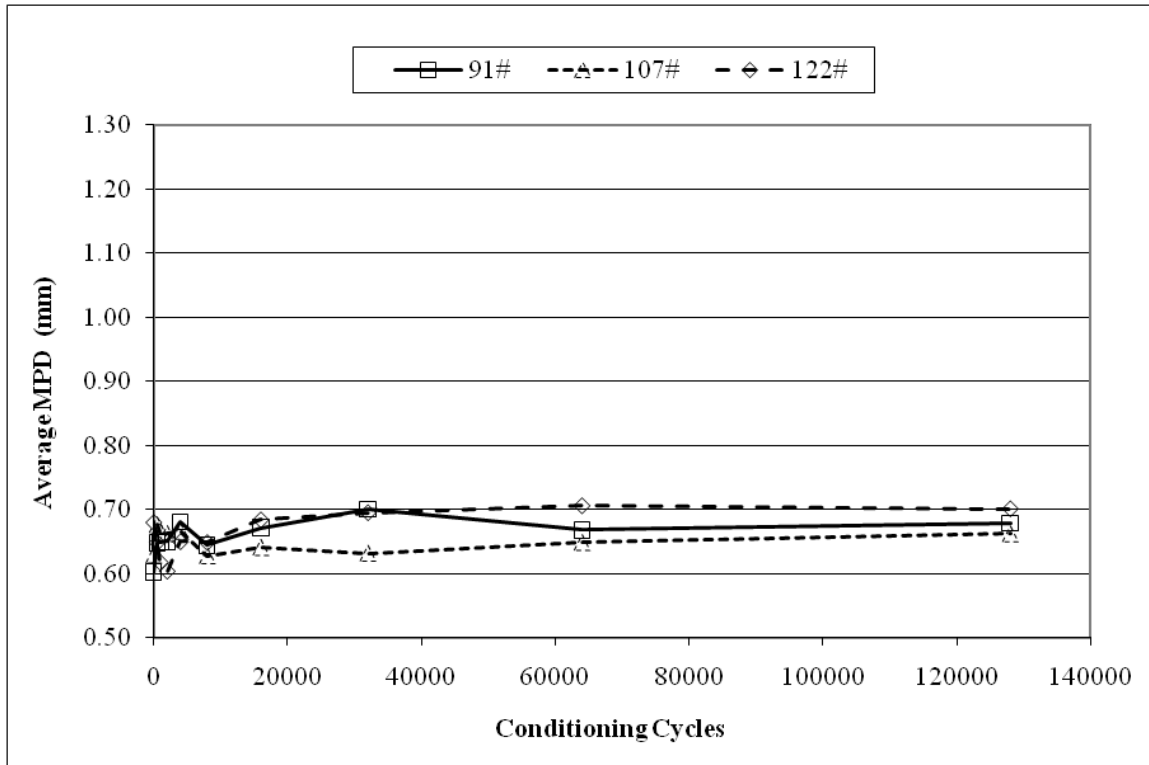
Figure 5.11 Average MPD vs. Conditioning Cycles for E1 Mix at 40 rpm Polishing Speed
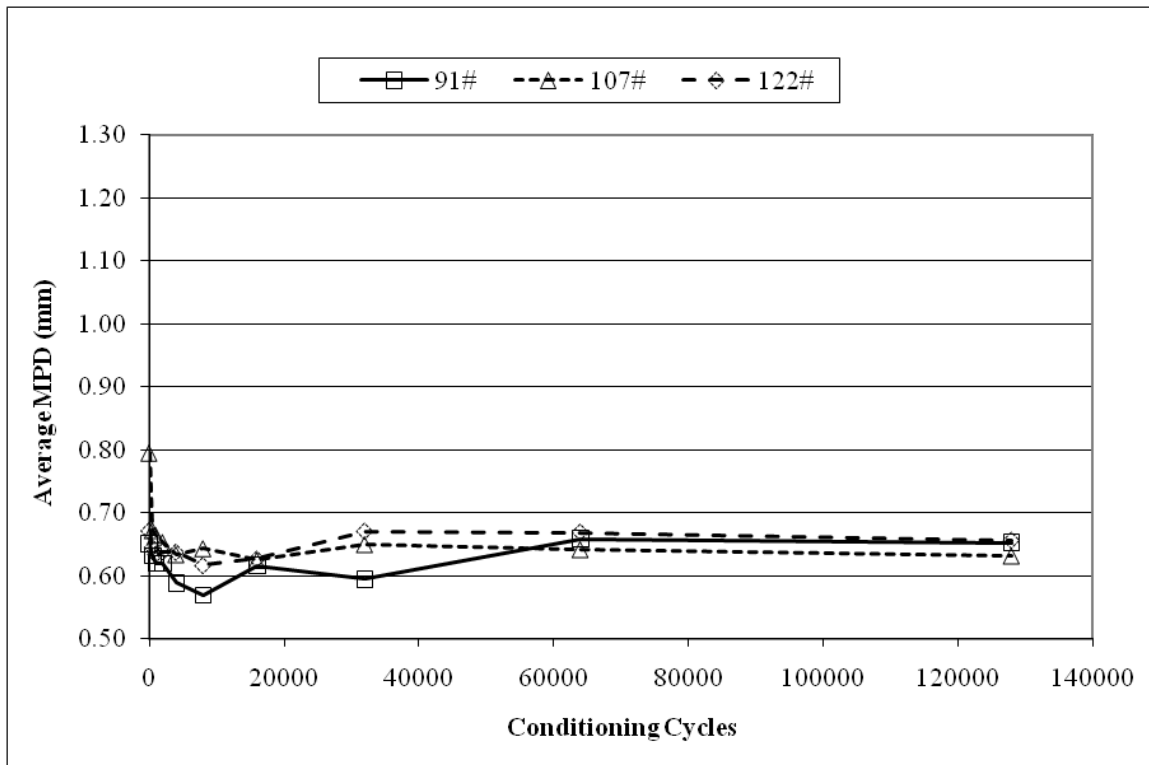
Figure 5.12 Average MPD vs. Conditioning Cycles for E1 Mix at 60 rpm Polishing Speed

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Figures 5.11 and 5.12 show the average MPD values plotted against the conditioning cycles at 3 load and 2 speed combinations for E1 mix. The MPD values plotted on the graph are the average measurements of 3 replicate slabs at each combination of speed and load (3 speeds*2 loads*3 replicates=18 slabs). From Figures 5.11 and 5.12 it can be noticed that there is only a small change in MPD values with respect to polishing cycles. There is no change in MPD values when the wheel load on the polisher is increased. The final MPD value for slabs polished at 40 rpm speed is approximately 0.70 mm and final MPD value for slabs polished at 60 rpm speed is around 0.65 mm. The smaller value of MPD at 60 rpm speed implies that more polishing occurs at higher polishing speed. Table 5.10 summarizes the CTM test results for E1 mix.
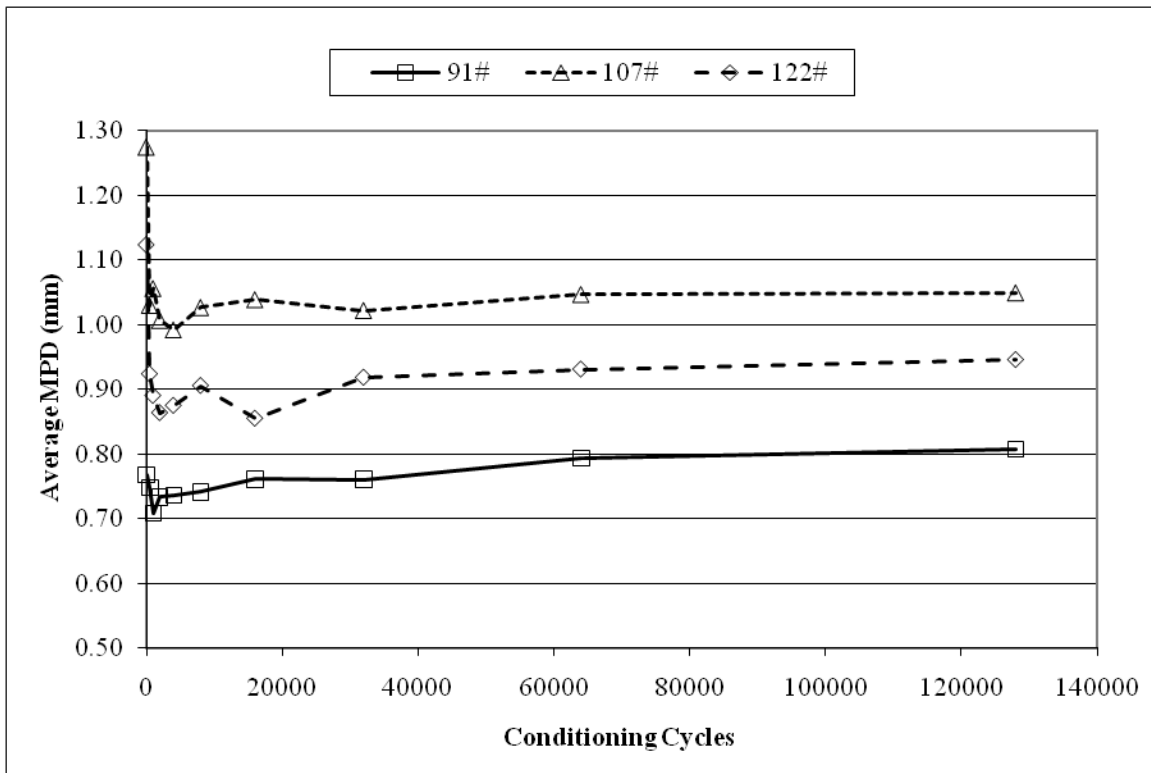
Figure 5.13 Average MPD vs. Conditioning Cycles for W7 Mix at 40 rpm Polishing Speed
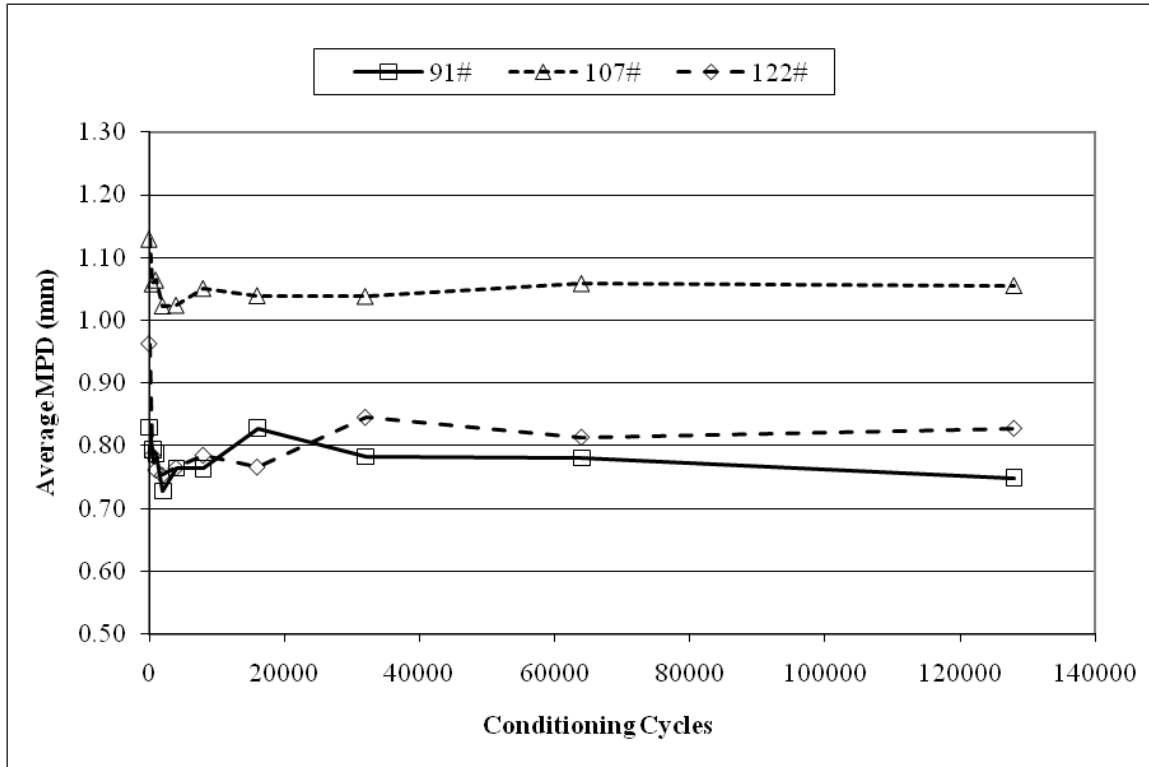
Figure 5.14 Average MPD vs. Conditioning Cycles for W7 Mix at 60 rpm Polishing Speed

Figures 5.13 and 5.14 show the average MPD values plotted against the conditioning cycles at three load and two speed combinations for W7 mix. The figures indicate that there is a small increase in MPD values initially due to binder and some mastic removal but remained constant for the rest of the polishing period. The MPD values vary with respect to load on the polisher but do not show a clear trend. The slabs polished at 91 lbs. load have lower MPD values at both polishing speeds. A smaller MPD value indicates a smoother surface texture. So the slabs appear to be subjected to more polishing at lower load. Table 5.11 summarizes the CTM test results for W3 mix.

Table 5.9 Summary of Average MPD Values for E1 Mix

Cycles	Old polisher, Load 91 lbs., Speed 40 rpm				Old polisher, Load 91 lbs., Speed 60 rpm			
	Slab 7	Slab 8	Slab 9	MPD Avg. (mm)	Slab 10	Slab 11	Slab 12	MPD Avg. (mm)
0	0.59	0.68	0.54	0.60	0.69	0.66	0.61	0.65
500	0.65	0.68	0.62	0.65	0.66	0.63	0.61	0.63
1000	0.65	0.73	0.57	0.65	0.66	0.61	0.59	0.62
2000	0.63	0.73	0.59	0.65	0.67	0.61	0.58	0.62
4000	0.69	0.72	0.63	0.68	0.65	0.57	0.55	0.59
8000	0.58	0.73	0.62	0.64	0.62	0.57	0.52	0.57
16000	0.66	0.71	0.64	0.67	0.63	0.66	0.56	0.62
32000	0.63	0.83	0.64	0.70	0.66	0.58	0.55	0.59
64000	0.62	0.72	0.66	0.67	0.76	0.64	0.57	0.66
128000	0.64	0.74	0.66	0.68	0.69	0.63	0.63	0.65

Cycles	Old polisher, Load 107 lbs., Speed 40 rpm				Old polisher, Load 107 lbs., Speed 60 rpm			
	Slab 1	Slab 2	Slab 3	MPD Avg. (mm)	Slab 4	Slab 5	Slab 6	MPD Avg. (mm)
0	0.61	0.59	0.69	0.63	0.83	0.79	0.76	0.79
500	0.62	0.66	0.75	0.68	0.60	0.84	0.57	0.67
1000	0.66	0.66	0.67	0.67	0.63	0.77	0.59	0.66
2000	0.64	0.64	0.71	0.66	0.63	0.76	0.57	0.65
4000	0.66	0.64	0.70	0.67	0.57	0.75	0.58	0.63
8000	0.61	0.60	0.67	0.63	0.58	0.77	0.58	0.64
16000	0.63	0.64	0.66	0.64	0.59	0.70	0.59	0.62
32000	0.64	0.61	0.65	0.63	0.59	0.71	0.65	0.65
64000	0.63	0.64	0.68	0.65	0.59	0.73	0.61	0.64
128000	0.64	0.67	0.68	0.66	0.64	0.67	0.59	0.63

Cycles	New polisher, Load 122 lbs., Speed 40 rpm				New polisher, Load 91 lbs., Speed 60 rpm			
	Slab 13	Slab 14	Slab 15	MPD Avg. (mm)	Slab 16	Slab 17	Slab 18	MPD Avg. (mm)
0	0.69	0.67	0.68	0.68	0.61	0.87	0.53	0.67
500	0.62	0.70	0.63	0.65	0.56	0.80	0.57	0.64
1000	0.62	0.63	0.61	0.62	0.58	0.81	0.51	0.63
2000	0.60	0.60	0.61	0.60	0.61	0.74	0.56	0.64
4000	0.61	0.72	0.62	0.65	0.59	0.76	0.56	0.64
8000	0.62	0.70	0.63	0.65	0.56	0.78	0.51	0.62
16000	0.60	0.84	0.61	0.68	0.57	0.74	0.57	0.63
32000	0.64	0.76	0.68	0.70	0.62	0.78	0.61	0.67
64000	0.65	0.76	0.71	0.71	0.62	0.77	0.61	0.67
128000	0.62	0.76	0.73	0.70	0.66	0.73	0.57	0.66

Table 5.10 Summary of Average MPD Values for W7 Mix

Cycles	New polisher, Load 91 lbs., Speed 40 rpm				New polisher, Load 91 lbs., Speed 60 rpm			
	Slab 13	Slab 14	Slab 15	MPD Avg. (mm)	Slab 16	Slab 17	Slab 18	MPD Avg. (mm)
0	0.69	0.74	0.87	0.77	0.91	0.86	0.72	0.83
500	0.74	0.65	0.85	0.75	0.83	0.81	0.73	0.79
1000	0.66	0.66	0.81	0.71	0.83	0.84	0.69	0.79
2000	0.69	0.65	0.86	0.73	0.79	0.70	0.70	0.73
4000	0.72	0.63	0.86	0.74	0.82	0.71	0.76	0.76
8000	0.70	0.65	0.87	0.74	0.79	0.74	0.76	0.76
16000	0.72	0.66	0.90	0.76	0.83	0.82	0.84	0.83
32000	0.74	0.67	0.87	0.76	0.86	0.73	0.76	0.78
64000	0.74	0.74	0.91	0.79	0.82	0.76	0.76	0.78
128000	0.75	0.74	0.93	0.81	0.76	0.64	0.84	0.75
	New polisher, Load 107 lbs., Speed 40 rpm				New polisher, Load 107 lbs., Speed 60 rpm			
	Slab 1	Slab 2	Slab 3	MPD Avg. (mm)	Slab 4	Slab 5	Slab 6	MPD Avg. (mm)
0	1.36	1.21	1.26	1.27	1.16	1.07	1.15	1.13
500	0.99	1.13	0.97	1.03	1.13	1.07	0.97	1.06
1000	1.04	1.16	0.96	1.06	1.13	1.08	0.98	1.06
2000	1.00	1.08	0.94	1.01	1.08	1.01	0.97	1.02
4000	0.93	1.11	0.94	0.99	1.07	1.03	0.97	1.02
8000	0.96	1.15	0.97	1.03	1.10	1.07	0.99	1.05
16000	0.99	1.12	1.01	1.04	1.08	1.02	1.02	1.04
32000	1.00	1.10	0.96	1.02	1.07	1.06	0.99	1.04
64000	1.00	1.11	1.03	1.05	1.10	1.04	1.03	1.06
128000	1.08	1.11	0.96	1.05	1.13	1.03	1.00	1.06
	Old polisher, Load 122 lbs., Speed 40rpm				Old polisher, Load 122 lbs., Speed 60rpm			
	Slab 7	Slab 8	Slab 9	MPD Avg. (mm)	Slab 10	Slab 11	Slab 12	MPD Avg. (mm)
0	1.14	1.32	0.91	1.12	0.82	1.25	0.82	0.96
500	0.93	1.17	0.67	0.92	0.59	1.07	0.70	0.79
1000	0.97	1.08	0.62	0.89	0.57	1.05	0.67	0.76
2000	0.88	1.10	0.61	0.86	0.58	1.00	0.68	0.75
4000	0.89	1.12	0.61	0.87	0.58	1.05	0.67	0.77
8000	0.95	1.08	0.69	0.91	0.66	1.01	0.68	0.79
16000	0.94	0.94	0.68	0.85	0.59	1.00	0.71	0.77
32000	0.99	1.11	0.66	0.92	0.73	1.07	0.73	0.85
64000	1.00	1.10	0.68	0.93	0.66	1.07	0.71	0.81
128000	0.99	1.09	0.75	0.95	0.66	1.08	0.74	0.83

CHAPTER 6. PHASE II RESEEARCH PLAN

6.1 Introduction

The objective of Phase II research is to study the impact of the amount of friction aggregate on the degree of friction change. In Phase II, two mixes are selected from the NCAT Test Track Database with different friction performance in the 2003 test track cycle. The first mix is from section N4 which showed good friction performance at the test track. The second mix is from section W3 which had poor friction performance at the test track. Both are dense graded mixtures.

6.2 Aggregate Characteristics

Two primary aggregate sources were used in this phase of the study. Section N4 used a granite aggregate from Columbus, GA. Section W3 used a limestone from the Goretown mine at Loris, SC. The aggregate blend used in the N4 was: (i) 89 Columbus Granite, (ii) 8910 Opelika Limestone, (iii) M10 Columbus Granite, (iv) Shorter sand. The materials used in W3 were: (i) 89M Goretown limestone, (ii) Goretown Washed Screenings, (iii) Goretown Regular Screenings. Table 6.1 and 6.2 show the properties of the aggregates used in mix production of N4 mix and W3 mix, respectively.

Table 6.1 Aggregate Properties of N4 Mix

Stockpile	Specific Gravities		Absorption, %
	Bulk (G_{sb})	Apparent (G_{sa})	
GRN 89s	2.610	2.713	1.5
LMS 8910	2.819	2.863	0.5
M10 GRN	2.707	2.725	0.3
Shorter Sand	2.628	2.649	0.3

Table 6.2 Aggregate Properties of W3 Mix

Stockpile	Specific Gravities		Absorption, %
	Bulk (G_{sb})	Apparent (G_{sa})	
Goretown 89 LMS	2.252	2.629	6.4
W. Screenings	2.554	2.666	1.7
R. screenings	2.376	2.643	4.3

The denominations "M" on some aggregates indicates manufactured screenings; "W" corresponds to washed screenings and "R" corresponds to Regular screenings. The gradations of these aggregates are shown in Appendix A.

6.3 Binder Characteristics

The binder grade used in the N4 mixes was a PG 76-22 and binder grade used in the W3 mixes was a PG 67-22. The optimum binder content for N4 and W3 mixes are 6.5% and 7.0%, respectively. Table 6.3 gives summary of binder properties.

Table 6.3 Binder Properties

Mix	Mix Type	Binder Grade	Asphalt Content (%)
N4	Dense-graded	76-22	6.5
W3	Dense-graded	67-22	7.0

6.4 Mix Designs

In this phase, three blends are designed for each mixture by substituting the amount of friction aggregate. The changes in aggregate proportion are made on sieve-by-sieve basis starting from No. 8 Sieve. Table 6.4 and 6.5 show the aggregate substitutions for three blends of N4 and W3 mix respectively.

Table 6.4 Aggregate substitution for N4 Mix

N4 mix	Original	19% substitute	50% substitute
	Blend 1	**Blend 2**	**Blend 3**
LMS 8910	27.0	27.0	27.0
M10 GRN	19.0	14.0	9.0
Shorter Sand	19.0	19.0	19.0
GRN 89s +4s	19.0	14.0	9.0
GRN 89s -4s	16.0	16.0	16.0
Calera 7s		5.0	10.0
Calera 821s		5.0	10.0
	100.00	100.00	100.00

In Table 6.4, 19% substitute indicates that 19% of #4s and #8s of granite were substituted with 19% of #4s and #8s of limestone. In the original mix there was about 20% #4s and 20% #8s. So 5% Calera 7s and 5% Calera 821s was added, which correlates to about 19% of the total of both the #4s and #8s. 50% substitute means that 50% of both the #4s and #8s of granite were substituted with limestone. So 10% Calera 7s and 10% Calera 821s were added, which relates to about 50% of the total of both the #4s and #8s. The granites in N4 mix were planned to be substituted with Goretown limestone used in W3 mix. Due to unavailability of the Goretown limestone at the time of mix preparation for Blend 2 and Blend 3 Calera limestone was used, which was available locally at East Alabama Paving Company Inc. in Opelika, AL.

Table 6.5 Aggregate substitution for W3 Mix

W3 mix	Original	25% substitute	50% substitute
	Blend 1	**Blend 2**	**Blend 3**
Goretown 89 LMS	48.0	36.0	20.0
R. Screens	43.0	35.0	34.0
W. Screens	8.0	15.0	19.0
Hydrated Lime	1.0	1.0	1.0
GRN 89s +4s		5.0	10.0
GRN 89s -4s		8.0	16.0
	100.00	100.00	100.00

In Table 6.5, 25% substitute means 25% of both the #4s and #8s of limestone were substituted with 25% of #4s and #8s of granite. In the original mix there was about 20% of #4s and 30% of #8s. So 5% of +#4s GRN and 8% -#4s GRN was added, which relates to about 25% of the total of both the #4s and #8s. 50% substitute means that 50% of both the #4s and #8s of limestone were substituted with granite. So 10% of +#4s GRN and 16% -#4s GRN was added, which results in roughly 50% of the total of both the #4s and #8s. The percent of washed screenings in Blend 3 was increased to adjust the gradation. Refer to Appendix B for summary of mix designs.

6.5 Testing Program for Phase II

The TWPD conditioning protocol selected from Phase I analysis is used in Phase II testing. The TWPD wheel load of 91 lbs. and polisher speed of 60 rpm is selected as standard conditioning protocol for Phase II analysis. A total of 18 HMA slabs with 3 slabs for each blend are prepared and tested in Phase II . The conditioning of HMA slabs is done on the two TWPD units in the NCAT laboratory. Table 6.6 shows the testing order for all the 18 slabs in the Phase II testing.

Table 6.6 Testing Order of HMA Slabs in Phase II

Mixture	Blend	Slab number	TWPD
N4 mix (Good Friction)	1	1, 3	Old
		2	New
	2	1	Old
		2, 3	New
	3	1, 3	Old
		2	New
W3 mix (Poor Friction)	1	1, 2	Old
		3	New
	2	2	Old
		1, 3	New
	3	3	Old
		1, 2	New

Two TWPD are used simultaneously for conditioning slabs in groups of nine. Testing and conditioning of Phase II started in June 2010 and ended in July 2010. Table 6.7 gives a summary of TWPD conditioning cycles.

Table 6.7 TWPD Conditioning Cycles at 91 lbs. Wheel Load and 60 rpm Speed

Conditioning cycles	0	500	500	1000	2000	4000	8000	16000	32000	36000
Accumulated cycles	0	500	1000	2000	4000	8000	16000	32000	64000	100000

CHAPTER 7. PHASE II RESULTS AND DATA ANALYSIS

7.1 Analysis of Friction Results

The HMA slabs are conditioned using NCAT TWPD and the friction properties of the slabs are measured using DFT at pre-defined intervals of conditioning cycles. As mentioned earlier, the test protocol of 91 lbs. wheel load and 60 rpm speed determined by Phase I analysis is used for testing. In Phase II the conditioning is stopped at 100,000 cycles as no change in friction was observed in Phase I after 100,000 cycles. Each mixture has 3 blends with 3 replicate slabs for each blend. An analysis is conducted to determine any change in friction values by varying the percent of friction aggregate in the mixtures. Figure 7.1 and 7.2 show the comparisons of average friction values (DFT_{40}) for 3 blends of N4 mix and W3 mix, respectively.
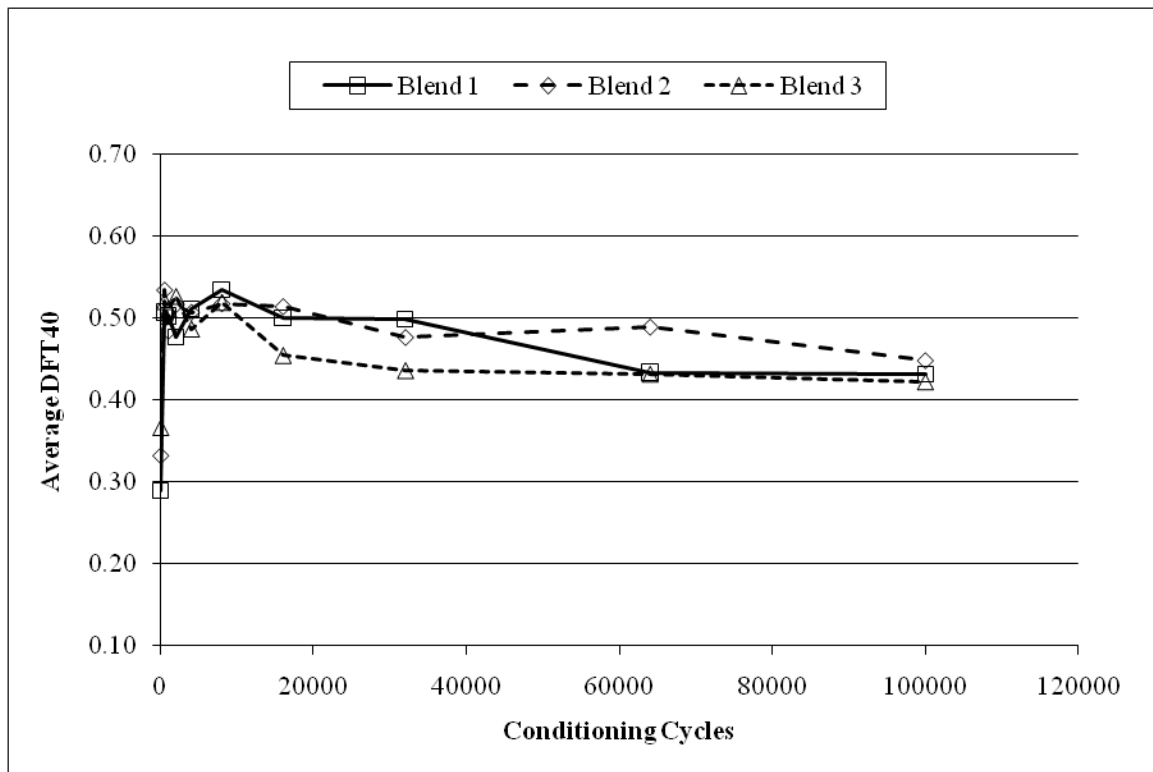
Figure 7.1 Average DFT_{40} vs. Conditioning Cycles for 3 Blends of N4 Mix
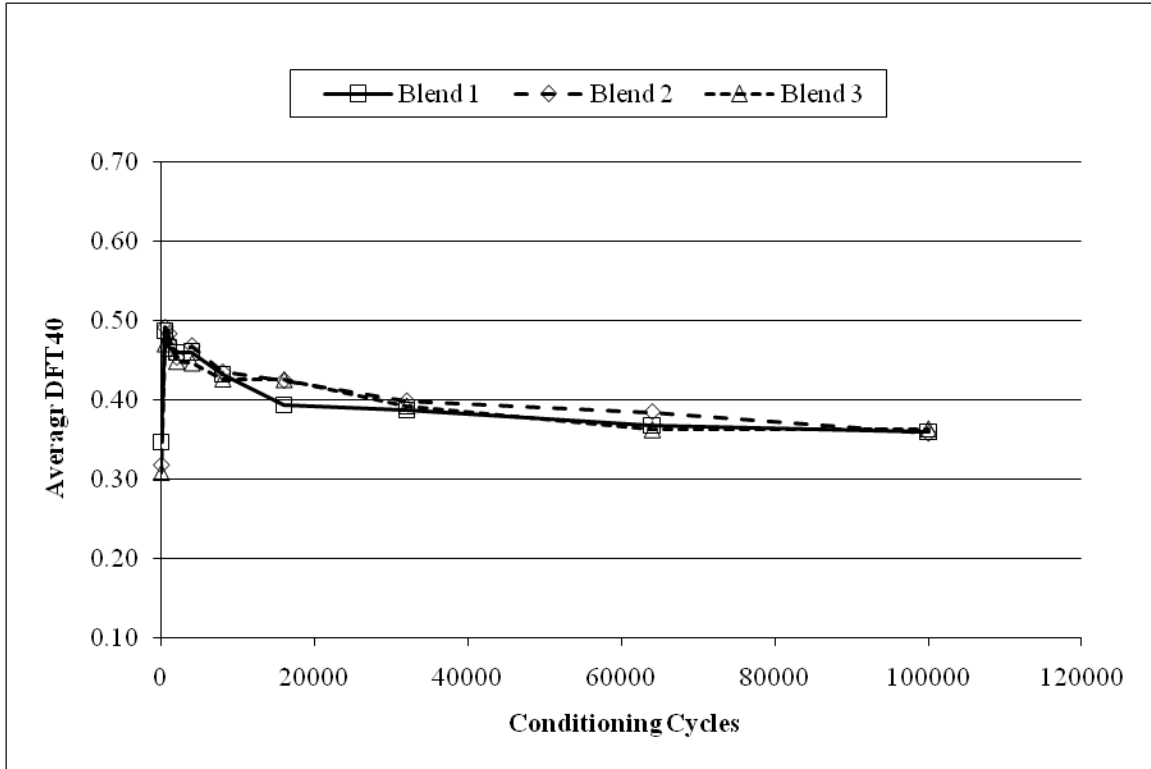
Figure 7.2 Average DFT$_{40}$ vs. Conditioning Cycles for 3 Blends of W3 Mix

Figures 7.1 and 7.2 show the trend of DFT$_{40}$ values for different blends when the amount of friction aggregate is varied in the mixture. In both mixtures, the first blend is the virgin mix without any variation in the proportion of friction aggregate. In Blend 2 , 19% of friction aggregate (granite) is replaced by limestone which has a lower resistance to polishing compared to granite. However, terminal friction values were around 0.45 for both blends, indicating that the substitution of only 19% of friction aggregate had no effect on the friction values. In Blend 3, 50% of the friction aggregate (granite) is replaced by limestone. The measured DFT$_{40}$ values for the slabs of Blend 3 mixture showed a rapid decrease in friction through 16,000 cycles, and then remained stable thereafter with terminal friction value slightly lower than the slabs of Blend 1 and 2 mixtures.

Figure 7.2 shows the DFT_{40} values for 3 blends of W3 mix. In Blend 2 and 3 of W3 mix the limestone was replaced by granite to improve the friction properties of the mix. In Blend 2, 25% of limestone and in Blend 3 fifty percent of limestone was replaced by granite. Figure 7.2 indicates that the DFT_{40} values for 3 blends of W3 mix follow closely, at all the intervals of polishing cycles. The terminal friction value was around 0.35 for all the blends in the mixture.

7.2 Calculation of Adjustment Factor for DFT_{40}

As determined in the Phase I study, there is a difference in polishing characteristics of two TWPD's used for conditioning of HMA slabs. To estimate the difference between the two devices a comparison is made between the replicate slabs conditioned on TWPD1 and TWPD2.

Table 7.1 Calculation of Adjustment Factor (Δ_{ij})

Mix	Blend	Avg. DFT_{40} TWPD 1	Avg. DFT_{40} TWPD 2	Adjustment Factor (Δ_{ij})
N4 mix	B1	0.467	0.463	-0.004
	B2	0.463	0.491	0.028
	B3	0.422	0.463	0.041
W3 mix	B1	0.365	0.403	0.039
	B2	0.373	0.401	0.028
	B3	0.344	0.407	0.064

Table 7.1 shows the calculation of adjustment factor (Δ_{ij}), where i = N4 mix, W3 mix and j = B1, B2, B3. The DFT_{40} data for the TWPD2 is adjusted by subtracting the adjustment factor for particular blend of the mixture (different adjustment factors used for the six blends). Further data analysis is done using the adjusted DFT_{40} data.

7.3 Statistical Analysis of Friction Results

A statistical analysis was performed to evaluate the effect of amount of friction aggregate on the rate of change in (DFT_{40}) friction values for different mixes. The General Linear Model (GLM) procedure was used to conduct the ANOVA. Table 7.2 gives information of the factors involved in ANOVA. There are 3 replicate slabs for each blend in the mixture; as a result the slabs are nested under the blend. The nested factors are shown in parenthesis. The last four intervals of polishing cycles are considered in the analysis because they represent relatively uniform polishing response from the slabs.

Table 7.2 ANOVA Factor Table

Factor	Type	Levels	Values
B - Blend	fixed	3	B1, B2, B3
S (B) - Slab	fixed	9	1, 2, 3, 1, 2, 3, 1, 2, 3
C - Cycles	fixed	4	16000, 32000, 64000, 128000

Minitab software generates the ANOVA table along with the factor table. The ANOVA table gives the *P-value* and *F-statistic* for each of the factors and interaction terms. If *P-value* is less than or equal to 0.05 then the effect of that factor is significant at 5% level. Table 7.3 and 7.4 summarize the results of ANOVA analysis at the 5% level of significance for N4 mix and W3 mix, respectively.

Table 7.3 ANOVA Results for the Effect of Percent Friction Aggregate for N4 Mix

Source	DF	F-statistic	P-value	Significant
B	2	533.97	0.000	Yes
S(B)	6	30.83	0.000	Yes
C	3	383.74	0.000	Yes
B*C	6	78.01	0.000	Yes
C*S(B)	18	41.82	0.000	Yes
Error	72			
Total	107			
R-Sq = 98.05% R-Sq(adj.) = 97.11%				

Table 7.4 ANOVA Results for the Effect of Percent Friction Aggregate for W3 Mix

Source	DF	F-statistic	P-value	Significant
B	2	227.89	0.000	Yes
S(B)	6	19.39	0.000	Yes
C	3	427.05	0.000	Yes
B*C	6	24.60	0.000	Yes
C*S(B)	18	24.78	0.000	Yes
Error	72			
Total	107			
R-Sq = 97.14%		R-Sq(adj.) = 95.75%		

The R-squared value from Table 7.3 indicates that 98.05% of the variation in DFT_{40} data is explained by the model. The *P-value* for all the terms are zero indicating that all factors and interaction terms are highly significant. The *F-statistic* for the factors B-blend and C-cycles are large indicating that the effect of these factors is high on the response variable (DFT_{40}) when compared to other terms. This analysis indicates that varying the amount of friction aggregate did impact the friction value. It also explains that the friction value changes as the number polishing cycle's increases.

The R-squared value from Table 7.4 indicates that 97.14% of the variation in DFT_{40} data is explained by the model. The same results can be concluded from Table 10 for the W3 mix. In W3 mix, the number of cycles is the major factor affecting the DFT_{40} value instead of blend as observed in N4 mix.

Further, a pairwise comparison is performed between the blends of each mixture to determine by how much DFT_{40} values are lowered or improved when the amount of friction aggregate is varied in the mixture. Tukey's method compares all possible pairs of level means for the specified factors. If the limits of confidence interval (lower, center and upper) does not contain zero, then the two blends are significantly different. Table 7.5 gives the confidence

intervals for two mixes generated by the Tukey's method to determine whether two means are significantly different.

Table 7.5 Tukey's 95.0% Simultaneous Confidence Interval

Mix Type	Blend	Lower	Upper
N4 Mix	B1 subtracted from:		
	B2	-0.00652	0.00063
	B3	-0.04733	-0.04017
	B2 subtracted from:		
	B3	-0.04438	-0.03723
W3 Mix	B1 subtracted from:		
	B2	0.00505	0.01184
	B3	-0.02443	-0.01763
	B2 subtracted from:		
	B3	-0.03287	-0.02607

Based on the results from Tukey's test, there was no significant difference between the mean friction values of Blend 1 and 2 of N4 mix indicating that 19% aggregate substitutions (granite replaced by limestone) did not affect the friction values. Further, it indicates that there is a significant difference between the mean friction values of Blend 1 and Blend 3. The negative values in the confidence interval indicate that the mean for Blend 3 was significantly lower than Blend 1. As expected, when the 50% aggregate substitutions (granite replaced by limestone) are made in N4 mix the friction values decreased. The confidence interval for the Blend 2 of W3 mix indicates the friction values increased very slightly when 25% aggregate substitutions (limestone replaced by granite) are made for W3 mix. But when the friction aggregate percent was further increased to 50 percent the friction values showed a decline. The reason for decline is not known.
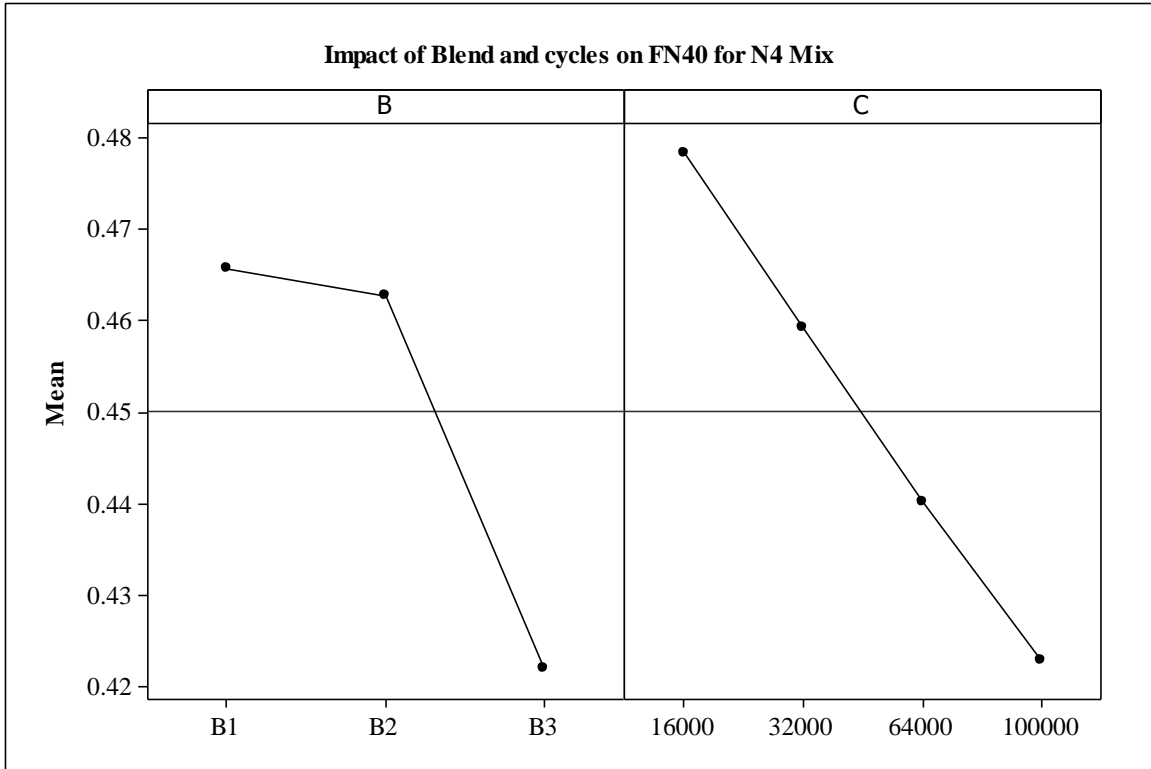
Figure 7.3 Main Effects Plot for N4 Mix
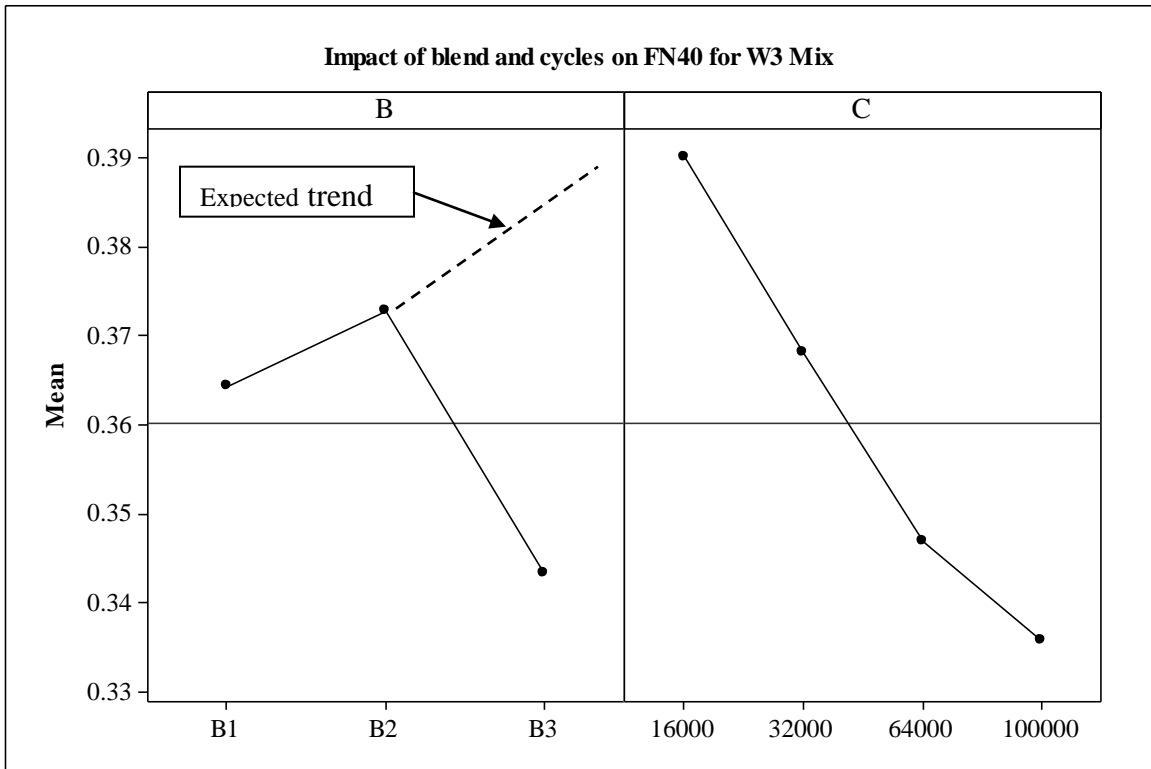
Figure 7.4 Main Effects Plot for W3 Mix

Figures 7.3 and 7.4 show the main effects plot for N4 mix and W3 mix respectively. The plots show that the DFT_{40} values decreases as the number of polishing cycles increases. Moreover, it indicates that TWPD is capable of wearing the HMA surface and reducing the skid resistance. From Figure 7.3 the trend of DFT_{40} values for N4 mix is seen to be decreasing when the amount of friction aggregate is reduced. These plots are in agreement with results obtained by Tukey's pairwise comparison between the blends of N4 mix. N4 mix fits the subjective "engineering reasonableness" test.

As observed in the previous analysis, the DFT_{40} values for the W3 mix increased when the percent of friction aggregate is increased to 25% in the mixture blend but declined on further increment to 50% in friction aggregate. The expected trend is shown by a dotted line. Several attempts were made to explain the variation in data. First, the data were checked for outliers and error due to data entry. Then the mix design for the particular blend of the mixture is verified to see if there are any deviations from the standard, but these attempts were not successful in explaining the deviation. Additional research is needed to examine the change in friction as the amount of friction aggregate increases.

Interaction plots for DFT_{40} values for N4 mix and W3 mix are shown in Figures 7.5 and 7.6. The interactions plots are one way to graphically visualize the data.
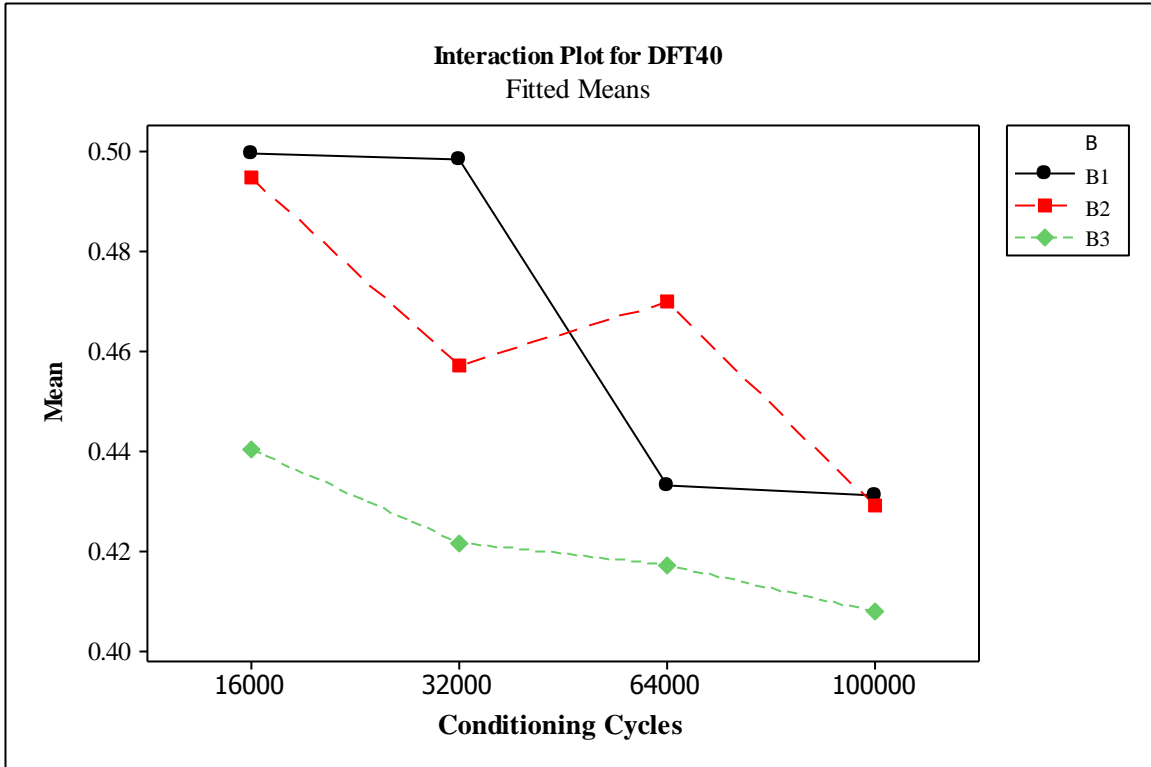
Figure 7.5 Interaction Plot of Average DFT_{40} vs. Conditioning Cycles for N4 Mix
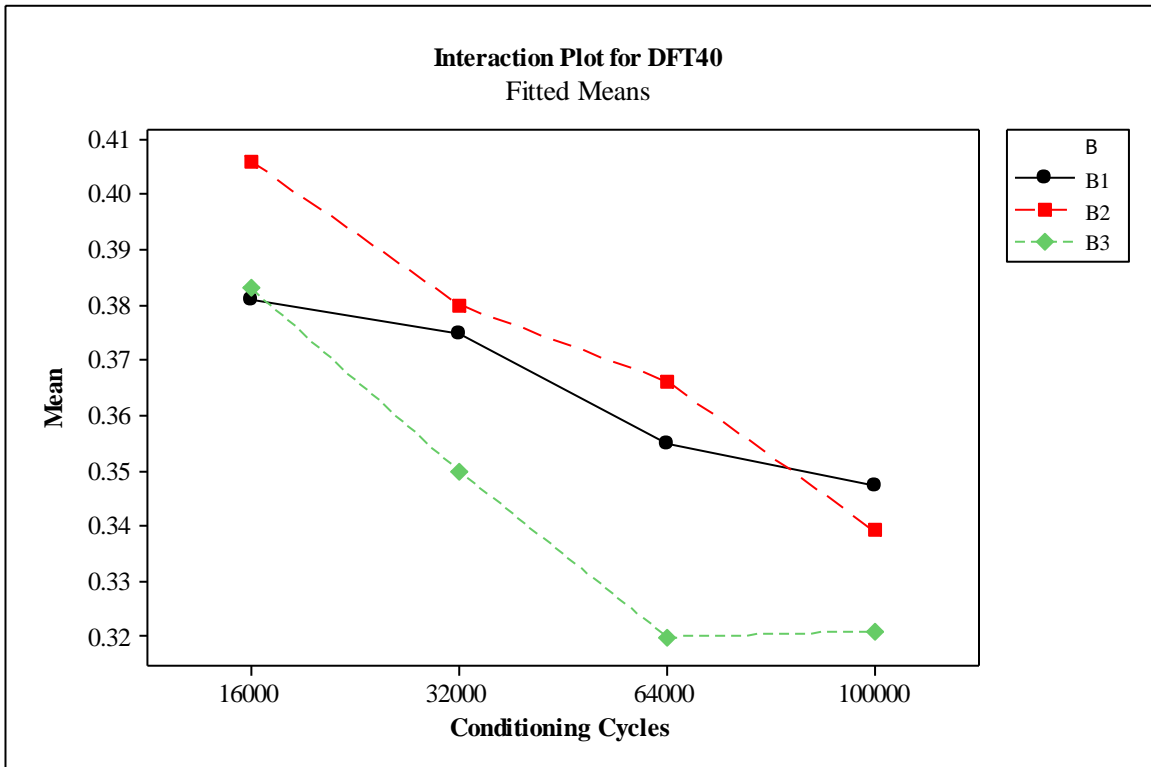
Figure 7.6 Interaction Plot of Average DFT_{40} vs. Conditioning Cycles for W3 Mix

The Figures 7.5 and 7.6 show that the DFT_{40} values decreases as the number of polishing cycles increases for all the mixture blends. In both the plots the DFT_{40} values for Blends 1 and 2 are closely related indicating that that there is no large difference in friction values when the amount of friction aggregate is varied by 25%. However, the curves for Blend 1 of both mixes tend to be flattened from 64,000 to 100,000 cycles. While, the curves for the Blend 2 mixture show a downward trend after 100,000 cycles which indicates that the friction values might decrease with further polishing. The slabs from Blend 3 of the N4 mix consistently measured lower DFT_{40} values. These results show that 50% substitution (granite replaced by limestone) of friction aggregate lowered the friction values. The DFT_{40} values for Blend 3 of W3 mix were expected to be higher than that of Blends 1 and 2 but they measured lower instead. The reason for odd behavior of the SC Blend 3 mixture is not known. Table 7.6 gives the summary of DFT_{40} data for Phase II.

Table 7.6 Summary of Average DFT$_{40}$ Values for 3 Blends of N4 Mix and W3 Mix

	N4 Mix Blend 1				W3 Mix Blend 1			
Cycles	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.
0	0.320	0.294	0.253	0.289	0.350	0.330	0.362	0.347
500	0.508	0.585	0.428	0.507	0.454	0.481	0.527	0.487
1000	0.518	0.539	0.451	0.503	0.445	0.448	0.504	0.466
2000	0.493	0.507	0.430	0.477	0.461	0.459	0.461	0.460
4000	0.511	0.557	0.465	0.511	0.437	0.459	0.487	0.461
8000	0.519	0.564	0.520	0.534	0.443	0.397	0.458	0.433
16000	0.495	0.542	0.462	0.500	0.360	0.372	0.450	0.394
32000	0.508	0.504	0.483	0.499	0.375	0.384	0.404	0.388
64000	0.470	0.414	0.416	0.433	0.352	0.368	0.383	0.368
100000	0.465	0.391	0.438	0.431	0.340	0.365	0.376	0.360

	N4 Mix Blend 2				W3 Mix Blend 2			
Cycles	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.
0	0.355	0.333	0.308	0.332	0.320	0.312	0.321	0.318
500	0.487	0.553	0.561	0.534	0.511	0.481	0.483	0.492
1000	0.471	0.481	0.499	0.484	0.505	0.458	0.488	0.484
2000	0.496	0.520	0.531	0.516	0.448	0.466	0.447	0.454
4000	0.488	0.527	0.504	0.507	0.487	0.445	0.474	0.468
8000	0.491	0.526	0.534	0.517	0.453	0.440	0.413	0.435
16000	0.466	0.547	0.527	0.513	0.457	0.382	0.435	0.425
32000	0.462	0.485	0.481	0.476	0.405	0.386	0.404	0.399
64000	0.467	0.501	0.498	0.489	0.392	0.378	0.384	0.385
100000	0.456	0.434	0.453	0.448	0.369	0.344	0.360	0.358

	N4 Mix Blend 3				W3 Mix Blend 3			
Cycles	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.	Slab 1	Slab 2	Slab 3	DFT$_{40}$ Avg.
0	0.355	0.373	0.369	0.366	0.325	0.323	0.277	0.308
500	0.489	0.574	0.497	0.520	0.456	0.521	0.436	0.471
1000	0.461	0.553	0.519	0.511	0.529	0.509	0.403	0.480
2000	0.503	0.598	0.477	0.526	0.449	0.463	0.433	0.449
4000	0.439	0.515	0.505	0.486	0.465	0.479	0.396	0.447
8000	0.485	0.541	0.531	0.519	0.410	0.464	0.406	0.427
16000	0.448	0.469	0.445	0.454	0.464	0.456	0.357	0.426
32000	0.427	0.469	0.411	0.436	0.420	0.403	0.354	0.392
64000	0.426	0.444	0.423	0.431	0.396	0.351	0.340	0.362
100000	0.391	0.469	0.406	0.422	0.387	0.381	0.323	0.364

7.4 Analysis of CTM Texture Results

The texture properties of the HMA slabs in Phase II are measured using Circular Texture Meter (CTM) at regular intervals during the polishing. Five replicate measurements are made for each test and the average MPD in mm is plotted against polishing cycles. The data quality check was performed using ASTM standard precision statement. All the MPD data (3 blends*3 slabs*10 sets=90 measurements) for N4 mix met the standard deviation of 0.03 and only five measurements from the W3 mix did not meet the standard. These five values were determined to be outliers and removed from data analysis.
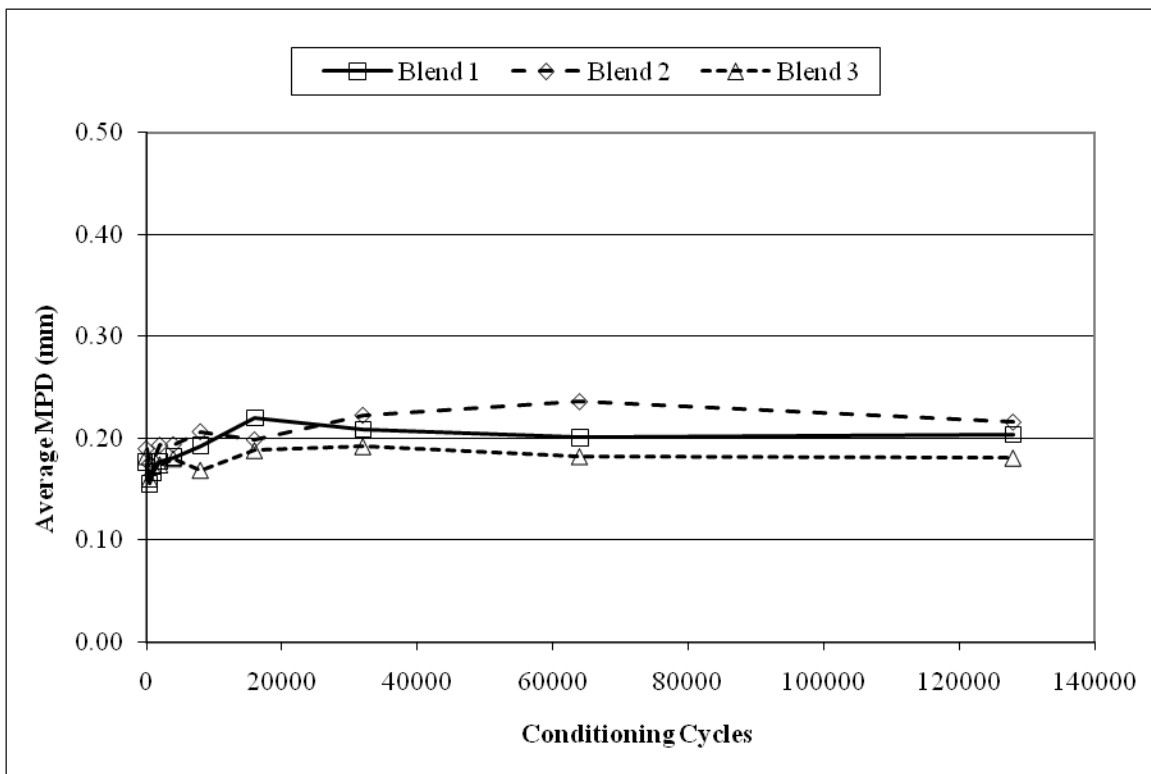
Figure 7.7 Average MPD vs. Conditioning Cycles for 3 Blends of N4 Mix
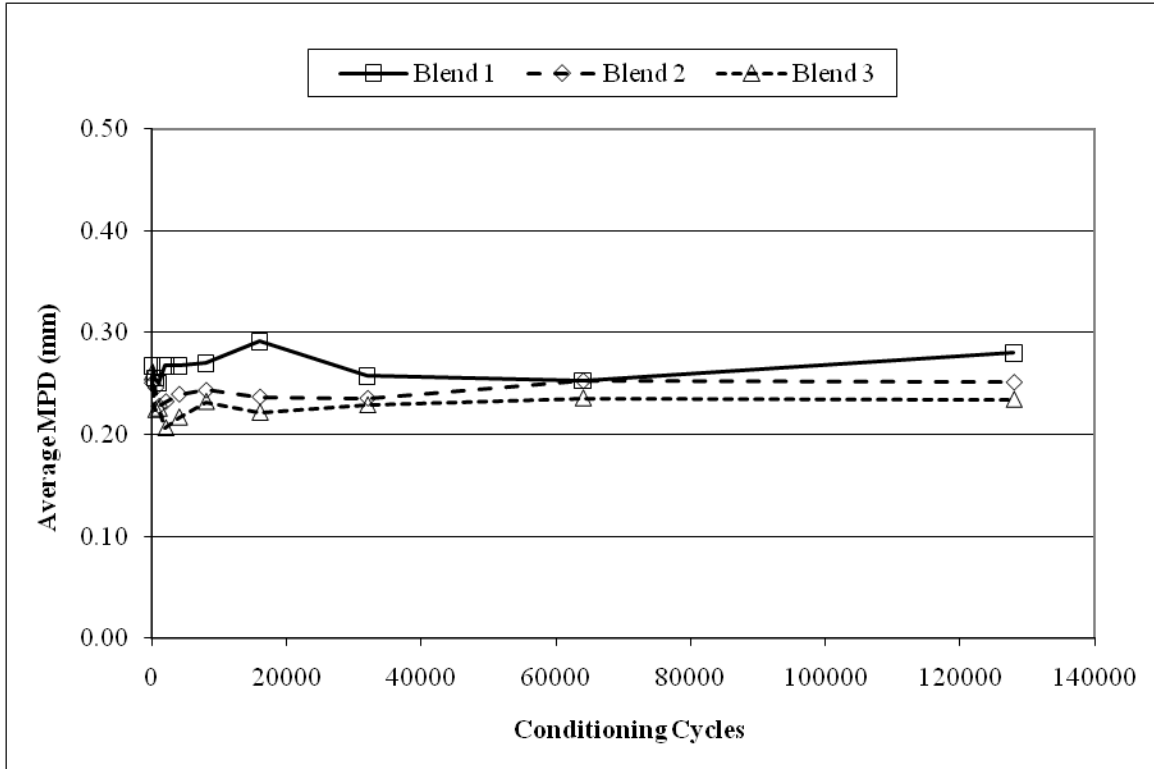
Figure 7.8 Average MPD vs. Conditioning Cycles for 3 Blends of W3 Mix

Figures 7.7 and 7.8 summarize the surface texture measurements for 3 blends of the N4 mix and W3 mix, respectively. Each point on the graph is the average value of MPD of three replicate slabs. Figure 7.7 show that all the blends of the N4 mix show similar trend for MPD values. The change in MPD values of N4 mix slabs are very small with regard to polishing cycles. The MPD values slightly increased after initial testing due to binder and some mastic removal. There is a small change in texture values by varying the amount of friction aggregate in the mixture but the graphs show mixed results with no trend. The Blend 3 mixture of N4 mix has the lowest MPD values than other two blends. The lower MPD values may be related to polishing of substituted limestone aggregate as they have low resistance to polishing compared to granite. The final MPD values for the slabs of N4 mix are around 0.20 mm. A smaller MPD value indicates a smoother surface texture.

Figure 7.8 show that there is only a slight change in MPD values of W3 mix slabs before and after polishing. The curves for each of the blend show that there is only small change in texture measurements when the amount of friction aggregate is varied in the mixture. The final MPD values for the slabs of W3 mix are around 0.25 mm. Table 7.7 gives the summary of CTM data for 3 blends of N4 mix and W3 mix.

Table 7.7 Summary of Average MPD values for 3 Blends of N4 Mix and W3 Mix

	N4 Mix Blend 1				W3 Mix Blend 1			
Cycles	**Slab 1**	**Slab 2**	**Slab 3**	**MPD Avg. (mm)**	**Slab 1**	**Slab 2**	**Slab 3**	**MPD Avg. (mm)**
0	0.16	0.18	0.19	0.18	0.29	0.23	0.29	0.27
500	0.16	0.17	0.13	0.16	0.24	0.30	0.23	0.26
1000	0.15	0.18	0.16	0.17	0.23	0.29	0.23	0.25
2000	0.16	0.21	0.17	0.18	0.25	0.33	0.22	0.27
4000	0.17	0.22	0.16	0.18	0.25	0.31	0.25	0.27
8000	0.19	0.23	0.15	0.19	0.27	0.29	0.25	0.27
16000	0.28	0.21	0.16	0.22	0.30	0.32	0.26	0.29
32000	0.22	0.24	0.17	0.21	0.23	0.28	0.26	0.26
64000	0.19	0.24	0.18	0.20	0.24	0.27	0.25	0.25
100000	0.21	0.24	0.16	0.20	0.30	0.28	0.26	0.28
	N4 Mix Blend 2				**W3 Mix Blend 2**			
Cycles	**Slab 4**	**Slab 5**	**Slab 6**	**MPD Avg. (mm)**	**Slab 4**	**Slab 5**	**Slab 6**	**MPD Avg. (mm)**
0	0.17	0.21	0.19	0.19	0.22	0.34	0.19	0.25
500	0.18	0.16	0.19	0.18	0.27	0.26	0.21	0.25
1000	0.18	0.18	0.18	0.18	0.25	0.25	0.19	0.23
2000	0.18	0.19	0.21	0.19	0.24	0.26	0.20	0.23
4000	0.18	0.19	0.21	0.19	0.24	0.28	0.20	0.24
8000	0.21	0.20	0.21	0.21	0.25	0.26	0.22	0.24
16000	0.16	0.22	0.22	0.20	0.24	0.25	0.22	0.24
32000	0.22	0.24	0.21	0.22	0.24	0.25	0.21	0.24
64000	0.25	0.22	0.24	0.24	0.25	0.28	0.23	0.25
100000	0.21	0.22	0.22	0.22	0.24	0.28	0.24	0.25
	N4 Mix Blend 3				**W3 Mix Blend 3**			
Cycles	**Slab 7**	**Slab 8**	**Slab 9**	**MPD Avg. (mm)**	**Slab 7**	**Slab 8**	**Slab 9**	**MPD Avg. (mm)**
0	0.18	0.14	0.22	0.18	0.28	0.24	0.26	0.26
500	0.16	0.15	0.17	0.16	0.23	0.23	0.21	0.22
1000	0.18	0.20	0.14	0.17	0.26	0.23	0.18	0.23
2000	0.18	0.18	0.16	0.17	0.22	0.21	0.19	0.21
4000	0.18	0.21	0.16	0.18	0.24	0.22	0.19	0.22
8000	0.17	0.19	0.15	0.17	0.23	0.25	0.22	0.23
16000	0.19	0.21	0.16	0.19	0.23	0.24	0.19	0.22
32000	0.19	0.20	0.19	0.19	0.26	0.23	0.20	0.23
64000	0.16	0.24	0.14	0.18	0.28	0.23	0.19	0.24
100000	0.20	0.19	0.15	0.18	0.26	0.24	0.20	0.23

CHAPTER 8. CORRELATION BETWEEN LABORATORY AND TEST TRACK DATA

8.1 Introduction

The objective of this chapter is to determine the correlation, if any, between DFT results from laboratory and friction history based on the Locked Wheel Skid Trailer (LWST) at the NCAT Test Track. The friction tests of the four mixtures selected for the Phase I and Phase II of the laboratory study were measured using Dynamic Friction Tester (DFT) in accordance with ASTM E 1911. The LWST friction results on the test track are measured according to ASTM E 274. A significant correlation between the two friction values measured using LSWT and DFT would help to assess the friction performance of a mix design.

8.2 Test Track Description

The NCAT Pavement Test Track is a full-scale Accelerated Pavement Testing (APT) facility. Experimental sections on the Pavement Test Track are cooperatively funded by external sponsors, most commonly state DOT's. Forty-six different flexible pavements are installed on 2.8 km (1.7 mile) oval track. A total of 10 million ESALs (Equivalent Single Axle Load) are applied over a period of two years. The ESALs are applied with four fully loaded trucks with 3 trailers per truck. The pavement performance is documented on regular basis.

8.3 Data Collection

Four different test sections were selected to provide a range of friction characteristics. The length of each test section is 200 ft. All testing were performed in the middle 150 ft leaving a transition region of 25 ft at the beginning and end of the sections. All the friction data on the

track were collected using the ribbed tire (SN(64)R) according to ASTM E 501. The laboratory

friction testing is performed using DFT on HMA slabs (20 in. x 20 in. x 2 in.) prepared in the

laboratory using a slab compactor. The aggregates used in the mix preparation are obtained from

same sources used in test track construction. The mixes produced in the laboratory were close to

the field mix designs.

8.4 Mixture Ranking Based on Laboratory and Test Track Results

The friction properties of each mixture in the laboratory are assessed based on the

mixture polishing curve. Figure 8.1 shows the DFT_{60} plot for all the mixtures in the laboratory.

The laboratory results demonstrate that E1 mix had superior frictional performance of all SMA

and dense-graded mixtures used in this study. This result is in agreement with test track mixture

ranking which is shown in Figure 8.2. Of the dense graded, mixes N4 mix had better frictional

performance when compared to W3 mix. W7 mix showed the poor frictional performance of all

the mixtures studied in this research. These results are in agreement with the test track friction

results. Table 8.1 shows the ranking of mixtures based on laboratory and test track results.

Table 8.1 Ranking Based on Laboratory and Test Track Results

Mix Type	Ranking based on	
	Laboratory Results	Test Track Results
E1	1	1
N4	2	2
W3	3	3
W7	4	4
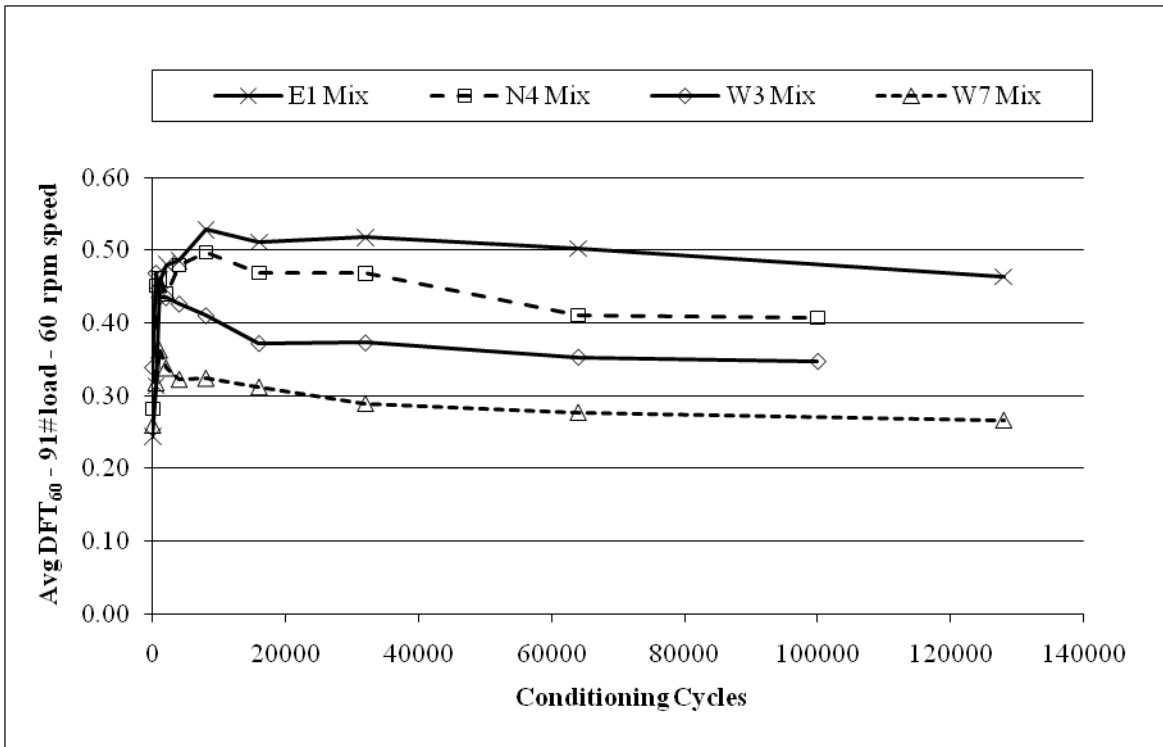
Figure 8.1 Average DFT$_{60}$ vs. Conditioning Cycles for Four Laboratory Mixtures
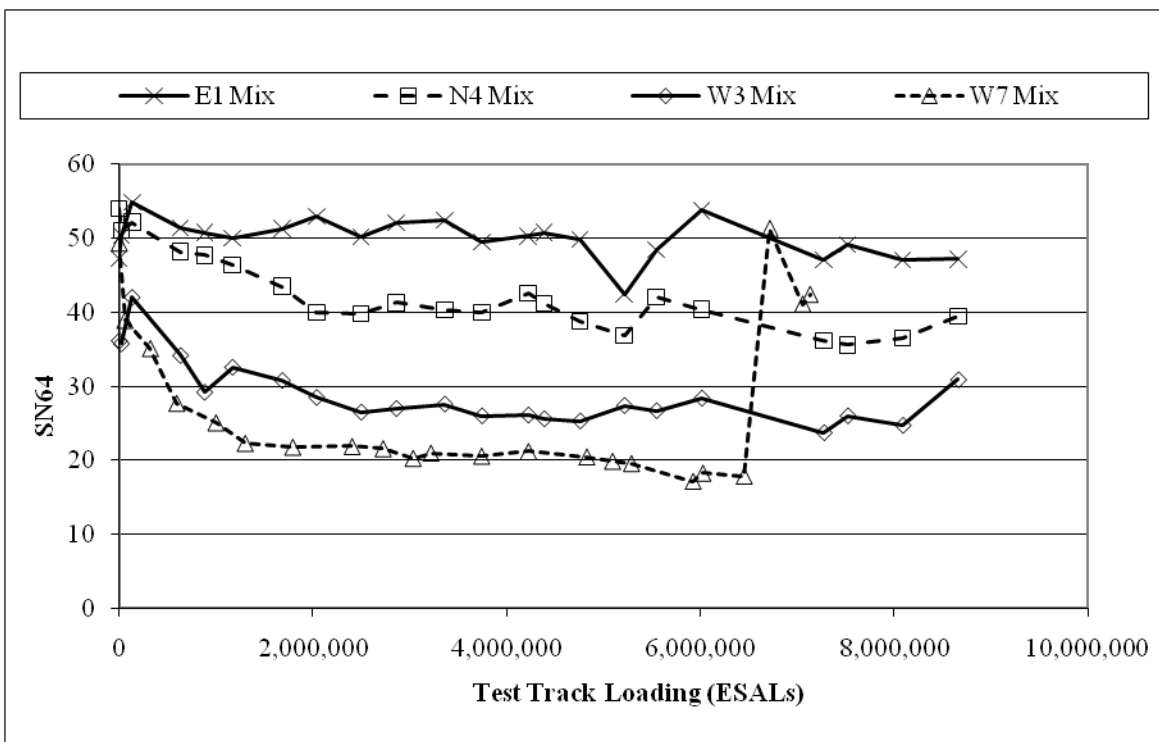
Figure 8.2 SN64 vs. ESALs for Four Test Track Sections

8.5 Results and Data Analysis

A simple linear regression analysis was performed to observe the correlation between the laboratory friction data measured using DFT with field friction data measured using LWST for similar mixtures. The regression analysis was performed between the friction coefficients measured by the DFT at slip speed of 60 km/h (DFT_{60}) and friction coefficient measured using LWST at slip speed of 64 km/h (SN64). SN64 is metric equivalent to SN40 at 40 mph. The DFT_{60} values are used in the analysis as they are the closest values comparable to SN64. In Table 8.2 the DFT_{60} values are multiplied by 100. The early friction measurements from the test track and laboratory are not included in the analysis due to rapid change in friction values. The friction values tend to stabilize after 16000 cycles in the laboratory and after 1.2 million ESALs on the test track. The polishing cycles are matched with corresponding ESALs in systematic order. Starting with 16000 cycles matched with 1.2 million ESALs and as the number of polishing cycles doubled the friction values are matched with roughly twice the previous ESALs. The summary of friction data are shown in the Table 8.2.

Table 8.2 Summary of Friction Data for DFT and LWST

Mix Type	Cycles	DFT 60km/h*100	Million ESALs	SN 64km/h
E1	16000	51.1	1.2	50.0
	32000	51.8	2.5	50.2
	64000	50.2	4.8	49.9
	128000	46.4	8.6	47.2
W7	16000	31.2	1.2	22.3
	32000	29.0	2.5	21.6
	64000	27.7	4.8	20.5
	128000	26.7	6.4	17.9
N4	16000	46.9	1.2	46.4
	32000	46.8	2.5	39.8
	64000	41.0	4.8	38.8
	100000	40.7	8.0	36.5
W3	16000	37.2	1.2	32.6
	32000	37.3	2.5	26.5
	64000	35.3	4.8	25.3
	100000	34.8	8.0	24.7

The results in Table 8.3 show that the DFT and LWST are highly correlated for SMA mixes in Phase I. The R-squared value for the regression between DFT_{60} and SN64 was determined to be 96.7% for the E1 mix and 79.9% for W7 mix. The dense graded mixes in Phase II showed low correlation between the laboratory and field friction values. The R-squared values are determined to be 57.0% for N4 mix and 50.0% for W3 mix. It is possible that a single outlier could significantly decrease the R-squared value. The DFT_{60} value at 32,000 cycles (46.8) for N4 mix is higher when compared to SN64 data (39.8), which resulted in low R-squared value. The results of regression analysis are presented in Table 8.3.

Table 8.3 Simple Linear Regression between DFT_{60} and SN64

Mix Type	Model	ANOVA Table		R-squared, %	Pearson's Correlation Coefficient
		F-Statistic	P-value		
E1 mix	SN64 = 20.3 + 0.582 DFT_{60}*100	59.34	0.016	96.7	0.984
W7 mix	SN64 = -4.6 + 0.878 DFT_{60}*100	7.93	0.106	79.9	0.894
N4 mix	SN64 = -0.3 + 0.927 DFT_{60}*100	2.65	0.245	57.0	0.755
W3 mix	SN64 = -44.0 + 1.97 DFT_{60}*100	2.00	0.293	50.0	0.707

The results of the regression analysis are confirmed by ANOVA results. It shows that the regression equation for E1 mix is significant at the 0.05 level. Table 8.3 presents the Pearson's correlation coefficient, which is used to evaluate the linear relationship between two continuous variables. The regression equation for W7 mix was not significant at the 0.05 level but the analysis gives high R-squared value because there is a bias between measurements of DFT_{60} and SN64 even though they are highly correlated. The Pearson's correlation coefficient shows that DFT_{60} and SN64 are highly correlated for E1 mix and W7 mix. The correlation coefficients in Table 8.3 are simply the square root of the corresponding R-squared values. The positive slope in the regression equations indicates that the two variables tend to increase together. Hence the correlation coefficient is also positive for all the mixtures.
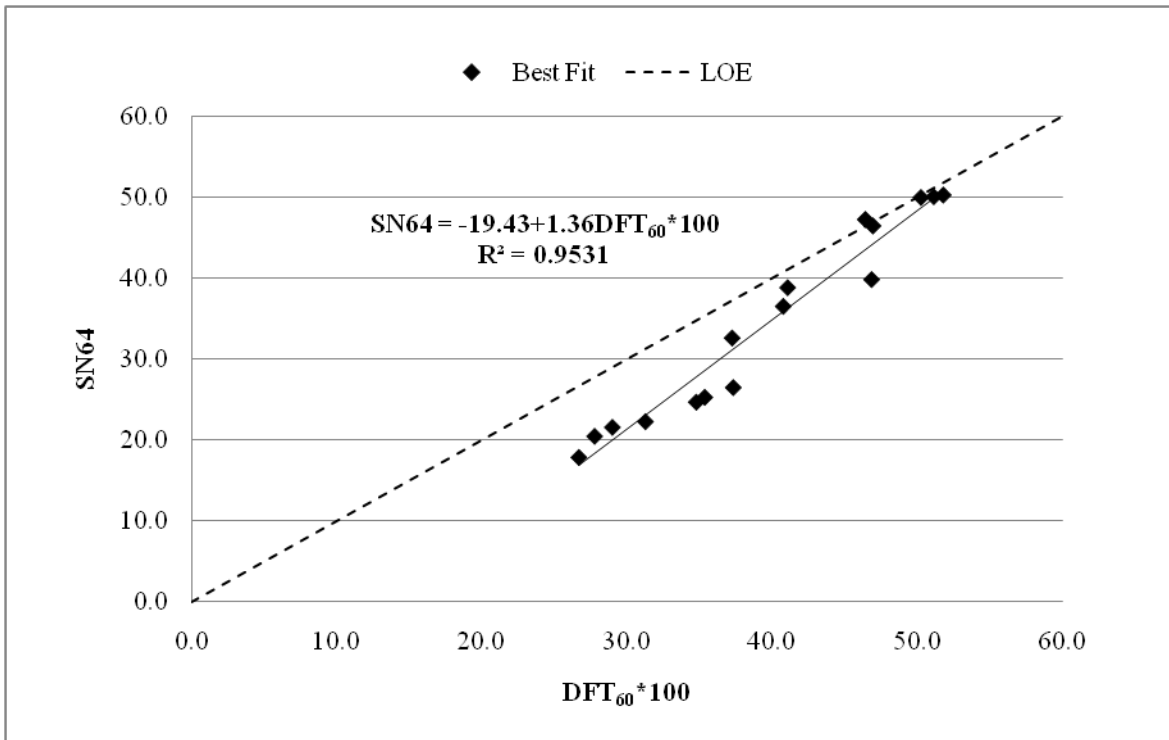
Figure 8.3 Laboratory (DFT$_{60}$*100) vs. Test Track (SN64) Friction Data

Figure 8.3 shows linear regression between the DFT$_{60}$ and SN64 by using the data for all

the four mixes from the laboratory and test track. The R-squared value for the correlation

between DFT$_{60}$ and SN64 was determined to be 0.953. Based on the observation, it can be

concluded that the DFT correlates very well to the LWST.

CHAPTER 9. CONCLUSIONS AND RECOMMENDATIONS

In this research, the frictional characteristics of different asphalt mixtures were measured and compared. The friction and texture properties of laboratory prepared HMA slabs were measured using Dynamic Friction Tester and Circular Texture Meter at specific intervals after polishing with NCAT Three Wheel Polishing Device. The results of these tests were analyzed using engineering and statistical methods. A summary of key findings along with recommendations for future research are discussed in this chapter.

The Phase I of this research developed a test protocol for NCAT Three Wheel Polishing Device. Three conditioning loads (91 lbs., 107 lbs. and 122 lbs.) and two polishing speeds (40 and 60 rpm) were evaluated. Two SMA mixtures (E1 mix, W7 mix) with three replicate slabs for six combinations of load and speed were tested. The conditioning was done using two TWPDs at NCAT. It was observed that the decrease in friction (DFT_{40}) and texture values (CTM) was highest during the initial polishing up to 16,000 cycles. The friction and texture values exhibit a slow rate of change on further polishing and eventually became essentially constant after 64,000 polishing cycles. This behavior of HMA surface is attributed to removal of binder and aggregate wear during initial polishing. On further polishing, the aggregates reveal a much smoother surface thus reaching a terminal condition. Based on the observations in Phase I testing, the number of TWPD conditioning cycles were reduced from 128,000 to 100,000 in Phase II testing to reduce the laboratory testing time.

Three replicate tests were performed for each DFT measurement by reporting the average DFT value for five test speeds (0, 20, 40, 60 80 km/h). The DFT pads were tested for consistent measurement after every 6 drops by using a textured steel calibration plate. The DFT test results

for SMA mixtures selected in Phase I was used to evaluate different load and speed combinations. The results at the DFT test speed of 40 km/h are used for data analysis. The tests gave mixed results with no trend for the DFT_{40} friction values. Later it was found that there is a difference in polishing characteristics of two TWPDs. As a result, the friction values (DFT_{40}) for the slabs were adjusted by using an adjustment factor found by comparing slabs tested on different polishers at similar conditions (mixture, load, speed). The adjusted friction values showed a clear trend. The combination with the lowest load (91 lbs.) and highest speed (60 rpm) was found to wear the HMA surface more than other combinations. Of the speed combinations evaluated, 60 rpm speed was the most productive. The reason for higher amount of polishing at lower load could be due to the fact that as load increases the amount of slip provided between tire and HMA surface is decreased. This would reduce the amount of polishing at higher loads. The texture properties of HMA surface are measured using CTM in terms of Mean Profile Depth (MPD). Five replicate tests were performed for each measurement and the average MPD value is reported. No particular trend was observed for MPD values measured with CTM at different speed and load combinations for both SMA mixtures in Phase I (E1 mix, W7 mix).

In Phase II, friction change was evaluated with varying amounts of friction aggregate in a mixture. Two dense graded mixtures (N4 mix and W3 mix) with 3 blends for each mixture were prepared and tested. The DFT results showed that the friction values decreases by decreasing the amount of friction aggregate in a mixture. No trend was observed in friction values by increasing the amount of friction aggregate.

A correlation was found between the DFT_{60} values measured in laboratory and SN64 values from NCAT test track measured using a skid trailer. The simple linear regression analysis was performed on friction data from laboratory and test track. Friction values measured in

laboratory highly correlated with field data for mixtures used in Phase I (E1 and W7 mixes) and reasonable correlation with Phase II mixtures (N4 and W3 mixes).

Thus the research was successful in developing a test protocol for NCAT Three Wheel Polishing Device to rapidly evaluate the friction properties of HMA surface in the laboratory. Further research is needed to validate the applicability of the developed test protocol to be used as a standard. Additional research is needed to study the friction behavior of HMA surface as the amount of friction aggregate is varied in the mixture by developing more mixture blends. Future research should be focused on validation of developed correlation between laboratory polishing cycles and test track ESALs.

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APPENDIX A – SLAB COMPACTION PROCEDURE

Preparing Hot-Mix Asphalt Specimens (HMA) by Means of the Rolling Slab Compactor

1.   Apparatus

1.1   Rolling Slab Compactor – A rolling compactor with a hydraulically lifted platform. The lift platform shall have a pressure gage capable of measuring pressure up to 3,000 psi. The platform shall be capable of being uniformly lifted (manually or automatically) across the bottom of the platform.

1.2   Specimen Mold – A rectangular, 2-piece, steel mold with walls at least 9 mm thick. When the mold is assembled it shall have inside dimensions of 510 mm by 507 mm. It shall have a height of 228 mm. The dimension perpendicular to the side marked "Front" is the length dimension specified in Section 3.1.

1.3   Base Insert Frame – A steel framed spacer with dimensions of 509 mm by 506 mm by 40 mm.

1.4   Thick Insert Plates – Steel plates with dimensions of 509 mm by 506 mm by 10 mm.

1.5   Thin Insert Plates – Steel plates with dimensions of 509 mm by 506 mm by 3 mm.

1.6   Vertical Kneading Plates – Steel plates that go on top of mix that are 105 mm by 10 mm by 505 mm. They are 105 mm tall when standing on their 10 mm side. There are 49 of the 10 mm kneading plates and one 3 mm thick plate.

1.7   Wax Paper – Paper coated with wax so the HMA will not stick to it.

1.8   Metal Partition – A metal partition capable of dividing the mix into four quadrants.

1.9   Mix Transfer Funnel – A metal device with a tapered end capable of transferring mix from pans into the four quadrants created by the splitter.

1.10   Thermometers – Armored, glass, or dial type thermometers with metal stems for determining the temperature of aggregates, binder, and HMA up to 204 °C and readable to 1°C.

1.11   Balance – A balance meeting the requirements of AASHTO M 231, Class G 5, for determining the mass of aggregates, binder, and HMA.

1.12   Oven – An oven thermostatically controlled to ±3°C, for heating aggregates, binder, HMA, and equipment as required. The oven shall be capable of maintaining the temperature required for mixture conditioning in accordance with AASHTO R 30.

1.13   Miscellaneous – Flat bottom scoop, large trowel, vice grips, rubber mallet, screw driver and mechanical jack.

2.   Equipment Preparation

2.1   Determine the number of insert plates needed to achieve desired slab thickness. Table 1 shows plates needed to achieve different thicknesses.

Table 1: Number of base plates required to reach desired slab thickness

Slab Ht. (mm)	Frame	10 mm plates	3 mm plates
113.3	No	1	0
110.0	No	1	1
103.8	No	2	0
100.5	No	2	1
94.3	No	3	0
91.0	No	3	1
79.9	yes	0	1
73.7	yes	1	0
70.4	yes	1	1
64.2	yes	2	0
60.9	yes	2	1
54.7	yes	3	0
51.4	yes	3	1
45.2	yes	4	0
41.9	yes	4	1

2.2   Cut two pieces of wax paper, one for the top and one for the bottom, to fit in mold by using one of the insert base plates as a template.

2.3   Place assembled mold, base plates, and partition in an oven set to the desired compaction temperature a minimum of 30 minutes prior to compaction.

3.   Material Preparation

3.1   Determine mass of total mix needed to achieve desired height and air voids (usually target 7%). Equation 1 shows how to calculate total mix mass.

$$m_T = (lwt)G_{mm}\left[\frac{(100 - \% \, V_a)}{(100 * G_m)}\right]$$

Where:

m_T = total mass of slab in g;

l = length of slab, 509.5 mm;

w = width of slab, 506.5 mm;

t = desired thickness of slab in mm;

G_{mm} = theoretical maximum specific gravity of the mix;

V_a = desired percent air voids of slab, usually 7%;

G_m = unit weight of water, 0.001 g/mm^3.

3.2   Prepare four separate batches. Determine the total mass of each batch by dividing m_T by four.

3.3   Mix each batch separately and set aside.

3.4   Place all 4 pans in oven for two hours at 300°F, or the desired compaction temperature, in accordance with AASHTO R 30.

3.5   For specimens using field mix, sample according to AASHTO T 168. Reduce the mix to batch size using Method B in AASHTO T 328.

4.   Procedure

4.1   When the compaction temperature of the mix is achieved, remove the heated mold and assemble it on the mechanical jack with the side marked "Front" facing the jack.

4.2   Place base frame in mold. Place base plates in mold.

4.3   On the top base plate, place a piece of pre-cut wax paper.

4.4   Place the metal partition on top of the wax paper. Pour mix from one pan into the mix transfer funnel, then into one quadrant. Pour the next into the mix transfer funnel and then into the quadrant diagonally across from the first quadrant. Repeat for the other two pans.

4.5   Carefully remove the metal partition from the mix.

4.6   Spade the mix with a large trowel until the mix is at a relatively uniform depth. Then level the mix out with the trowel, taking care not to segregate the mix. The mix should be kept in the vicinity of the quadrant in which it was poured.

4.7   Place the other piece of wax paper on top of the leveled mix.

4.8   Place 49 vertical kneading plates on the mix, taking care not to wrinkle the paper or move the mix. Put the plates in simultaneously from each side. The plates should be orientated perpendicular to the front of the compaction mold. The rubber mallet may be required to get the last plate in the mold.

4.9   Move specimen mold to the rolling compactor using the mechanical jack. Adjust the jack platform with the specimen mold until it is level with the compactor platform. Slide the mold onto the compactor's platform with one person guiding from behind the compactor and one person pushing from the front. Do this in one uniform motion. Take care not to let the frame or bottom plate slip out of the bottom of the mold.

4.10   Once mold is set on the platform make sure the entire base of the mold is touching the platform. The rubber mallet may be needed here.

4.11   Turn hydraulic valves to the closed position and turn the roller on. Lift the mold and platform to the roller by pumping the hydraulic handle.

4.12   When the top of the kneading plates reaches the roller, stop pumping the handle and let the roller roll atop the kneading plates. Now only pump the handle when the roller is at the ends of the mold. This will pick up the other end of the mold. Slightly pump the handle each time the roller goes to the end without letting the pressure go above 1200 psi. If the pressure is increasing too rapidly, let out a small amount of pressure using the hydraulic valves. Continue gradually lifting the compaction platform until the kneading plates are level with the top of the mold.

4.13   Stop the roller and release the pressure so that the platform is lowered.

4.14   Slide specimen mold back onto the mechanical jack. One person should hold the jack against the compactor platform while the other pushes the mold from the back of the compactor at the same time.

4.15   Remove the kneading plates. A screw driver and vise grips shall be used to pull the first couple of plates out. The plates should be removed starting in the middle and working out to each side simultaneously.

4.16   Slide the mold onto a counter and let it cool in front of a fan for a minimum of one hour before removing the mold. Do not handle the slab before it reaches room temperature.

4.17   Once the slab has cooled to room temperature, flip the slab over and remove the wax paper from the bottom. The bottom of the slab is the ideal side for most testing.

4.18   The slab should be stored on a rigid plate such as a 1-inch thick piece of plywood to protect against deformation. Never stack slabs or leave on a non-flat surface.

Figure 1 Modified Hamburg Slab Compactor

APPENDIX B – MIX DESIGNS

Table A.1 Mix Design for E1 Mix

Sieve Size	Percent Passing				
	Rinker Limestone 7s	Danley Limestone 8s	Rinker LMS Screenings 10s	Fly Ash	Blend
2"	100.0	100.0	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0	100.0	100.0
1"	100.0	100.0	100.0	100.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0
1/2"	93.6	100.0	100.0	100.0	95.1
3/8"	64.3	99.1	99.6	100.0	72.8
#4	15.2	30.8	95.7	100.0	34.8
#8	5.1	3.2	63.7	100.0	21.4
#16	3.7	0.6	39.1	100.0	15.8
#30	3.3	0.5	26.5	100.0	13.3
#50	3.1	0.5	20.0	100.0	12.0
#100	3.0	0.4	16.5	100.0	11.2
#200	2.8	0.4	14.3	100.0	10.7
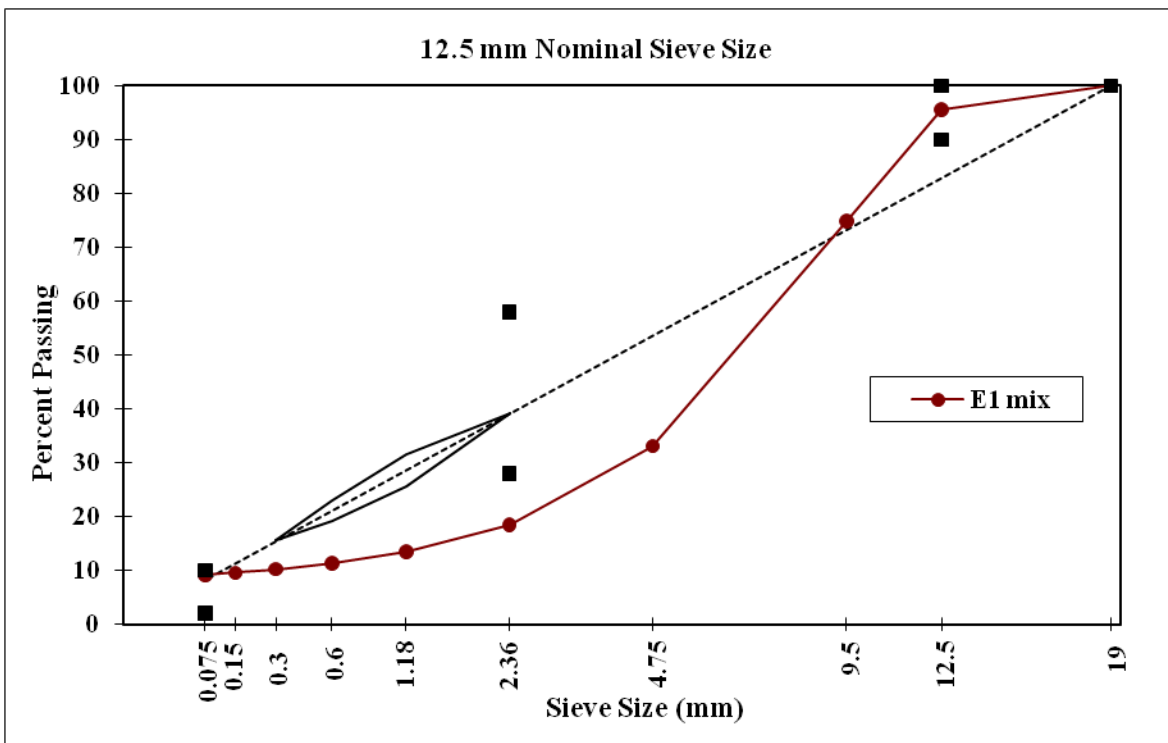
Table A.2 Mix Design for W7 Mix

Sieve Size	Percent Passing

91

	Calera 7s	Calera 821s	Fly Ash	Blend
2"	100.0	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0	100.0
1"	100.0	100.0	100.0	100.0
3/4"	100.0	100.0	100.0	100.0
1/2"	95.9	100.0	100.0	96.6
3/8"	64.6	100.0	100.0	71.0
#4	5.0	98.7	100.0	22.0
#8	0.7	78.6	100.0	16.2
#16	0.7	52.3	100.0	13.3
#30	0.7	34.7	100.0	11.4
#50	0.7	24.1	100.0	10.2
#100	0.7	17.1	100.0	9.4
#200	0.6	13.6	100.0	9.0
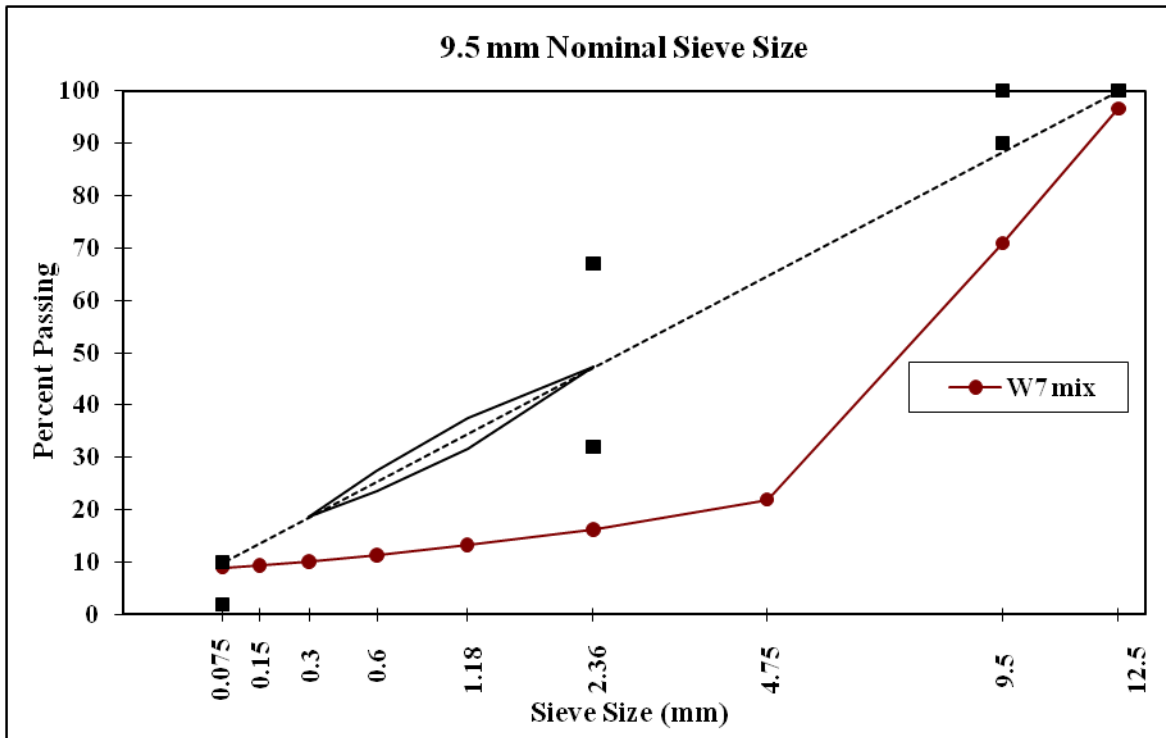
Table A.3 Mix Design for N4 Mix

Sieve Size	Percent Passing										
	Granite 89s	Limestone 8910	Granite M10s	Shorter Sand	Granite 89s +4s	Granite 89s - 4s	Calera 7s	Calera 821s	B1	B2	B3
2"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1/2"	99.9	100.0	100.0	100.0	99.8	100.0	95.9	100.0	100.0	99.8	99.6
3/8"	99.6	100.0	100.0	100.0	99.4	100.0	64.6	100.0	99.9	98.1	96.4
#4	36.2	99.5	99.0	99.2	0.0	100.0	5.0	98.7	80.5	80.8	81.0
#8	2.5	97.1	86.0	91.6	0.0	6.9	0.7	78.6	61.1	60.7	60.4
#16	0.7	67.1	65.0	75.2	0.0	1.9	0.7	52.3	45.1	44.5	43.9
#30	0.6	51.9	47.0	46.1	0.0	1.7	0.7	34.7	32.0	31.4	30.8
#50	0.6	37.9	31.0	11.6	0.0	1.7	0.7	24.1	18.6	18.3	18.0
#100	0.5	25.7	19.7	3.6	0.0	1.4	0.7	17.1	11.6	11.5	11.4
#200	0.4	16.8	10.6	2.2	0.0	1.1	0.6	13.6	7.1	7.3	7.5
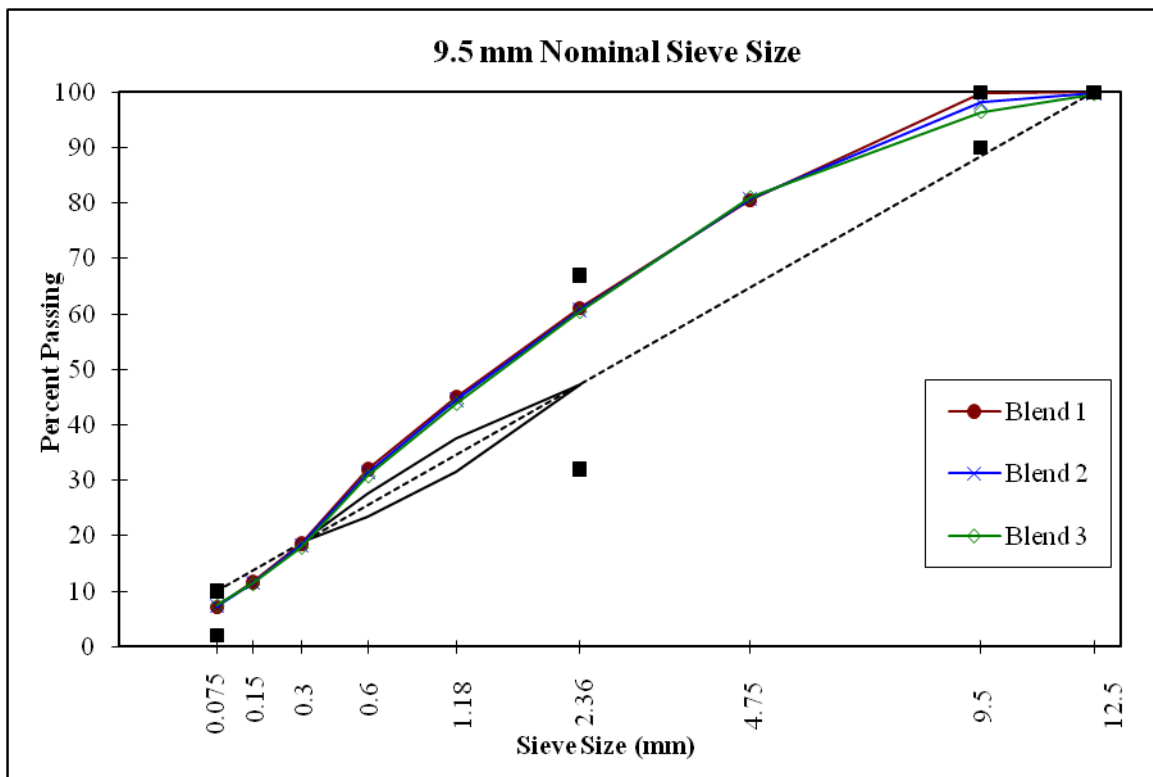
Table A.4 Mix Design for W3 Mix

Sieve Size	Percent Passing							
	Goretown 89 Limestone	Regular Screenings	Washed Screenings	Granite 89s +4s	Granite 89s -4s	B1	B2	B3
2"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1 1/2"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/4"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1/2"	100.0	100.0	100.0	99.8	100.0	100.0	100.0	100.0
3/8"	98.7	99.9	100.0	99.4	100.0	99.3	99.5	99.7
#4	63.3	93.4	100.0	0.0	100.0	79.6	79.5	80.4
#8	24.2	70.9	94.9	0.0	6.9	50.7	49.3	49.1
#16	14.7	50.7	68.3	0.0	1.9	35.3	34.4	34.4
#30	7.8	36.4	36.2	0.0	1.7	23.3	22.1	22.1
#50	3.8	24.9	16.9	0.0	1.7	14.9	13.8	13.7
#100	2.3	17.4	5.5	0.0	1.4	10.0	8.8	8.6
#200	1.7	11.4	2.2	0.0	1.1	6.9	6.0	5.8
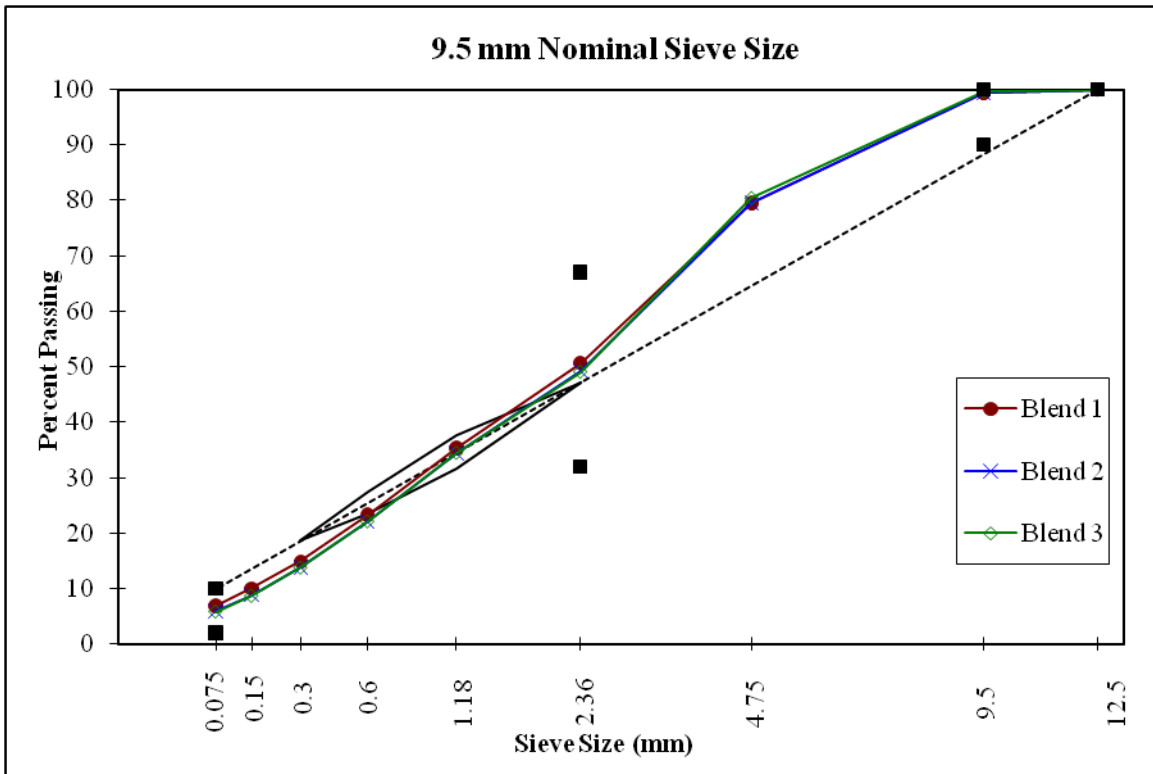
APPENDIX C – DFT TEST RESULTS

Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	1	OLD	107#	40rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.688	0.807	0.821	0.772	0.133	0.073	0.095
	20	0.299	0.318	0.325	0.314	0.026	0.013	0.043
	40	0.254	0.245	0.234	0.244	0.020	0.010	0.041
	60	0.248	0.239	0.228	0.238	0.020	0.010	0.042
	80	0.146	0.139	0.153	0.146	0.014	0.007	0.048
500	0	0.533	0.524	0.626	0.561	0.102	0.056	0.101
	20	0.237	0.246	0.249	0.244	0.012	0.006	0.026
	40	0.193	0.190	0.189	0.191	0.004	0.002	0.011
	60	0.194	0.191	0.188	0.191	0.006	0.003	0.016
	80	0.167	0.152	0.159	0.159	0.015	0.008	0.047
1000	0	0.636	0.598	0.698	0.644	0.100	0.050	0.078
	20	0.384	0.368	0.365	0.372	0.019	0.010	0.027
	40	0.341	0.328	0.319	0.329	0.022	0.011	0.034
	60	0.343	0.321	0.304	0.323	0.039	0.020	0.061
	80	0.151	0.131	0.137	0.140	0.020	0.010	0.073
2000	0	0.692	0.716	0.637	0.682	0.079	0.041	0.059
	20	0.550	0.525	0.505	0.527	0.045	0.023	0.043
	40	0.483	0.460	0.448	0.464	0.035	0.018	0.038
	60	0.450	0.426	0.420	0.432	0.030	0.016	0.037
	80	0.124	0.172	0.153	0.150	0.048	0.024	0.162
4000	0	0.781	0.736	0.619	0.712	0.162	0.084	0.117
	20	0.580	0.572	0.561	0.571	0.019	0.010	0.017
	40	0.524	0.509	0.500	0.511	0.024	0.012	0.024
	60	0.501	0.474	0.464	0.480	0.037	0.019	0.040
	80	0.154	0.198	0.124	0.159	0.074	0.037	0.235
8000	0	0.642	0.676	0.583	0.634	0.093	0.047	0.074
	20	0.582	0.551	0.539	0.557	0.043	0.022	0.040
	40	0.526	0.503	0.492	0.507	0.034	0.017	0.034
	60	0.505	0.486	0.465	0.485	0.040	0.020	0.041
	80	0.143	0.092	0.124	0.120	0.051	0.026	0.215
16000	0	0.593	0.671	0.593	0.619	0.078	0.045	0.073
	20	0.545	0.533	0.525	0.534	0.020	0.010	0.019
	40	0.502	0.492	0.482	0.492	0.020	0.010	0.020
	60	0.471	0.466	0.457	0.465	0.014	0.007	0.015
	80	0.132	0.148	0.140	0.140	0.016	0.008	0.057
32000	0	0.666	0.661	0.612	0.646	0.054	0.030	0.046
	20	0.558	0.547	0.541	0.549	0.017	0.009	0.016
	40	0.518	0.514	0.511	0.514	0.007	0.004	0.007
	60	0.506	0.497	0.494	0.499	0.012	0.006	0.013
	80	0.175	0.144	0.159	0.159	0.031	0.016	0.097
64000	0	0.676	0.624	0.633	0.644	0.052	0.028	0.043
	20	0.516	0.537	0.538	0.530	0.022	0.012	0.023
	40	0.439	0.471	0.473	0.461	0.034	0.019	0.041
	60	0.417	0.447	0.448	0.437	0.031	0.018	0.040
	80	0.000	0.123	0.196	0.106	0.196	0.099	0.932
128000	0	0.556	0.537	0.524	0.539	0.032	0.016	0.030
	20	0.519	0.516	0.509	0.515	0.010	0.005	0.010
	40	0.498	0.493	0.491	0.494	0.007	0.004	0.007
	60	0.504	0.498	0.490	0.497	0.014	0.007	0.014
	80	0.179	0.034	0.131	0.115	0.145	0.074	0.644
Outliers								

DFT plots (slab 1)

- 20 km/hr
- 40 km/hr
- 60 km/hr
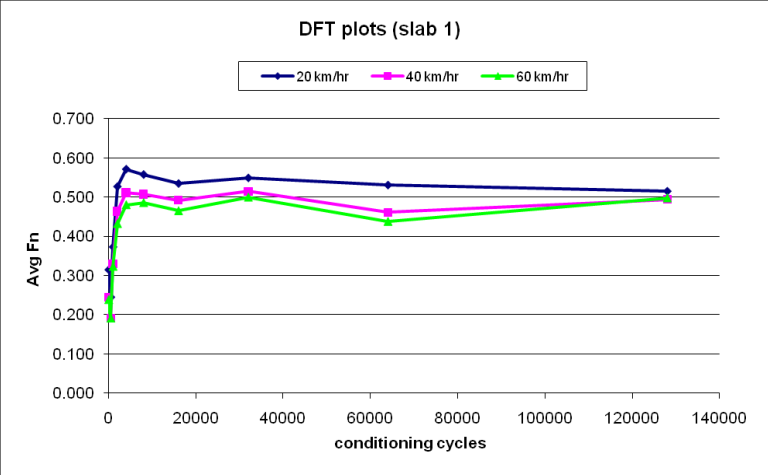
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	2	OLD	107#	40rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.639	0.682	0.794	0.705	0.155	0.080	0.114
	20	0.300	0.289	0.285	0.291	0.015	0.008	0.027
	40	0.216	0.204	0.205	0.208	0.012	0.007	0.032
	60	0.220	0.203	0.203	0.209	0.017	0.010	0.047
	80	0.188	0.158	0.185	0.177	0.030	0.017	0.093
500	0	0.671	0.588	0.677	0.645	0.089	0.050	0.077
	20	0.251	0.273	0.284	0.269	0.033	0.017	0.062
	40	0.198	0.199	0.200	0.199	0.002	0.001	0.005
	60	0.199	0.199	0.201	0.200	0.002	0.001	0.006
	80	0.183	0.128	0.173	0.161	0.055	0.029	0.182
1000	0	0.777	0.689	0.702	0.723	0.088	0.048	0.066
	20	0.405	0.380	0.371	0.385	0.034	0.018	0.046
	40	0.348	0.342	0.338	0.343	0.010	0.005	0.015
	60	0.343	0.336	0.332	0.337	0.011	0.006	0.017
	80	0.113	0.082	0.098	0.098	0.031	0.016	0.159
2000	0	0.742	0.756	0.748	0.749	0.014	0.007	0.009
	20	0.520	0.503	0.486	0.503	0.034	0.017	0.034
	40	0.462	0.438	0.429	0.443	0.033	0.017	0.039
	60	0.435	0.419	0.414	0.423	0.021	0.011	0.026
	80	0.176	0.189	0.186	0.184	0.013	0.007	0.037
4000	0	0.772	0.722	0.722	0.739	0.050	0.029	0.039
	20	0.545	0.530	0.523	0.533	0.022	0.011	0.021
	40	0.493	0.480	0.489	0.487	0.013	0.007	0.014
	60	0.462	0.448	0.432	0.447	0.030	0.015	0.034
	80	0.147	0.133	0.144	0.141	0.014	0.007	0.052
8000	0	0.739	0.717	0.599	0.685	0.140	0.075	0.110
	20	0.546	0.535	0.531	0.537	0.015	0.008	0.014
	40	0.501	0.487	0.482	0.490	0.019	0.010	0.020
	60	0.479	0.461	0.452	0.464	0.027	0.014	0.030
	80	0.127	0.156	0.114	0.132	0.042	0.022	0.162
16000	0	0.647	0.662	0.672	0.660	0.025	0.013	0.019
	20	0.547	0.537	0.534	0.539	0.013	0.007	0.013
	40	0.496	0.481	0.476	0.484	0.020	0.010	0.021
	60	0.456	0.449	0.438	0.448	0.018	0.009	0.020
	80	0.200	0.095	0.155	0.150	0.105	0.053	0.351
32000	0	0.704	0.639	0.732	0.692	0.093	0.048	0.069
	20	0.554	0.545	0.542	0.547	0.012	0.006	0.011
	40	0.508	0.498	0.501	0.502	0.010	0.005	0.010
	60	0.498	0.493	0.485	0.492	0.013	0.007	0.013
	80	0.093	0.132	0.173	0.133	0.080	0.040	0.302
64000	0	0.647	0.653	0.568	0.623	0.085	0.047	0.076
	20	0.531	0.518	0.514	0.521	0.017	0.009	0.017
	40	0.497	0.474	0.474	0.482	0.023	0.013	0.028
	60	0.476	0.459	0.462	0.466	0.017	0.009	0.019
	80	0.060	0.095	0.152	0.102	0.092	0.046	0.454
128000	0	0.710	0.618	0.606	0.645	0.104	0.057	0.088
	20	0.580	0.566	0.555	0.567	0.025	0.013	0.022
	40	0.520	0.515	0.514	0.516	0.006	0.003	0.006
	60	0.514	0.510	0.511	0.512	0.004	0.002	0.004
	80	0.155	0.103	0.143	0.134	0.052	0.027	0.204
Outliers								

DFT plots (slab 2)

—♦— 20 km/hr   —■— 40 km/hr   —▲— 60 km/hr

Avg Fn

condotioning cycles

97
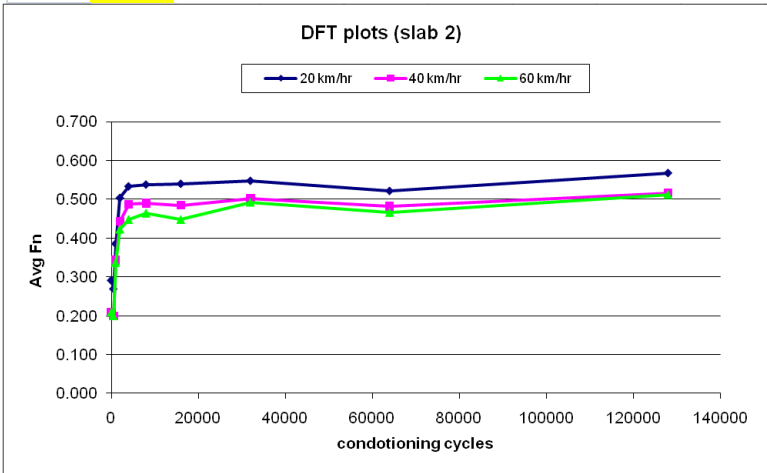
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	3	OLD	107#	40rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.812	0.847	0.844	0.834	0.035	0.019	0.023
	20	0.429	0.359	0.344	0.377	0.085	0.045	0.120
	40	0.292	0.253	0.250	0.265	0.042	0.023	0.088
	60	0.277	0.247	0.246	0.257	0.031	0.018	0.069
	80	0.139	0.165	0.180	0.161	0.041	0.021	0.129
500	0	0.801	0.740	0.733	0.758	0.068	0.037	0.049
	20	0.427	0.393	0.381	0.400	0.046	0.024	0.060
	40	0.347	0.320	0.302	0.323	0.045	0.023	0.070
	60	0.345	0.303	0.293	0.314	0.052	0.028	0.088
	80	0.177	0.188	0.154	0.173	0.034	0.017	0.100
1000	0	0.716	0.725	0.689	0.710	0.036	0.019	0.026
	20	0.454	0.443	0.436	0.444	0.018	0.009	0.020
	40	0.400	0.391	0.386	0.392	0.014	0.007	0.018
	60	0.391	0.361	0.354	0.369	0.037	0.020	0.053
	80	0.234	0.124	0.140	0.166	0.110	0.059	0.358
2000	0	0.745	0.760	0.727	0.744	0.033	0.017	0.022
	20	0.572	0.550	0.534	0.552	0.038	0.019	0.035
	40	0.508	0.491	0.478	0.492	0.030	0.015	0.031
	60	0.483	0.461	0.445	0.463	0.038	0.019	0.041
	80	0.154	0.156	0.172	0.161	0.018	0.010	0.061
4000	0	0.753	0.696	0.689	0.713	0.064	0.035	0.049
	20	0.595	0.577	0.565	0.579	0.030	0.015	0.026
	40	0.540	0.518	0.513	0.524	0.027	0.014	0.027
	60	0.511	0.496	0.479	0.495	0.032	0.016	0.032
	80	0.166	0.156	0.163	0.162	0.010	0.005	0.032
8000	0	0.733	0.646	0.631	0.670	0.102	0.055	0.082
	20	0.594	0.577	0.569	0.580	0.025	0.013	0.022
	40	0.553	0.532	0.524	0.536	0.029	0.015	0.028
	60	0.517	0.507	0.505	0.510	0.012	0.006	0.013
	80	0.126	0.141	0.154	0.140	0.028	0.014	0.100
16000	0	0.638	0.619	0.603	0.620	0.035	0.018	0.028
	20	0.566	0.562	0.552	0.560	0.014	0.007	0.013
	40	0.501	0.498	0.496	0.498	0.005	0.003	0.005
	60	0.463	0.462	0.458	0.461	0.005	0.003	0.006
	80	0.115	0.130	0.132	0.126	0.017	0.009	0.074
32000	0	0.666	0.631	0.616	0.638	0.050	0.026	0.040
	20	0.580	0.557	0.554	0.564	0.026	0.014	0.025
	40	0.527	0.518	0.515	0.520	0.012	0.006	0.012
	60	0.519	0.508	0.510	0.512	0.011	0.006	0.011
	80	0.088	0.189	0.141	0.139	0.101	0.051	0.363
64000	0	0.671	0.638	0.626	0.645	0.045	0.023	0.036
	20	0.551	0.532	0.528	0.537	0.023	0.012	0.023
	40	0.493	0.482	0.481	0.485	0.012	0.007	0.014
	60	0.476	0.464	0.466	0.469	0.012	0.006	0.014
	80	0.280	0.147	0.132	0.186	0.148	0.081	0.437
128000	0	0.534	0.538	0.533	0.535	0.005	0.003	0.005
	20	0.528	0.525	0.516	0.523	0.012	0.006	0.012
	40	0.519	0.513	0.505	0.512	0.014	0.007	0.014
	60	0.519	0.509	0.511	0.513	0.010	0.005	0.010
	80	0.105	0.068	0.113	0.095	0.045	0.024	0.252
Outliers								

DFT plots (slab 3)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles
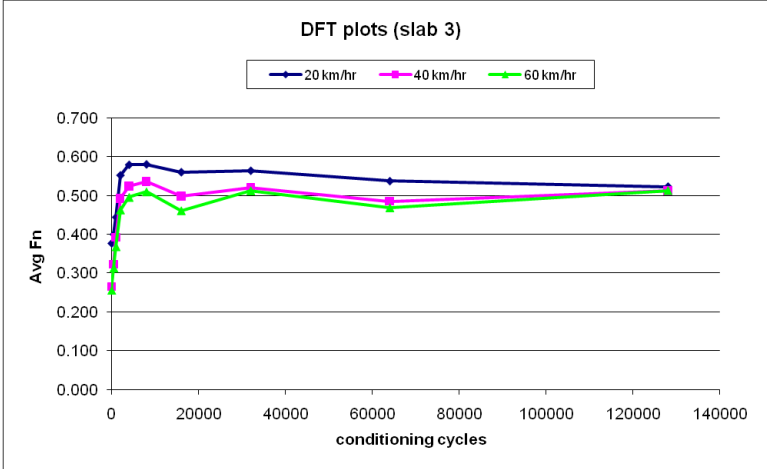
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	4	OLD	107#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.721	0.701	0.717	0.713	0.020	0.011	0.015
	20	0.267	0.245	0.302	0.271	0.057	0.029	0.106
	40	0.191	0.182	0.219	0.197	0.037	0.019	0.098
	60	0.193	0.182	0.215	0.197	0.033	0.017	0.085
	80	0.183	0.146	0.166	0.165	0.037	0.019	0.112
500	0	0.758	0.762	0.787	0.769	0.029	0.016	0.020
	20	0.368	0.349	0.339	0.352	0.029	0.015	0.042
	40	0.272	0.258	0.257	0.262	0.015	0.008	0.032
	60	0.255	0.246	0.247	0.249	0.009	0.005	0.020
	80	0.191	0.140	0.131	0.154	0.060	0.032	0.210
1000	0	0.774	0.767	0.737	0.759	0.037	0.020	0.026
	20	0.399	0.401	0.419	0.406	0.020	0.011	0.027
	40	0.320	0.338	0.345	0.334	0.025	0.013	0.039
	60	0.290	0.300	0.330	0.307	0.040	0.021	0.068
	80	0.103	0.139	0.194	0.145	0.091	0.046	0.315
2000	0	0.682	0.707	0.705	0.698	0.025	0.014	0.020
	20	0.416	0.452	0.468	0.445	0.052	0.027	0.060
	40	0.353	0.403	0.412	0.389	0.059	0.032	0.082
	60	0.316	0.346	0.356	0.339	0.040	0.021	0.061
	80	0.170	0.155	0.192	0.172	0.037	0.019	0.108
4000	0	0.757	0.726	0.691	0.725	0.066	0.033	0.046
	20	0.549	0.530	0.509	0.529	0.040	0.020	0.038
	40	0.489	0.472	0.457	0.473	0.032	0.016	0.034
	60	0.452	0.430	0.420	0.434	0.032	0.016	0.038
	80	0.137	0.137	0.149	0.141	0.012	0.007	0.049
8000	0	0.777	0.756	0.691	0.741	0.086	0.045	0.060
	20	0.576	0.555	0.545	0.559	0.031	0.016	0.028
	40	0.515	0.510	0.503	0.509	0.012	0.006	0.012
	60	0.496	0.472	0.458	0.475	0.038	0.019	0.040
	80	0.164	0.163	0.145	0.157	0.019	0.011	0.068
16000	0	0.705	0.686	0.648	0.680	0.057	0.029	0.043
	20	0.564	0.549	0.534	0.549	0.030	0.015	0.027
	40	0.513	0.508	0.492	0.504	0.021	0.011	0.022
	60	0.505	0.485	0.471	0.487	0.034	0.017	0.035
	80	0.194	0.162	0.154	0.170	0.040	0.021	0.125
32000	0	0.643	0.627	0.617	0.629	0.026	0.013	0.021
	20	0.563	0.561	0.544	0.556	0.019	0.010	0.019
	40	0.520	0.509	0.503	0.511	0.017	0.009	0.017
	60	0.509	0.499	0.497	0.502	0.012	0.006	0.013
	80	0.117	0.156	0.146	0.140	0.039	0.020	0.145
64000	0	0.628	0.563	0.584	0.592	0.065	0.033	0.056
	20	0.521	0.515	0.511	0.516	0.010	0.005	0.010
	40	0.489	0.485	0.478	0.484	0.011	0.006	0.012
	60	0.487	0.476	0.465	0.476	0.022	0.011	0.023
	80	0.118	0.199	0.208	0.175	0.090	0.050	0.283
128000	0	0.618	0.653	0.576	0.616	0.077	0.039	0.063
	20	0.542	0.536	0.527	0.535	0.015	0.008	0.014
	40	0.506	0.507	0.502	0.505	0.005	0.003	0.005
	60	0.505	0.505	0.500	0.503	0.005	0.003	0.006
	80	0.146	0.174	0.105	0.142	0.069	0.035	0.245

Outliers

DFT plots (slab 4)

99
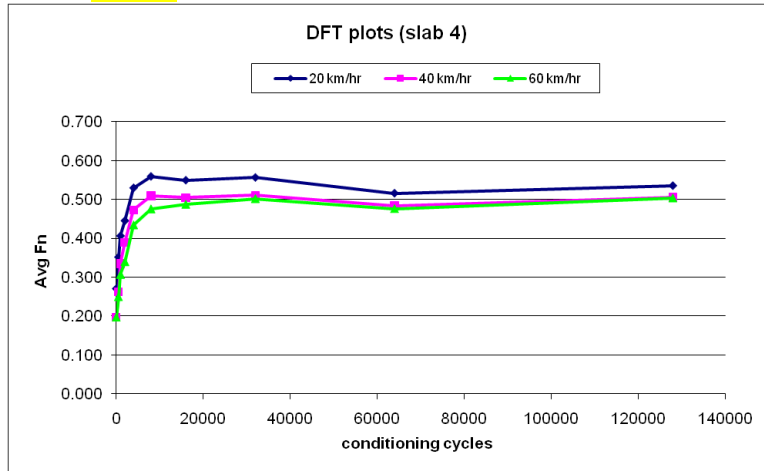
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	5	OLD	107#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.766	0.703	0.732	0.734	0.063	0.032	0.043
	20	0.345	0.289	0.291	0.308	0.056	0.032	0.103
	40	0.250	0.215	0.216	0.227	0.035	0.020	0.088
	60	0.246	0.218	0.214	0.226	0.032	0.017	0.077
	80	0.188	0.168	0.136	0.164	0.052	0.026	0.160
500	0	0.650	0.711	0.617	0.659	0.094	0.048	0.072
	20	0.341	0.324	0.324	0.330	0.017	0.010	0.030
	40	0.257	0.252	0.249	0.253	0.008	0.004	0.016
	60	0.241	0.239	0.239	0.240	0.002	0.001	0.005
	80	0.109	0.157	0.140	0.135	0.048	0.024	0.180
1000	0	0.738	0.723	0.706	0.722	0.032	0.016	0.022
	20	0.408	0.387	0.377	0.391	0.031	0.016	0.040
	40	0.347	0.343	0.338	0.343	0.009	0.005	0.013
	60	0.341	0.330	0.305	0.325	0.036	0.018	0.057
	80	0.128	0.175	0.130	0.144	0.047	0.027	0.184
2000	0	0.665	0.564	0.615	0.615	0.101	0.051	0.082
	20	0.466	0.451	0.438	0.452	0.028	0.014	0.031
	40	0.412	0.402	0.385	0.400	0.027	0.014	0.034
	60	0.367	0.354	0.351	0.357	0.016	0.009	0.024
	80	0.197	0.182	0.174	0.184	0.023	0.012	0.063
4000	0	0.693	0.653	0.652	0.666	0.041	0.023	0.035
	20	0.533	0.520	0.498	0.517	0.035	0.018	0.034
	40	0.450	0.439	0.429	0.439	0.021	0.011	0.024
	60	0.417	0.410	0.403	0.410	0.014	0.007	0.017
	80	0.153	0.153	0.135	0.147	0.018	0.010	0.071
8000	0	0.673	0.742	0.683	0.699	0.069	0.037	0.053
	20	0.565	0.544	0.531	0.547	0.034	0.017	0.031
	40	0.505	0.476	0.470	0.484	0.035	0.019	0.039
	60	0.458	0.432	0.423	0.438	0.035	0.018	0.042
	80	0.149	0.188	0.166	0.168	0.039	0.020	0.117
16000	0	0.671	0.656	0.671	0.666	0.015	0.009	0.013
	20	0.572	0.564	0.572	0.569	0.008	0.005	0.008
	40	0.505	0.493	0.505	0.501	0.012	0.007	0.014
	60	0.448	0.444	0.448	0.447	0.004	0.002	0.005
	80	0.215	0.090	0.215	0.173	0.125	0.072	0.416
32000	0	0.631	0.657	0.616	0.635	0.041	0.021	0.033
	20	0.528	0.513	0.514	0.518	0.015	0.008	0.016
	40	0.482	0.470	0.468	0.473	0.014	0.008	0.016
	60	0.467	0.452	0.448	0.456	0.019	0.010	0.022
	80	0.156	0.133	0.099	0.129	0.057	0.029	0.222
64000	0	0.692	0.687	0.584	0.654	0.108	0.061	0.093
	20	0.546	0.545	0.540	0.544	0.006	0.003	0.006
	40	0.496	0.488	0.484	0.489	0.012	0.006	0.012
	60	0.469	0.466	0.459	0.465	0.010	0.005	0.011
	80	0.171	0.117	0.047	0.112	0.124	0.062	0.557
128000	0	0.618	0.581	0.553	0.584	0.065	0.033	0.056
	20	0.545	0.535	0.533	0.538	0.012	0.006	0.012
	40	0.518	0.507	0.506	0.510	0.012	0.007	0.013
	60	0.515	0.506	0.507	0.509	0.009	0.005	0.010
	80	0.197	0.218	0.137	0.184	0.081	0.042	0.228

Outliers

DFT plots (slab 5)
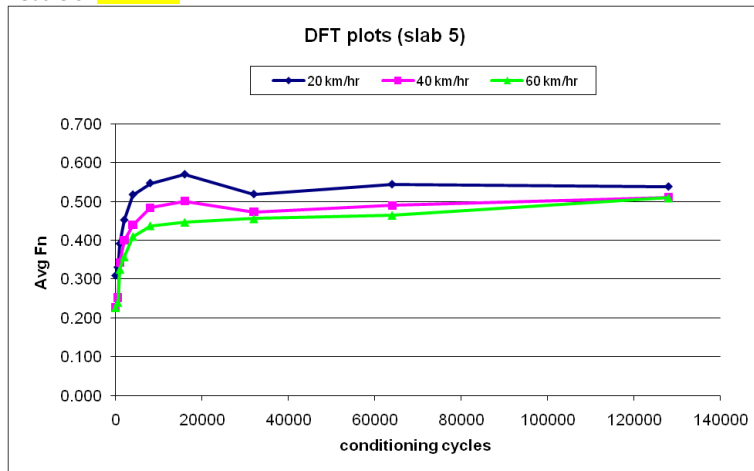
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	6	OLD	107#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.648	0.643	0.610	0.634	0.038	0.021	0.033
	20	0.226	0.201	0.209	0.212	0.025	0.013	0.060
	40	0.164	0.148	0.145	0.152	0.019	0.010	0.067
	60	0.163	0.138	0.136	0.146	0.027	0.015	0.103
	80	0.149	0.139	0.154	0.147	0.015	0.008	0.052
500	0	0.608	0.559	0.732	0.633	0.173	0.089	0.141
	20	0.384	0.368	0.358	0.370	0.026	0.013	0.035
	40	0.301	0.293	0.293	0.296	0.008	0.005	0.016
	60	0.261	0.257	0.261	0.260	0.004	0.002	0.009
	80	0.170	0.176	0.143	0.163	0.033	0.018	0.108
1000	0	0.624	0.666	0.648	0.646	0.042	0.021	0.033
	20	0.405	0.391	0.386	0.394	0.019	0.010	0.025
	40	0.340	0.328	0.324	0.331	0.016	0.008	0.025
	60	0.305	0.299	0.295	0.300	0.010	0.005	0.017
	80	0.180	0.114	0.166	0.153	0.066	0.035	0.227
2000	0	0.612	0.628	0.678	0.639	0.066	0.034	0.054
	20	0.484	0.472	0.456	0.471	0.028	0.014	0.030
	40	0.416	0.400	0.385	0.400	0.031	0.016	0.039
	60	0.388	0.352	0.345	0.362	0.043	0.023	0.064
	80	0.154	0.174	0.173	0.167	0.020	0.011	0.067
4000	0	0.607	0.702	0.566	0.625	0.136	0.070	0.112
	20	0.517	0.507	0.488	0.504	0.029	0.015	0.029
	40	0.446	0.431	0.420	0.432	0.026	0.013	0.030
	60	0.412	0.397	0.387	0.399	0.025	0.013	0.032
	80	0.187	0.167	0.149	0.168	0.038	0.019	0.113
8000	0	0.723	0.733	0.642	0.699	0.091	0.050	0.071
	20	0.565	0.558	0.540	0.554	0.025	0.013	0.023
	40	0.504	0.497	0.475	0.492	0.029	0.015	0.031
	60	0.469	0.449	0.427	0.448	0.042	0.021	0.047
	80	0.128	0.130	0.128	0.129	0.002	0.001	0.009
16000	0	0.608	0.601	0.596	0.602	0.012	0.006	0.010
	20	0.423	0.465	0.480	0.456	0.057	0.030	0.065
	40	0.351	0.395	0.405	0.384	0.054	0.029	0.075
	60	0.309	0.347	0.354	0.337	0.045	0.024	0.072
	80	0.035	0.156	0.145	0.112	0.121	0.067	0.597
32000	0	0.613	0.611	0.591	0.605	0.022	0.012	0.020
	20	0.536	0.536	0.529	0.534	0.007	0.004	0.008
	40	0.484	0.489	0.480	0.484	0.009	0.005	0.009
	60	0.467	0.466	0.459	0.464	0.008	0.004	0.009
	80	0.202	0.161	0.163	0.175	0.041	0.023	0.132
64000	0	0.573	0.601	0.553	0.576	0.048	0.024	0.042
	20	0.495	0.492	0.484	0.490	0.011	0.006	0.012
	40	0.430	0.429	0.418	0.426	0.012	0.007	0.016
	60	0.412	0.409	0.409	0.410	0.003	0.002	0.004
	80	0.112	0.179	0.237	0.176	0.125	0.063	0.355
128000	0	0.677	0.594	0.537	0.603	0.140	0.070	0.117
	20	0.512	0.508	0.501	0.507	0.011	0.006	0.011
	40	0.469	0.459	0.455	0.461	0.014	0.007	0.016
	60	0.464	0.446	0.440	0.450	0.024	0.012	0.028
	80	0.129	0.119	0.128	0.125	0.010	0.006	0.044

Outliers

DFT plots (slab 6)
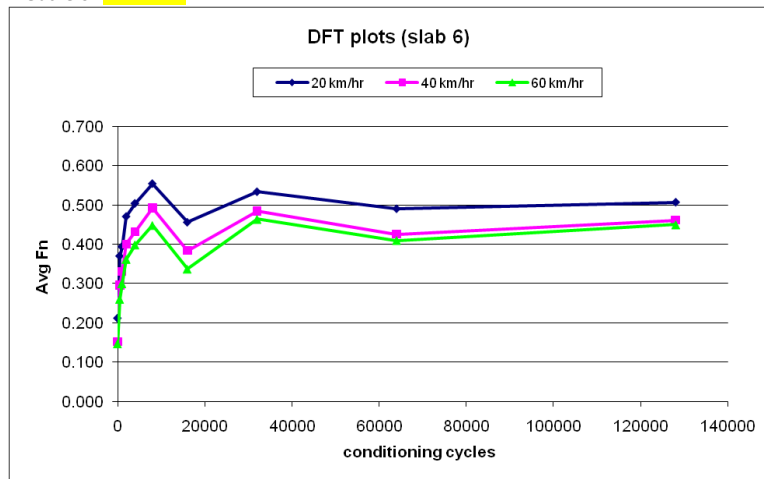
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	7	NEW	95#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.685	0.806	0.614	0.702	0.192	0.097	0.138
	20	0.373	0.325	0.336	0.345	0.048	0.025	0.073
	40	0.251	0.216	0.222	0.230	0.035	0.019	0.081
	60	0.248	0.225	0.231	0.235	0.023	0.012	0.051
	80	0.162	0.115	0.176	0.151	0.061	0.032	0.212
500	0	0.692	0.731	0.714	0.712	0.039	0.020	0.027
	20	0.379	0.360	0.343	0.361	0.036	0.018	0.050
	40	0.281	0.264	0.257	0.267	0.024	0.012	0.046
	60	0.284	0.263	0.255	0.267	0.029	0.015	0.056
	80	0.169	0.142	0.175	0.162	0.033	0.018	0.109
1000	0	0.724	0.651	0.761	0.712	0.110	0.056	0.079
	20	0.538	0.513	0.495	0.515	0.043	0.022	0.042
	40	0.478	0.452	0.452	0.461	0.026	0.015	0.033
	60	0.439	0.423	0.421	0.428	0.018	0.010	0.023
	80	0.138	0.139	0.164	0.147	0.026	0.015	0.100
2000	0	0.767	0.712	0.636	0.705	0.131	0.066	0.093
	20	0.560	0.552	0.538	0.550	0.022	0.011	0.020
	40	0.501	0.503	0.487	0.497	0.016	0.009	0.018
	60	0.469	0.468	0.459	0.465	0.010	0.006	0.012
	80	0.135	0.167	0.173	0.158	0.038	0.020	0.129
4000	0	0.713	0.741	0.669	0.708	0.072	0.036	0.051
	20	0.630	0.595	0.602	0.609	0.035	0.019	0.030
	40	0.576	0.550	0.546	0.557	0.030	0.016	0.029
	60	0.542	0.513	0.508	0.521	0.034	0.018	0.035
	80	0.112	0.141	0.151	0.135	0.039	0.020	0.150
8000	0	0.647	0.666	0.659	0.657	0.019	0.010	0.015
	20	0.605	0.592	0.571	0.589	0.034	0.017	0.029
	40	0.568	0.549	0.539	0.552	0.029	0.015	0.027
	60	0.550	0.513	0.509	0.524	0.041	0.023	0.043
	80	0.102	0.133	0.160	0.132	0.058	0.029	0.220
16000	0	0.703	0.669	0.743	0.705	0.074	0.037	0.053
	20	0.572	0.556	0.552	0.560	0.020	0.011	0.019
	40	0.513	0.503	0.501	0.506	0.012	0.006	0.013
	60	0.497	0.485	0.470	0.484	0.027	0.014	0.028
	80	0.177	0.181	0.160	0.173	0.021	0.011	0.065
32000	0	0.726	0.604	0.653	0.661	0.122	0.061	0.093
	20	0.566	0.546	0.540	0.551	0.026	0.014	0.025
	40	0.523	0.504	0.502	0.510	0.021	0.012	0.023
	60	0.516	0.503	0.501	0.507	0.015	0.008	0.016
	80	0.163	0.070	0.142	0.125	0.093	0.049	0.390
64000	0	0.629	0.613	0.624	0.622	0.016	0.008	0.013
	20	0.566	0.549	0.553	0.556	0.017	0.009	0.016
	40	0.511	0.502	0.505	0.506	0.009	0.005	0.009
	60	0.501	0.488	0.490	0.493	0.013	0.007	0.014
	80	0.155	0.160	0.132	0.149	0.028	0.015	0.100
128000	0	0.557	0.544	0.528	0.543	0.029	0.015	0.027
	20	0.537	0.534	0.526	0.532	0.011	0.006	0.011
	40	0.495	0.492	0.487	0.491	0.008	0.004	0.008
	60	0.474	0.469	0.462	0.468	0.012	0.006	0.013
	80	0.097	0.122	0.075	0.098	0.047	0.024	0.240
Outliers								

DFT plots (slab 7)
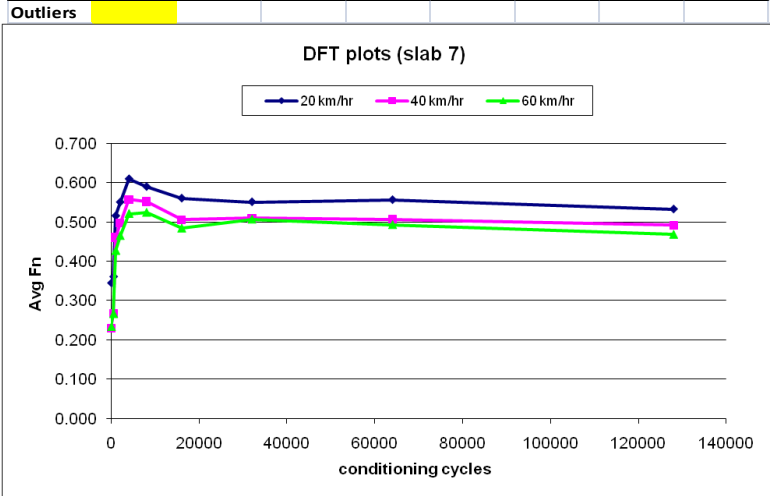
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	8	NEW	95#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.784	0.771	0.792	0.782	0.021	0.011	0.014
	20	0.414	0.443	0.438	0.432	0.029	0.016	0.036
	40	0.304	0.286	0.258	0.283	0.046	0.023	0.082
	60	0.303	0.269	0.254	0.275	0.049	0.025	0.091
	80	0.198	0.146	0.186	0.177	0.052	0.027	0.154
500	0	0.892	0.831	0.802	0.842	0.090	0.046	0.055
	20	0.460	0.404	0.391	0.418	0.069	0.037	0.088
	40	0.307	0.278	0.276	0.287	0.031	0.017	0.060
	60	0.305	0.284	0.280	0.290	0.025	0.013	0.046
	80	0.201	0.198	0.144	0.181	0.057	0.032	0.177
1000	0	0.820	0.821	0.752	0.798	0.069	0.040	0.050
	20	0.552	0.527	0.522	0.534	0.030	0.016	0.030
	40	0.452	0.446	0.447	0.448	0.006	0.003	0.007
	60	0.424	0.420	0.426	0.423	0.006	0.003	0.007
	80	0.164	0.172	0.141	0.159	0.031	0.016	0.101
2000	0	0.654	0.691	0.761	0.702	0.107	0.054	0.077
	20	0.437	0.478	0.523	0.479	0.086	0.043	0.090
	40	0.377	0.418	0.462	0.419	0.085	0.043	0.101
	60	0.345	0.393	0.423	0.387	0.078	0.039	0.102
	80	0.142	0.195	0.193	0.177	0.053	0.030	0.170
4000	0	0.788	0.786	0.758	0.777	0.030	0.017	0.022
	20	0.648	0.632	0.614	0.631	0.034	0.017	0.027
	40	0.587	0.576	0.556	0.573	0.031	0.016	0.027
	60	0.569	0.555	0.516	0.547	0.053	0.027	0.050
	80	0.188	0.153	0.164	0.168	0.035	0.018	0.106
8000	0	0.772	0.809	0.751	0.777	0.058	0.029	0.038
	20	0.688	0.666	0.636	0.663	0.052	0.026	0.039
	40	0.623	0.605	0.578	0.602	0.045	0.023	0.038
	60	0.591	0.584	0.538	0.571	0.053	0.029	0.050
	80	0.195	0.266	0.182	0.214	0.084	0.045	0.211
16000	0	0.753	0.729	0.766	0.749	0.037	0.019	0.025
	20	0.671	0.651	0.636	0.653	0.035	0.018	0.027
	40	0.603	0.592	0.580	0.592	0.023	0.012	0.019
	60	0.576	0.567	0.542	0.562	0.034	0.018	0.031
	80	0.153	0.123	0.117	0.131	0.036	0.019	0.147
32000	0	0.807	0.722	0.771	0.767	0.085	0.043	0.056
	20	0.578	0.590	0.590	0.586	0.012	0.007	0.012
	40	0.462	0.518	0.530	0.503	0.068	0.036	0.072
	60	0.417	0.499	0.509	0.475	0.092	0.050	0.106
	80	0.082	0.121	0.148	0.117	0.066	0.033	0.284
64000	0	0.641	0.623	0.678	0.647	0.055	0.028	0.043
	20	0.540	0.562	0.565	0.556	0.025	0.014	0.025
	40	0.476	0.510	0.515	0.500	0.039	0.021	0.042
	60	0.451	0.478	0.493	0.474	0.042	0.021	0.045
	80	0.131	0.156	0.194	0.160	0.063	0.032	0.198
128000	0	0.592	0.567	0.563	0.574	0.029	0.016	0.027
	20	0.561	0.559	0.552	0.557	0.009	0.005	0.008
	40	0.521	0.516	0.512	0.516	0.009	0.005	0.009
	60	0.494	0.487	0.484	0.488	0.010	0.005	0.011
	80	0.126	0.119	0.136	0.127	0.017	0.009	0.067
Outliers								

DFT plots (slab 8)

— 20 km/hr   — 40 km/hr   — 60 km/hr

Avg Fn

condotioning cycles

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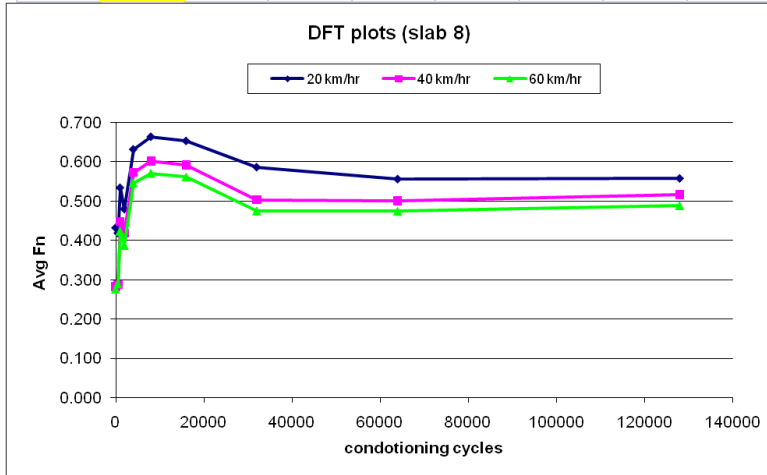
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	9	NEW	95#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.776	0.766	0.724	0.755	0.052	0.028	0.037
	20	0.351	0.287	0.285	0.308	0.066	0.038	0.122
	40	0.240	0.208	0.207	0.218	0.033	0.019	0.086
	60	0.245	0.229	0.229	0.234	0.016	0.009	0.039
	80	0.163	0.202	0.164	0.176	0.039	0.022	0.126
500	0	0.764	0.791	0.792	0.782	0.028	0.016	0.020
	20	0.381	0.381	0.368	0.377	0.013	0.008	0.020
	40	0.275	0.271	0.267	0.271	0.008	0.004	0.015
	60	0.265	0.273	0.265	0.268	0.008	0.005	0.017
	80	0.215	0.170	0.176	0.187	0.045	0.024	0.131
1000	0	0.801	0.694	0.733	0.743	0.107	0.054	0.073
	20	0.590	0.565	0.546	0.567	0.044	0.022	0.039
	40	0.538	0.513	0.500	0.517	0.038	0.019	0.037
	60	0.522	0.503	0.472	0.499	0.050	0.025	0.051
	80	0.165	0.153	0.170	0.163	0.017	0.009	0.054
2000	0	0.680	0.680	0.596	0.652	0.084	0.048	0.074
	20	0.602	0.587	0.572	0.587	0.030	0.015	0.026
	40	0.539	0.529	0.514	0.527	0.025	0.013	0.024
	60	0.508	0.511	0.494	0.504	0.017	0.009	0.018
	80	0.154	0.180	0.164	0.166	0.026	0.013	0.079
4000	0	0.781	0.638	0.643	0.687	0.143	0.081	0.118
	20	0.646	0.624	0.622	0.631	0.024	0.013	0.021
	40	0.592	0.569	0.558	0.573	0.034	0.017	0.030
	60	0.569	0.525	0.522	0.539	0.047	0.026	0.049
	80	0.105	0.178	0.178	0.154	0.073	0.042	0.274
8000	0	0.752	0.757	0.659	0.723	0.098	0.055	0.076
	20	0.657	0.623	0.614	0.631	0.043	0.023	0.036
	40	0.599	0.578	0.562	0.580	0.037	0.019	0.032
	60	0.576	0.559	0.524	0.553	0.052	0.027	0.048
	80	0.114	0.103	0.109	0.109	0.011	0.006	0.051
16000	0	0.710	0.702	0.726	0.713	0.024	0.012	0.017
	20	0.619	0.605	0.595	0.606	0.024	0.012	0.020
	40	0.573	0.551	0.550	0.558	0.023	0.013	0.023
	60	0.547	0.517	0.517	0.527	0.030	0.017	0.033
	80	0.170	0.137	0.156	0.154	0.033	0.017	0.107
32000	0	0.713	0.619	0.612	0.648	0.101	0.056	0.087
	20	0.575	0.560	0.555	0.563	0.020	0.010	0.018
	40	0.536	0.519	0.521	0.525	0.017	0.009	0.018
	60	0.520	0.508	0.511	0.513	0.012	0.006	0.012
	80	0.071	0.223	0.127	0.140	0.152	0.077	0.548
64000	0	0.715	0.633	0.701	0.683	0.082	0.044	0.064
	20	0.635	0.615	0.604	0.618	0.031	0.016	0.025
	40	0.599	0.582	0.564	0.582	0.035	0.018	0.030
	60	0.560	0.541	0.528	0.543	0.032	0.016	0.030
	80	0.118	0.131	0.141	0.130	0.023	0.012	0.089
128000	0	0.503	0.539	0.559	0.534	0.056	0.028	0.053
	20	0.488	0.521	0.527	0.512	0.039	0.021	0.041
	40	0.444	0.474	0.489	0.469	0.045	0.023	0.049
	60	0.399	0.438	0.454	0.430	0.055	0.028	0.066
	80	0.107	0.105	0.125	0.112	0.020	0.011	0.098

Outliers

DFT plots (slab 9)

— 20 km/hr   — 40 km/hr   — 60 km/hr
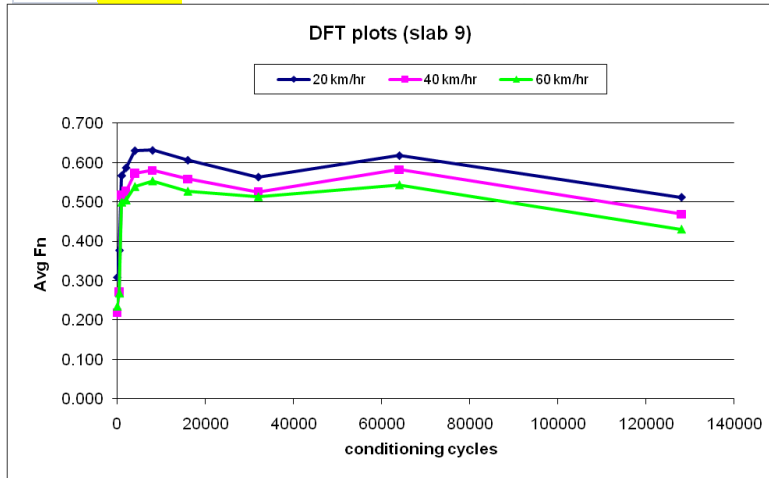
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	10	NEW	95#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.706	0.871	0.836	0.804	0.165	0.087	0.108
	20	0.357	0.306	0.313	0.325	0.051	0.028	0.085
	40	0.252	0.232	0.232	0.239	0.020	0.012	0.048
	60	0.260	0.241	0.239	0.247	0.021	0.012	0.047
	80	0.147	0.133	0.116	0.132	0.031	0.016	0.118
500	0	0.851	0.809	0.805	0.822	0.046	0.025	0.031
	20	0.470	0.441	0.428	0.446	0.042	0.022	0.048
	40	0.346	0.343	0.343	0.344	0.003	0.002	0.005
	60	0.333	0.333	0.331	0.332	0.002	0.001	0.003
	80	0.166	0.165	0.182	0.171	0.017	0.010	0.056
1000	0	0.777	0.742	0.727	0.749	0.050	0.026	0.034
	20	0.613	0.598	0.586	0.599	0.027	0.014	0.023
	40	0.553	0.540	0.527	0.540	0.026	0.013	0.024
	60	0.530	0.517	0.510	0.519	0.020	0.010	0.020
	80	0.201	0.190	0.114	0.168	0.087	0.047	0.281
2000	0	0.752	0.716	0.746	0.738	0.036	0.019	0.026
	20	0.633	0.608	0.594	0.612	0.039	0.020	0.032
	40	0.568	0.556	0.528	0.551	0.040	0.021	0.037
	60	0.543	0.515	0.506	0.521	0.037	0.019	0.037
	80	0.135	0.174	0.135	0.148	0.039	0.023	0.152
4000	0	0.777	0.756	0.717	0.750	0.060	0.030	0.041
	20	0.650	0.630	0.612	0.631	0.038	0.019	0.030
	40	0.589	0.571	0.559	0.573	0.030	0.015	0.026
	60	0.567	0.537	0.521	0.542	0.046	0.023	0.043
	80	0.183	0.142	0.141	0.155	0.042	0.024	0.154
8000	0	0.737	0.709	0.717	0.721	0.028	0.014	0.020
	20	0.647	0.628	0.611	0.629	0.036	0.018	0.029
	40	0.593	0.583	0.567	0.581	0.026	0.013	0.023
	60	0.577	0.567	0.560	0.568	0.017	0.009	0.015
	80	0.049	0.136	0.120	0.102	0.087	0.046	0.455
16000	0	0.693	0.663	0.678	0.678	0.030	0.015	0.022
	20	0.608	0.595	0.585	0.596	0.023	0.012	0.019
	40	0.566	0.551	0.537	0.551	0.029	0.015	0.026
	60	0.553	0.519	0.520	0.531	0.034	0.019	0.036
	80	0.114	0.102	0.115	0.110	0.013	0.007	0.066
32000	0	0.677	0.689	0.673	0.680	0.016	0.008	0.012
	20	0.607	0.590	0.585	0.594	0.022	0.012	0.019
	40	0.558	0.536	0.531	0.542	0.027	0.014	0.027
	60	0.535	0.516	0.516	0.522	0.019	0.011	0.021
	80	0.153	0.144	0.143	0.147	0.010	0.006	0.038
64000	0	0.689	0.659	0.659	0.669	0.030	0.017	0.026
	20	0.626	0.608	0.597	0.610	0.029	0.015	0.024
	40	0.583	0.567	0.548	0.566	0.035	0.018	0.031
	60	0.543	0.532	0.519	0.531	0.024	0.012	0.023
	80	0.107	0.085	0.086	0.093	0.022	0.012	0.134
128000	0	0.597	0.570	0.543	0.570	0.054	0.027	0.047
	20	0.532	0.532	0.527	0.530	0.005	0.003	0.005
	40	0.486	0.491	0.487	0.488	0.005	0.003	0.005
	60	0.466	0.464	0.461	0.464	0.005	0.003	0.005
	80	0.138	0.101	0.126	0.122	0.037	0.019	0.155
Outliers								

DFT plots (slab 10)

105
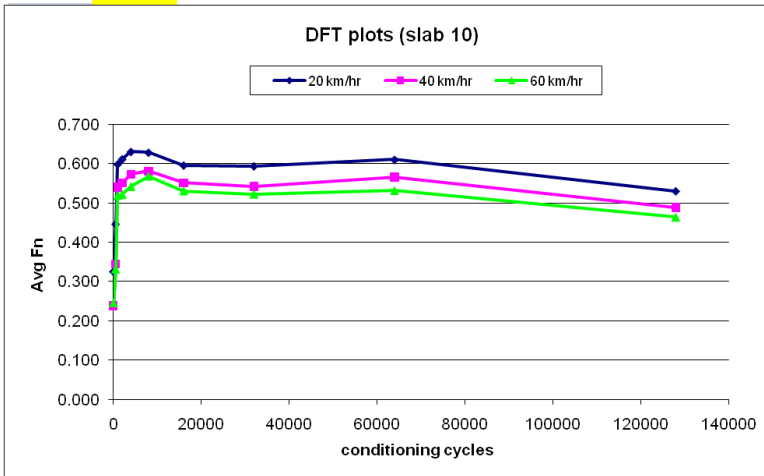
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	11	NEW	95#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.734	0.782	0.784	0.767	0.050	0.028	0.037
	20	0.325	0.282	0.295	0.301	0.043	0.022	0.073
	40	0.239	0.217	0.227	0.228	0.022	0.011	0.048
	60	0.249	0.232	0.239	0.240	0.017	0.009	0.036
	80	0.171	0.133	0.162	0.155	0.038	0.020	0.128
500	0	0.673	0.636	0.652	0.654	0.037	0.019	0.028
	20	0.440	0.415	0.400	0.418	0.040	0.020	0.048
	40	0.343	0.339	0.336	0.339	0.007	0.004	0.010
	60	0.345	0.332	0.328	0.335	0.017	0.009	0.027
	80	0.177	0.143	0.129	0.150	0.048	0.025	0.165
1000	0	0.739	0.659	0.711	0.703	0.080	0.041	0.058
	20	0.529	0.509	0.495	0.511	0.034	0.017	0.033
	40	0.484	0.457	0.446	0.462	0.038	0.020	0.042
	60	0.471	0.445	0.428	0.448	0.043	0.022	0.048
	80	0.158	0.143	0.137	0.146	0.021	0.011	0.074
2000	0	0.691	0.753	0.712	0.719	0.062	0.032	0.044
	20	0.554	0.538	0.527	0.540	0.027	0.014	0.025
	40	0.505	0.493	0.477	0.492	0.028	0.014	0.029
	60	0.499	0.466	0.458	0.474	0.041	0.022	0.046
	80	0.064	0.119	0.142	0.108	0.078	0.040	0.370
4000	0	0.692	0.654	0.702	0.683	0.048	0.025	0.037
	20	0.573	0.575	0.565	0.571	0.010	0.005	0.009
	40	0.510	0.512	0.509	0.510	0.003	0.002	0.003
	60	0.468	0.486	0.473	0.476	0.018	0.009	0.020
	80	0.092	0.165	0.160	0.139	0.073	0.041	0.293
8000	0	0.759	0.682	0.678	0.706	0.081	0.046	0.065
	20	0.623	0.591	0.579	0.598	0.044	0.023	0.038
	40	0.567	0.539	0.524	0.543	0.043	0.022	0.040
	60	0.526	0.508	0.503	0.512	0.023	0.012	0.024
	80	0.070	0.158	0.221	0.150	0.151	0.076	0.507
16000	0	0.737	0.716	0.678	0.710	0.059	0.030	0.042
	20	0.612	0.601	0.585	0.599	0.027	0.014	0.023
	40	0.555	0.546	0.530	0.544	0.025	0.013	0.023
	60	0.520	0.509	0.505	0.511	0.015	0.008	0.015
	80	0.143	0.112	0.125	0.127	0.031	0.016	0.123
32000	0	0.669	0.657	0.654	0.660	0.015	0.008	0.012
	20	0.594	0.575	0.567	0.579	0.027	0.014	0.024
	40	0.557	0.532	0.525	0.538	0.032	0.017	0.031
	60	0.521	0.511	0.513	0.515	0.010	0.005	0.010
	80	0.099	0.094	0.102	0.098	0.008	0.004	0.041
64000	0	0.658	0.726	0.666	0.683	0.068	0.037	0.054
	20	0.573	0.563	0.551	0.562	0.022	0.011	0.020
	40	0.528	0.520	0.516	0.521	0.012	0.006	0.012
	60	0.510	0.500	0.483	0.498	0.027	0.014	0.027
	80	0.127	0.149	0.156	0.144	0.029	0.015	0.105
128000	0	0.592	0.577	0.548	0.572	0.044	0.022	0.039
	20	0.547	0.537	0.532	0.539	0.015	0.008	0.014
	40	0.505	0.503	0.500	0.503	0.005	0.003	0.005
	60	0.475	0.475	0.465	0.472	0.010	0.006	0.012
	80	0.098	0.034	0.070	0.067	0.064	0.032	0.476

Outliers

DFT plots (slab 11)
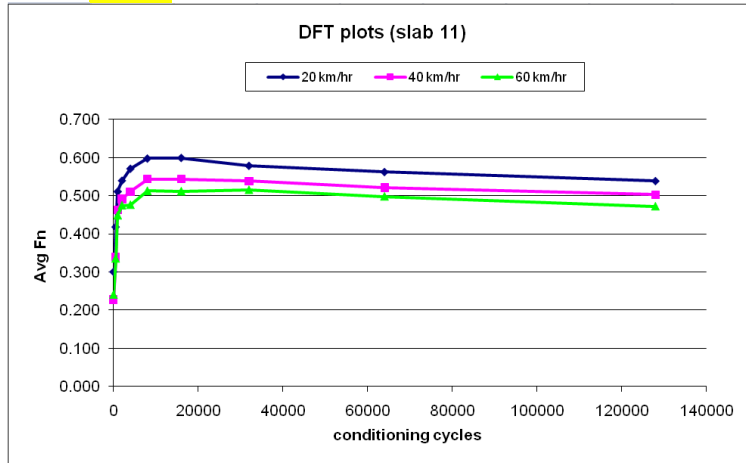
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	12	NEW	95#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.803	0.772	0.817	0.797	0.045	0.023	0.029
	20	0.329	0.290	0.286	0.302	0.043	0.024	0.079
	40	0.247	0.223	0.223	0.231	0.024	0.014	0.060
	60	0.255	0.239	0.238	0.244	0.017	0.010	0.039
	80	0.244	0.162	0.188	0.198	0.082	0.042	0.212
500	0	0.834	0.822	0.803	0.820	0.031	0.016	0.019
	20	0.444	0.401	0.397	0.414	0.047	0.026	0.063
	40	0.300	0.277	0.285	0.287	0.023	0.012	0.041
	60	0.291	0.264	0.269	0.275	0.027	0.014	0.052
	80	0.198	0.163	0.165	0.175	0.035	0.020	0.112
1000	0	0.682	0.718	0.761	0.720	0.079	0.040	0.055
	20	0.515	0.500	0.481	0.499	0.034	0.017	0.034
	40	0.447	0.436	0.420	0.434	0.027	0.014	0.031
	60	0.425	0.407	0.398	0.410	0.027	0.014	0.034
	80	0.105	0.167	0.159	0.144	0.062	0.034	0.235
2000	0	0.767	0.732	0.683	0.727	0.084	0.042	0.058
	20	0.546	0.532	0.515	0.531	0.031	0.016	0.029
	40	0.486	0.471	0.447	0.468	0.039	0.020	0.042
	60	0.464	0.447	0.425	0.445	0.039	0.020	0.044
	80	0.129	0.073	0.135	0.112	0.062	0.034	0.304
4000	0	0.692	0.712	0.686	0.697	0.026	0.014	0.020
	20	0.554	0.538	0.513	0.535	0.041	0.021	0.039
	40	0.500	0.470	0.452	0.474	0.048	0.024	0.051
	60	0.468	0.432	0.424	0.441	0.044	0.023	0.053
	80	0.141	0.145	0.136	0.141	0.009	0.005	0.032
8000	0	0.732	0.756	0.688	0.725	0.068	0.034	0.048
	20	0.584	0.582	0.566	0.577	0.018	0.010	0.017
	40	0.539	0.517	0.509	0.522	0.030	0.016	0.030
	60	0.512	0.505	0.497	0.505	0.015	0.008	0.015
	80	0.112	0.115	0.122	0.116	0.010	0.005	0.044
16000	0	0.694	0.696	0.684	0.691	0.012	0.006	0.009
	20	0.597	0.579	0.568	0.581	0.029	0.015	0.025
	40	0.524	0.511	0.508	0.514	0.016	0.009	0.017
	60	0.510	0.489	0.475	0.491	0.035	0.018	0.036
	80	0.157	0.126	0.182	0.155	0.056	0.028	0.181
32000	0	0.721	0.669	0.623	0.671	0.098	0.049	0.073
	20	0.599	0.582	0.568	0.583	0.031	0.016	0.027
	40	0.551	0.532	0.517	0.533	0.034	0.017	0.032
	60	0.529	0.512	0.506	0.516	0.023	0.012	0.023
	80	0.107	0.155	0.173	0.145	0.066	0.034	0.235
64000	0	0.607	0.611	0.608	0.609	0.004	0.002	0.003
	20	0.564	0.549	0.535	0.549	0.029	0.015	0.026
	40	0.512	0.502	0.489	0.501	0.023	0.012	0.023
	60	0.485	0.478	0.471	0.478	0.014	0.007	0.015
	80	0.100	0.157	0.139	0.132	0.057	0.029	0.221
128000	0	0.612	0.628	0.543	0.594	0.085	0.045	0.076
	20	0.532	0.518	0.516	0.522	0.016	0.009	0.017
	40	0.491	0.478	0.478	0.482	0.013	0.008	0.016
	60	0.465	0.454	0.450	0.456	0.015	0.008	0.017
	80	0.103	0.079	0.083	0.088	0.024	0.013	0.146

Outliers

DFT plots (slab 12)

107
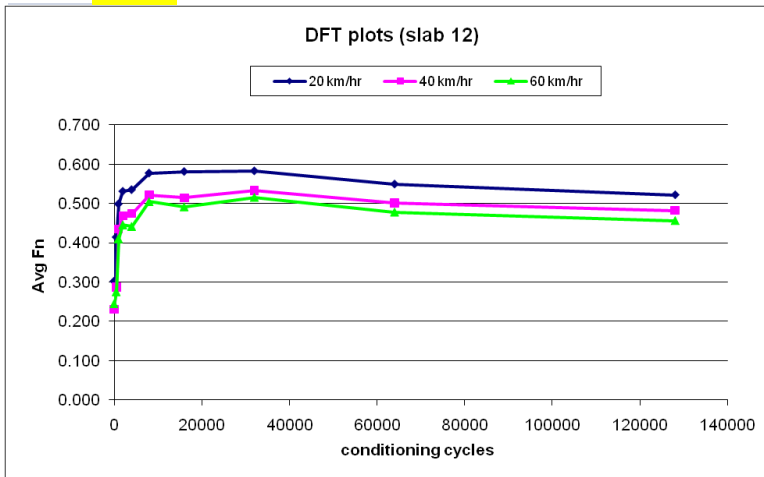
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	13	OLD	122#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.688	0.712	0.791	0.730	0.103	0.054	0.074
	20	0.466	0.372	0.366	0.401	0.100	0.056	0.140
	40	0.304	0.257	0.258	0.273	0.047	0.027	0.098
	60	0.307	0.257	0.264	0.276	0.050	0.027	0.098
	80	0.215	0.226	0.152	0.198	0.074	0.040	0.202
500	0	0.703	0.791	0.749	0.748	0.088	0.044	0.059
	20	0.542	0.512	0.491	0.515	0.051	0.026	0.050
	40	0.490	0.457	0.432	0.460	0.058	0.029	0.063
	60	0.480	0.435	0.422	0.446	0.058	0.030	0.068
	80	0.144	0.094	0.138	0.125	0.050	0.027	0.218
1000	0	0.646	0.694	0.607	0.649	0.087	0.044	0.067
	20	0.591	0.581	0.553	0.575	0.038	0.020	0.034
	40	0.529	0.524	0.507	0.520	0.022	0.012	0.022
	60	0.515	0.506	0.480	0.500	0.035	0.018	0.036
	80	0.136	0.218	0.158	0.171	0.082	0.042	0.249
2000	0	0.816	0.746	0.781	0.781	0.070	0.035	0.045
	20	0.566	0.551	0.544	0.554	0.022	0.011	0.020
	40	0.515	0.507	0.504	0.509	0.011	0.006	0.011
	60	0.496	0.473	0.468	0.479	0.028	0.015	0.031
	80	0.182	0.148	0.159	0.163	0.034	0.017	0.106
4000	0	0.734	0.757	0.723	0.738	0.034	0.017	0.024
	20	0.646	0.633	0.606	0.628	0.040	0.020	0.032
	40	0.594	0.576	0.560	0.577	0.034	0.017	0.029
	60	0.570	0.538	0.519	0.542	0.051	0.026	0.048
	80	0.148	0.172	0.185	0.168	0.037	0.019	0.112
8000	0	0.726	0.736	0.755	0.739	0.029	0.015	0.020
	20	0.705	0.691	0.677	0.691	0.028	0.014	0.020
	40	0.658	0.635	0.616	0.636	0.042	0.021	0.033
	60	0.617	0.589	0.577	0.594	0.040	0.021	0.035
	80	0.103	0.091	0.111	0.102	0.020	0.010	0.099
16000	0	0.757	0.786	0.752	0.765	0.034	0.018	0.024
	20	0.697	0.673	0.663	0.678	0.034	0.017	0.026
	40	0.651	0.639	0.618	0.636	0.033	0.017	0.026
	60	0.620	0.593	0.576	0.596	0.044	0.022	0.037
	80	0.078	0.081	0.107	0.089	0.029	0.016	0.180
32000	0	0.647	0.628	0.646	0.640	0.019	0.011	0.017
	20	0.619	0.608	0.587	0.605	0.032	0.016	0.027
	40	0.569	0.559	0.544	0.557	0.025	0.013	0.023
	60	0.535	0.526	0.508	0.523	0.027	0.014	0.026
	80	0.037	0.090	0.105	0.077	0.068	0.036	0.462
64000	0	0.654	0.659	0.647	0.653	0.012	0.006	0.009
	20	0.617	0.602	0.596	0.605	0.021	0.011	0.018
	40	0.570	0.565	0.557	0.564	0.013	0.007	0.012
	60	0.535	0.529	0.524	0.529	0.011	0.006	0.010
	80	0.098	0.094	0.154	0.115	0.060	0.034	0.291
128000	0	0.696	0.611	0.653	0.653	0.085	0.043	0.065
	20	0.621	0.611	0.608	0.613	0.013	0.007	0.011
	40	0.569	0.561	0.562	0.564	0.008	0.004	0.008
	60	0.537	0.532	0.532	0.534	0.005	0.003	0.005
	80	0.072	0.103	0.122	0.099	0.050	0.025	0.255
Outliers								

DFT plots (slab 13)

108
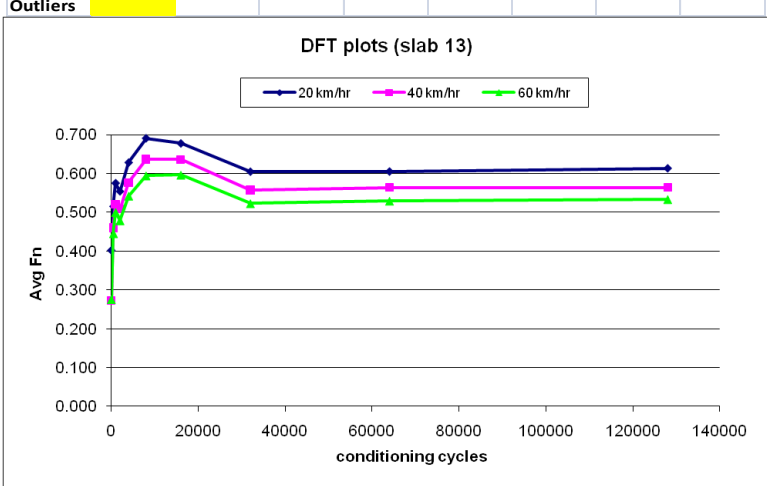
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	14	OLD	122#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.652	0.651	0.772	0.692	0.121	0.070	0.101
	20	0.316	0.324	0.346	0.329	0.030	0.016	0.047
	40	0.274	0.258	0.259	0.264	0.016	0.009	0.034
	60	0.299	0.275	0.266	0.280	0.033	0.017	0.061
	80	0.173	0.159	0.087	0.140	0.086	0.046	0.330
500	0	0.838	0.748	0.737	0.774	0.101	0.055	0.072
	20	0.519	0.500	0.499	0.506	0.020	0.011	0.022
	40	0.470	0.443	0.441	0.451	0.029	0.016	0.036
	60	0.474	0.432	0.438	0.448	0.042	0.023	0.051
	80	0.080	0.171	0.149	0.133	0.091	0.047	0.356
1000	0	0.752	0.723	0.729	0.735	0.029	0.015	0.021
	20	0.575	0.567	0.536	0.559	0.039	0.021	0.037
	40	0.527	0.519	0.505	0.517	0.022	0.011	0.022
	60	0.523	0.510	0.491	0.508	0.032	0.016	0.032
	80	0.111	0.136	0.102	0.116	0.034	0.018	0.151
2000	0	0.743	0.721	0.697	0.720	0.046	0.023	0.032
	20	0.592	0.571	0.556	0.573	0.036	0.018	0.032
	40	0.528	0.515	0.503	0.515	0.025	0.013	0.024
	60	0.513	0.508	0.495	0.505	0.018	0.009	0.018
	80	0.101	0.148	0.131	0.127	0.047	0.024	0.188
4000	0	0.746	0.714	0.683	0.714	0.063	0.032	0.044
	20	0.603	0.579	0.572	0.585	0.031	0.016	0.028
	40	0.556	0.532	0.520	0.536	0.036	0.018	0.034
	60	0.539	0.518	0.508	0.522	0.031	0.016	0.030
	80	0.117	0.137	0.148	0.134	0.031	0.016	0.117
8000	0	0.759	0.723	0.692	0.725	0.067	0.034	0.046
	20	0.661	0.642	0.622	0.642	0.039	0.020	0.030
	40	0.616	0.594	0.569	0.593	0.047	0.024	0.040
	60	0.579	0.560	0.551	0.563	0.028	0.014	0.025
	80	0.126	0.076	0.094	0.099	0.050	0.025	0.257
16000	0	0.691	0.731	0.691	0.704	0.040	0.023	0.033
	20	0.637	0.638	0.623	0.633	0.015	0.008	0.013
	40	0.600	0.594	0.584	0.593	0.016	0.008	0.014
	60	0.585	0.559	0.549	0.564	0.036	0.019	0.033
	80	0.056	0.062	0.072	0.063	0.016	0.008	0.128
32000	0	0.731	0.732	0.721	0.728	0.011	0.006	0.008
	20	0.647	0.628	0.630	0.635	0.019	0.010	0.016
	40	0.586	0.567	0.565	0.573	0.021	0.012	0.020
	60	0.553	0.531	0.536	0.540	0.022	0.012	0.021
	80	0.088	0.183	0.117	0.129	0.095	0.049	0.376
64000	0	0.701	0.672	0.668	0.680	0.033	0.018	0.026
	20	0.622	0.616	0.611	0.616	0.011	0.006	0.009
	40	0.585	0.573	0.565	0.574	0.020	0.010	0.018
	60	0.552	0.540	0.535	0.542	0.017	0.009	0.016
	80	0.106	0.095	0.112	0.104	0.017	0.009	0.083
128000	0	0.638	0.633	0.603	0.625	0.035	0.019	0.030
	20	0.602	0.580	0.573	0.585	0.029	0.015	0.026
	40	0.549	0.530	0.533	0.537	0.019	0.010	0.019
	60	0.525	0.503	0.502	0.510	0.023	0.013	0.025
	80	0.125	0.124	0.053	0.101	0.072	0.041	0.410

Outliers

DFT plots (slab 14)

20 km/hr   40 km/hr   60 km/hr
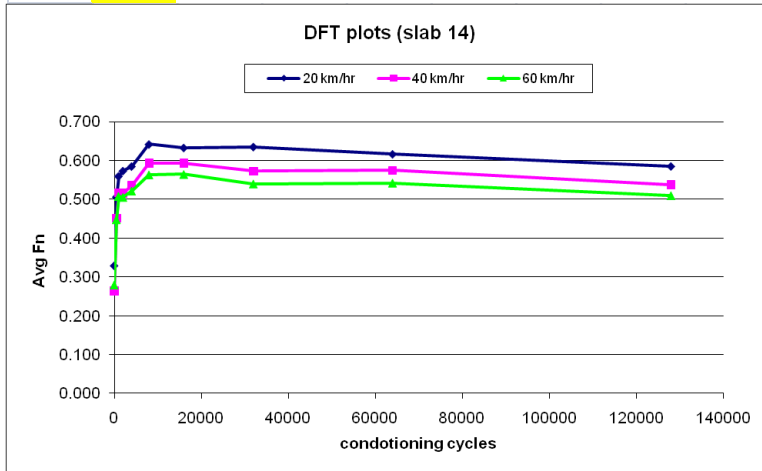
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	15	OLD	122#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.809	0.778	0.871	0.819	0.093	0.047	0.058
	20	0.358	0.373	0.367	0.366	0.015	0.008	0.021
	40	0.259	0.259	0.265	0.261	0.006	0.003	0.013
	60	0.261	0.261	0.268	0.263	0.007	0.004	0.015
	80	0.147	0.125	0.154	0.142	0.029	0.015	0.107
500	0	0.472	0.531	0.415	0.473	0.116	0.058	0.123
	20	0.324	0.294	0.288	0.302	0.036	0.019	0.064
	40	0.290	0.270	0.269	0.276	0.021	0.012	0.043
	60	0.284	0.261	0.262	0.269	0.023	0.013	0.048
	80	0.123	0.069	0.016	0.069	0.107	0.054	0.772
1000	0	0.802	0.741	0.781	0.775	0.061	0.031	0.040
	20	0.591	0.564	0.546	0.567	0.045	0.023	0.040
	40	0.526	0.513	0.493	0.511	0.033	0.017	0.033
	60	0.522	0.502	0.478	0.501	0.044	0.022	0.044
	80	0.161	0.169	0.175	0.168	0.014	0.007	0.042
2000	0	0.731	0.724	0.731	0.729	0.007	0.004	0.006
	20	0.593	0.588	0.575	0.585	0.018	0.009	0.016
	40	0.531	0.530	0.520	0.527	0.011	0.006	0.012
	60	0.509	0.518	0.505	0.511	0.013	0.007	0.013
	80	0.168	0.139	0.148	0.152	0.029	0.015	0.098
4000	0	0.781	0.619	0.781	0.727	0.162	0.094	0.129
	20	0.607	0.598	0.580	0.595	0.027	0.014	0.023
	40	0.564	0.538	0.523	0.542	0.041	0.021	0.038
	60	0.530	0.520	0.514	0.521	0.016	0.008	0.016
	80	0.174	0.124	0.106	0.135	0.068	0.035	0.262
8000	0	0.755	0.775	0.731	0.754	0.044	0.022	0.029
	20	0.630	0.622	0.614	0.622	0.016	0.008	0.013
	40	0.582	0.575	0.561	0.573	0.021	0.011	0.019
	60	0.538	0.530	0.517	0.528	0.021	0.011	0.020
	80	0.105	0.060	0.099	0.088	0.045	0.024	0.278
16000	0	0.692	0.736	0.613	0.680	0.123	0.062	0.092
	20	0.658	0.644	0.623	0.642	0.035	0.018	0.027
	40	0.615	0.607	0.582	0.601	0.033	0.017	0.029
	60	0.573	0.555	0.545	0.558	0.028	0.014	0.025
	80	0.066	0.064	0.076	0.069	0.012	0.006	0.094
32000	0	0.703	0.673	0.707	0.694	0.034	0.019	0.027
	20	0.586	0.631	0.614	0.610	0.045	0.023	0.037
	40	0.522	0.558	0.563	0.548	0.041	0.022	0.041
	60	0.455	0.511	0.520	0.495	0.065	0.035	0.071
	80	0.097	0.116	0.118	0.110	0.021	0.012	0.105
64000	0	0.731	0.712	0.642	0.695	0.089	0.047	0.067
	20	0.632	0.613	0.612	0.619	0.020	0.011	0.018
	40	0.586	0.580	0.574	0.580	0.012	0.006	0.010
	60	0.560	0.545	0.543	0.549	0.017	0.009	0.017
	80	0.130	0.111	0.085	0.109	0.045	0.023	0.208
128000	0	0.661	0.587	0.641	0.630	0.074	0.038	0.061
	20	0.583	0.571	0.582	0.579	0.012	0.007	0.012
	40	0.550	0.524	0.539	0.538	0.026	0.013	0.024
	60	0.517	0.500	0.507	0.508	0.017	0.009	0.017
	80	0.080	0.098	0.095	0.091	0.018	0.010	0.106
Outliers								

DFT plots (slab 15)

110
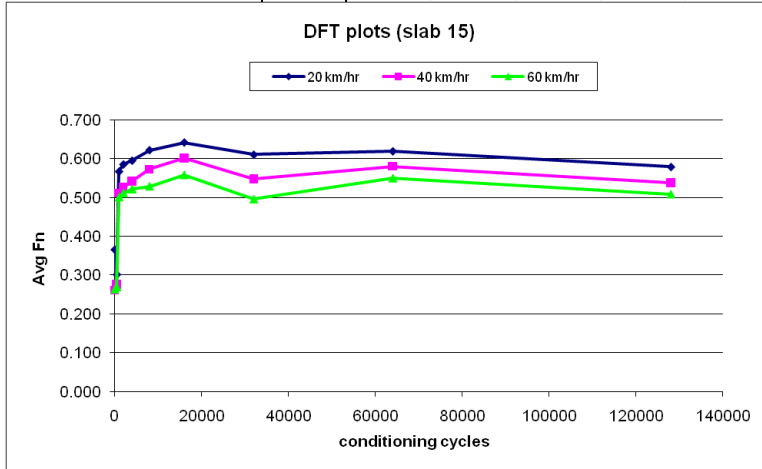
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	16	OLD	122#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.708	0.758	0.683	0.716	0.075	0.038	0.053
	20	0.293	0.253	0.249	0.265	0.044	0.024	0.092
	40	0.222	0.206	0.202	0.210	0.020	0.011	0.050
	60	0.229	0.221	0.211	0.220	0.018	0.009	0.041
	80	0.157	0.159	0.166	0.161	0.009	0.005	0.029
500	0	0.735	0.682	0.749	0.722	0.067	0.035	0.049
	20	0.451	0.434	0.429	0.438	0.022	0.012	0.026
	40	0.417	0.399	0.381	0.399	0.036	0.018	0.045
	60	0.403	0.361	0.360	0.375	0.043	0.025	0.066
	80	0.066	0.119	0.161	0.115	0.095	0.048	0.413
1000	0	0.669	0.703	0.601	0.658	0.102	0.052	0.079
	20	0.421	0.456	0.469	0.449	0.048	0.025	0.055
	40	0.357	0.404	0.415	0.392	0.058	0.031	0.079
	60	0.344	0.357	0.395	0.365	0.051	0.027	0.073
	80	0.157	0.187	0.097	0.147	0.090	0.046	0.312
2000	0	0.713	0.694	0.711	0.706	0.019	0.010	0.015
	20	0.527	0.517	0.502	0.515	0.025	0.013	0.024
	40	0.464	0.452	0.440	0.452	0.024	0.012	0.027
	60	0.432	0.424	0.417	0.424	0.015	0.008	0.018
	80	0.166	0.134	0.155	0.152	0.032	0.016	0.107
4000	0	0.694	0.671	0.730	0.698	0.059	0.030	0.043
	20	0.549	0.548	0.530	0.542	0.019	0.011	0.020
	40	0.494	0.490	0.472	0.485	0.022	0.012	0.024
	60	0.459	0.456	0.429	0.448	0.030	0.017	0.037
	80	0.115	0.153	0.142	0.137	0.038	0.020	0.143
8000	0	0.795	0.757	0.749	0.767	0.046	0.025	0.032
	20	0.654	0.643	0.625	0.641	0.029	0.015	0.023
	40	0.588	0.568	0.555	0.570	0.033	0.017	0.029
	60	0.537	0.516	0.508	0.520	0.029	0.015	0.029
	80	0.112	0.146	0.145	0.134	0.034	0.019	0.144
16000	0	0.757	0.748	0.733	0.746	0.024	0.012	0.016
	20	0.650	0.642	0.616	0.636	0.034	0.018	0.028
	40	0.611	0.594	0.575	0.593	0.036	0.018	0.030
	60	0.562	0.555	0.540	0.552	0.022	0.011	0.020
	80	0.118	0.088	0.098	0.101	0.030	0.015	0.151
32000	0	0.677	0.677	0.648	0.667	0.029	0.017	0.025
	20	0.618	0.611	0.604	0.611	0.014	0.007	0.011
	40	0.561	0.558	0.549	0.556	0.012	0.006	0.011
	60	0.536	0.524	0.502	0.521	0.034	0.017	0.033
	80	0.111	0.096	0.067	0.091	0.044	0.022	0.245
64000	0	0.551	0.598	0.651	0.600	0.100	0.050	0.083
	20	0.492	0.509	0.504	0.502	0.017	0.009	0.017
	40	0.460	0.474	0.472	0.469	0.014	0.008	0.016
	60	0.437	0.454	0.451	0.447	0.017	0.009	0.020
	80	0.121	0.073	0.057	0.084	0.064	0.033	0.398
128000	0	0.554	0.576	0.568	0.566	0.022	0.011	0.020
	20	0.548	0.547	0.545	0.547	0.003	0.002	0.003
	40	0.507	0.503	0.508	0.506	0.005	0.003	0.005
	60	0.479	0.478	0.476	0.478	0.003	0.002	0.003
	80	0.100	0.149	0.098	0.116	0.051	0.029	0.250

Outliers

DFT plots (slab 16)

111
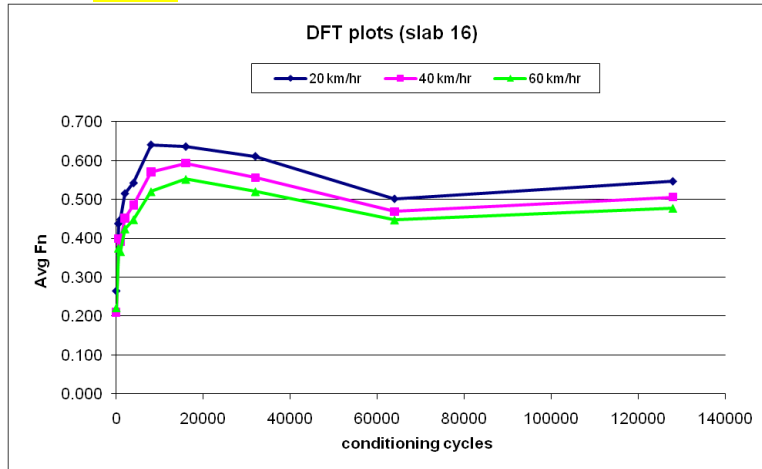
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	17	OLD	122#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.746	0.829	0.852	0.809	0.106	0.056	0.069
	20	0.429	0.660	0.414	0.501	0.246	0.138	0.275
	40	0.295	0.441	0.306	0.347	0.146	0.081	0.234
	60	0.296	0.290	0.306	0.297	0.016	0.008	0.027
	80	0.185	0.163	0.178	0.175	0.022	0.011	0.064
500	0	0.660	0.493	0.538	0.564	0.167	0.086	0.153
	20	0.441	0.422	0.401	0.421	0.040	0.020	0.047
	40	0.408	0.389	0.380	0.392	0.028	0.014	0.036
	60	0.394	0.370	0.357	0.374	0.037	0.019	0.050
	80	0.108	0.064	0.138	0.103	0.074	0.037	0.360
1000	0	0.758	0.667	0.673	0.699	0.091	0.051	0.073
	20	0.574	0.561	0.553	0.563	0.021	0.011	0.019
	40	0.514	0.506	0.496	0.505	0.018	0.009	0.018
	60	0.501	0.477	0.472	0.483	0.029	0.016	0.032
	80	0.082	0.109	0.093	0.095	0.027	0.014	0.143
2000	0	0.754	0.673	0.687	0.705	0.081	0.043	0.061
	20	0.604	0.581	0.577	0.587	0.027	0.015	0.025
	40	0.546	0.525	0.517	0.529	0.029	0.015	0.028
	60	0.526	0.509	0.505	0.513	0.021	0.011	0.022
	80	0.171	0.168	0.127	0.155	0.044	0.025	0.158
4000	0	0.756	0.713	0.701	0.723	0.055	0.029	0.040
	20	0.635	0.614	0.600	0.616	0.035	0.018	0.029
	40	0.582	0.561	0.551	0.565	0.031	0.016	0.028
	60	0.564	0.525	0.516	0.535	0.048	0.026	0.048
	80	0.154	0.140	0.148	0.147	0.014	0.007	0.048
8000	0	0.744	0.712	0.712	0.723	0.032	0.018	0.026
	20	0.684	0.676	0.652	0.671	0.032	0.017	0.025
	40	0.625	0.606	0.602	0.611	0.023	0.012	0.020
	60	0.565	0.560	0.554	0.560	0.011	0.006	0.010
	80	0.154	0.102	0.111	0.122	0.052	0.028	0.227
16000	0	0.696	0.653	0.652	0.667	0.044	0.025	0.038
	20	0.657	0.648	0.640	0.648	0.017	0.009	0.013
	40	0.612	0.610	0.597	0.606	0.015	0.008	0.013
	60	0.584	0.571	0.558	0.571	0.026	0.013	0.023
	80	0.071	0.123	0.089	0.094	0.052	0.026	0.280
32000	0	0.715	0.647	0.584	0.649	0.131	0.066	0.101
	20	0.617	0.586	0.590	0.598	0.031	0.017	0.028
	40	0.563	0.534	0.541	0.546	0.029	0.015	0.028
	60	0.529	0.505	0.508	0.514	0.024	0.013	0.025
	80	0.108	0.114	0.095	0.106	0.019	0.010	0.092
64000	0	0.622	0.613	0.601	0.612	0.021	0.011	0.017
	20	0.580	0.576	0.560	0.572	0.020	0.011	0.019
	40	0.557	0.551	0.538	0.549	0.019	0.010	0.018
	60	0.539	0.529	0.518	0.529	0.021	0.011	0.020
	80	0.095	0.122	0.130	0.116	0.035	0.018	0.159
128000	0	0.577	0.583	0.549	0.570	0.034	0.018	0.032
	20	0.571	0.560	0.554	0.562	0.017	0.009	0.015
	40	0.534	0.532	0.526	0.531	0.008	0.004	0.008
	60	0.515	0.513	0.508	0.512	0.007	0.004	0.007
	80	0.103	0.115	0.067	0.095	0.048	0.025	0.263

Outliers

DFT plots (slab 17)

20 km/hr   40 km/hr   60 km/hr

112
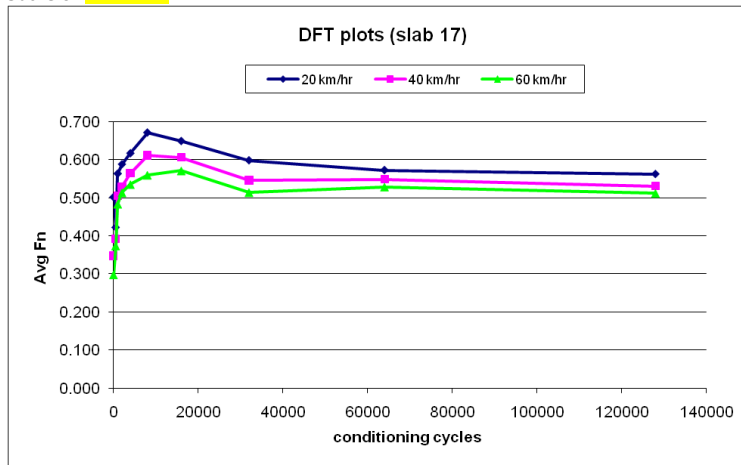
Phase	Mix	Slab#	Polisher	Load	Speed			
1	TN hard	18	OLD	122#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.673	0.729	0.761	0.721	0.088	0.045	0.062
	20	0.305	0.277	0.267	0.283	0.038	0.020	0.070
	40	0.223	0.202	0.201	0.209	0.022	0.012	0.060
	60	0.239	0.212	0.210	0.220	0.029	0.016	0.074
	80	0.099	0.153	0.127	0.126	0.054	0.027	0.214
500	0	0.437	0.381	0.437	0.418	0.056	0.032	0.077
	20	0.270	0.260	0.251	0.260	0.019	0.010	0.037
	40	0.253	0.238	0.234	0.242	0.019	0.010	0.041
	60	0.248	0.232	0.230	0.237	0.018	0.010	0.042
	80	0.072	0.098	0.100	0.090	0.028	0.016	0.174
1000	0	0.722	0.693	0.706	0.707	0.029	0.015	0.021
	20	0.544	0.530	0.515	0.530	0.029	0.015	0.027
	40	0.502	0.469	0.455	0.475	0.047	0.024	0.051
	60	0.489	0.464	0.440	0.464	0.049	0.025	0.053
	80	0.156	0.173	0.151	0.160	0.022	0.012	0.072
2000	0	0.738	0.707	0.687	0.711	0.051	0.026	0.036
	20	0.597	0.571	0.560	0.576	0.037	0.019	0.033
	40	0.537	0.512	0.499	0.516	0.038	0.019	0.037
	60	0.515	0.506	0.479	0.500	0.036	0.019	0.037
	80	0.141	0.116	0.153	0.137	0.037	0.019	0.138
4000	0	0.703	0.669	0.597	0.656	0.106	0.054	0.082
	20	0.594	0.578	0.563	0.578	0.031	0.016	0.027
	40	0.538	0.518	0.515	0.524	0.023	0.013	0.024
	60	0.522	0.507	0.500	0.510	0.022	0.011	0.022
	80	0.183	0.159	0.151	0.164	0.032	0.017	0.101
8000	0	0.762	0.762	0.757	0.760	0.005	0.003	0.004
	20	0.675	0.660	0.640	0.658	0.035	0.018	0.027
	40	0.611	0.597	0.579	0.596	0.032	0.016	0.027
	60	0.563	0.554	0.536	0.551	0.027	0.014	0.025
	80	0.102	0.127	0.147	0.125	0.045	0.023	0.180
16000	0	0.728	0.716	0.692	0.712	0.036	0.018	0.026
	20	0.654	0.648	0.631	0.644	0.023	0.012	0.019
	40	0.617	0.599	0.588	0.601	0.029	0.015	0.024
	60	0.580	0.554	0.546	0.560	0.034	0.018	0.032
	80	0.095	0.090	0.092	0.092	0.005	0.003	0.027
32000	0	0.673	0.653	0.622	0.649	0.051	0.026	0.040
	20	0.619	0.609	0.614	0.614	0.010	0.005	0.008
	40	0.556	0.552	0.548	0.552	0.008	0.004	0.007
	60	0.527	0.507	0.500	0.511	0.027	0.014	0.027
	80	0.074	0.097	0.092	0.088	0.023	0.012	0.138
64000	0	0.652	0.672	0.594	0.639	0.078	0.041	0.063
	20	0.591	0.580	0.567	0.579	0.024	0.012	0.021
	40	0.540	0.532	0.526	0.533	0.014	0.007	0.013
	60	0.513	0.506	0.497	0.505	0.016	0.008	0.016
	80	0.118	0.097	0.080	0.098	0.038	0.019	0.194
128000	0	0.583	0.583	0.547	0.571	0.036	0.021	0.036
	20	0.535	0.582	0.535	0.551	0.047	0.027	0.049
	40	0.479	0.494	0.496	0.490	0.017	0.009	0.019
	60	0.456	0.471	0.472	0.466	0.016	0.009	0.019
	80	0.132	0.095	0.107	0.111	0.037	0.019	0.170

Outliers

DFT plots (slab 18)
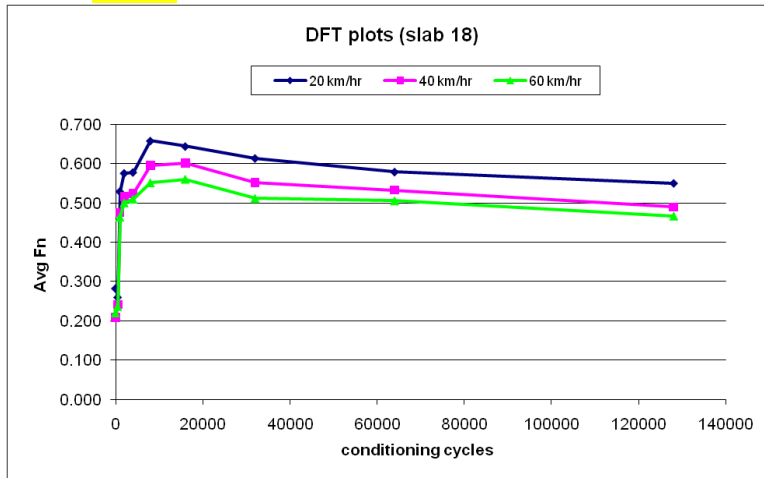
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	1	NEW	107#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.992	0.947	0.997	0.979	0.050	0.028	0.028
	20	0.555	0.465	0.457	0.492	0.098	0.054	0.111
	40	0.386	0.352	0.357	0.365	0.034	0.018	0.050
	60	0.369	0.343	0.342	0.351	0.027	0.015	0.044
	80	0.115	0.065	0.101	0.094	0.050	0.026	0.275
500	0	0.842	0.696	0.644	0.727	0.198	0.103	0.141
	20	0.517	0.474	0.462	0.484	0.055	0.029	0.060
	40	0.420	0.394	0.383	0.399	0.037	0.019	0.048
	60	0.411	0.388	0.377	0.392	0.034	0.017	0.044
	80	0.136	0.123	0.084	0.114	0.052	0.027	0.237
1000	0	0.698	0.660	0.544	0.634	0.154	0.080	0.127
	20	0.516	0.494	0.480	0.497	0.036	0.018	0.037
	40	0.463	0.452	0.436	0.450	0.027	0.014	0.030
	60	0.468	0.448	0.436	0.451	0.032	0.016	0.036
	80	0.118	0.119	0.119	0.119	0.001	0.001	0.005
2000	0	0.576	0.474	0.529	0.526	0.102	0.051	0.097
	20	0.482	0.464	0.448	0.465	0.034	0.017	0.037
	40	0.444	0.430	0.416	0.430	0.028	0.014	0.033
	60	0.452	0.425	0.408	0.428	0.044	0.022	0.052
	80	0.093	0.106	0.072	0.090	0.034	0.017	0.190
4000	0	0.506	0.502	0.471	0.493	0.035	0.019	0.039
	20	0.403	0.389	0.387	0.393	0.016	0.009	0.022
	40	0.390	0.373	0.369	0.377	0.021	0.011	0.030
	60	0.388	0.378	0.372	0.379	0.016	0.008	0.021
	80	0.168	0.103	0.109	0.127	0.065	0.036	0.284
8000	0	0.433	0.404	0.363	0.400	0.070	0.035	0.088
	20	0.369	0.350	0.345	0.355	0.024	0.013	0.036
	40	0.360	0.345	0.343	0.349	0.017	0.009	0.027
	60	0.364	0.346	0.342	0.351	0.022	0.012	0.033
	80	0.121	0.096	0.117	0.111	0.025	0.013	0.121
16000	0	0.428	0.387	0.345	0.387	0.083	0.042	0.107
	20	0.332	0.320	0.315	0.322	0.017	0.009	0.027
	40	0.337	0.323	0.317	0.326	0.020	0.010	0.032
	60	0.337	0.328	0.324	0.330	0.013	0.007	0.020
	80	0.063	0.071	0.072	0.069	0.009	0.005	0.072
32000	0	0.289	0.293	0.271	0.284	0.022	0.012	0.041
	20	0.299	0.288	0.286	0.291	0.013	0.007	0.024
	40	0.310	0.299	0.296	0.302	0.014	0.007	0.024
	60	0.322	0.310	0.307	0.313	0.015	0.008	0.025
	80	0.090	0.088	0.065	0.081	0.025	0.014	0.172
64000	0	0.337	0.287	0.274	0.299	0.063	0.033	0.111
	20	0.285	0.275	0.274	0.278	0.011	0.006	0.022
	40	0.290	0.282	0.282	0.285	0.008	0.005	0.016
	60	0.309	0.300	0.291	0.300	0.018	0.009	0.030
	80	0.103	0.084	0.097	0.095	0.019	0.010	0.103
128000	0	0.326	0.303	0.294	0.308	0.032	0.017	0.054
	20	0.296	0.287	0.282	0.288	0.014	0.007	0.025
	40	0.301	0.292	0.289	0.294	0.012	0.006	0.021
	60	0.314	0.304	0.296	0.305	0.018	0.009	0.030
	80	0.100	0.074	0.082	0.085	0.026	0.013	0.156
Outliers								

DFT plots (slab 1)

Legend: 20 km/hr, 40 km/hr, 60 km/hr

Y-axis: Avg Fn (0.000 – 0.700)
X-axis: conditioning cycles (0 – 140000)
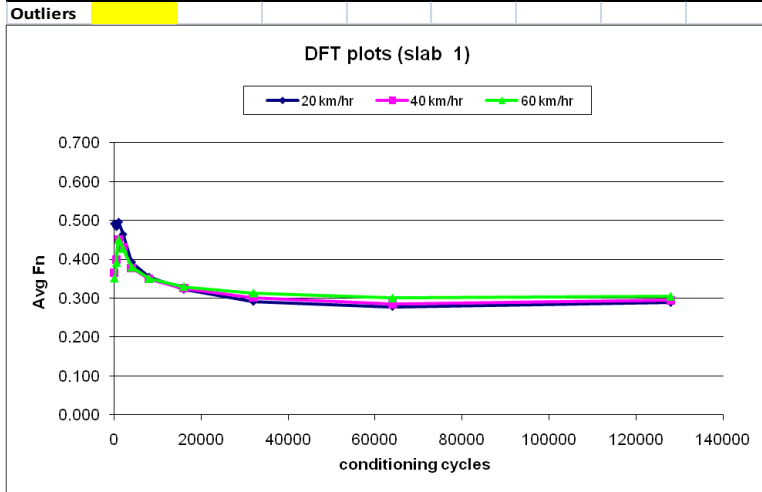
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	2	NEW	107#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.932	0.832	0.878	0.881	0.100	0.050	0.057
	20	0.550	0.461	0.439	0.483	0.111	0.059	0.122
	40	0.374	0.334	0.331	0.346	0.043	0.024	0.069
	60	0.354	0.319	0.316	0.330	0.038	0.021	0.064
	80	0.074	0.116	0.142	0.111	0.068	0.034	0.310
500	0	0.797	0.647	0.672	0.705	0.150	0.080	0.114
	20	0.498	0.464	0.445	0.469	0.053	0.027	0.057
	40	0.413	0.388	0.377	0.393	0.036	0.018	0.047
	60	0.389	0.369	0.355	0.371	0.034	0.017	0.046
	80	0.083	0.126	0.136	0.115	0.053	0.028	0.245
1000	0	0.602	0.568	0.573	0.581	0.034	0.018	0.032
	20	0.448	0.430	0.416	0.431	0.032	0.016	0.037
	40	0.389	0.375	0.364	0.376	0.025	0.013	0.033
	60	0.366	0.359	0.351	0.359	0.015	0.008	0.021
	80	0.091	0.124	0.100	0.105	0.033	0.017	0.162
2000	0	0.557	0.496	0.493	0.515	0.064	0.036	0.070
	20	0.466	0.431	0.425	0.441	0.041	0.022	0.050
	40	0.430	0.396	0.389	0.405	0.041	0.022	0.054
	60	0.414	0.386	0.381	0.394	0.033	0.018	0.045
	80	0.105	0.119	0.112	0.112	0.014	0.007	0.063
4000	0	0.408	0.421	0.444	0.424	0.036	0.018	0.043
	20	0.404	0.383	0.371	0.386	0.033	0.017	0.043
	40	0.382	0.368	0.355	0.368	0.027	0.014	0.037
	60	0.385	0.366	0.358	0.370	0.027	0.014	0.038
	80	0.097	0.026	0.092	0.072	0.071	0.040	0.553
8000	0	0.388	0.407	0.357	0.384	0.050	0.025	0.066
	20	0.359	0.345	0.335	0.346	0.024	0.012	0.035
	40	0.356	0.337	0.331	0.341	0.025	0.013	0.038
	60	0.359	0.333	0.324	0.339	0.035	0.018	0.054
	80	0.108	0.085	0.082	0.092	0.026	0.014	0.155
16000	0	0.343	0.296	0.329	0.323	0.047	0.024	0.075
	20	0.325	0.336	0.310	0.324	0.026	0.013	0.040
	40	0.316	0.325	0.306	0.316	0.019	0.010	0.030
	60	0.323	0.327	0.306	0.319	0.021	0.011	0.035
	80	0.125	0.066	0.072	0.088	0.059	0.032	0.370
32000	0	0.383	0.346	0.294	0.341	0.089	0.045	0.131
	20	0.300	0.289	0.284	0.291	0.016	0.008	0.028
	40	0.298	0.284	0.283	0.288	0.015	0.008	0.029
	60	0.310	0.291	0.288	0.296	0.022	0.012	0.040
	80	0.083	0.101	0.091	0.092	0.018	0.009	0.098
64000	0	0.338	0.299	0.316	0.318	0.039	0.020	0.062
	20	0.293	0.283	0.275	0.284	0.018	0.009	0.032
	40	0.300	0.288	0.284	0.291	0.016	0.008	0.029
	60	0.300	0.286	0.279	0.288	0.021	0.011	0.037
	80	0.135	0.068	0.119	0.107	0.067	0.035	0.326
128000	0	0.298	0.318	0.328	0.315	0.030	0.015	0.049
	20	0.301	0.278	0.276	0.285	0.025	0.014	0.049
	40	0.303	0.283	0.280	0.289	0.023	0.013	0.043
	60	0.308	0.285	0.285	0.293	0.023	0.013	0.045
	80	0.084	0.090	0.113	0.096	0.029	0.015	0.160

Outliers

DFT plots (slab 2)

20 km/hr   40 km/hr   60 km/hr
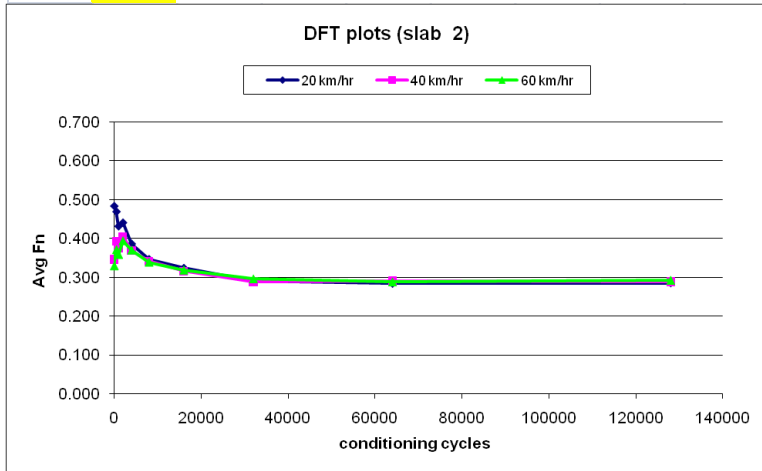
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	3	NEW	107#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.893	0.886	0.821	0.867	0.072	0.040	0.046
	20	0.523	0.475	0.466	0.488	0.057	0.031	0.063
	40	0.401	0.362	0.355	0.373	0.046	0.025	0.067
	60	0.395	0.357	0.342	0.365	0.053	0.027	0.075
	80	0.069	0.097	0.147	0.104	0.078	0.040	0.379
500	0	0.857	0.803	0.761	0.807	0.096	0.048	0.060
	20	0.507	0.481	0.456	0.481	0.051	0.026	0.053
	40	0.412	0.393	0.380	0.395	0.032	0.016	0.041
	60	0.405	0.383	0.369	0.386	0.036	0.018	0.047
	80	0.045	0.119	0.116	0.093	0.074	0.042	0.449
1000	0	0.712	0.492	0.536	0.580	0.220	0.116	0.201
	20	0.485	0.460	0.445	0.463	0.040	0.020	0.044
	40	0.421	0.398	0.391	0.403	0.030	0.016	0.039
	60	0.412	0.394	0.387	0.398	0.025	0.013	0.032
	80	0.067	0.105	0.125	0.099	0.058	0.029	0.298
2000	0	0.543	0.434	0.478	0.485	0.109	0.055	0.113
	20	0.458	0.449	0.428	0.445	0.030	0.015	0.035
	40	0.423	0.407	0.399	0.410	0.024	0.012	0.030
	60	0.412	0.394	0.385	0.397	0.027	0.014	0.034
	80	0.100	0.075	0.089	0.088	0.025	0.013	0.142
4000	0	0.443	0.423	0.436	0.434	0.020	0.010	0.023
	20	0.410	0.397	0.385	0.397	0.025	0.013	0.031
	40	0.377	0.364	0.355	0.365	0.022	0.011	0.030
	60	0.379	0.369	0.357	0.368	0.022	0.011	0.030
	80	0.213	0.088	0.010	0.104	0.203	0.102	0.988
8000	0	0.428	0.378	0.382	0.396	0.050	0.028	0.070
	20	0.358	0.347	0.340	0.348	0.018	0.009	0.026
	40	0.339	0.329	0.321	0.330	0.018	0.009	0.027
	60	0.344	0.338	0.331	0.338	0.013	0.007	0.019
	80	0.135	0.103	0.096	0.111	0.039	0.021	0.187
16000	0	0.403	0.373	0.368	0.381	0.035	0.019	0.050
	20	0.344	0.323	0.318	0.328	0.026	0.014	0.042
	40	0.337	0.315	0.306	0.319	0.031	0.016	0.050
	60	0.345	0.323	0.318	0.329	0.027	0.014	0.044
	80	0.092	0.119	0.120	0.110	0.028	0.016	0.144
32000	0	0.386	0.368	0.323	0.359	0.063	0.032	0.090
	20	0.309	0.297	0.286	0.297	0.023	0.012	0.039
	40	0.297	0.284	0.275	0.285	0.022	0.011	0.039
	60	0.313	0.300	0.293	0.302	0.020	0.010	0.034
	80	0.056	0.076	0.088	0.073	0.032	0.016	0.220
64000	0	0.303	0.269	0.286	0.286	0.034	0.017	0.059
	20	0.264	0.259	0.259	0.261	0.005	0.003	0.011
	40	0.263	0.261	0.259	0.261	0.004	0.002	0.008
	60	0.275	0.272	0.270	0.272	0.005	0.003	0.009
	80	0.062	0.075	0.097	0.078	0.035	0.018	0.227
128000	0	0.286	0.288	0.281	0.285	0.007	0.004	0.013
	20	0.271	0.265	0.265	0.267	0.006	0.003	0.013
	40	0.261	0.263	0.261	0.262	0.002	0.001	0.004
	60	0.280	0.275	0.274	0.276	0.006	0.003	0.012
	80	0.097	0.086	0.087	0.090	0.011	0.006	0.068
Outliers								

DFT plots (slab 3)

116
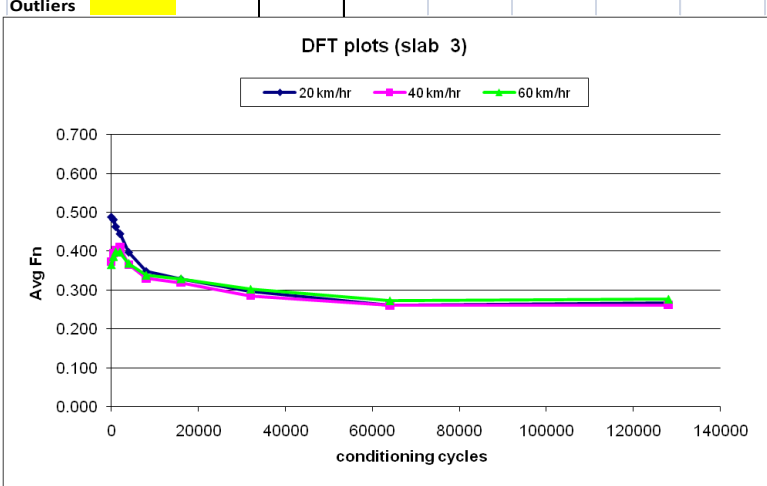
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	4	NEW	107#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.881	0.869	0.843	0.864	0.038	0.019	0.022
	20	0.503	0.466	0.460	0.476	0.043	0.023	0.049
	40	0.400	0.350	0.346	0.365	0.054	0.030	0.082
	60	0.405	0.350	0.342	0.366	0.063	0.034	0.094
	80	0.073	0.121	0.078	0.091	0.048	0.026	0.291
500	0	0.845	0.807	0.723	0.792	0.122	0.062	0.079
	20	0.508	0.476	0.457	0.480	0.051	0.026	0.054
	40	0.415	0.397	0.383	0.398	0.032	0.016	0.040
	60	0.400	0.379	0.371	0.383	0.029	0.015	0.039
	80	0.107	0.126	0.121	0.121	0.024	0.013	0.104
1000	0	0.568	0.629	0.534	0.577	0.095	0.048	0.083
	20	0.494	0.479	0.465	0.479	0.029	0.015	0.030
	40	0.455	0.438	0.428	0.440	0.027	0.014	0.031
	60	0.441	0.425	0.419	0.428	0.022	0.011	0.027
	80	0.112	0.124	0.111	0.116	0.013	0.007	0.063
2000	0	0.522	0.466	0.488	0.492	0.056	0.028	0.057
	20	0.442	0.446	0.447	0.445	0.005	0.003	0.006
	40	0.400	0.412	0.410	0.407	0.012	0.006	0.016
	60	0.388	0.398	0.392	0.393	0.010	0.005	0.013
	80	0.055	0.144	0.147	0.115	0.092	0.052	0.453
4000	0	0.425	0.467	0.443	0.445	0.042	0.021	0.047
	20	0.419	0.417	0.406	0.414	0.013	0.007	0.017
	40	0.397	0.389	0.381	0.389	0.016	0.008	0.021
	60	0.393	0.389	0.382	0.388	0.011	0.006	0.014
	80	0.074	0.084	0.074	0.077	0.010	0.006	0.075
8000	0	0.427	0.398	0.324	0.383	0.103	0.053	0.139
	20	0.372	0.361	0.348	0.360	0.024	0.012	0.033
	40	0.356	0.349	0.340	0.348	0.016	0.008	0.023
	60	0.358	0.354	0.344	0.352	0.014	0.007	0.020
	80	0.008	0.115	0.088	0.070	0.107	0.056	0.791
16000	0	0.418	0.346	0.363	0.376	0.072	0.038	0.100
	20	0.338	0.323	0.321	0.327	0.017	0.009	0.028
	40	0.325	0.316	0.315	0.319	0.010	0.006	0.017
	60	0.327	0.322	0.319	0.323	0.008	0.004	0.013
	80	0.068	0.070	0.087	0.075	0.019	0.010	0.139
32000	0	0.343	0.306	0.318	0.322	0.037	0.019	0.059
	20	0.311	0.300	0.300	0.304	0.011	0.006	0.021
	40	0.309	0.302	0.297	0.303	0.012	0.006	0.020
	60	0.314	0.306	0.306	0.309	0.008	0.005	0.015
	80	0.097	0.098	0.110	0.102	0.013	0.007	0.071
64000	0	0.398	0.300	0.278	0.325	0.120	0.064	0.196
	20	0.292	0.292	0.289	0.291	0.003	0.002	0.006
	40	0.294	0.293	0.291	0.293	0.003	0.002	0.005
	60	0.308	0.308	0.306	0.307	0.002	0.001	0.004
	80	0.084	0.099	0.102	0.095	0.018	0.010	0.102
128000	0	0.293	0.237	0.288	0.273	0.056	0.031	0.114
	20	0.281	0.275	0.278	0.278	0.006	0.003	0.011
	40	0.281	0.276	0.278	0.278	0.005	0.003	0.009
	60	0.291	0.286	0.287	0.288	0.005	0.003	0.009
	80	0.000	0.081	0.117	0.066	0.117	0.060	0.908

Outliers

DFT plots (slab 4)

117
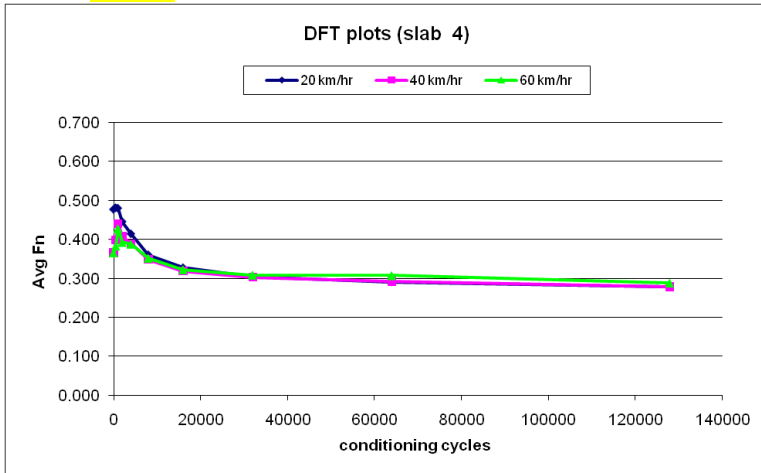
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	5	NEW	107#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.982	0.919	0.858	0.920	0.124	0.062	0.067
	20	0.595	0.480	0.450	0.508	0.145	0.077	0.151
	40	0.396	0.358	0.349	0.368	0.047	0.025	0.068
	60	0.362	0.335	0.328	0.342	0.034	0.018	0.053
	80	0.116	0.127	0.110	0.118	0.017	0.009	0.073
500	0	0.856	0.772	0.766	0.798	0.090	0.050	0.063
	20	0.497	0.456	0.438	0.464	0.059	0.030	0.065
	40	0.412	0.389	0.371	0.391	0.041	0.021	0.053
	60	0.394	0.369	0.358	0.374	0.036	0.018	0.049
	80	0.113	0.110	0.107	0.110	0.006	0.003	0.027
1000	0	0.601	0.508	0.583	0.564	0.093	0.049	0.087
	20	0.453	0.443	0.476	0.457	0.033	0.017	0.037
	40	0.428	0.417	0.449	0.431	0.032	0.016	0.038
	60	0.409	0.402	0.431	0.414	0.029	0.015	0.037
	80	0.104	0.105	0.126	0.112	0.022	0.012	0.111
2000	0	0.527	0.508	0.493	0.509	0.034	0.017	0.033
	20	0.427	0.406	0.399	0.411	0.028	0.015	0.035
	40	0.406	0.385	0.379	0.390	0.027	0.014	0.036
	60	0.387	0.367	0.366	0.373	0.021	0.012	0.032
	80	0.081	0.102	0.006	0.063	0.096	0.050	0.801
4000	0	0.446	0.401	0.382	0.410	0.064	0.033	0.080
	20	0.380	0.371	0.357	0.369	0.023	0.012	0.031
	40	0.376	0.362	0.351	0.363	0.025	0.013	0.035
	60	0.369	0.351	0.342	0.354	0.027	0.014	0.039
	80	0.115	0.085	0.087	0.096	0.030	0.017	0.175
8000	0	0.394	0.387	0.314	0.365	0.080	0.044	0.121
	20	0.335	0.319	0.326	0.327	0.016	0.008	0.025
	40	0.339	0.320	0.323	0.327	0.019	0.010	0.031
	60	0.327	0.309	0.313	0.316	0.018	0.009	0.030
	80	0.142	0.123	0.130	0.132	0.019	0.010	0.073
16000	0	0.341	0.338	0.317	0.332	0.024	0.013	0.039
	20	0.299	0.286	0.284	0.290	0.015	0.008	0.028
	40	0.303	0.295	0.287	0.295	0.016	0.008	0.027
	60	0.299	0.287	0.282	0.289	0.017	0.009	0.030
	80	0.109	0.059	0.090	0.086	0.050	0.025	0.293
32000	0	0.352	0.358	0.316	0.342	0.042	0.023	0.066
	20	0.302	0.294	0.293	0.296	0.009	0.005	0.017
	40	0.309	0.302	0.303	0.305	0.007	0.004	0.012
	60	0.305	0.295	0.294	0.298	0.011	0.006	0.020
	80	0.113	0.115	0.090	0.106	0.025	0.014	0.131
64000	0	0.282	0.298	0.275	0.285	0.023	0.012	0.041
	20	0.276	0.274	0.271	0.274	0.005	0.003	0.009
	40	0.280	0.276	0.277	0.278	0.004	0.002	0.007
	60	0.283	0.281	0.280	0.281	0.003	0.002	0.005
	80	0.067	0.080	0.111	0.086	0.044	0.023	0.263
128000	0	0.304	0.281	0.274	0.286	0.030	0.016	0.055
	20	0.248	0.247	0.250	0.248	0.003	0.002	0.006
	40	0.249	0.254	0.256	0.253	0.007	0.004	0.014
	60	0.260	0.261	0.264	0.262	0.004	0.002	0.008
	80	0.000	0.082	0.116	0.066	0.116	0.060	0.904

Outliers

DFT plots (slab 5)
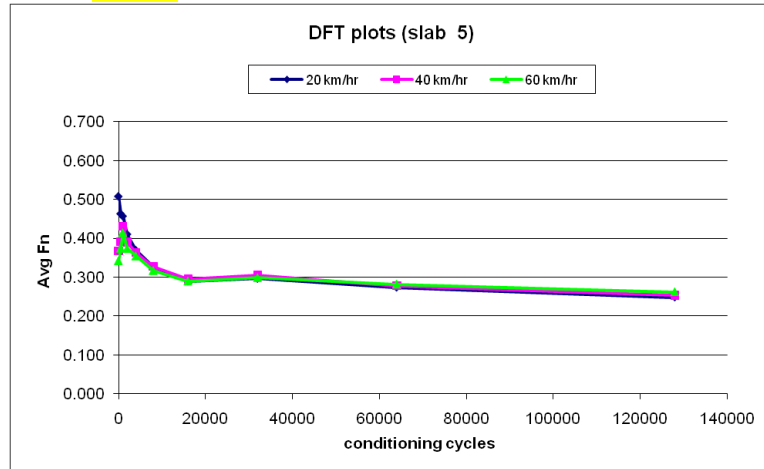
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	6	NEW	107#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.999	0.976	0.936	0.970	0.063	0.032	0.033
	20	0.546	0.458	0.445	0.483	0.101	0.055	0.114
	40	0.388	0.346	0.338	0.357	0.050	0.027	0.075
	60	0.363	0.336	0.327	0.342	0.036	0.019	0.055
	80	0.141	0.150	0.109	0.133	0.041	0.022	0.162
500	0	0.728	0.658	0.713	0.700	0.070	0.037	0.053
	20	0.494	0.448	0.431	0.458	0.063	0.033	0.071
	40	0.408	0.368	0.363	0.380	0.045	0.025	0.065
	60	0.412	0.375	0.369	0.385	0.043	0.023	0.060
	80	0.126	0.099	0.093	0.106	0.033	0.018	0.166
1000	0	0.672	0.644	0.512	0.609	0.160	0.085	0.140
	20	0.445	0.429	0.415	0.430	0.030	0.015	0.035
	40	0.407	0.378	0.376	0.387	0.031	0.017	0.045
	60	0.418	0.392	0.387	0.399	0.031	0.017	0.042
	80	0.100	0.112	0.121	0.111	0.021	0.011	0.095
2000	0	0.557	0.543	0.484	0.528	0.073	0.039	0.073
	20	0.426	0.408	0.397	0.410	0.029	0.015	0.036
	40	0.384	0.367	0.356	0.369	0.028	0.014	0.038
	60	0.390	0.376	0.368	0.378	0.022	0.011	0.029
	80	0.070	0.152	0.037	0.086	0.115	0.059	0.686
4000	0	0.702	0.603	0.571	0.625	0.131	0.068	0.109
	20	0.495	0.451	0.439	0.462	0.056	0.029	0.064
	40	0.444	0.404	0.395	0.414	0.049	0.026	0.063
	60	0.457	0.408	0.399	0.421	0.058	0.031	0.074
	80	0.108	0.095	0.061	0.088	0.047	0.024	0.276
8000	0	0.482	0.428	0.407	0.439	0.075	0.039	0.088
	20	0.412	0.396	0.367	0.392	0.045	0.023	0.058
	40	0.389	0.373	0.345	0.369	0.044	0.022	0.060
	60	0.392	0.367	0.344	0.368	0.048	0.024	0.065
	80	0.003	0.047	0.085	0.045	0.082	0.041	0.912
16000	0	0.408	0.411	0.403	0.407	0.008	0.004	0.010
	20	0.331	0.315	0.312	0.319	0.019	0.010	0.032
	40	0.324	0.311	0.304	0.313	0.020	0.010	0.032
	60	0.332	0.321	0.317	0.323	0.015	0.008	0.024
	80	0.088	0.066	0.063	0.072	0.025	0.014	0.189
32000	0	0.280	0.314	0.362	0.319	0.082	0.041	0.129
	20	0.321	0.311	0.300	0.311	0.021	0.011	0.034
	40	0.311	0.301	0.302	0.305	0.010	0.006	0.018
	60	0.312	0.313	0.305	0.310	0.008	0.004	0.014
	80	0.073	0.058	0.136	0.089	0.078	0.041	0.465
64000	0	0.357	0.346	0.348	0.350	0.011	0.006	0.017
	20	0.296	0.289	0.286	0.290	0.010	0.005	0.018
	40	0.289	0.283	0.280	0.284	0.009	0.005	0.016
	60	0.307	0.298	0.294	0.300	0.013	0.007	0.022
	80	0.124	0.104	0.091	0.106	0.033	0.017	0.156
128000	0	0.303	0.280	0.266	0.283	0.037	0.019	0.066
	20	0.271	0.267	0.259	0.266	0.012	0.006	0.023
	40	0.273	0.265	0.259	0.266	0.014	0.007	0.026
	60	0.283	0.277	0.274	0.278	0.009	0.005	0.016
	80	0.130	0.092	0.050	0.091	0.080	0.040	0.441

Outliers

DFT plots (slab 6)

— 20 km/hr — 40 km/hr — 60 km/hr
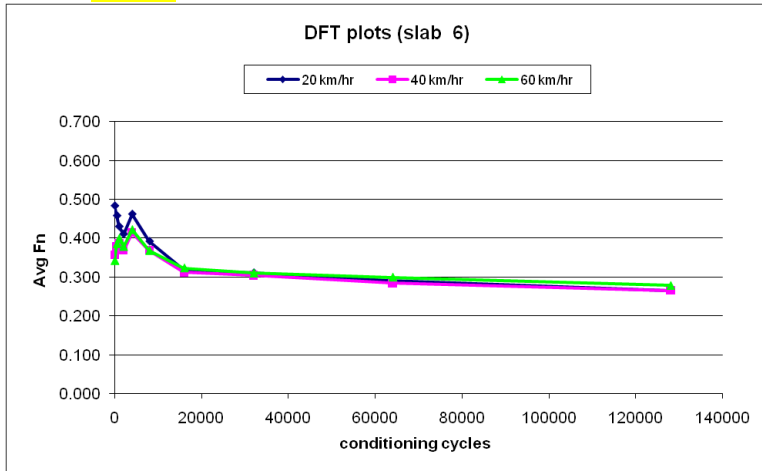
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	7	OLD	122#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.872	0.866	0.784	0.841	0.088	0.049	0.058
	20	0.473	0.436	0.420	0.443	0.053	0.027	0.061
	40	0.382	0.355	0.340	0.359	0.042	0.021	0.059
	60	0.383	0.348	0.332	0.354	0.051	0.026	0.074
	80	0.113	0.119	0.109	0.114	0.010	0.005	0.044
500	0	0.638	0.590	0.511	0.580	0.127	0.064	0.111
	20	0.488	0.453	0.425	0.455	0.063	0.032	0.069
	40	0.432	0.408	0.354	0.398	0.078	0.040	0.100
	60	0.404	0.365	0.375	0.381	0.039	0.020	0.053
	80	0.091	0.109	0.104	0.101	0.018	0.009	0.092
1000	0	0.599	0.667	0.547	0.604	0.120	0.060	0.100
	20	0.484	0.467	0.459	0.470	0.025	0.013	0.027
	40	0.435	0.416	0.413	0.421	0.022	0.012	0.028
	60	0.412	0.395	0.392	0.400	0.020	0.011	0.027
	80	0.114	0.078	0.098	0.097	0.036	0.018	0.187
2000	0	0.581	0.478	0.544	0.534	0.103	0.052	0.098
	20	0.448	0.434	0.422	0.435	0.026	0.013	0.030
	40	0.417	0.397	0.391	0.402	0.026	0.014	0.034
	60	0.394	0.377	0.366	0.379	0.028	0.014	0.037
	80	0.092	0.110	0.100	0.101	0.018	0.009	0.090
4000	0	0.511	0.463	0.488	0.487	0.048	0.024	0.049
	20	0.412	0.407	0.393	0.404	0.019	0.010	0.024
	40	0.393	0.382	0.371	0.382	0.022	0.011	0.029
	60	0.380	0.362	0.355	0.366	0.025	0.013	0.035
	80	0.097	0.084	0.084	0.088	0.013	0.008	0.085
8000	0	0.402	0.389	0.369	0.387	0.033	0.017	0.043
	20	0.355	0.336	0.336	0.342	0.019	0.011	0.032
	40	0.340	0.324	0.319	0.328	0.021	0.011	0.033
	60	0.330	0.327	0.317	0.325	0.013	0.007	0.021
	80	0.049	0.089	0.090	0.076	0.041	0.023	0.308
16000	0	0.339	0.354	0.323	0.339	0.031	0.016	0.046
	20	0.319	0.309	0.302	0.310	0.017	0.009	0.028
	40	0.305	0.300	0.296	0.300	0.009	0.005	0.015
	60	0.312	0.301	0.301	0.305	0.011	0.006	0.021
	80	0.099	0.075	0.084	0.086	0.024	0.012	0.141
32000	0	0.308	0.299	0.239	0.282	0.069	0.038	0.133
	20	0.290	0.281	0.270	0.280	0.020	0.010	0.036
	40	0.291	0.281	0.272	0.281	0.019	0.010	0.034
	60	0.301	0.286	0.278	0.288	0.023	0.012	0.040
	80	0.108	0.131	0.092	0.110	0.039	0.020	0.178
64000	0	0.283	0.253	0.226	0.254	0.057	0.029	0.112
	20	0.245	0.245	0.245	0.245	0.000	0.000	0.000
	40	0.250	0.249	0.250	0.250	0.001	0.001	0.002
	60	0.257	0.264	0.263	0.261	0.007	0.004	0.014
	80	0.000	0.098	0.077	0.058	0.098	0.052	0.885
128000	0	0.249	0.215	0.219	0.228	0.034	0.019	0.082
	20	0.250	0.249	0.245	0.248	0.005	0.003	0.011
	40	0.269	0.251	0.245	0.255	0.024	0.012	0.049
	60	0.271	0.269	0.268	0.269	0.003	0.002	0.006
	80	0.058	0.035	0.112	0.068	0.077	0.040	0.578
Outliers								

DFT plots (slab 7)

—— 20 km/hr   —— 40 km/hr   —— 60 km/hr
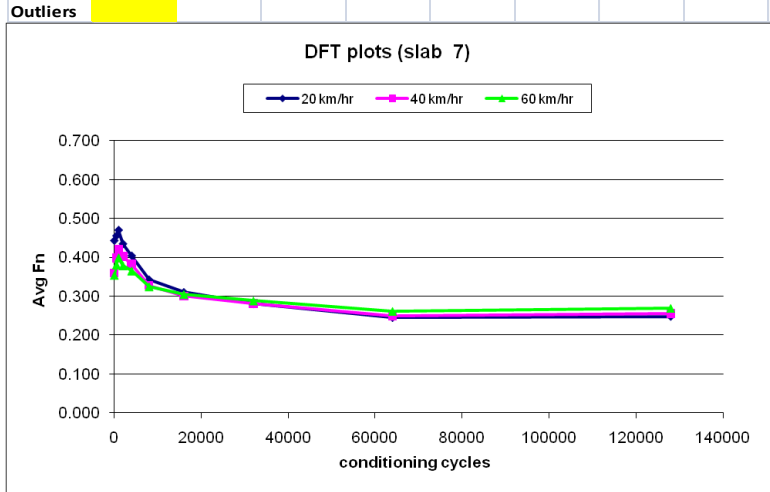
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	8	OLD	122#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.896	0.833	0.738	0.822	0.158	0.080	0.097
	20	0.499	0.408	0.404	0.437	0.095	0.054	0.123
	40	0.346	0.307	0.310	0.321	0.039	0.022	0.068
	60	0.364	0.331	0.318	0.338	0.046	0.024	0.070
	80	0.089	0.010	0.148	0.082	0.138	0.069	0.841
500	0	0.549	0.601	0.531	0.560	0.070	0.036	0.065
	20	0.422	0.420	0.409	0.417	0.013	0.007	0.017
	40	0.322	0.321	0.319	0.321	0.003	0.002	0.005
	60	0.324	0.316	0.313	0.318	0.011	0.006	0.018
	80	0.125	0.093	0.102	0.107	0.032	0.017	0.155
1000	0	0.681	0.612	0.556	0.616	0.125	0.063	0.102
	20	0.467	0.450	0.432	0.450	0.035	0.018	0.039
	40	0.427	0.408	0.392	0.409	0.035	0.018	0.043
	60	0.416	0.392	0.376	0.395	0.040	0.020	0.051
	80	0.099	0.108	0.077	0.095	0.031	0.016	0.168
2000	0	0.576	0.559	0.577	0.571	0.018	0.010	0.018
	20	0.432	0.413	0.401	0.415	0.031	0.016	0.038
	40	0.393	0.371	0.364	0.376	0.029	0.015	0.040
	60	0.400	0.376	0.360	0.379	0.040	0.020	0.053
	80	0.113	0.097	0.102	0.104	0.016	0.008	0.079
4000	0	0.481	0.434	0.508	0.474	0.074	0.037	0.079
	20	0.392	0.385	0.373	0.383	0.019	0.010	0.025
	40	0.371	0.361	0.351	0.361	0.020	0.010	0.028
	60	0.376	0.356	0.346	0.359	0.030	0.015	0.043
	80	0.078	0.103	0.082	0.088	0.025	0.013	0.153
8000	0	0.458	0.438	0.438	0.445	0.020	0.012	0.026
	20	0.358	0.345	0.343	0.349	0.015	0.008	0.023
	40	0.346	0.333	0.331	0.337	0.015	0.008	0.024
	60	0.347	0.337	0.336	0.340	0.011	0.006	0.018
	80	0.097	0.129	0.075	0.100	0.054	0.027	0.271
16000	0	0.386	0.359	0.336	0.360	0.050	0.025	0.069
	20	0.319	0.308	0.302	0.310	0.017	0.009	0.028
	40	0.310	0.300	0.292	0.301	0.018	0.009	0.030
	60	0.329	0.317	0.311	0.319	0.018	0.009	0.029
	80	0.118	0.082	0.103	0.101	0.036	0.018	0.179
32000	0	0.450	0.401	0.421	0.424	0.049	0.025	0.058
	20	0.311	0.300	0.290	0.300	0.021	0.011	0.035
	40	0.288	0.277	0.272	0.279	0.016	0.008	0.029
	60	0.292	0.285	0.283	0.287	0.009	0.005	0.016
	80	0.112	0.094	0.073	0.093	0.039	0.020	0.210
64000	0	0.336	0.210	0.313	0.286	0.126	0.067	0.234
	20	0.291	0.261	0.271	0.274	0.030	0.015	0.056
	40	0.279	0.252	0.259	0.263	0.027	0.014	0.053
	60	0.288	0.269	0.270	0.276	0.019	0.011	0.039
	80	0.086	0.090	0.099	0.092	0.013	0.007	0.073
128000	0	0.268	0.240	0.220	0.243	0.048	0.024	0.099
	20	0.269	0.266	0.259	0.265	0.010	0.005	0.019
	40	0.267	0.262	0.257	0.262	0.010	0.005	0.019
	60	0.283	0.279	0.280	0.281	0.004	0.002	0.007
	80	0.079	0.092	0.085	0.085	0.013	0.007	0.076
Outliers								

DFT plots (slab 8)

— 20 km/hr   — 40 km/hr   — 60 km/hr

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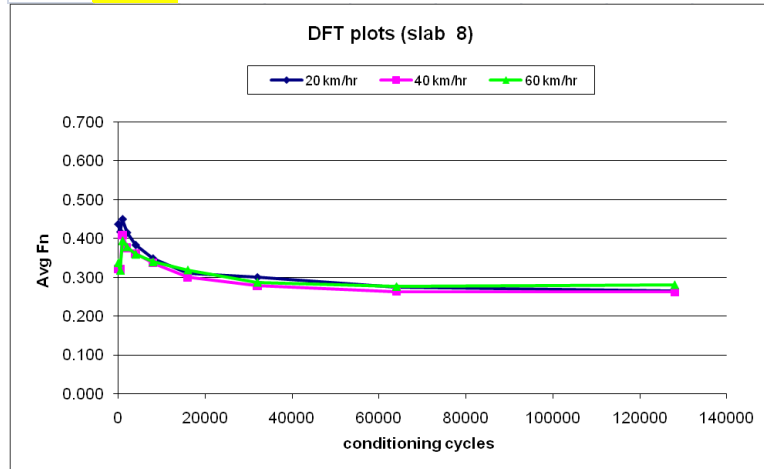
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	9	OLD	122#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.693	0.817	0.757	0.756	0.124	0.062	0.082
	20	0.405	0.364	0.353	0.374	0.052	0.027	0.073
	40	0.276	0.238	0.249	0.254	0.038	0.020	0.077
	60	0.276	0.254	0.253	0.261	0.023	0.013	0.050
	80	0.130	0.075	0.092	0.099	0.055	0.028	0.284
500	0	0.761	0.706	0.708	0.725	0.055	0.031	0.043
	20	0.457	0.418	0.397	0.424	0.060	0.030	0.072
	40	0.375	0.348	0.326	0.350	0.049	0.025	0.070
	60	0.351	0.322	0.303	0.325	0.048	0.024	0.074
	80	0.128	0.081	0.107	0.105	0.047	0.024	0.224
1000	0	0.704	0.653	0.627	0.661	0.077	0.039	0.059
	20	0.442	0.410	0.404	0.419	0.038	0.020	0.049
	40	0.381	0.351	0.346	0.359	0.035	0.019	0.053
	60	0.347	0.326	0.318	0.330	0.029	0.015	0.045
	80	0.117	0.046	0.116	0.093	0.071	0.041	0.438
2000	0	0.577	0.533	0.550	0.553	0.044	0.022	0.040
	20	0.413	0.392	0.376	0.394	0.037	0.019	0.047
	40	0.371	0.352	0.338	0.354	0.033	0.017	0.047
	60	0.352	0.335	0.328	0.338	0.024	0.012	0.036
	80	0.018	0.107	0.110	0.078	0.092	0.052	0.667
4000	0	0.573	0.531	0.526	0.543	0.047	0.026	0.048
	20	0.418	0.399	0.384	0.400	0.034	0.017	0.043
	40	0.382	0.361	0.345	0.363	0.037	0.019	0.051
	60	0.365	0.346	0.329	0.347	0.036	0.018	0.052
	80	0.122	0.121	0.088	0.110	0.034	0.019	0.175
8000	0	0.391	0.383	0.443	0.406	0.060	0.033	0.080
	20	0.317	0.315	0.316	0.316	0.002	0.001	0.003
	40	0.289	0.283	0.284	0.285	0.006	0.003	0.011
	60	0.277	0.278	0.276	0.277	0.002	0.001	0.004
	80	0.096	0.076	0.112	0.095	0.036	0.018	0.191
16000	0	0.341	0.347	0.321	0.336	0.026	0.014	0.040
	20	0.306	0.295	0.286	0.296	0.020	0.010	0.034
	40	0.285	0.278	0.271	0.278	0.014	0.007	0.025
	60	0.289	0.284	0.278	0.284	0.011	0.006	0.019
	80	0.116	0.143	0.085	0.115	0.058	0.029	0.253
32000	0	0.304	0.323	0.303	0.310	0.020	0.011	0.036
	20	0.282	0.275	0.269	0.275	0.013	0.007	0.024
	40	0.275	0.263	0.258	0.265	0.017	0.009	0.033
	60	0.280	0.272	0.265	0.272	0.015	0.008	0.028
	80	0.076	0.098	0.091	0.088	0.022	0.011	0.127
64000	0	0.264	0.233	0.259	0.252	0.031	0.017	0.066
	20	0.253	0.253	0.249	0.252	0.004	0.002	0.009
	40	0.243	0.245	0.243	0.244	0.002	0.001	0.005
	60	0.253	0.255	0.250	0.253	0.005	0.003	0.010
	80	0.000	0.068	0.099	0.056	0.099	0.051	0.910
128000	0	0.240	0.229	0.219	0.229	0.021	0.011	0.046
	20	0.253	0.246	0.246	0.248	0.007	0.004	0.016
	40	0.246	0.240	0.239	0.242	0.007	0.004	0.016
	60	0.250	0.245	0.244	0.246	0.006	0.003	0.013
	80	0.062	0.083	0.092	0.079	0.030	0.015	0.195
Outliers								

DFT plots (slab 9)

— 20 km/hr   — 40 km/hr   — 60 km/hr

Avg Fn

conditioning cycles

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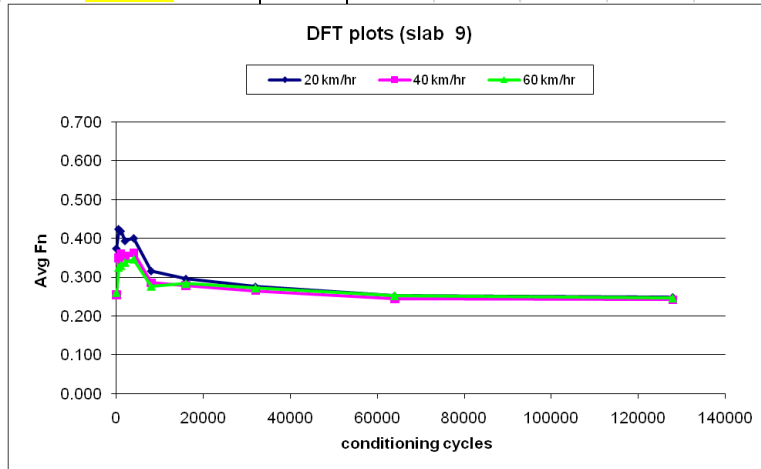
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	10	OLD	122#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.742	0.807	0.716	0.755	0.091	0.047	0.062
	20	0.452	0.364	0.344	0.354	0.020	0.014	0.040
	40	0.3	0.257	0.249	0.253	0.008	0.006	0.022
	60	0.29	0.252	0.241	0.247	0.011	0.008	0.032
	80	0.130	0.132	0.102	0.121	0.030	0.017	0.138
500	0	0.714	0.725	0.547	0.662	0.178	0.100	0.151
	20	0.450	0.413	0.353	0.432	0.037	0.026	0.061
	40	0.358	0.334	0.255	0.316	0.103	0.054	0.171
	60	0.331	0.301	0.217	0.316	0.030	0.021	0.067
	80	0.074	0.101	0.045	0.073	0.056	0.028	0.382
1000	0	0.618	0.537	0.562	0.572	0.081	0.041	0.072
	20	0.413	0.394	0.382	0.396	0.031	0.016	0.039
	40	0.356	0.338	0.326	0.340	0.030	0.015	0.044
	60	0.322	0.303	0.297	0.307	0.025	0.013	0.042
	80	0.090	0.119	0.035	0.081	0.084	0.043	0.525
2000	0	0.566	0.491	0.419	0.492	0.147	0.074	0.149
	20	0.384	0.362	0.354	0.367	0.030	0.016	0.042
	40	0.340	0.326	0.320	0.329	0.020	0.010	0.031
	60	0.318	0.299	0.293	0.303	0.025	0.013	0.043
	80	0.082	0.070	0.076	0.076	0.012	0.006	0.079
4000	0	0.373	0.403	0.368	0.381	0.035	0.019	0.050
	20	0.342	0.330	0.327	0.333	0.015	0.008	0.024
	40	0.311	0.294	0.297	0.301	0.017	0.009	0.030
	60	0.293	0.284	0.286	0.288	0.009	0.005	0.016
	80	0.101	0.086	0.105	0.097	0.019	0.010	0.103
8000	0	0.360	0.424	0.306	0.363	0.118	0.059	0.163
	20	0.315	0.304	0.294	0.304	0.021	0.011	0.035
	40	0.292	0.279	0.277	0.283	0.015	0.008	0.029
	60	0.283	0.274	0.271	0.276	0.012	0.006	0.023
	80	0.114	0.107	0.065	0.095	0.049	0.027	0.278
16000	0	0.327	0.309	0.287	0.308	0.040	0.020	0.065
	20	0.310	0.283	0.282	0.292	0.028	0.016	0.054
	40	0.297	0.268	0.268	0.278	0.029	0.017	0.060
	60	0.291	0.258	0.258	0.269	0.033	0.019	0.071
	80	0.072	0.087	0.088	0.082	0.016	0.009	0.109
32000	0	0.358	0.326	0.264	0.316	0.094	0.048	0.151
	20	0.264	0.257	0.254	0.258	0.010	0.005	0.020
	40	0.241	0.239	0.233	0.238	0.008	0.004	0.018
	60	0.244	0.238	0.235	0.239	0.009	0.005	0.019
	80	0.089	0.111	0.131	0.110	0.042	0.021	0.190
64000	0	0.303	0.312	0.283	0.299	0.029	0.015	0.050
	20	0.259	0.246	0.240	0.248	0.019	0.010	0.039
	40	0.232	0.216	0.212	0.220	0.020	0.011	0.048
	60	0.242	0.220	0.215	0.226	0.027	0.014	0.064
	80	0.069	0.082	0.091	0.081	0.022	0.011	0.137
128000	0	0.204	0.214	0.204	0.207	0.010	0.006	0.028
	20	0.219	0.217	0.217	0.218	0.002	0.001	0.005
	40	0.223	0.220	0.218	0.220	0.005	0.003	0.011
	60	0.220	0.218	0.217	0.218	0.003	0.002	0.007
	80	0.064	0.102	0.117	0.094	0.053	0.027	0.290

Outliers

DFT plots (slab 10)
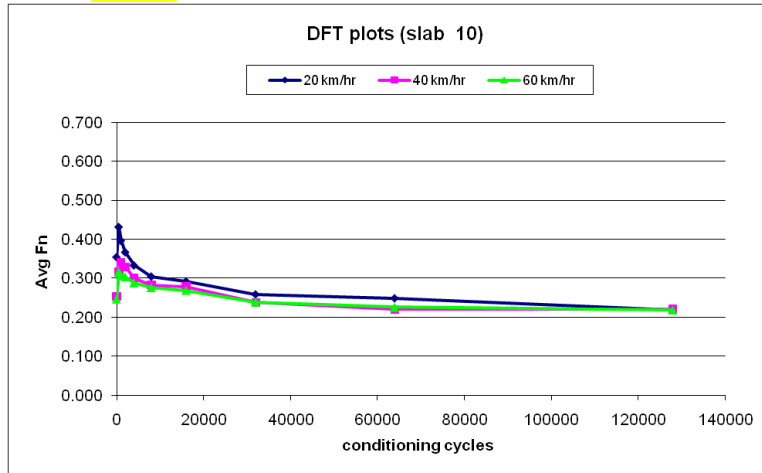
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	11	OLD	122#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	1.041	0.996	0.976	1.004	0.065	0.033	0.033
	20	0.661	0.541	0.536	0.539	0.005	0.004	0.007
	40	0.434	0.384	0.396	0.405	0.050	0.026	0.065
	60	0.409	0.381	0.389	0.393	0.028	0.014	0.037
	80	0.100	0.089	0.138	0.109	0.049	0.026	0.236
500	0	0.744	0.775	0.681	0.733	0.094	0.048	0.065
	20	0.478	0.450	0.447	0.458	0.031	0.017	0.037
	40	0.392	0.375	0.374	0.380	0.018	0.010	0.027
	60	0.367	0.355	0.351	0.358	0.016	0.008	0.023
	80	0.129	0.103	0.103	0.112	0.026	0.015	0.134
1000	0	0.638	0.560	0.616	0.605	0.078	0.040	0.067
	20	0.454	0.439	0.429	0.441	0.025	0.013	0.029
	40	0.426	0.412	0.400	0.413	0.026	0.013	0.032
	60	0.412	0.395	0.383	0.397	0.029	0.015	0.037
	80	0.103	0.147	0.121	0.124	0.044	0.022	0.179
2000	0	0.559	0.522	0.621	0.567	0.099	0.050	0.088
	20	0.414	0.397	0.396	0.402	0.018	0.010	0.025
	40	0.385	0.370	0.369	0.375	0.016	0.009	0.024
	60	0.382	0.356	0.357	0.365	0.026	0.015	0.040
	80	0.099	0.065	0.130	0.098	0.065	0.033	0.332
4000	0	0.489	0.466	0.522	0.492	0.056	0.028	0.057
	20	0.457	0.407	0.393	0.419	0.064	0.034	0.080
	40	0.444	0.385	0.380	0.403	0.064	0.036	0.088
	60	0.440	0.380	0.372	0.397	0.068	0.037	0.094
	80	0.162	0.127	0.117	0.135	0.045	0.024	0.175
8000	0	0.439	0.418	0.378	0.412	0.061	0.031	0.075
	20	0.364	0.354	0.347	0.355	0.017	0.009	0.024
	40	0.351	0.350	0.340	0.347	0.011	0.006	0.018
	60	0.360	0.348	0.339	0.349	0.021	0.011	0.030
	80	0.140	0.118	0.125	0.128	0.022	0.011	0.088
16000	0	0.417	0.338	0.329	0.361	0.088	0.048	0.134
	20	0.357	0.327	0.323	0.336	0.034	0.019	0.055
	40	0.353	0.319	0.315	0.329	0.038	0.021	0.063
	60	0.360	0.328	0.324	0.337	0.036	0.020	0.058
	80	0.063	0.103	0.130	0.099	0.067	0.034	0.342
32000	0	0.411	0.388	0.368	0.389	0.043	0.022	0.055
	20	0.310	0.302	0.293	0.302	0.017	0.009	0.028
	40	0.282	0.279	0.277	0.279	0.005	0.003	0.009
	60	0.290	0.286	0.284	0.287	0.006	0.003	0.011
	80	0.074	0.132	0.131	0.112	0.058	0.033	0.296
64000	0	0.287	0.258	0.284	0.276	0.029	0.016	0.058
	20	0.274	0.271	0.267	0.271	0.007	0.004	0.013
	40	0.272	0.270	0.266	0.269	0.006	0.003	0.011
	60	0.286	0.281	0.279	0.282	0.007	0.004	0.013
	80	0.135	0.115	0.074	0.108	0.061	0.031	0.288
128000	0	0.289	0.303	0.304	0.299	0.015	0.008	0.028
	20	0.276	0.273	0.271	0.273	0.005	0.003	0.009
	40	0.277	0.269	0.270	0.272	0.008	0.004	0.016
	60	0.288	0.284	0.284	0.285	0.004	0.002	0.008
	80	0.072	0.071	0.070	0.071	0.002	0.001	0.014

Outliers

DFT plots (slab 11)
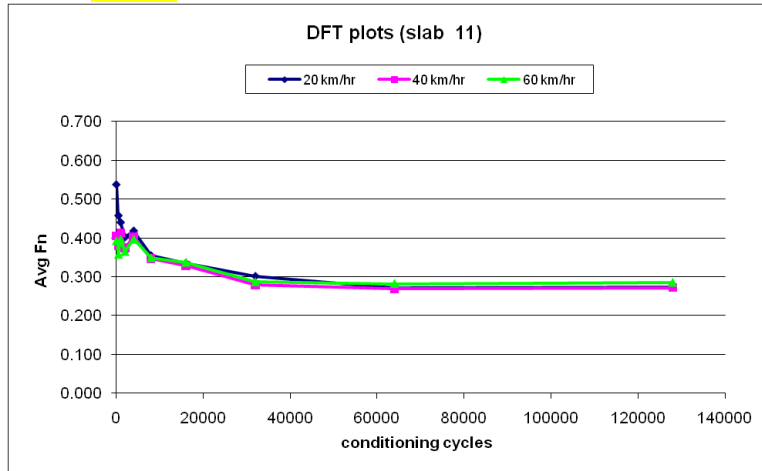
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	12	OLD	122#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.753	0.816	0.709	0.759	0.107	0.054	0.071
	20	0.386	0.324	0.314	0.341	0.072	0.039	0.114
	40	0.252	0.222	0.223	0.232	0.030	0.017	0.073
	60	0.260	0.232	0.227	0.240	0.033	0.018	0.074
	80	0.079	0.114	0.104	0.099	0.035	0.018	0.182
500	0	0.847	0.668	0.656	0.724	0.191	0.107	0.148
	20	0.415	0.404	0.387	0.402	0.028	0.014	0.035
	40	0.314	0.320	0.308	0.314	0.012	0.006	0.019
	60	0.298	0.292	0.288	0.293	0.010	0.005	0.017
	80	0.105	0.110	0.084	0.100	0.026	0.014	0.138
1000	0	0.607	0.536	0.653	0.599	0.117	0.059	0.098
	20	0.394	0.395	0.398	0.396	0.004	0.002	0.005
	40	0.345	0.345	0.346	0.345	0.001	0.001	0.002
	60	0.311	0.315	0.318	0.315	0.007	0.004	0.011
	80	0.087	0.108	0.077	0.091	0.031	0.016	0.175
2000	0	0.693	0.663	0.588	0.648	0.105	0.054	0.083
	20	0.429	0.404	0.396	0.410	0.033	0.017	0.042
	40	0.375	0.356	0.347	0.359	0.028	0.014	0.040
	60	0.342	0.324	0.314	0.327	0.028	0.014	0.043
	80	0.097	0.086	0.116	0.100	0.030	0.015	0.152
4000	0	0.582	0.518	0.533	0.544	0.064	0.033	0.061
	20	0.428	0.409	0.399	0.412	0.029	0.015	0.036
	40	0.375	0.358	0.351	0.361	0.024	0.012	0.034
	60	0.351	0.339	0.326	0.339	0.025	0.013	0.037
	80	0.092	0.094	0.103	0.096	0.011	0.006	0.061
8000	0	0.456	0.443	0.436	0.445	0.020	0.010	0.023
	20	0.347	0.329	0.323	0.333	0.024	0.012	0.038
	40	0.317	0.299	0.296	0.304	0.021	0.011	0.037
	60	0.306	0.281	0.279	0.289	0.027	0.015	0.052
	80	0.096	0.086	0.056	0.079	0.040	0.021	0.262
16000	0	0.406	0.344	0.336	0.362	0.070	0.038	0.106
	20	0.305	0.296	0.288	0.296	0.017	0.009	0.029
	40	0.295	0.285	0.278	0.286	0.017	0.009	0.030
	60	0.284	0.280	0.275	0.280	0.009	0.005	0.016
	80	0.080	0.111	0.093	0.095	0.031	0.016	0.164
32000	0	0.352	0.317	0.299	0.323	0.053	0.027	0.084
	20	0.281	0.270	0.264	0.272	0.017	0.009	0.032
	40	0.256	0.251	0.247	0.251	0.009	0.005	0.018
	60	0.262	0.258	0.251	0.257	0.011	0.006	0.022
	80	0.113	0.125	0.099	0.112	0.026	0.013	0.116
64000	0	0.286	0.249	0.249	0.261	0.037	0.021	0.082
	20	0.267	0.266	0.264	0.266	0.003	0.002	0.006
	40	0.262	0.260	0.262	0.261	0.002	0.001	0.004
	60	0.275	0.272	0.268	0.272	0.007	0.004	0.013
	80	0.123	0.110	0.110	0.114	0.013	0.008	0.066
128000	0	0.240	0.225	0.205	0.223	0.035	0.018	0.079
	20	0.253	0.246	0.236	0.245	0.017	0.009	0.035
	40	0.249	0.242	0.234	0.242	0.015	0.008	0.031
	60	0.252	0.245	0.236	0.244	0.016	0.008	0.033
	80	0.069	0.056	0.071	0.065	0.015	0.008	0.125

Outliers

DFT plots (slab 12)

— 20 km/hr   — 40 km/hr   — 60 km/hr
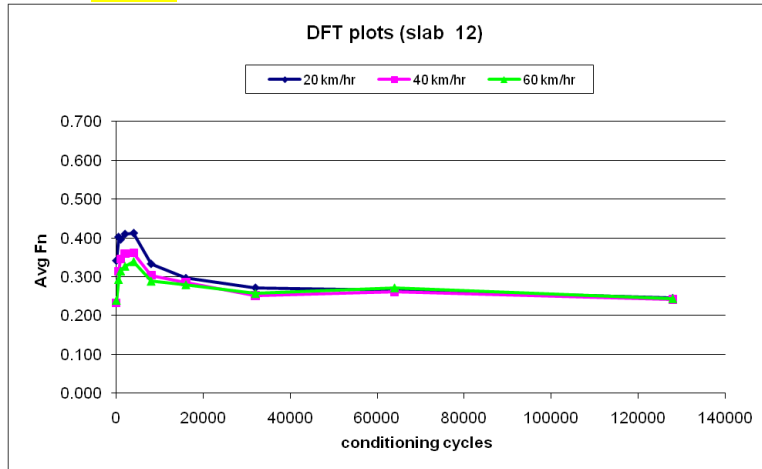
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	13	NEW	95#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.703	0.652	0.728	0.694	0.076	0.039	0.056
	20	0.329	0.288	0.286	0.301	0.043	0.024	0.081
	40	0.290	0.250	0.247	0.262	0.043	0.024	0.092
	60	0.307	0.270	0.267	0.281	0.040	0.022	0.079
	80	0.085	0.059	0.026	0.057	0.059	0.030	0.522
500	0	0.718	0.705	0.606	0.676	0.112	0.061	0.091
	20	0.379	0.364	0.349	0.364	0.030	0.015	0.041
	40	0.313	0.301	0.292	0.302	0.021	0.011	0.035
	60	0.308	0.296	0.284	0.296	0.024	0.012	0.041
	80	0.092	0.122	0.130	0.115	0.038	0.020	0.175
1000	0	0.586	0.574	0.518	0.559	0.068	0.036	0.065
	20	0.418	0.425	0.425	0.423	0.007	0.004	0.010
	40	0.371	0.372	0.374	0.372	0.003	0.002	0.004
	60	0.348	0.358	0.360	0.355	0.012	0.006	0.018
	80	0.053	0.116	0.116	0.095	0.063	0.036	0.383
2000	0	0.649	0.517	0.613	0.593	0.132	0.068	0.115
	20	0.427	0.405	0.394	0.409	0.033	0.017	0.041
	40	0.380	0.354	0.348	0.361	0.032	0.017	0.047
	60	0.372	0.348	0.337	0.352	0.035	0.018	0.051
	80	0.123	0.078	0.064	0.088	0.059	0.031	0.349
4000	0	0.486	0.446	0.502	0.478	0.056	0.029	0.060
	20	0.408	0.372	0.369	0.383	0.039	0.022	0.057
	40	0.357	0.329	0.321	0.336	0.036	0.019	0.056
	60	0.365	0.329	0.327	0.340	0.038	0.021	0.063
	80	0.128	0.088	0.080	0.099	0.048	0.026	0.261
8000	0	0.473	0.442	0.449	0.455	0.031	0.016	0.036
	20	0.368	0.352	0.342	0.354	0.026	0.013	0.037
	40	0.352	0.337	0.320	0.336	0.032	0.016	0.048
	60	0.348	0.327	0.317	0.331	0.031	0.016	0.048
	80	0.130	0.108	0.122	0.120	0.022	0.011	0.093
16000	0	0.429	0.446	0.384	0.420	0.062	0.032	0.076
	20	0.348	0.334	0.370	0.351	0.036	0.018	0.052
	40	0.332	0.307	0.301	0.313	0.031	0.016	0.052
	60	0.345	0.328	0.321	0.331	0.024	0.012	0.037
	80	0.099	0.097	0.107	0.101	0.010	0.005	0.052
32000	0	0.388	0.353	0.358	0.366	0.035	0.019	0.052
	20	0.341	0.319	0.309	0.323	0.032	0.016	0.051
	40	0.323	0.302	0.294	0.306	0.029	0.015	0.049
	60	0.350	0.330	0.318	0.333	0.032	0.016	0.049
	80	0.114	0.110	0.117	0.114	0.007	0.004	0.031
64000	0	0.431	0.372	0.403	0.402	0.059	0.030	0.073
	20	0.304	0.292	0.283	0.293	0.021	0.011	0.036
	40	0.262	0.260	0.252	0.258	0.010	0.005	0.021
	60	0.286	0.277	0.276	0.280	0.010	0.006	0.020
	80	0.075	0.127	0.085	0.096	0.052	0.028	0.288
128000	0	0.288	0.300	0.259	0.282	0.041	0.021	0.075
	20	0.277	0.269	0.268	0.271	0.009	0.005	0.018
	40	0.268	0.263	0.264	0.265	0.005	0.003	0.010
	60	0.296	0.292	0.292	0.293	0.004	0.002	0.008
	80	0.137	0.108	0.108	0.118	0.029	0.017	0.142
Outliers								

DFT plots (slab 13)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles

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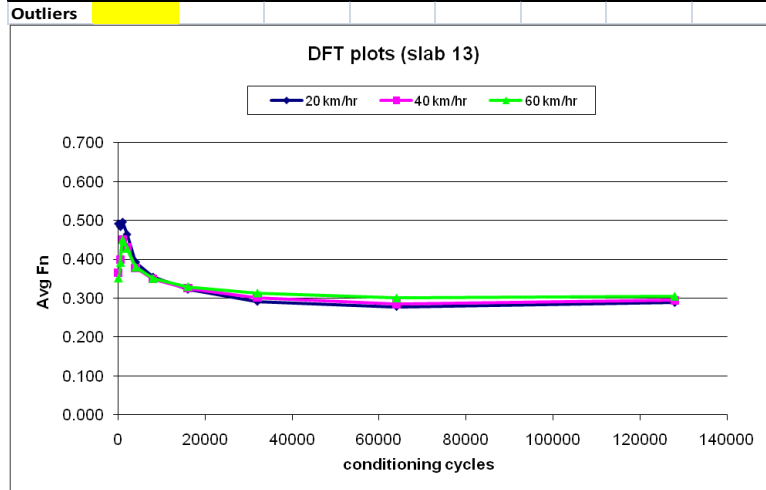
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	14	NEW	95#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.745	0.727	0.771	0.748	0.044	0.022	0.030
	20	0.414	0.355	0.343	0.371	0.071	0.038	0.103
	40	0.266	0.239	0.233	0.246	0.033	0.018	0.071
	60	0.269	0.244	0.238	0.250	0.031	0.016	0.066
	80	0.132	0.116	0.109	0.119	0.023	0.012	0.099
500	0	0.754	0.648	0.719	0.707	0.106	0.054	0.076
	20	0.400	0.348	0.333	0.360	0.067	0.035	0.098
	40	0.311	0.280	0.269	0.287	0.042	0.022	0.076
	60	0.309	0.273	0.267	0.283	0.042	0.023	0.080
	80	0.104	0.095	0.102	0.100	0.009	0.005	0.047
1000	0	0.631	0.691	0.727	0.683	0.096	0.048	0.071
	20	0.461	0.428	0.408	0.432	0.053	0.027	0.062
	40	0.385	0.355	0.341	0.360	0.044	0.022	0.062
	60	0.370	0.335	0.325	0.343	0.045	0.024	0.069
	80	0.164	0.106	0.105	0.125	0.059	0.034	0.270
2000	0	0.692	0.674	0.568	0.645	0.124	0.067	0.104
	20	0.476	0.448	0.431	0.452	0.045	0.023	0.050
	40	0.407	0.375	0.353	0.378	0.054	0.027	0.072
	60	0.378	0.350	0.340	0.356	0.038	0.020	0.055
	80	0.123	0.095	0.066	0.095	0.057	0.029	0.301
4000	0	0.693	0.686	0.572	0.650	0.121	0.068	0.104
	20	0.432	0.415	0.403	0.417	0.029	0.015	0.035
	40	0.370	0.353	0.344	0.356	0.026	0.013	0.037
	60	0.356	0.339	0.329	0.341	0.027	0.014	0.040
	80	0.112	0.113	0.131	0.119	0.019	0.011	0.090
8000	0	0.441	0.539	0.478	0.486	0.098	0.049	0.102
	20	0.408	0.401	0.394	0.401	0.014	0.007	0.017
	40	0.359	0.354	0.344	0.352	0.015	0.008	0.022
	60	0.346	0.346	0.338	0.343	0.008	0.005	0.013
	80	0.126	0.095	0.105	0.109	0.031	0.016	0.146
16000	0	0.452	0.407	0.424	0.428	0.045	0.023	0.053
	20	0.383	0.362	0.358	0.368	0.025	0.013	0.037
	40	0.358	0.340	0.336	0.345	0.022	0.012	0.034
	60	0.346	0.332	0.331	0.336	0.015	0.008	0.025
	80	0.151	0.084	0.120	0.118	0.067	0.034	0.283
32000	0	0.391	0.319	0.368	0.359	0.072	0.037	0.102
	20	0.345	0.323	0.313	0.327	0.032	0.016	0.050
	40	0.328	0.299	0.288	0.305	0.040	0.021	0.068
	60	0.336	0.313	0.304	0.318	0.032	0.017	0.052
	80	0.122	0.104	0.100	0.109	0.022	0.012	0.108
64000	0	0.359	0.311	0.334	0.335	0.048	0.024	0.072
	20	0.290	0.288	0.285	0.288	0.005	0.003	0.009
	40	0.270	0.271	0.271	0.271	0.001	0.001	0.002
	60	0.284	0.285	0.284	0.284	0.001	0.001	0.002
	80	0.058	0.072	0.086	0.072	0.028	0.014	0.194
128000	0	0.263	0.289	0.276	0.276	0.026	0.013	0.047
	20	0.280	0.277	0.270	0.276	0.010	0.005	0.019
	40	0.273	0.268	0.265	0.269	0.008	0.004	0.015
	60	0.290	0.293	0.286	0.290	0.007	0.004	0.012
	80	0.103	0.108	0.115	0.109	0.012	0.006	0.055

Outliers

DFT plots (slab 14)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles
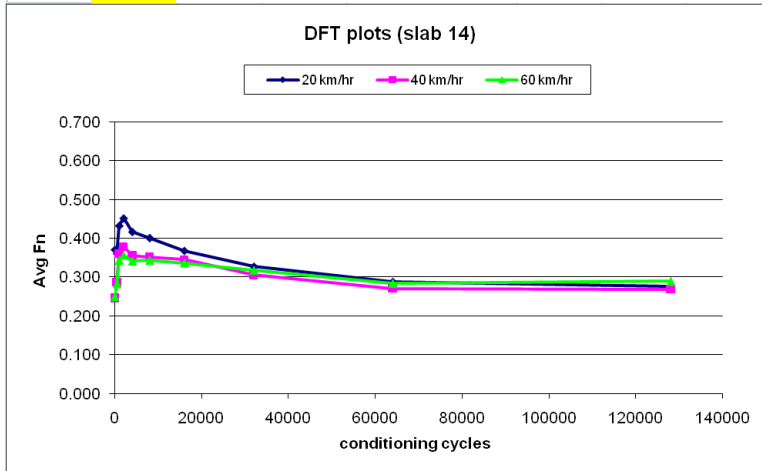
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	15	NEW	95#	40 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.733	0.776	0.722	0.744	0.054	0.029	0.038
	20	0.338	0.354	0.354	0.349	0.016	0.009	0.026
	40	0.249	0.257	0.258	0.255	0.009	0.005	0.019
	60	0.259	0.265	0.261	0.262	0.006	0.003	0.012
	80	0.127	0.078	0.099	0.101	0.049	0.025	0.243
500	0	0.767	0.702	0.706	0.725	0.065	0.036	0.050
	20	0.383	0.363	0.352	0.366	0.031	0.016	0.043
	40	0.309	0.298	0.292	0.300	0.017	0.009	0.029
	60	0.287	0.280	0.276	0.281	0.011	0.006	0.020
	80	0.124	0.111	0.076	0.104	0.048	0.025	0.239
1000	0	0.694	0.656	0.671	0.674	0.038	0.019	0.028
	20	0.440	0.416	0.405	0.420	0.035	0.018	0.043
	40	0.371	0.357	0.346	0.358	0.025	0.013	0.035
	60	0.349	0.333	0.323	0.335	0.026	0.013	0.039
	80	0.114	0.105	0.111	0.110	0.009	0.005	0.042
2000	0	0.593	0.578	0.554	0.575	0.039	0.020	0.034
	20	0.438	0.415	0.404	0.419	0.034	0.017	0.041
	40	0.375	0.353	0.348	0.359	0.027	0.014	0.040
	60	0.359	0.342	0.334	0.345	0.025	0.013	0.037
	80	0.098	0.101	0.122	0.107	0.024	0.013	0.122
4000	0	0.552	0.590	0.504	0.549	0.086	0.043	0.079
	20	0.400	0.374	0.363	0.379	0.037	0.019	0.050
	40	0.351	0.327	0.318	0.332	0.033	0.017	0.051
	60	0.339	0.318	0.307	0.321	0.032	0.016	0.051
	80	0.057	0.102	0.146	0.102	0.089	0.045	0.438
8000	0	0.458	0.474	0.437	0.456	0.037	0.019	0.041
	20	0.354	0.353	0.344	0.350	0.010	0.006	0.016
	40	0.318	0.314	0.303	0.312	0.015	0.008	0.025
	60	0.317	0.314	0.307	0.313	0.010	0.005	0.016
	80	0.088	0.115	0.091	0.098	0.027	0.015	0.151
16000	0	0.388	0.362	0.343	0.364	0.045	0.023	0.062
	20	0.322	0.311	0.305	0.313	0.017	0.009	0.028
	40	0.306	0.298	0.287	0.297	0.019	0.010	0.032
	60	0.310	0.300	0.292	0.301	0.018	0.009	0.030
	80	0.093	0.048	0.055	0.065	0.045	0.024	0.371
32000	0	0.303	0.297	0.308	0.303	0.011	0.006	0.018
	20	0.301	0.282	0.286	0.290	0.019	0.010	0.035
	40	0.288	0.270	0.270	0.276	0.018	0.010	0.038
	60	0.294	0.274	0.280	0.283	0.020	0.010	0.036
	80	0.094	0.110	0.101	0.102	0.016	0.008	0.079
64000	0	0.452	0.392	0.364	0.403	0.088	0.045	0.112
	20	0.313	0.297	0.290	0.300	0.023	0.012	0.039
	40	0.297	0.285	0.276	0.286	0.021	0.011	0.037
	60	0.295	0.291	0.287	0.291	0.008	0.004	0.014
	80	0.086	0.103	0.069	0.086	0.034	0.017	0.198
128000	0	0.460	0.434	0.334	0.409	0.126	0.067	0.163
	20	0.297	0.286	0.273	0.285	0.024	0.012	0.042
	40	0.268	0.266	0.258	0.264	0.010	0.005	0.020
	60	0.273	0.271	0.266	0.270	0.007	0.004	0.013
	80	0.103	0.083	0.014	0.067	0.089	0.047	0.700
Outliers								

DFT plots (slab 15)
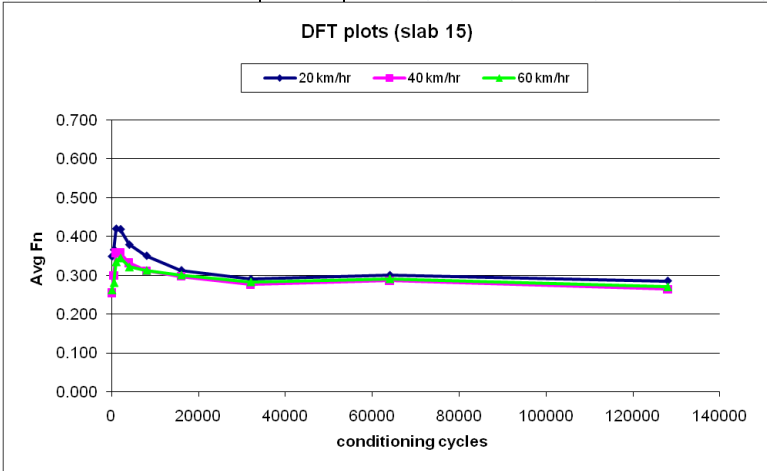
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	16	NEW	95#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.716	0.707	0.777	0.733	0.070	0.038	0.052
	20	0.279	0.300	0.282	0.287	0.021	0.011	0.040
	40	0.204	0.215	0.209	0.209	0.011	0.006	0.026
	60	0.207	0.215	0.207	0.210	0.008	0.005	0.022
	80	0.120	0.083	0.117	0.107	0.037	0.021	0.193
500	0	0.677	0.661	0.568	0.635	0.109	0.059	0.093
	20	0.374	0.357	0.348	0.360	0.026	0.013	0.037
	40	0.304	0.295	0.289	0.296	0.015	0.008	0.026
	60	0.295	0.283	0.279	0.286	0.016	0.008	0.029
	80	0.138	0.087	0.124	0.116	0.051	0.026	0.227
1000	0	0.661	0.511	0.632	0.601	0.150	0.080	0.132
	20	0.446	0.420	0.410	0.425	0.036	0.019	0.044
	40	0.391	0.369	0.356	0.372	0.035	0.018	0.048
	60	0.382	0.350	0.339	0.357	0.043	0.022	0.063
	80	0.125	0.105	0.104	0.111	0.021	0.012	0.106
2000	0	0.697	0.655	0.568	0.640	0.129	0.066	0.103
	20	0.420	0.389	0.383	0.397	0.037	0.020	0.050
	40	0.357	0.330	0.327	0.338	0.030	0.017	0.049
	60	0.343	0.315	0.314	0.324	0.029	0.016	0.051
	80	0.137	0.131	0.048	0.105	0.089	0.050	0.472
4000	0	0.599	0.557	0.552	0.569	0.047	0.026	0.045
	20	0.391	0.373	0.362	0.375	0.029	0.015	0.039
	40	0.342	0.326	0.317	0.328	0.025	0.013	0.039
	60	0.331	0.310	0.306	0.316	0.025	0.013	0.043
	80	0.104	0.107	0.123	0.111	0.019	0.010	0.092
8000	0	0.436	0.431	0.454	0.440	0.023	0.012	0.027
	20	0.375	0.360	0.353	0.363	0.022	0.011	0.031
	40	0.349	0.328	0.323	0.333	0.026	0.014	0.041
	60	0.337	0.318	0.311	0.322	0.026	0.013	0.042
	80	0.083	0.126	0.132	0.114	0.049	0.027	0.235
16000	0	0.571	0.394	0.423	0.463	0.177	0.095	0.205
	20	0.345	0.336	0.331	0.337	0.014	0.007	0.021
	40	0.331	0.312	0.311	0.318	0.020	0.011	0.035
	60	0.324	0.307	0.305	0.312	0.019	0.010	0.033
	80	0.049	0.135	0.108	0.097	0.086	0.044	0.452
32000	0	0.424	0.411	0.459	0.431	0.048	0.025	0.058
	20	0.325	0.313	0.303	0.314	0.022	0.011	0.035
	40	0.299	0.294	0.283	0.292	0.016	0.008	0.028
	60	0.307	0.295	0.290	0.297	0.017	0.009	0.029
	80	0.092	0.116	0.088	0.099	0.028	0.015	0.153
64000	0	0.419	0.375	0.409	0.401	0.044	0.023	0.058
	20	0.286	0.279	0.272	0.279	0.014	0.007	0.025
	40	0.267	0.261	0.251	0.260	0.016	0.008	0.031
	60	0.276	0.272	0.262	0.270	0.014	0.007	0.027
	80	0.131	0.095	0.061	0.096	0.070	0.035	0.366
128000	0	0.251	0.281	0.248	0.260	0.033	0.018	0.070
	20	0.256	0.254	0.248	0.253	0.008	0.004	0.016
	40	0.249	0.244	0.239	0.244	0.010	0.005	0.020
	60	0.277	0.273	0.264	0.271	0.013	0.007	0.025
	80	0.098	0.107	0.080	0.095	0.027	0.014	0.145

Outliers

DFT plots (slab 16)
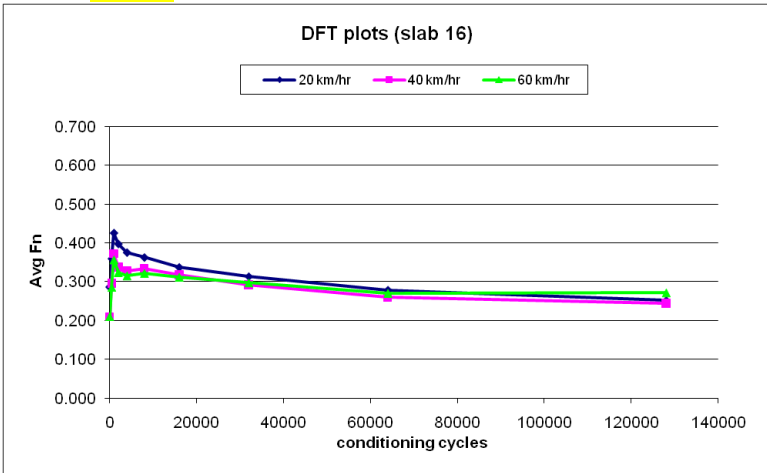
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	17	NEW	95#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.736	0.872	0.811	0.806	0.136	0.068	0.084
	20	0.448	0.376	0.361	0.395	0.087	0.047	0.118
	40	0.334	0.281	0.270	0.295	0.064	0.034	0.116
	60	0.338	0.284	0.280	0.301	0.058	0.032	0.108
	80	0.084	0.102	0.110	0.099	0.026	0.013	0.135
500	0	0.687	0.609	0.740	0.679	0.131	0.066	0.097
	20	0.487	0.454	0.436	0.459	0.051	0.026	0.056
	40	0.411	0.384	0.374	0.390	0.037	0.019	0.049
	60	0.398	0.362	0.352	0.371	0.046	0.024	0.065
	80	0.090	0.111	0.061	0.087	0.050	0.025	0.287
1000	0	0.648	0.606	0.614	0.623	0.042	0.022	0.036
	20	0.491	0.475	0.462	0.476	0.029	0.015	0.031
	40	0.428	0.413	0.408	0.416	0.020	0.010	0.025
	60	0.400	0.395	0.389	0.395	0.011	0.006	0.014
	80	0.184	0.107	0.132	0.141	0.077	0.039	0.279
2000	0	0.601	0.593	0.622	0.605	0.029	0.015	0.025
	20	0.439	0.423	0.410	0.424	0.029	0.015	0.034
	40	0.388	0.373	0.365	0.375	0.023	0.012	0.031
	60	0.376	0.351	0.343	0.357	0.033	0.017	0.048
	80	0.119	0.101	0.062	0.094	0.057	0.029	0.310
4000	0	0.492	0.454	0.467	0.471	0.038	0.019	0.041
	20	0.382	0.388	0.384	0.385	0.006	0.003	0.008
	40	0.337	0.338	0.341	0.339	0.004	0.002	0.006
	60	0.323	0.330	0.327	0.327	0.007	0.004	0.011
	80	0.120	0.111	0.086	0.106	0.034	0.018	0.167
8000	0	0.441	0.438	0.454	0.444	0.016	0.009	0.019
	20	0.390	0.372	0.364	0.375	0.026	0.013	0.035
	40	0.355	0.339	0.333	0.342	0.022	0.011	0.033
	60	0.346	0.332	0.327	0.335	0.019	0.010	0.029
	80	0.102	0.095	0.112	0.103	0.017	0.009	0.083
16000	0	0.398	0.364	0.349	0.370	0.049	0.025	0.068
	20	0.348	0.336	0.332	0.339	0.016	0.008	0.025
	40	0.327	0.308	0.307	0.314	0.020	0.011	0.036
	60	0.331	0.317	0.310	0.319	0.021	0.011	0.033
	80	0.098	0.101	0.113	0.104	0.015	0.008	0.076
32000	0	0.348	0.353	0.339	0.347	0.014	0.007	0.020
	20	0.304	0.293	0.293	0.297	0.011	0.006	0.021
	40	0.294	0.288	0.282	0.288	0.012	0.006	0.021
	60	0.296	0.289	0.286	0.290	0.010	0.005	0.018
	80	0.110	0.072	0.117	0.100	0.045	0.024	0.243
64000	0	0.338	0.323	0.318	0.326	0.020	0.010	0.032
	20	0.286	0.279	0.276	0.280	0.010	0.005	0.018
	40	0.266	0.263	0.258	0.262	0.008	0.004	0.015
	60	0.280	0.275	0.275	0.277	0.005	0.003	0.010
	80	0.136	0.095	0.112	0.114	0.041	0.021	0.180
128000	0	0.404	0.363	0.368	0.378	0.041	0.022	0.059
	20	0.280	0.273	0.266	0.273	0.014	0.007	0.026
	40	0.251	0.252	0.248	0.250	0.004	0.002	0.008
	60	0.259	0.255	0.246	0.253	0.013	0.007	0.026
	80	0.116	0.107	0.093	0.105	0.023	0.012	0.110

Outliers

DFT plots (slab 17)

130
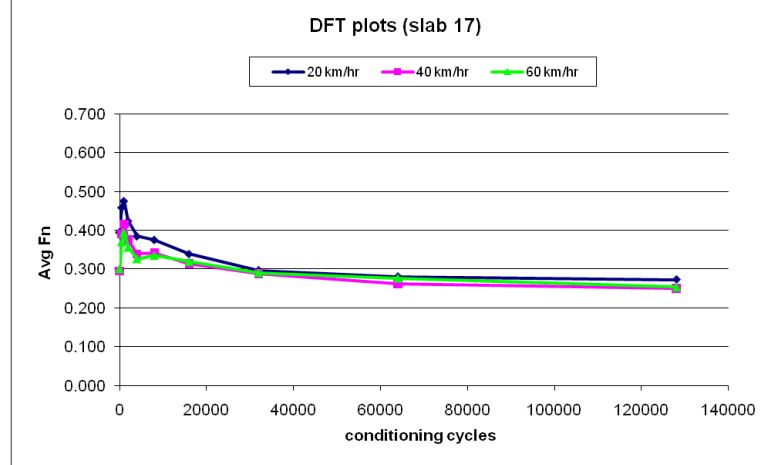
Phase	Mix	Slab#	Polisher	Load	Speed			
1	AL soft	18	NEW	95#	60 rpm			
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	COV
0	0	0.731	0.839	0.818	0.796	0.108	0.057	0.072
	20	0.447	0.387	0.367	0.400	0.080	0.042	0.104
	40	0.303	0.271	0.269	0.281	0.034	0.019	0.068
	60	0.282	0.262	0.260	0.268	0.022	0.012	0.045
	80	0.096	0.126	0.131	0.118	0.035	0.019	0.161
500	0	0.807	0.717	0.689	0.738	0.118	0.062	0.084
	20	0.419	0.380	0.370	0.390	0.049	0.026	0.066
	40	0.329	0.317	0.306	0.317	0.023	0.012	0.036
	60	0.315	0.293	0.287	0.298	0.028	0.015	0.049
	80	0.136	0.113	0.107	0.119	0.029	0.015	0.129
1000	0	0.671	0.661	0.649	0.660	0.022	0.011	0.017
	20	0.448	0.426	0.416	0.430	0.032	0.016	0.038
	40	0.382	0.362	0.356	0.367	0.026	0.014	0.037
	60	0.350	0.336	0.330	0.339	0.020	0.010	0.030
	80	0.078	0.081	0.069	0.076	0.012	0.006	0.082
2000	0	0.624	0.631	0.528	0.594	0.103	0.058	0.097
	20	0.431	0.405	0.397	0.411	0.034	0.018	0.043
	40	0.373	0.348	0.347	0.356	0.026	0.015	0.041
	60	0.349	0.332	0.327	0.336	0.022	0.012	0.034
	80	0.079	0.090	0.101	0.090	0.022	0.011	0.122
4000	0	0.607	0.567	0.527	0.567	0.080	0.040	0.071
	20	0.397	0.379	0.372	0.383	0.025	0.013	0.034
	40	0.349	0.343	0.332	0.341	0.017	0.009	0.025
	60	0.342	0.323	0.315	0.327	0.027	0.014	0.042
	80	0.092	0.087	0.082	0.087	0.010	0.005	0.057
8000	0	0.438	0.479	0.419	0.445	0.060	0.031	0.069
	20	0.350	0.346	0.342	0.346	0.008	0.004	0.012
	40	0.323	0.321	0.319	0.321	0.004	0.002	0.006
	60	0.321	0.316	0.314	0.317	0.007	0.004	0.011
	80	0.098	0.092	0.117	0.102	0.025	0.013	0.128
16000	0	0.403	0.389	0.379	0.390	0.024	0.012	0.031
	20	0.336	0.328	0.320	0.328	0.016	0.008	0.024
	40	0.321	0.309	0.301	0.310	0.020	0.010	0.032
	60	0.315	0.304	0.299	0.306	0.016	0.008	0.027
	80	0.136	0.090	0.094	0.107	0.046	0.025	0.239
32000	0	0.371	0.374	0.349	0.365	0.025	0.014	0.037
	20	0.298	0.287	0.286	0.290	0.012	0.007	0.023
	40	0.281	0.275	0.275	0.277	0.006	0.003	0.013
	60	0.287	0.277	0.280	0.281	0.010	0.005	0.018
	80	0.107	0.101	0.117	0.108	0.016	0.008	0.075
64000	0	0.314	0.310	0.337	0.320	0.027	0.015	0.045
	20	0.296	0.280	0.283	0.286	0.016	0.009	0.030
	40	0.286	0.276	0.277	0.280	0.010	0.006	0.020
	60	0.293	0.283	0.281	0.286	0.012	0.006	0.023
	80	0.102	0.118	0.085	0.102	0.033	0.017	0.162
128000	0	0.263	0.258	0.263	0.261	0.005	0.003	0.011
	20	0.258	0.254	0.254	0.255	0.004	0.002	0.009
	40	0.266	0.260	0.253	0.260	0.013	0.007	0.025
	60	0.278	0.276	0.272	0.275	0.006	0.003	0.011
	80	0.093	0.113	0.133	0.113	0.040	0.020	0.177

Outliers

DFT plots (slab 18)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles

131
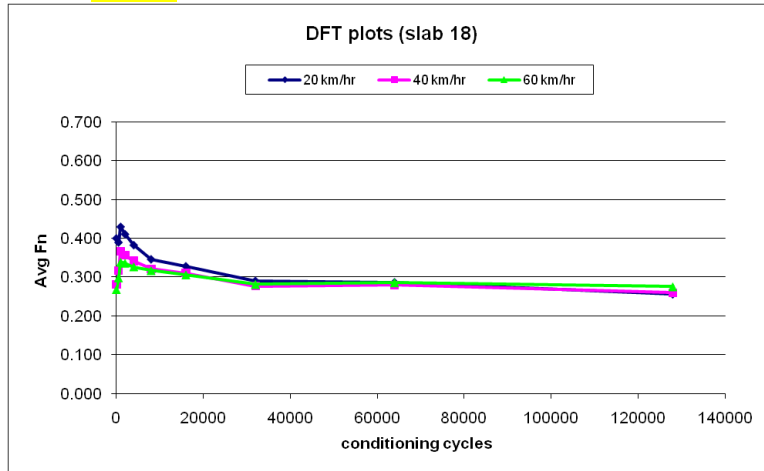
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	1	1	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.779	0.859	0.872	0.837	0.093	0.050	0.060
	20	0.424	0.379	0.367	0.390	0.057	0.030	0.077
	40	0.349	0.309	0.303	0.320	0.046	0.025	0.078
	60	0.339	0.292	0.292	0.308	0.047	0.027	0.088
	80	0.062	0.062	0.121	0.082	0.059	0.034	0.417
500	0	0.706	0.691	0.692	0.696	0.015	0.008	0.012
	20	0.540	0.524	0.519	0.528	0.021	0.011	0.021
	40	0.522	0.504	0.498	0.508	0.024	0.012	0.025
	60	0.470	0.454	0.450	0.458	0.020	0.011	0.023
	80	0.108	0.098	0.060	0.089	0.048	0.025	0.286
1000	0	0.672	0.575	0.601	0.616	0.097	0.050	0.082
	20	0.537	0.524	0.517	0.526	0.020	0.010	0.019
	40	0.524	0.517	0.512	0.518	0.012	0.006	0.012
	60	0.493	0.480	0.471	0.481	0.022	0.011	0.023
	80	0.084	0.102	0.164	0.117	0.080	0.042	0.360
2000	0	0.713	0.657	0.680	0.683	0.056	0.028	0.041
	20	0.494	0.526	0.524	0.515	0.032	0.018	0.035
	40	0.467	0.504	0.508	0.493	0.041	0.023	0.046
	60	0.430	0.460	0.460	0.450	0.030	0.017	0.038
	80	0.086	0.129	0.048	0.088	0.081	0.041	0.462
4000	0	0.625	0.565	0.599	0.596	0.060	0.030	0.050
	20	0.531	0.507	0.500	0.513	0.031	0.016	0.032
	40	0.517	0.509	0.506	0.511	0.011	0.006	0.011
	60	0.489	0.483	0.478	0.483	0.011	0.006	0.011
	80	0.093	0.111	0.098	0.101	0.018	0.009	0.092
8000	0	0.535	0.611	0.582	0.576	0.076	0.038	0.067
	20	0.528	0.510	0.503	0.514	0.025	0.013	0.025
	40	0.523	0.524	0.510	0.519	0.014	0.008	0.015
	60	0.491	0.479	0.477	0.482	0.014	0.008	0.016
	80	0.110	0.094	0.114	0.106	0.020	0.011	0.100
16000	0	0.564	0.589	0.551	0.568	0.038	0.019	0.034
	20	0.502	0.497	0.495	0.498	0.007	0.004	0.007
	40	0.497	0.497	0.490	0.495	0.007	0.004	0.008
	60	0.474	0.469	0.469	0.471	0.005	0.003	0.006
	80	0.000	0.111	0.090	0.067	0.111	0.059	0.880
32000	0	0.568	0.543	0.553	0.555	0.025	0.013	0.023
	20	0.525	0.515	0.505	0.515	0.020	0.010	0.019
	40	0.516	0.510	0.499	0.508	0.017	0.009	0.017
	60	0.487	0.477	0.464	0.476	0.023	0.012	0.024
	80	0.208	0.129	0.038	0.125	0.170	0.085	0.681
64000	0	0.482	0.488	0.455	0.475	0.033	0.018	0.037
	20	0.504	0.493	0.488	0.495	0.016	0.008	0.017
	40	0.478	0.469	0.463	0.470	0.015	0.008	0.016
	60	0.449	0.440	0.433	0.441	0.016	0.008	0.018
	80	0.088	0.165	0.061	0.105	0.104	0.054	0.516
100000	0	0.472	0.462	0.452	0.462	0.020	0.010	0.022
	20	0.484	0.480	0.471	0.478	0.013	0.007	0.014
	40	0.467	0.469	0.460	0.465	0.009	0.005	0.010
	60	0.447	0.443	0.432	0.441	0.015	0.008	0.018
	80	0.125	0.044	0.166	0.112	0.122	0.062	0.556
Outliers								

DFT plots (slab 1)
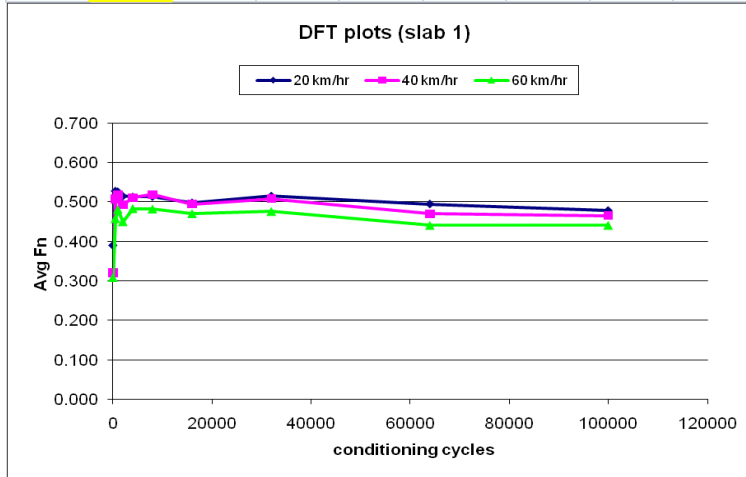
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	1	2	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.689	0.767	0.744	0.733	0.078	0.040	0.055
	20	0.374	0.325	0.331	0.343	0.049	0.027	0.078
	40	0.308	0.282	0.291	0.294	0.026	0.013	0.045
	60	0.310	0.285	0.290	0.295	0.025	0.013	0.045
	80	0.085	0.113	0.118	0.105	0.033	0.018	0.169
500	0	0.716	0.691	0.620	0.676	0.096	0.050	0.074
	20	0.623	0.609	0.595	0.609	0.028	0.014	0.023
	40	0.599	0.586	0.569	0.585	0.030	0.015	0.026
	60	0.539	0.525	0.513	0.526	0.026	0.013	0.025
	80	0.106	0.135	0.081	0.107	0.054	0.027	0.252
1000	0	0.657	0.655	0.632	0.648	0.025	0.014	0.021
	20	0.571	0.557	0.561	0.563	0.014	0.007	0.013
	40	0.547	0.537	0.533	0.539	0.014	0.007	0.013
	60	0.502	0.493	0.491	0.495	0.011	0.006	0.012
	80	0.104	0.093	0.119	0.105	0.026	0.013	0.124
2000	0	0.752	0.674	0.539	0.655	0.213	0.108	0.165
	20	0.532	0.520	0.517	0.523	0.015	0.008	0.015
	40	0.517	0.499	0.504	0.507	0.018	0.009	0.018
	60	0.496	0.471	0.469	0.479	0.027	0.015	0.031
	80	0.000	0.180	0.114	0.098	0.180	0.091	0.929
4000	0	0.551	0.637	0.612	0.600	0.086	0.044	0.074
	20	0.564	0.550	0.541	0.552	0.023	0.012	0.021
	40	0.568	0.556	0.546	0.557	0.022	0.011	0.020
	60	0.537	0.530	0.519	0.529	0.018	0.009	0.017
	80	0.104	0.136	0.071	0.104	0.065	0.033	0.314
8000	0	0.579	0.628	0.541	0.583	0.087	0.044	0.075
	20	0.567	0.557	0.551	0.558	0.016	0.008	0.014
	40	0.575	0.566	0.550	0.564	0.025	0.013	0.022
	60	0.551	0.534	0.530	0.538	0.021	0.011	0.021
	80	0.130	0.109	0.083	0.107	0.047	0.024	0.219
16000	0	0.603	0.556	0.514	0.558	0.089	0.045	0.080
	20	0.542	0.541	0.533	0.539	0.009	0.005	0.009
	40	0.547	0.546	0.533	0.542	0.014	0.008	0.014
	60	0.535	0.527	0.517	0.526	0.018	0.009	0.017
	80	0.140	0.115	0.115	0.123	0.025	0.014	0.117
32000	0	0.513	0.493	0.469	0.492	0.044	0.022	0.045
	20	0.505	0.495	0.491	0.497	0.014	0.007	0.015
	40	0.507	0.504	0.501	0.504	0.006	0.003	0.006
	60	0.486	0.480	0.476	0.481	0.010	0.005	0.010
	80	0.115	0.133	0.149	0.132	0.034	0.017	0.129
64000	0	0.483	0.446	0.458	0.462	0.037	0.019	0.041
	20	0.447	0.454	0.456	0.452	0.009	0.005	0.010
	40	0.401	0.415	0.426	0.414	0.025	0.013	0.030
	60	0.397	0.410	0.412	0.406	0.015	0.008	0.020
	80	0.096	0.096	0.109	0.100	0.013	0.008	0.075
100000	0	0.537	0.473	0.454	0.488	0.083	0.043	0.089
	20	0.412	0.423	0.430	0.422	0.018	0.009	0.022
	40	0.385	0.389	0.399	0.391	0.014	0.007	0.018
	60	0.369	0.378	0.386	0.378	0.017	0.009	0.023
	80	0.092	0.100	0.125	0.106	0.033	0.017	0.163
Outliers								

DFT plots (slab 2)

20 km/hr   40 km/hr   60 km/hr

Avg Fn vs condotioning cycles
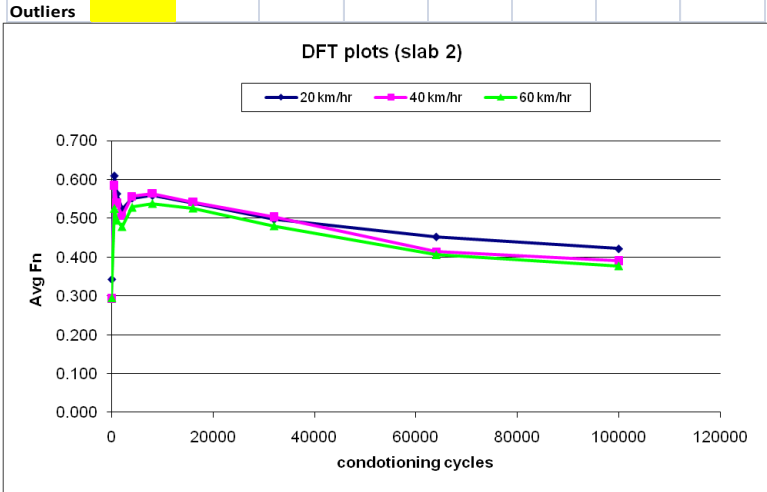
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	1	3	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.590	0.746	0.687	0.674	0.156	0.079	0.117
	20	0.343	0.288	0.284	0.305	0.059	0.033	0.108
	40	0.265	0.251	0.244	0.253	0.021	0.011	0.042
	60	0.254	0.239	0.240	0.244	0.015	0.008	0.034
	80	0.102	0.121	0.107	0.110	0.019	0.010	0.090
500	0	0.707	0.601	0.578	0.629	0.129	0.069	0.109
	20	0.468	0.474	0.467	0.470	0.007	0.004	0.008
	40	0.423	0.429	0.433	0.428	0.010	0.005	0.012
	60	0.370	0.370	0.374	0.371	0.004	0.002	0.006
	80	0.116	0.100	0.095	0.104	0.021	0.011	0.106
1000	0	0.657	0.545	0.731	0.644	0.186	0.094	0.145
	20	0.485	0.475	0.472	0.477	0.013	0.007	0.014
	40	0.451	0.452	0.450	0.451	0.002	0.001	0.002
	60	0.409	0.406	0.406	0.407	0.003	0.002	0.004
	80	0.118	0.125	0.131	0.125	0.013	0.007	0.052
2000	0	0.618	0.499	0.592	0.570	0.119	0.063	0.110
	20	0.451	0.450	0.438	0.446	0.013	0.007	0.016
	40	0.432	0.433	0.426	0.430	0.007	0.004	0.009
	60	0.392	0.389	0.389	0.390	0.003	0.002	0.004
	80	0.141	0.049	0.117	0.102	0.092	0.048	0.466
4000	0	0.513	0.533	0.644	0.563	0.131	0.071	0.125
	20	0.491	0.481	0.476	0.483	0.015	0.008	0.016
	40	0.475	0.468	0.452	0.465	0.023	0.012	0.025
	60	0.433	0.432	0.419	0.428	0.014	0.008	0.018
	80	0.094	0.090	0.108	0.097	0.018	0.009	0.097
8000	0	0.498	0.574	0.537	0.536	0.076	0.038	0.071
	20	0.546	0.519	0.521	0.529	0.027	0.015	0.028
	40	0.531	0.516	0.514	0.520	0.017	0.009	0.018
	60	0.479	0.471	0.467	0.472	0.012	0.006	0.013
	80	0.114	0.124	0.100	0.113	0.024	0.012	0.107
16000	0	0.626	0.576	0.611	0.604	0.050	0.026	0.042
	20	0.492	0.492	0.486	0.490	0.006	0.003	0.007
	40	0.468	0.457	0.462	0.462	0.011	0.006	0.012
	60	0.413	0.410	0.409	0.411	0.004	0.002	0.005
	80	0.071	0.101	0.133	0.102	0.062	0.031	0.305
32000	0	0.522	0.533	0.511	0.522	0.022	0.011	0.021
	20	0.490	0.490	0.481	0.487	0.009	0.005	0.011
	40	0.486	0.483	0.481	0.483	0.005	0.003	0.005
	60	0.456	0.448	0.441	0.448	0.015	0.008	0.017
	80	0.139	0.070	0.080	0.096	0.069	0.037	0.387
64000	0	0.473	0.457	0.478	0.469	0.021	0.011	0.023
	20	0.445	0.447	0.439	0.444	0.008	0.004	0.009
	40	0.419	0.417	0.412	0.416	0.007	0.004	0.009
	60	0.384	0.385	0.384	0.384	0.001	0.001	0.002
	80	0.114	0.103	0.100	0.106	0.014	0.007	0.070
100000	0	0.428	0.418	0.423	0.423	0.010	0.005	0.012
	20	0.452	0.451	0.445	0.449	0.007	0.004	0.008
	40	0.446	0.434	0.433	0.438	0.013	0.007	0.017
	60	0.412	0.402	0.398	0.404	0.014	0.007	0.018
	80	0.091	0.117	0.152	0.120	0.061	0.031	0.255
Outliers								

DFT plots (slab 3)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles

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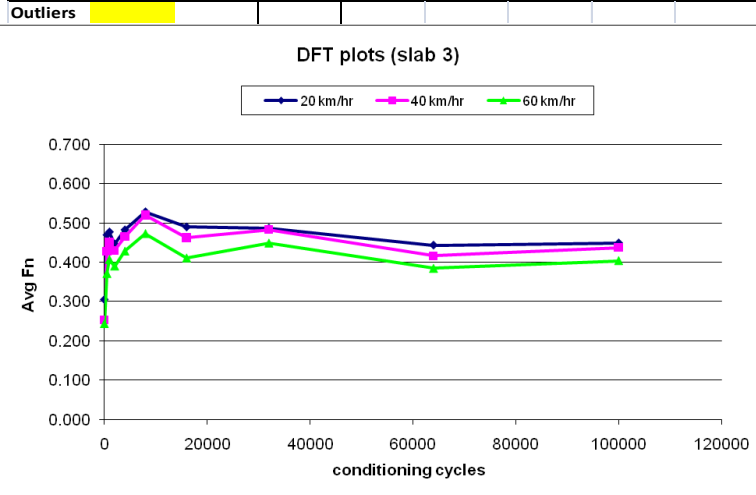
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	2	1	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.726	0.691	0.775	0.731	0.084	0.042	0.058
	20	0.402	0.398	0.402	0.401	0.004	0.002	0.006
	40	0.366	0.347	0.353	0.355	0.019	0.010	0.027
	60	0.348	0.331	0.344	0.341	0.017	0.009	0.026
	80	0.104	0.096	0.095	0.098	0.009	0.005	0.050
500	0	0.709	0.614	0.593	0.639	0.116	0.062	0.097
	20	0.520	0.505	0.495	0.507	0.025	0.013	0.025
	40	0.495	0.483	0.482	0.487	0.013	0.007	0.015
	60	0.480	0.455	0.456	0.464	0.025	0.014	0.031
	80	0.164	0.089	0.082	0.112	0.082	0.045	0.407
1000	0	0.589	0.584	0.538	0.570	0.051	0.028	0.049
	20	0.497	0.502	0.479	0.493	0.023	0.012	0.025
	40	0.475	0.475	0.463	0.471	0.012	0.007	0.015
	60	0.434	0.432	0.425	0.430	0.009	0.005	0.011
	80	0.142	0.115	0.110	0.122	0.032	0.017	0.141
2000	0	0.597	0.543	0.623	0.588	0.080	0.041	0.069
	20	0.520	0.507	0.499	0.509	0.021	0.011	0.021
	40	0.506	0.498	0.485	0.496	0.021	0.011	0.021
	60	0.477	0.465	0.451	0.464	0.026	0.013	0.028
	80	0.157	0.119	0.000	0.092	0.157	0.082	0.890
4000	0	0.670	0.644	0.628	0.647	0.042	0.021	0.033
	20	0.513	0.502	0.491	0.502	0.022	0.011	0.022
	40	0.497	0.492	0.476	0.488	0.021	0.011	0.022
	60	0.467	0.450	0.444	0.454	0.023	0.012	0.026
	80	0.091	0.124	0.050	0.088	0.074	0.037	0.420
8000	0	0.539	0.562	0.488	0.530	0.074	0.038	0.072
	20	0.503	0.497	0.472	0.491	0.031	0.016	0.034
	40	0.499	0.500	0.474	0.491	0.026	0.015	0.030
	60	0.463	0.459	0.440	0.454	0.023	0.012	0.027
	80	0.116	0.083	0.147	0.115	0.064	0.032	0.278
16000	0	0.484	0.568	0.448	0.500	0.120	0.062	0.123
	20	0.500	0.499	0.488	0.496	0.012	0.007	0.013
	40	0.471	0.464	0.462	0.466	0.009	0.005	0.010
	60	0.436	0.427	0.425	0.429	0.011	0.006	0.014
	80	0.088	0.133	0.072	0.098	0.061	0.032	0.324
32000	0	0.600	0.504	0.507	0.537	0.096	0.055	0.102
	20	0.495	0.475	0.470	0.480	0.025	0.013	0.028
	40	0.472	0.455	0.459	0.462	0.017	0.009	0.019
	60	0.447	0.436	0.434	0.439	0.013	0.007	0.016
	80	0.162	0.095	0.079	0.112	0.083	0.044	0.393
64000	0	0.414	0.417	0.509	0.447	0.095	0.054	0.121
	20	0.470	0.461	0.453	0.461	0.017	0.009	0.018
	40	0.475	0.466	0.459	0.467	0.016	0.008	0.017
	60	0.449	0.438	0.432	0.440	0.017	0.009	0.020
	80	0.072	0.111	0.112	0.098	0.040	0.023	0.232
100000	0	0.491	0.419	0.442	0.451	0.072	0.037	0.082
	20	0.453	0.458	0.446	0.452	0.012	0.006	0.013
	40	0.459	0.456	0.453	0.456	0.006	0.003	0.007
	60	0.439	0.435	0.429	0.434	0.010	0.005	0.012
	80	0.091	0.118	0.095	0.101	0.027	0.015	0.144
Outliers								

DFT plots (slab 1)

— 20 km/hr   — 40 km/hr   — 60 km/hr

135
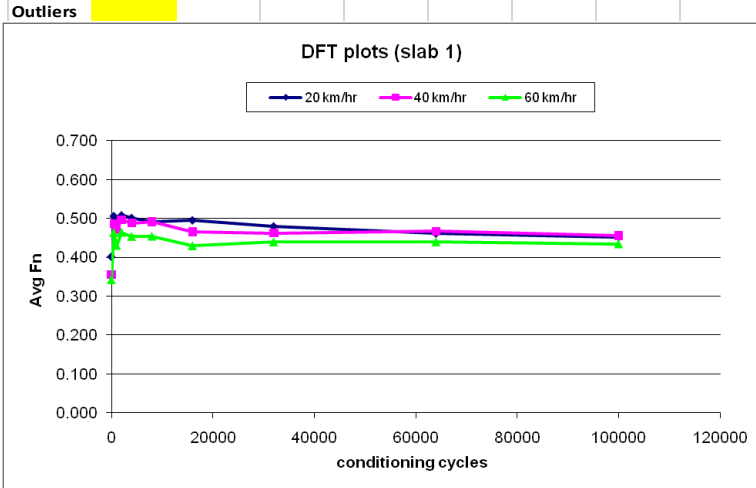
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	2	2	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.856	0.812	0.706	0.791	0.150	0.077	0.097
	20	0.496	0.391	0.384	0.424	0.112	0.063	0.148
	40	0.362	0.319	0.317	0.333	0.045	0.025	0.076
	60	0.350	0.305	0.308	0.321	0.045	0.025	0.078
	80	0.118	0.099	0.104	0.107	0.019	0.010	0.092
500	0	0.598	0.686	0.574	0.619	0.112	0.059	0.095
	20	0.595	0.567	0.565	0.576	0.030	0.017	0.029
	40	0.565	0.552	0.542	0.553	0.023	0.012	0.021
	60	0.525	0.510	0.504	0.513	0.021	0.011	0.021
	80	0.095	0.113	0.095	0.101	0.018	0.010	0.103
1000	0	0.606	0.627	0.612	0.615	0.021	0.011	0.018
	20	0.531	0.534	0.521	0.529	0.013	0.007	0.013
	40	0.478	0.484	0.480	0.481	0.006	0.003	0.006
	60	0.467	0.452	0.445	0.455	0.022	0.011	0.025
	80	0.120	0.188	0.147	0.152	0.068	0.034	0.226
2000	0	0.608	0.583	0.562	0.584	0.046	0.023	0.039
	20	0.545	0.536	0.531	0.537	0.014	0.007	0.013
	40	0.529	0.520	0.512	0.520	0.017	0.009	0.016
	60	0.495	0.486	0.475	0.485	0.020	0.010	0.021
	80	0.128	0.122	0.097	0.116	0.031	0.016	0.142
4000	0	0.609	0.612	0.562	0.594	0.050	0.028	0.047
	20	0.549	0.534	0.529	0.537	0.020	0.010	0.019
	40	0.537	0.530	0.515	0.527	0.022	0.011	0.021
	60	0.500	0.494	0.479	0.491	0.021	0.011	0.022
	80	0.138	0.077	0.254	0.156	0.177	0.090	0.575
8000	0	0.541	0.591	0.542	0.558	0.050	0.029	0.051
	20	0.542	0.531	0.517	0.530	0.025	0.013	0.024
	40	0.532	0.525	0.520	0.526	0.012	0.006	0.011
	60	0.488	0.490	0.480	0.486	0.010	0.005	0.011
	80	0.062	0.123	0.100	0.095	0.061	0.031	0.324
16000	0	0.578	0.566	0.552	0.565	0.026	0.013	0.023
	20	0.555	0.543	0.541	0.546	0.014	0.008	0.014
	40	0.558	0.544	0.540	0.547	0.018	0.009	0.017
	60	0.526	0.515	0.510	0.517	0.016	0.008	0.016
	80	0.126	0.115	0.152	0.131	0.037	0.019	0.145
32000	0	0.587	0.515	0.498	0.533	0.089	0.047	0.089
	20	0.497	0.504	0.494	0.498	0.010	0.005	0.010
	40	0.485	0.489	0.481	0.485	0.008	0.004	0.008
	60	0.457	0.467	0.457	0.460	0.010	0.006	0.013
	80	0.063	0.110	0.100	0.091	0.047	0.025	0.272
64000	0	0.521	0.497	0.495	0.504	0.026	0.014	0.029
	20	0.498	0.498	0.488	0.495	0.010	0.006	0.012
	40	0.504	0.504	0.496	0.501	0.008	0.005	0.009
	60	0.486	0.482	0.479	0.482	0.007	0.004	0.007
	80	0.057	0.055	0.075	0.062	0.020	0.011	0.177
100000	0	0.526	0.493	0.473	0.497	0.053	0.027	0.054
	20	0.472	0.475	0.473	0.473	0.003	0.002	0.003
	40	0.431	0.437	0.435	0.434	0.006	0.003	0.007
	60	0.431	0.429	0.423	0.428	0.008	0.004	0.010
	80	0.087	0.138	0.096	0.107	0.051	0.027	0.254
Outliers								

DFT plots (slab 2)

20 km/hr   40 km/hr   60 km/hr

Avg Fn vs conditioning cycles

136
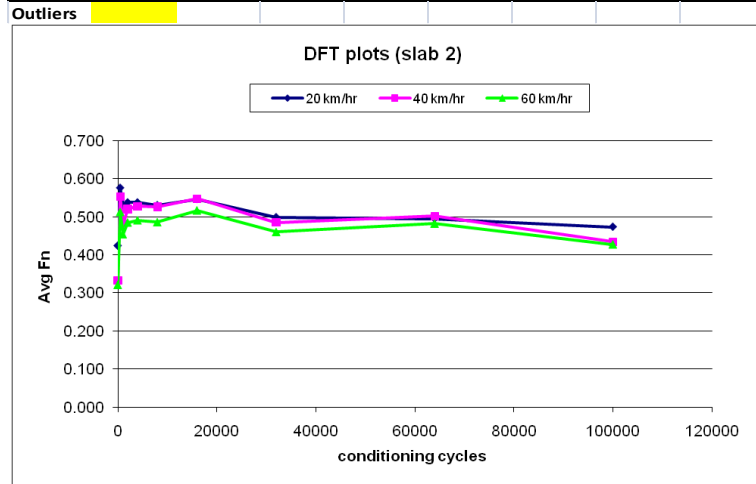
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	2	3	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.972	0.810	0.839	0.874	0.162	0.086	0.099
	20	0.499	0.360	0.352	0.404	0.147	0.083	0.205
	40	0.343	0.290	0.292	0.308	0.053	0.030	0.097
	60	0.362	0.298	0.299	0.320	0.064	0.037	0.115
	80	0.133	0.110	0.100	0.114	0.033	0.017	0.148
500	0	0.667	0.639	0.588	0.631	0.079	0.040	0.063
	20	0.587	0.586	0.563	0.579	0.024	0.014	0.023
	40	0.578	0.567	0.538	0.561	0.040	0.021	0.037
	60	0.542	0.515	0.495	0.517	0.047	0.024	0.046
	80	0.105	0.123	0.096	0.108	0.027	0.014	0.127
1000	0	0.629	0.609	0.602	0.613	0.027	0.014	0.023
	20	0.544	0.538	0.531	0.538	0.013	0.007	0.012
	40	0.505	0.496	0.497	0.499	0.009	0.005	0.010
	60	0.469	0.461	0.461	0.464	0.008	0.005	0.010
	80	0.081	0.107	0.147	0.112	0.066	0.033	0.298
2000	0	0.605	0.563	0.548	0.572	0.057	0.030	0.052
	20	0.554	0.539	0.532	0.542	0.022	0.011	0.021
	40	0.538	0.529	0.527	0.531	0.011	0.006	0.011
	60	0.500	0.492	0.484	0.492	0.016	0.008	0.016
	80	0.143	0.089	0.056	0.096	0.087	0.044	0.458
4000	0	0.557	0.567	0.570	0.565	0.013	0.007	0.012
	20	0.542	0.517	0.522	0.527	0.025	0.013	0.025
	40	0.509	0.507	0.496	0.504	0.013	0.007	0.014
	60	0.473	0.469	0.458	0.467	0.015	0.008	0.017
	80	0.181	0.117	0.140	0.146	0.064	0.032	0.222
8000	0	0.548	0.522	0.552	0.541	0.030	0.016	0.030
	20	0.536	0.546	0.526	0.536	0.020	0.010	0.019
	40	0.538	0.533	0.532	0.534	0.006	0.003	0.006
	60	0.502	0.497	0.493	0.497	0.009	0.005	0.009
	80	0.097	0.191	0.152	0.147	0.094	0.047	0.322
16000	0	0.539	0.523	0.528	0.530	0.016	0.008	0.015
	20	0.540	0.529	0.516	0.528	0.024	0.012	0.023
	40	0.535	0.525	0.522	0.527	0.013	0.007	0.013
	60	0.513	0.505	0.497	0.505	0.016	0.008	0.016
	80	0.115	0.130	0.144	0.130	0.029	0.015	0.112
32000	0	0.528	0.498	0.478	0.501	0.050	0.025	0.050
	20	0.487	0.480	0.475	0.481	0.012	0.006	0.013
	40	0.486	0.482	0.475	0.481	0.011	0.006	0.012
	60	0.462	0.455	0.448	0.455	0.014	0.007	0.015
	80	0.127	0.129	0.100	0.119	0.029	0.016	0.136
64000	0	0.539	0.516	0.478	0.511	0.061	0.031	0.060
	20	0.499	0.504	0.487	0.497	0.017	0.009	0.018
	40	0.495	0.503	0.495	0.498	0.008	0.005	0.009
	60	0.478	0.477	0.473	0.476	0.005	0.003	0.006
	80	0.078	0.127	0.067	0.091	0.060	0.032	0.352
100000	0	0.519	0.494	0.469	0.494	0.050	0.025	0.051
	20	0.484	0.481	0.469	0.478	0.015	0.008	0.017
	40	0.457	0.455	0.447	0.453	0.010	0.005	0.012
	60	0.437	0.439	0.425	0.434	0.014	0.008	0.017
	80	0.112	0.170	0.158	0.147	0.058	0.031	0.209
Outliers								

DFT plots (slab 3)

— 20 km/hr   — 40 km/hr   — 60 km/hr

Avg Fn vs conditioning cycles
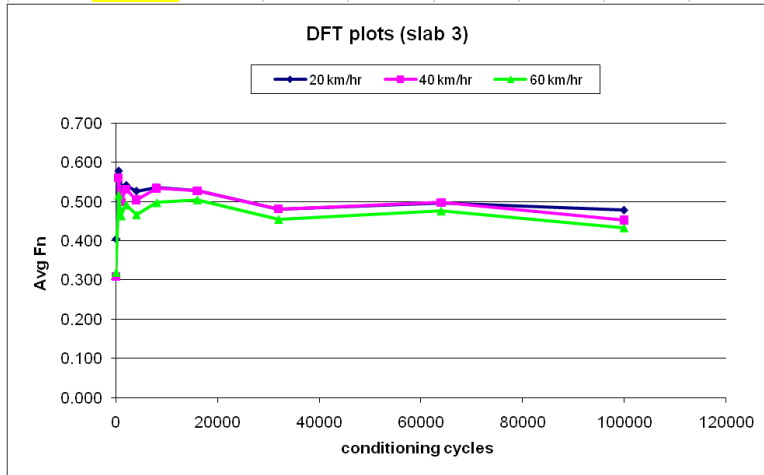
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	3	1	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.726	0.691	0.775	0.731	0.084	0.042	0.058
	20	0.402	0.398	0.402	0.401	0.004	0.002	0.006
	40	0.366	0.347	0.353	0.355	0.019	0.010	0.027
	60	0.348	0.331	0.344	0.341	0.017	0.009	0.026
	80	0.104	0.096	0.095	0.098	0.009	0.005	0.050
500	0	0.630	0.714	0.668	0.671	0.084	0.042	0.063
	20	0.518	0.516	0.514	0.516	0.004	0.002	0.004
	40	0.495	0.490	0.481	0.489	0.014	0.007	0.015
	60	0.465	0.452	0.438	0.452	0.027	0.014	0.030
	80	0.129	0.114	0.031	0.091	0.098	0.053	0.578
1000	0	0.589	0.561	0.614	0.588	0.053	0.027	0.045
	20	0.505	0.493	0.508	0.502	0.015	0.008	0.016
	40	0.470	0.458	0.456	0.461	0.014	0.008	0.016
	60	0.456	0.437	0.425	0.439	0.031	0.016	0.036
	80	0.129	0.112	0.078	0.106	0.051	0.026	0.244
2000	0	0.558	0.667	0.673	0.633	0.115	0.065	0.102
	20	0.532	0.522	0.528	0.527	0.010	0.005	0.010
	40	0.509	0.503	0.496	0.503	0.013	0.007	0.013
	60	0.465	0.458	0.456	0.460	0.009	0.005	0.010
	80	0.122	0.103	0.115	0.113	0.019	0.010	0.085
4000	0	0.636	0.609	0.642	0.629	0.033	0.018	0.028
	20	0.468	0.474	0.485	0.476	0.017	0.009	0.018
	40	0.434	0.441	0.442	0.439	0.008	0.004	0.010
	60	0.418	0.432	0.430	0.427	0.014	0.008	0.018
	80	0.096	0.054	0.106	0.085	0.052	0.028	0.323
8000	0	0.540	0.529	0.579	0.549	0.050	0.026	0.048
	20	0.509	0.489	0.491	0.496	0.020	0.011	0.022
	40	0.494	0.483	0.477	0.485	0.017	0.009	0.018
	60	0.461	0.453	0.450	0.455	0.011	0.006	0.013
	80	0.114	0.097	0.092	0.101	0.022	0.012	0.114
16000	0	0.498	0.517	0.516	0.510	0.019	0.011	0.021
	20	0.486	0.480	0.488	0.485	0.008	0.004	0.009
	40	0.456	0.443	0.446	0.448	0.013	0.007	0.015
	60	0.421	0.416	0.413	0.417	0.008	0.004	0.010
	80	0.182	0.245	0.137	0.188	0.108	0.054	0.289
32000	0	0.526	0.468	0.454	0.483	0.072	0.038	0.079
	20	0.444	0.451	0.444	0.446	0.007	0.004	0.009
	40	0.428	0.425	0.428	0.427	0.003	0.002	0.004
	60	0.400	0.396	0.395	0.397	0.005	0.003	0.007
	80	0.112	0.124	0.103	0.113	0.021	0.011	0.093
64000	0	0.462	0.439	0.450	0.450	0.023	0.012	0.026
	20	0.448	0.441	0.445	0.445	0.007	0.004	0.008
	40	0.430	0.423	0.424	0.426	0.007	0.004	0.009
	60	0.400	0.391	0.392	0.394	0.009	0.005	0.013
	80	0.152	0.107	0.110	0.123	0.045	0.025	0.205
100000	0	0.460	0.448	0.439	0.449	0.021	0.011	0.023
	20	0.422	0.426	0.422	0.423	0.004	0.002	0.005
	40	0.393	0.389	0.391	0.391	0.004	0.002	0.005
	60	0.385	0.385	0.384	0.385	0.001	0.001	0.002
	80	0.120	0.132	0.100	0.117	0.032	0.016	0.138
Outliers								

DFT plots (slab 1)

— 20 km/hr   — 40 km/hr   — 60 km/hr
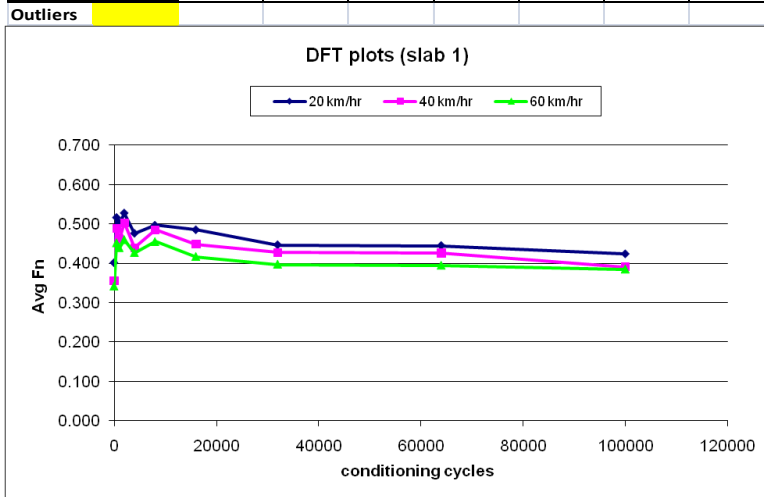
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	3	2	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.942	0.784	0.709	0.812	0.233	0.119	0.147
	20	0.455	0.417	0.419	0.430	0.038	0.021	0.050
	40	0.372	0.364	0.384	0.373	0.020	0.010	0.027
	60	0.378	0.341	0.373	0.364	0.037	0.020	0.055
	80	0.113	0.127	0.110	0.117	0.017	0.009	0.078
500	0	0.687	0.673	0.673	0.678	0.014	0.008	0.012
	20	0.629	0.603	0.589	0.607	0.040	0.020	0.033
	40	0.592	0.574	0.557	0.574	0.035	0.018	0.030
	60	0.541	0.515	0.504	0.520	0.037	0.019	0.037
	80	0.116	0.083	0.079	0.093	0.037	0.020	0.219
1000	0	0.696	0.636	0.596	0.643	0.100	0.050	0.078
	20	0.600	0.587	0.591	0.593	0.013	0.007	0.011
	40	0.562	0.552	0.545	0.553	0.017	0.009	0.015
	60	0.516	0.494	0.493	0.501	0.023	0.013	0.026
	80	0.154	0.093	0.101	0.116	0.061	0.033	0.286
2000	0	0.653	0.608	0.623	0.628	0.045	0.023	0.036
	20	0.619	0.620	0.605	0.615	0.015	0.008	0.014
	40	0.605	0.598	0.592	0.598	0.013	0.007	0.011
	60	0.556	0.549	0.541	0.549	0.015	0.008	0.014
	80	0.155	0.116	0.144	0.138	0.039	0.020	0.145
4000	0	0.574	0.559	0.550	0.561	0.024	0.012	0.022
	20	0.560	0.555	0.547	0.554	0.013	0.007	0.012
	40	0.518	0.519	0.508	0.515	0.011	0.006	0.012
	60	0.486	0.481	0.477	0.481	0.009	0.005	0.009
	80	0.105	0.113	0.103	0.107	0.010	0.005	0.049
8000	0	0.556	0.534	0.528	0.539	0.028	0.015	0.027
	20	0.553	0.542	0.531	0.542	0.022	0.011	0.020
	40	0.544	0.540	0.539	0.541	0.005	0.003	0.005
	60	0.515	0.511	0.511	0.512	0.004	0.002	0.005
	80	0.100	0.138	0.135	0.124	0.038	0.021	0.170
16000	0	0.508	0.482	0.478	0.489	0.030	0.016	0.033
	20	0.505	0.503	0.506	0.505	0.003	0.002	0.003
	40	0.472	0.470	0.466	0.469	0.006	0.003	0.007
	60	0.458	0.451	0.448	0.452	0.010	0.005	0.011
	80	0.207	0.128	0.127	0.154	0.080	0.046	0.298
32000	0	0.495	0.476	0.494	0.488	0.019	0.011	0.022
	20	0.488	0.482	0.480	0.483	0.008	0.004	0.009
	40	0.472	0.468	0.467	0.469	0.005	0.003	0.006
	60	0.453	0.448	0.449	0.450	0.005	0.003	0.006
	80	0.169	0.177	0.139	0.162	0.038	0.020	0.124
64000	0	0.644	0.574	0.514	0.577	0.130	0.065	0.113
	20	0.468	0.481	0.470	0.473	0.013	0.007	0.015
	40	0.431	0.454	0.448	0.444	0.023	0.012	0.027
	60	0.416	0.439	0.432	0.429	0.023	0.012	0.027
	80	0.112	0.122	0.097	0.110	0.025	0.013	0.114
100000	0	0.533	0.499	0.476	0.503	0.057	0.029	0.057
	20	0.494	0.488	0.479	0.487	0.015	0.008	0.016
	40	0.473	0.472	0.461	0.469	0.012	0.007	0.014
	60	0.458	0.451	0.446	0.452	0.012	0.006	0.013
	80	0.082	0.091	0.063	0.079	0.028	0.014	0.182
Outliers								

DFT plots (slab 2)

— 20 km/hr — 40 km/hr — 60 km/hr
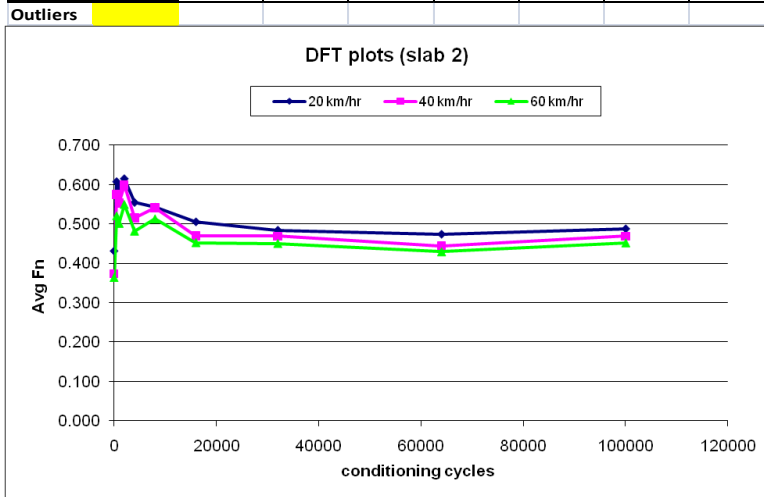
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	AL hard	3	3	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.874	0.699	0.703	0.759	0.175	0.100	0.132
	20	0.427	0.398	0.396	0.407	0.031	0.017	0.043
	40	0.362	0.371	0.374	0.369	0.012	0.006	0.017
	60	0.367	0.359	0.366	0.364	0.008	0.004	0.012
	80	0.056	0.067	0.109	0.077	0.053	0.028	0.362
500	0	0.698	0.716	0.578	0.664	0.138	0.075	0.113
	20	0.545	0.537	0.522	0.535	0.023	0.012	0.022
	40	0.493	0.500	0.499	0.497	0.007	0.004	0.008
	60	0.430	0.440	0.445	0.438	0.015	0.008	0.017
	80	0.138	0.116	0.086	0.113	0.052	0.026	0.230
1000	0	0.647	0.623	0.564	0.611	0.083	0.043	0.070
	20	0.576	0.545	0.524	0.548	0.052	0.026	0.048
	40	0.530	0.518	0.508	0.519	0.022	0.011	0.021
	60	0.477	0.467	0.465	0.470	0.012	0.006	0.014
	80	0.101	0.097	0.099	0.099	0.004	0.002	0.020
2000	0	0.626	0.604	0.589	0.606	0.037	0.019	0.031
	20	0.528	0.513	0.510	0.517	0.018	0.010	0.019
	40	0.476	0.477	0.478	0.477	0.002	0.001	0.002
	60	0.431	0.437	0.438	0.435	0.007	0.004	0.009
	80	0.043	0.069	0.125	0.079	0.082	0.042	0.530
4000	0	0.616	0.576	0.559	0.584	0.057	0.029	0.050
	20	0.540	0.526	0.522	0.529	0.018	0.009	0.018
	40	0.512	0.504	0.498	0.505	0.014	0.007	0.014
	60	0.468	0.462	0.456	0.462	0.012	0.006	0.013
	80	0.097	0.102	0.107	0.102	0.010	0.005	0.049
8000	0	0.572	0.591	0.561	0.575	0.030	0.015	0.026
	20	0.574	0.550	0.535	0.553	0.039	0.020	0.036
	40	0.541	0.533	0.519	0.531	0.022	0.011	0.021
	60	0.492	0.482	0.474	0.483	0.018	0.009	0.019
	80	0.090	0.125	0.079	0.098	0.046	0.024	0.245
16000	0	0.514	0.541	0.516	0.524	0.027	0.015	0.029
	20	0.475	0.480	0.496	0.484	0.021	0.011	0.023
	40	0.443	0.444	0.447	0.445	0.004	0.002	0.005
	60	0.412	0.420	0.420	0.417	0.008	0.005	0.011
	80	0.115	0.112	0.231	0.153	0.119	0.068	0.444
32000	0	0.550	0.498	0.466	0.505	0.084	0.042	0.084
	20	0.447	0.462	0.443	0.451	0.019	0.010	0.022
	40	0.398	0.420	0.414	0.411	0.022	0.011	0.028
	60	0.382	0.394	0.382	0.386	0.012	0.007	0.018
	80	0.106	0.126	0.060	0.097	0.066	0.034	0.348
64000	0	0.448	0.441	0.431	0.440	0.017	0.009	0.019
	20	0.453	0.450	0.443	0.449	0.010	0.005	0.011
	40	0.423	0.425	0.422	0.423	0.003	0.002	0.004
	60	0.391	0.391	0.390	0.391	0.001	0.001	0.001
	80	0.082	0.120	0.125	0.109	0.043	0.024	0.216
100000	0	0.426	0.435	0.429	0.430	0.009	0.005	0.011
	20	0.438	0.434	0.430	0.434	0.008	0.004	0.009
	40	0.413	0.398	0.406	0.406	0.015	0.008	0.019
	60	0.376	0.365	0.374	0.372	0.011	0.006	0.016
	80	0.123	0.074	0.063	0.087	0.060	0.032	0.369
Outliers								

DFT plots (slab 3)

— 20 km/hr   — 40 km/hr   — 60 km/hr

Avg Fn / conditioning cycles

140
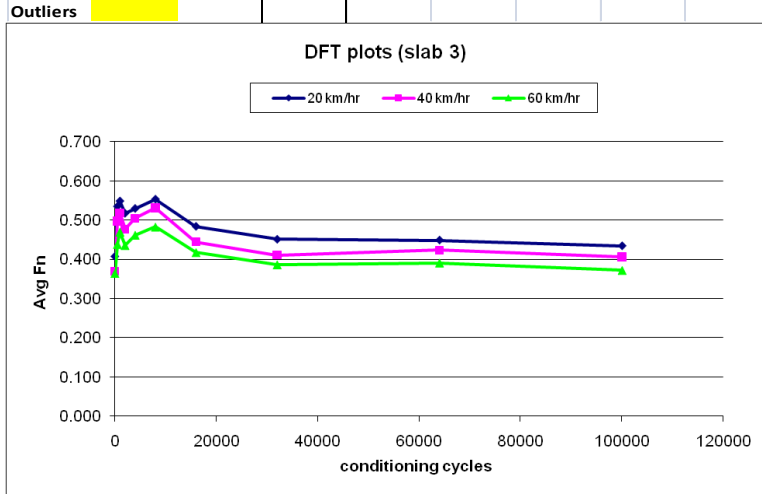
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	1	1	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.927	0.906	0.877	0.903	0.050	0.025	0.028
	20	0.657	0.415	0.451	0.433	0.036	0.025	0.059
	40	0.377	0.333	0.340	0.350	0.044	0.024	0.068
	60	0.361	0.326	0.326	0.338	0.035	0.020	0.060
	80	0.118	0.090	0.171	0.126	0.081	0.041	0.326
500	0	0.561	0.518	0.533	0.537	0.043	0.022	0.041
	20	0.464	0.459	0.435	0.453	0.029	0.016	0.034
	40	0.464	0.459	0.440	0.454	0.024	0.013	0.028
	60	0.453	0.446	0.421	0.440	0.032	0.017	0.038
	80	0.093	0.108	0.067	0.089	0.041	0.021	0.232
1000	0	0.569	0.549	0.563	0.560	0.020	0.010	0.018
	20	0.469	0.456	0.449	0.458	0.020	0.010	0.022
	40	0.456	0.441	0.438	0.445	0.018	0.010	0.022
	60	0.424	0.415	0.407	0.415	0.017	0.009	0.020
	80	0.000	0.106	0.118	0.075	0.118	0.065	0.870
2000	0	0.601	0.531	0.531	0.554	0.070	0.040	0.073
	20	0.479	0.467	0.449	0.465	0.030	0.015	0.032
	40	0.474	0.462	0.446	0.461	0.028	0.014	0.030
	60	0.448	0.436	0.422	0.435	0.026	0.013	0.030
	80	0.133	0.101	0.098	0.111	0.035	0.019	0.175
4000	0	0.577	0.505	0.519	0.534	0.072	0.038	0.072
	20	0.467	0.459	0.449	0.458	0.018	0.009	0.020
	40	0.441	0.435	0.434	0.437	0.007	0.004	0.009
	60	0.407	0.399	0.400	0.402	0.008	0.004	0.011
	80	0.106	0.125	0.070	0.100	0.055	0.028	0.278
8000	0	0.499	0.503	0.459	0.487	0.044	0.024	0.050
	20	0.462	0.441	0.450	0.451	0.021	0.011	0.023
	40	0.453	0.438	0.439	0.443	0.015	0.008	0.019
	60	0.436	0.422	0.426	0.428	0.014	0.007	0.017
	80	0.089	0.113	0.094	0.099	0.024	0.013	0.128
16000	0	0.478	0.461	0.428	0.456	0.050	0.025	0.056
	20	0.375	0.382	0.381	0.379	0.007	0.004	0.010
	40	0.352	0.362	0.365	0.360	0.013	0.007	0.019
	60	0.325	0.335	0.343	0.334	0.018	0.009	0.027
	80	0.094	0.126	0.076	0.099	0.050	0.025	0.257
32000	0	0.373	0.374	0.371	0.373	0.003	0.002	0.004
	20	0.383	0.378	0.373	0.378	0.010	0.005	0.013
	40	0.370	0.379	0.376	0.375	0.009	0.005	0.012
	60	0.364	0.361	0.358	0.361	0.006	0.003	0.008
	80	0.112	0.092	0.132	0.112	0.040	0.020	0.179
64000	0	0.373	0.368	0.343	0.361	0.030	0.016	0.044
	20	0.353	0.344	0.342	0.346	0.011	0.006	0.017
	40	0.352	0.351	0.354	0.352	0.003	0.002	0.004
	60	0.345	0.329	0.340	0.338	0.016	0.008	0.024
	80	0.276	0.121	0.161	0.186	0.155	0.080	0.433
100000	0	0.373	0.341	0.343	0.352	0.032	0.018	0.051
	20	0.346	0.337	0.333	0.339	0.013	0.007	0.020
	40	0.340	0.345	0.334	0.340	0.011	0.006	0.016
	60	0.327	0.329	0.319	0.325	0.010	0.005	0.016
	80	0.093	0.091	0.105	0.096	0.014	0.008	0.079
Outliers								

DFT plots (slab 1)

20 km/hr   40 km/hr   60 km/hr
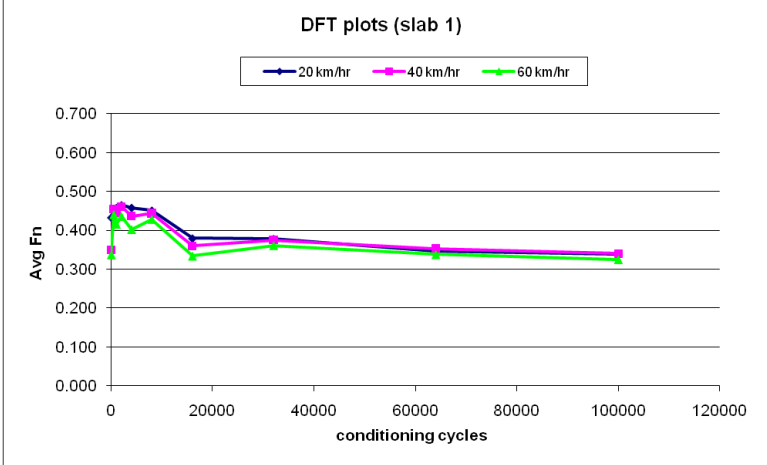
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	1	2	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.986	0.884	0.994	0.955	0.110	0.061	0.064
	20	0.66	0.432	0.412	0.422	0.020	0.014	0.034
	40	0.367	0.310	0.313	0.330	0.057	0.032	0.097
	60	0.344	0.299	0.304	0.316	0.045	0.025	0.078
	80	0.138	0.150	0.179	0.156	0.041	0.021	0.135
500	0	0.571	0.542	0.607	0.573	0.065	0.033	0.057
	20	0.466	0.454	0.497	0.472	0.043	0.022	0.047
	40	0.477	0.462	0.503	0.481	0.041	0.021	0.043
	60	0.464	0.447	0.494	0.468	0.047	0.024	0.051
	80	0.092	0.081	0.084	0.086	0.011	0.006	0.066
1000	0	0.676	0.592	0.575	0.614	0.101	0.054	0.088
	20	0.466	0.448	0.441	0.452	0.025	0.013	0.029
	40	0.458	0.448	0.439	0.448	0.019	0.010	0.021
	60	0.421	0.419	0.404	0.415	0.017	0.009	0.022
	80	0.115	0.086	0.119	0.107	0.033	0.018	0.169
2000	0	0.519	0.553	0.502	0.525	0.051	0.026	0.049
	20	0.464	0.447	0.436	0.449	0.028	0.014	0.031
	40	0.471	0.454	0.452	0.459	0.019	0.010	0.023
	60	0.446	0.431	0.425	0.434	0.021	0.011	0.025
	80	0.106	0.093	0.068	0.089	0.038	0.019	0.217
4000	0	0.562	0.529	0.546	0.546	0.033	0.017	0.030
	20	0.468	0.458	0.452	0.459	0.016	0.008	0.018
	40	0.467	0.459	0.450	0.459	0.017	0.009	0.019
	60	0.434	0.424	0.416	0.425	0.018	0.009	0.021
	80	0.091	0.170	0.155	0.139	0.079	0.042	0.303
8000	0	0.427	0.394	0.400	0.407	0.033	0.018	0.043
	20	0.387	0.381	0.376	0.381	0.011	0.006	0.014
	40	0.404	0.396	0.392	0.397	0.012	0.006	0.015
	60	0.388	0.380	0.373	0.380	0.015	0.008	0.020
	80	0.207	0.062	0.072	0.114	0.145	0.081	0.712
16000	0	0.406	0.393	0.379	0.393	0.027	0.014	0.034
	20	0.379	0.368	0.367	0.371	0.012	0.007	0.018
	40	0.374	0.366	0.376	0.372	0.010	0.005	0.014
	60	0.349	0.346	0.345	0.347	0.004	0.002	0.006
	80	0.130	0.069	0.114	0.104	0.061	0.032	0.303
32000	0	0.384	0.372	0.378	0.378	0.012	0.006	0.016
	20	0.385	0.386	0.379	0.383	0.007	0.004	0.010
	40	0.386	0.387	0.379	0.384	0.008	0.004	0.011
	60	0.377	0.377	0.370	0.375	0.007	0.004	0.011
	80	0.075	0.110	0.165	0.117	0.090	0.045	0.389
64000	0	0.387	0.406	0.353	0.382	0.053	0.027	0.070
	20	0.363	0.354	0.360	0.359	0.009	0.005	0.013
	40	0.370	0.366	0.368	0.368	0.004	0.002	0.005
	60	0.352	0.343	0.348	0.348	0.009	0.005	0.013
	80	0.073	0.078	0.091	0.081	0.018	0.009	0.115
100000	0	0.426	0.373	0.358	0.386	0.068	0.036	0.093
	20	0.374	0.352	0.354	0.360	0.022	0.012	0.034
	40	0.374	0.359	0.363	0.365	0.015	0.008	0.021
	60	0.362	0.345	0.344	0.350	0.018	0.010	0.029
	80	0.099	0.079	0.103	0.094	0.024	0.013	0.137
Outliers								

DFT plots (slab 2)

— 20 km/hr   — 40 km/hr   — 60 km/hr
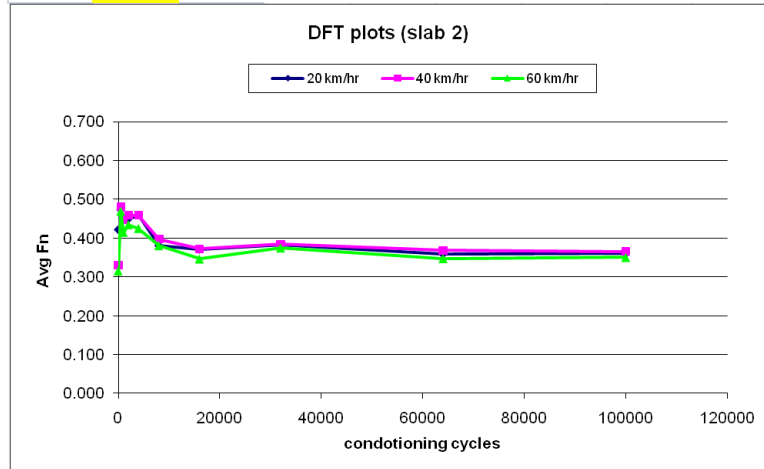
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	1	3	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.773	0.689	0.633	0.698	0.140	0.070	0.101
	20	0.433	0.389	0.374	0.399	0.059	0.031	0.077
	40	0.378	0.351	0.357	0.362	0.027	0.014	0.039
	60	0.385	0.353	0.354	0.364	0.032	0.018	0.050
	80	0.245	0.086	0.103	0.145	0.159	0.087	0.603
500	0	0.633	0.594	0.543	0.590	0.090	0.045	0.076
	20	0.561	0.538	0.509	0.536	0.052	0.026	0.049
	40	0.556	0.529	0.495	0.527	0.061	0.031	0.058
	60	0.531	0.496	0.469	0.499	0.062	0.031	0.062
	80	0.123	0.089	0.107	0.106	0.034	0.017	0.160
1000	0	0.568	0.546	0.541	0.552	0.027	0.014	0.026
	20	0.519	0.518	0.495	0.511	0.024	0.014	0.027
	40	0.513	0.504	0.496	0.504	0.017	0.009	0.017
	60	0.487	0.476	0.466	0.476	0.021	0.011	0.022
	80	0.077	0.068	0.098	0.081	0.030	0.015	0.190
2000	0	0.523	0.498	0.482	0.501	0.041	0.021	0.041
	20	0.505	0.490	0.476	0.490	0.029	0.015	0.030
	40	0.472	0.457	0.454	0.461	0.018	0.010	0.021
	60	0.447	0.438	0.424	0.436	0.023	0.012	0.027
	80	0.116	0.161	0.151	0.143	0.045	0.024	0.166
4000	0	0.588	0.534	0.523	0.548	0.065	0.035	0.063
	20	0.503	0.488	0.490	0.494	0.015	0.008	0.016
	40	0.499	0.479	0.482	0.487	0.020	0.011	0.022
	60	0.464	0.449	0.446	0.453	0.018	0.010	0.021
	80	0.062	0.137	0.097	0.099	0.075	0.038	0.380
8000	0	0.532	0.474	0.459	0.488	0.073	0.039	0.079
	20	0.499	0.455	0.447	0.467	0.052	0.028	0.060
	40	0.488	0.448	0.438	0.458	0.050	0.026	0.058
	60	0.453	0.415	0.402	0.423	0.051	0.027	0.063
	80	0.078	0.101	0.109	0.096	0.031	0.016	0.168
16000	0	0.584	0.526	0.465	0.525	0.119	0.060	0.113
	20	0.452	0.447	0.441	0.447	0.011	0.006	0.012
	40	0.452	0.449	0.450	0.450	0.003	0.002	0.003
	60	0.436	0.434	0.437	0.436	0.003	0.002	0.004
	80	0.159	0.211	0.151	0.174	0.060	0.033	0.188
32000	0	0.427	0.424	0.419	0.423	0.008	0.004	0.010
	20	0.426	0.418	0.413	0.419	0.013	0.007	0.016
	40	0.411	0.404	0.397	0.404	0.014	0.007	0.017
	60	0.389	0.382	0.379	0.383	0.010	0.005	0.013
	80	0.111	0.083	0.101	0.098	0.028	0.014	0.144
64000	0	0.428	0.390	0.394	0.404	0.038	0.021	0.052
	20	0.406	0.400	0.387	0.398	0.019	0.010	0.024
	40	0.385	0.387	0.376	0.383	0.011	0.006	0.015
	60	0.377	0.377	0.369	0.374	0.008	0.005	0.012
	80	0.041	0.105	0.128	0.091	0.087	0.045	0.494
100000	0	0.409	0.392	0.393	0.398	0.017	0.010	0.024
	20	0.398	0.396	0.383	0.392	0.015	0.008	0.021
	40	0.377	0.379	0.371	0.376	0.008	0.004	0.011
	60	0.364	0.371	0.367	0.367	0.007	0.004	0.010
	80	0.122	0.109	0.113	0.115	0.013	0.007	0.058
Outliers								

DFT plots (slab 3)

20 km/hr   40 km/hr   60 km/hr

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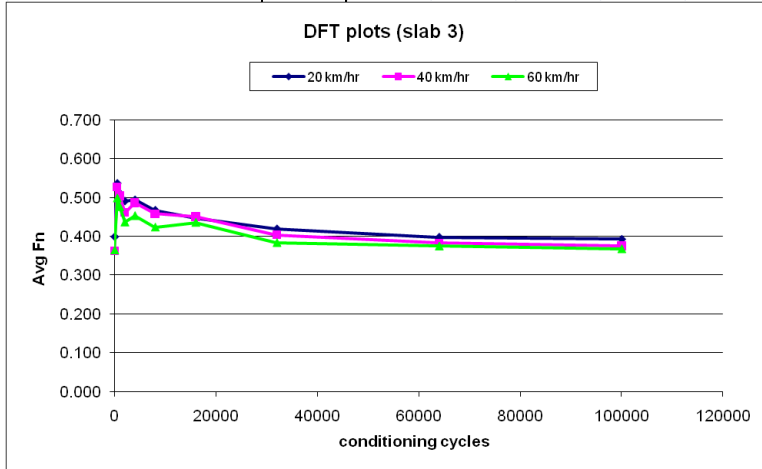
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	2	1	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.972	0.797	0.831	0.867	0.175	0.093	0.107
	20	0.495	0.376	0.372	0.414	0.123	0.070	0.169
	40	0.345	0.308	0.307	0.320	0.038	0.022	0.068
	60	0.351	0.303	0.297	0.317	0.054	0.030	0.093
	80	0.079	0.122	0.084	0.095	0.043	0.024	0.248
500	0	0.656	0.619	0.564	0.613	0.092	0.046	0.076
	20	0.553	0.525	0.506	0.528	0.047	0.024	0.045
	40	0.535	0.507	0.491	0.511	0.044	0.022	0.044
	60	0.510	0.475	0.460	0.482	0.050	0.026	0.053
	80	0.170	0.131	0.080	0.127	0.090	0.045	0.355
1000	0	0.667	0.649	0.599	0.638	0.068	0.035	0.055
	20	0.541	0.513	0.497	0.517	0.044	0.022	0.043
	40	0.526	0.501	0.488	0.505	0.038	0.019	0.038
	60	0.491	0.474	0.459	0.475	0.032	0.016	0.034
	80	0.124	0.070	0.108	0.101	0.054	0.028	0.276
2000	0	0.568	0.528	0.491	0.529	0.077	0.039	0.073
	20	0.503	0.484	0.468	0.485	0.035	0.018	0.036
	40	0.464	0.444	0.437	0.448	0.027	0.014	0.031
	60	0.448	0.420	0.416	0.428	0.032	0.017	0.041
	80	0.087	0.148	0.142	0.126	0.061	0.034	0.268
4000	0	0.598	0.537	0.507	0.547	0.091	0.046	0.085
	20	0.511	0.496	0.486	0.498	0.025	0.013	0.025
	40	0.501	0.484	0.475	0.487	0.026	0.013	0.027
	60	0.470	0.455	0.444	0.456	0.026	0.013	0.029
	80	0.101	0.096	0.144	0.114	0.048	0.026	0.232
8000	0	0.524	0.498	0.482	0.501	0.042	0.021	0.042
	20	0.480	0.468	0.460	0.469	0.020	0.010	0.021
	40	0.464	0.449	0.445	0.453	0.019	0.010	0.022
	60	0.433	0.416	0.409	0.419	0.024	0.012	0.029
	80	0.050	0.051	0.040	0.047	0.011	0.006	0.129
16000	0	0.484	0.493	0.431	0.469	0.062	0.034	0.071
	20	0.460	0.464	0.455	0.460	0.009	0.005	0.010
	40	0.463	0.457	0.451	0.457	0.012	0.006	0.013
	60	0.445	0.442	0.436	0.441	0.009	0.005	0.010
	80	0.080	0.133	0.132	0.115	0.053	0.030	0.264
32000	0	0.458	0.433	0.423	0.438	0.035	0.018	0.041
	20	0.432	0.425	0.415	0.424	0.017	0.009	0.020
	40	0.411	0.405	0.400	0.405	0.011	0.006	0.014
	60	0.390	0.387	0.376	0.384	0.014	0.007	0.019
	80	0.159	0.109	0.166	0.145	0.057	0.031	0.215
64000	0	0.430	0.421	0.411	0.421	0.019	0.010	0.023
	20	0.417	0.409	0.406	0.411	0.011	0.006	0.014
	40	0.398	0.394	0.385	0.392	0.013	0.007	0.017
	60	0.391	0.375	0.369	0.378	0.022	0.011	0.030
	80	0.120	0.070	0.125	0.105	0.055	0.030	0.290
100000	0	0.438	0.416	0.377	0.410	0.061	0.031	0.075
	20	0.394	0.385	0.377	0.385	0.017	0.009	0.022
	40	0.370	0.373	0.365	0.369	0.008	0.004	0.011
	60	0.358	0.358	0.349	0.355	0.009	0.005	0.015
	80	0.085	0.109	0.077	0.090	0.032	0.017	0.184

Outliers

DFT plots (slab 1)

144
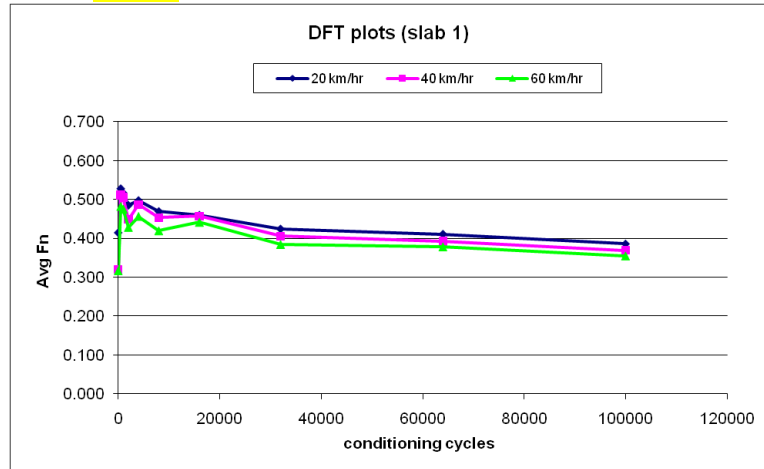
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	2	2	OLD	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.888	0.893	0.872	0.884	0.021	0.011	0.012
	20	0.506	0.403	0.388	0.432	0.118	0.064	0.149
	40	0.325	0.302	0.309	0.312	0.023	0.012	0.038
	60	0.322	0.299	0.306	0.309	0.023	0.012	0.038
	80	0.175	0.048	0.155	0.126	0.127	0.068	0.542
500	0	0.593	0.581	0.586	0.587	0.012	0.006	0.010
	20	0.497	0.470	0.458	0.475	0.039	0.020	0.042
	40	0.501	0.481	0.461	0.481	0.040	0.020	0.042
	60	0.485	0.458	0.445	0.463	0.040	0.020	0.044
	80	0.150	0.026	0.156	0.111	0.130	0.073	0.663
1000	0	0.609	0.578	0.538	0.575	0.071	0.036	0.062
	20	0.494	0.473	0.459	0.475	0.035	0.018	0.037
	40	0.475	0.458	0.441	0.458	0.034	0.017	0.037
	60	0.441	0.416	0.403	0.420	0.038	0.019	0.046
	80	0.112	0.146	0.139	0.132	0.034	0.018	0.136
2000	0	0.568	0.541	0.564	0.558	0.027	0.015	0.026
	20	0.478	0.466	0.457	0.467	0.021	0.011	0.023
	40	0.477	0.466	0.454	0.466	0.023	0.012	0.025
	60	0.450	0.428	0.420	0.433	0.030	0.016	0.036
	80	0.099	0.081	0.140	0.107	0.059	0.030	0.283
4000	0	0.574	0.536	0.530	0.547	0.044	0.024	0.044
	20	0.473	0.459	0.454	0.462	0.019	0.010	0.021
	40	0.460	0.441	0.433	0.445	0.027	0.014	0.031
	60	0.419	0.403	0.399	0.407	0.020	0.011	0.026
	80	0.127	0.107	0.080	0.105	0.047	0.024	0.225
8000	0	0.554	0.469	0.467	0.497	0.087	0.050	0.100
	20	0.455	0.438	0.432	0.442	0.023	0.012	0.027
	40	0.448	0.436	0.435	0.440	0.013	0.007	0.016
	60	0.422	0.410	0.404	0.412	0.018	0.009	0.022
	80	0.131	0.051	0.110	0.097	0.080	0.041	0.426
16000	0	0.445	0.423	0.394	0.421	0.051	0.026	0.061
	20	0.417	0.404	0.382	0.401	0.035	0.018	0.044
	40	0.392	0.387	0.366	0.382	0.026	0.014	0.036
	60	0.374	0.363	0.349	0.362	0.025	0.013	0.035
	80	0.147	0.089	0.051	0.096	0.096	0.048	0.505
32000	0	0.406	0.394	0.379	0.393	0.027	0.014	0.034
	20	0.395	0.394	0.386	0.392	0.009	0.005	0.013
	40	0.387	0.389	0.383	0.386	0.006	0.003	0.008
	60	0.375	0.376	0.372	0.374	0.004	0.002	0.006
	80	0.173	0.142	0.095	0.137	0.078	0.039	0.287
64000	0	0.426	0.388	0.389	0.401	0.038	0.022	0.054
	20	0.386	0.385	0.366	0.379	0.020	0.011	0.030
	40	0.383	0.387	0.365	0.378	0.022	0.012	0.031
	60	0.385	0.382	0.364	0.377	0.021	0.011	0.030
	80	0.000	0.133	0.106	0.080	0.133	0.070	0.882
100000	0	0.364	0.358	0.351	0.358	0.013	0.007	0.018
	20	0.352	0.350	0.346	0.349	0.006	0.003	0.009
	40	0.341	0.346	0.345	0.344	0.005	0.003	0.008
	60	0.338	0.338	0.334	0.337	0.004	0.002	0.007
	80	0.070	0.102	0.080	0.084	0.032	0.016	0.195

Outliers

DFT plots (slab 2)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles
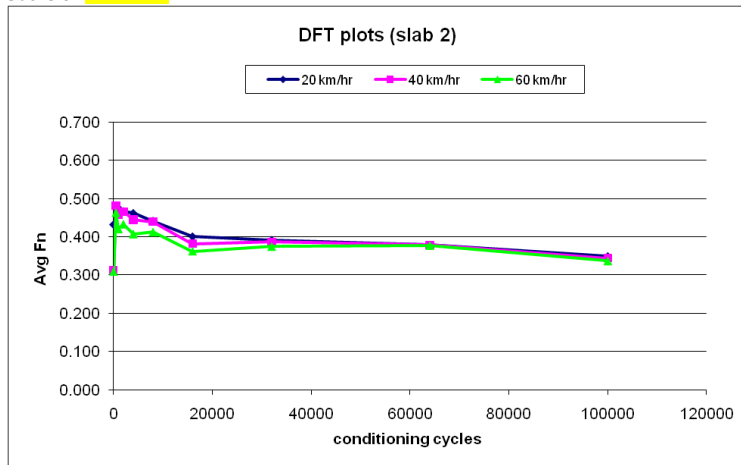
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	2	3	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.852	0.889	0.759	0.833	0.130	0.067	0.080
	20	0.522	0.399	0.387	0.436	0.135	0.075	0.171
	40	0.343	0.315	0.306	0.321	0.037	0.019	0.060
	60	0.331	0.310	0.305	0.315	0.026	0.014	0.044
	80	0.153	0.130	0.138	0.140	0.023	0.012	0.083
500	0	0.642	0.584	0.553	0.593	0.089	0.045	0.076
	20	0.544	0.524	0.502	0.523	0.042	0.021	0.040
	40	0.499	0.482	0.467	0.483	0.032	0.016	0.033
	60	0.471	0.446	0.431	0.449	0.040	0.020	0.045
	80	0.037	0.184	0.110	0.110	0.147	0.074	0.666
1000	0	0.622	0.565	0.543	0.577	0.079	0.041	0.071
	20	0.521	0.501	0.489	0.504	0.032	0.016	0.032
	40	0.505	0.485	0.473	0.488	0.032	0.016	0.033
	60	0.466	0.452	0.443	0.454	0.023	0.012	0.026
	80	0.088	0.128	0.077	0.098	0.051	0.027	0.275
2000	0	0.539	0.529	0.518	0.529	0.021	0.011	0.020
	20	0.500	0.481	0.470	0.484	0.030	0.015	0.031
	40	0.462	0.445	0.434	0.447	0.028	0.014	0.032
	60	0.427	0.409	0.399	0.412	0.028	0.014	0.034
	80	0.095	0.068	0.133	0.099	0.065	0.033	0.331
4000	0	0.545	0.521	0.507	0.524	0.038	0.019	0.037
	20	0.497	0.487	0.479	0.488	0.018	0.009	0.018
	40	0.482	0.473	0.466	0.474	0.016	0.008	0.017
	60	0.463	0.444	0.438	0.448	0.025	0.013	0.029
	80	0.203	0.112	0.119	0.145	0.091	0.051	0.350
8000	0	0.637	0.529	0.533	0.566	0.108	0.061	0.108
	20	0.451	0.452	0.449	0.451	0.003	0.002	0.003
	40	0.411	0.416	0.413	0.413	0.005	0.003	0.006
	60	0.412	0.407	0.390	0.403	0.022	0.012	0.029
	80	0.032	0.080	0.140	0.084	0.108	0.054	0.644
16000	0	0.484	0.479	0.441	0.468	0.043	0.024	0.050
	20	0.454	0.447	0.439	0.447	0.015	0.008	0.017
	40	0.448	0.427	0.431	0.435	0.021	0.011	0.026
	60	0.421	0.408	0.401	0.410	0.020	0.010	0.025
	80	0.130	0.055	0.129	0.105	0.075	0.043	0.411
32000	0	0.443	0.419	0.423	0.428	0.024	0.013	0.030
	20	0.439	0.422	0.413	0.425	0.026	0.013	0.031
	40	0.410	0.404	0.399	0.404	0.011	0.006	0.014
	60	0.390	0.379	0.375	0.381	0.015	0.008	0.020
	80	0.144	0.115	0.077	0.112	0.067	0.034	0.300
64000	0	0.433	0.400	0.401	0.411	0.033	0.019	0.046
	20	0.408	0.405	0.397	0.403	0.011	0.006	0.014
	40	0.381	0.386	0.385	0.384	0.005	0.003	0.007
	60	0.362	0.368	0.365	0.365	0.006	0.003	0.008
	80	0.108	0.106	0.134	0.116	0.028	0.016	0.135
100000	0	0.456	0.410	0.396	0.421	0.060	0.031	0.075
	20	0.396	0.383	0.385	0.388	0.013	0.007	0.018
	40	0.360	0.360	0.360	0.360	0.000	0.000	0.000
	60	0.368	0.367	0.360	0.365	0.008	0.004	0.012
	80	0.073	0.100	0.107	0.093	0.034	0.018	0.192

Outliers

DFT plots (slab 3)

— 20 km/hr — 40 km/hr — 60 km/hr

Avg Fn

conditioning cycles
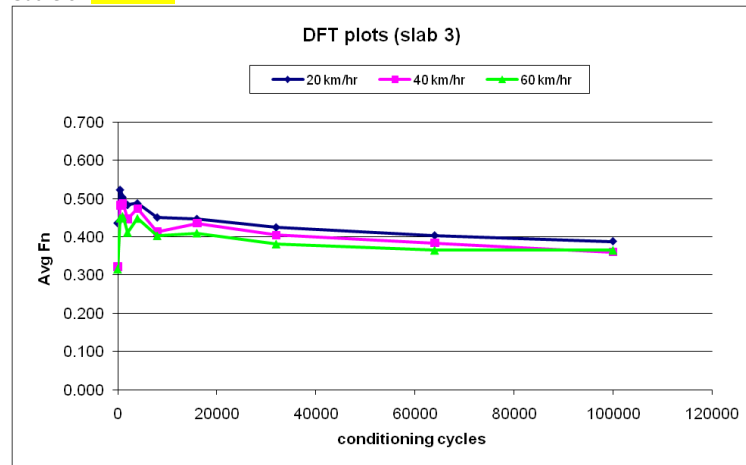
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	3	1	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.893	0.909	0.957	0.920	0.064	0.033	0.036
	20	0.566	0.417	0.400	0.461	0.166	0.091	0.198
	40	0.350	0.312	0.312	0.325	0.038	0.022	0.068
	60	0.337	0.309	0.309	0.318	0.028	0.016	0.051
	80	0.181	0.170	0.103	0.151	0.078	0.042	0.279
500	0	0.884	0.689	0.644	0.739	0.240	0.128	0.173
	20	0.521	0.515	0.514	0.517	0.007	0.004	0.007
	40	0.433	0.461	0.475	0.456	0.042	0.021	0.047
	60	0.411	0.436	0.446	0.431	0.035	0.018	0.042
	80	0.053	0.194	0.146	0.131	0.141	0.072	0.547
1000	0	0.594	0.571	0.533	0.566	0.061	0.031	0.054
	20	0.564	0.523	0.512	0.533	0.052	0.027	0.051
	40	0.554	0.525	0.508	0.529	0.046	0.023	0.044
	60	0.530	0.495	0.479	0.501	0.051	0.026	0.052
	80	0.103	0.109	0.103	0.105	0.006	0.003	0.033
2000	0	0.567	0.502	0.513	0.527	0.065	0.035	0.066
	20	0.482	0.479	0.472	0.478	0.010	0.005	0.011
	40	0.450	0.448	0.449	0.449	0.002	0.001	0.002
	60	0.431	0.437	0.430	0.433	0.007	0.004	0.009
	80	0.106	0.078	0.105	0.096	0.028	0.016	0.165
4000	0	0.548	0.514	0.509	0.524	0.039	0.021	0.041
	20	0.500	0.484	0.468	0.484	0.032	0.016	0.033
	40	0.480	0.462	0.452	0.465	0.028	0.014	0.031
	60	0.450	0.435	0.427	0.437	0.023	0.012	0.027
	80	0.133	0.066	0.130	0.110	0.067	0.038	0.345
8000	0	0.509	0.488	0.459	0.485	0.050	0.025	0.052
	20	0.445	0.450	0.448	0.448	0.005	0.003	0.006
	40	0.399	0.409	0.421	0.410	0.022	0.011	0.027
	60	0.386	0.395	0.396	0.392	0.010	0.006	0.014
	80	0.102	0.077	0.119	0.099	0.042	0.021	0.213
16000	0	0.506	0.514	0.478	0.499	0.036	0.019	0.038
	20	0.484	0.467	0.459	0.470	0.025	0.013	0.027
	40	0.474	0.461	0.456	0.464	0.018	0.009	0.020
	60	0.451	0.438	0.432	0.440	0.019	0.010	0.022
	80	0.087	0.073	0.158	0.106	0.085	0.046	0.430
32000	0	0.444	0.444	0.421	0.436	0.023	0.013	0.030
	20	0.447	0.432	0.430	0.436	0.017	0.009	0.021
	40	0.425	0.420	0.416	0.420	0.009	0.005	0.011
	60	0.404	0.393	0.387	0.395	0.017	0.009	0.022
	80	0.107	0.073	0.139	0.106	0.066	0.033	0.310
64000	0	0.433	0.413	0.408	0.418	0.025	0.013	0.032
	20	0.414	0.414	0.406	0.411	0.008	0.005	0.011
	40	0.394	0.398	0.396	0.396	0.004	0.002	0.005
	60	0.381	0.381	0.378	0.380	0.003	0.002	0.005
	80	0.149	0.106	0.111	0.122	0.043	0.024	0.193
100000	0	0.419	0.414	0.388	0.407	0.031	0.017	0.041
	20	0.411	0.405	0.401	0.406	0.010	0.005	0.012
	40	0.387	0.387	0.386	0.387	0.001	0.001	0.001
	60	0.389	0.387	0.380	0.385	0.009	0.005	0.012
	80	0.096	0.079	0.100	0.092	0.021	0.011	0.122
Outliers								

DFT plots (slab 1)

20 km/hr   40 km/hr   60 km/hr

Avg Fn vs conditioning cycles

147
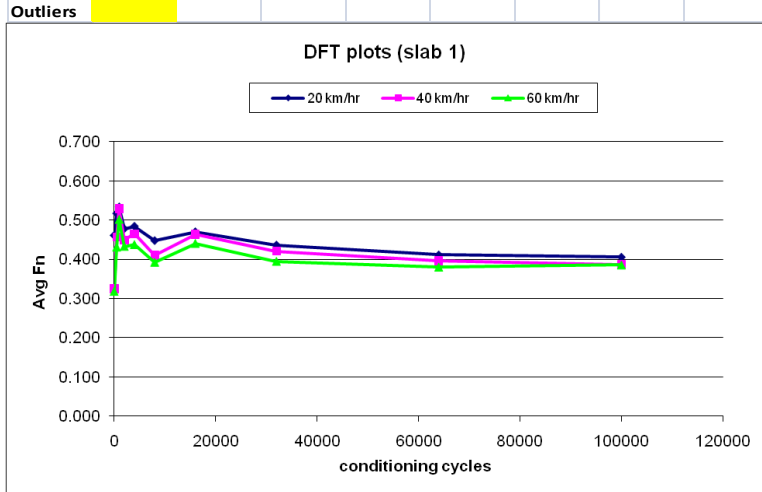
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	3	2	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.928	0.814	0.753	0.832	0.175	0.089	0.107
	20	0.528	0.417	0.390	0.445	0.138	0.073	0.164
	40	0.340	0.317	0.313	0.323	0.027	0.015	0.045
	60	0.323	0.308	0.305	0.312	0.018	0.010	0.031
	80	0.203	0.115	0.072	0.130	0.131	0.067	0.514
500	0	0.638	0.599	0.593	0.610	0.045	0.024	0.040
	20	0.595	0.543	0.525	0.554	0.070	0.036	0.066
	40	0.544	0.519	0.499	0.521	0.045	0.023	0.043
	60	0.534	0.488	0.476	0.499	0.058	0.031	0.061
	80	0.129	0.081	0.130	0.113	0.049	0.028	0.247
1000	0	0.586	0.558	0.538	0.561	0.048	0.024	0.043
	20	0.537	0.518	0.505	0.520	0.032	0.016	0.031
	40	0.530	0.504	0.494	0.509	0.036	0.019	0.036
	60	0.496	0.473	0.464	0.478	0.032	0.017	0.035
	80	0.145	0.084	0.077	0.102	0.068	0.037	0.367
2000	0	0.562	0.543	0.533	0.546	0.029	0.015	0.027
	20	0.517	0.500	0.485	0.501	0.032	0.016	0.032
	40	0.476	0.464	0.450	0.463	0.026	0.013	0.028
	60	0.448	0.436	0.424	0.436	0.024	0.012	0.028
	80	0.098	0.099	0.084	0.094	0.015	0.008	0.090
4000	0	0.553	0.533	0.522	0.536	0.031	0.016	0.029
	20	0.513	0.491	0.485	0.496	0.028	0.015	0.030
	40	0.496	0.475	0.467	0.479	0.029	0.015	0.031
	60	0.466	0.446	0.439	0.450	0.027	0.014	0.031
	80	0.065	0.062	0.047	0.058	0.018	0.010	0.166
8000	0	0.529	0.516	0.489	0.511	0.040	0.020	0.040
	20	0.490	0.485	0.474	0.483	0.016	0.008	0.017
	40	0.470	0.465	0.458	0.464	0.012	0.006	0.013
	60	0.443	0.432	0.419	0.431	0.024	0.012	0.028
	80	0.033	0.059	0.094	0.062	0.061	0.031	0.494
16000	0	0.470	0.444	0.437	0.450	0.033	0.017	0.039
	20	0.459	0.451	0.449	0.453	0.010	0.005	0.012
	40	0.458	0.456	0.455	0.456	0.003	0.002	0.003
	60	0.437	0.432	0.429	0.433	0.008	0.004	0.009
	80	0.150	0.152	0.077	0.126	0.075	0.043	0.338
32000	0	0.458	0.416	0.437	0.437	0.042	0.021	0.048
	20	0.430	0.430	0.425	0.428	0.005	0.003	0.007
	40	0.403	0.403	0.402	0.403	0.001	0.001	0.001
	60	0.384	0.378	0.378	0.380	0.006	0.003	0.009
	80	0.116	0.145	0.154	0.138	0.038	0.020	0.144
64000	0	0.468	0.433	0.411	0.437	0.057	0.029	0.066
	20	0.363	0.379	0.384	0.375	0.021	0.011	0.029
	40	0.340	0.354	0.360	0.351	0.020	0.010	0.029
	60	0.328	0.344	0.351	0.341	0.023	0.012	0.035
	80	0.078	0.073	0.090	0.080	0.017	0.009	0.109
100000	0	0.433	0.406	0.388	0.409	0.045	0.023	0.055
	20	0.410	0.403	0.390	0.401	0.020	0.010	0.025
	40	0.382	0.388	0.372	0.381	0.016	0.008	0.021
	60	0.380	0.379	0.373	0.377	0.007	0.004	0.010
	80	0.090	0.073	0.083	0.082	0.017	0.009	0.104

Outliers

DFT plots (slab 2)

148
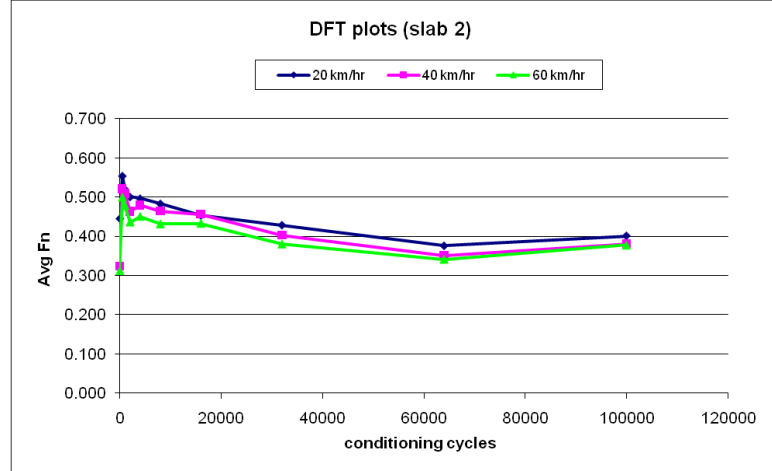
Phase	Mix	Blend	Slab#	Polisher	Load	Speed		
2	SC soft	3	3	NEW	91#	60 rpm		
Cycles	km/h	test 1	test 2	test 3	Avg	Range	Std Dev	Cv
0	0	0.798	0.783	0.821	0.801	0.038	0.019	0.024
	20	0.426	0.354	0.343	0.374	0.083	0.045	0.120
	40	0.298	0.267	0.266	0.277	0.032	0.018	0.066
	60	0.305	0.265	0.265	0.278	0.040	0.023	0.083
	80	0.127	0.121	0.096	0.115	0.031	0.016	0.143
500	0	0.662	0.568	0.603	0.611	0.094	0.048	0.078
	20	0.470	0.449	0.433	0.451	0.037	0.019	0.041
	40	0.455	0.428	0.424	0.436	0.031	0.017	0.039
	60	0.438	0.403	0.397	0.413	0.041	0.022	0.054
	80	0.108	0.098	0.097	0.101	0.011	0.006	0.060
1000	0	0.604	0.586	0.594	0.595	0.018	0.009	0.015
	20	0.446	0.419	0.426	0.430	0.027	0.014	0.033
	40	0.414	0.392	0.403	0.403	0.022	0.011	0.027
	60	0.375	0.353	0.365	0.364	0.022	0.011	0.030
	80	0.084	0.124	0.057	0.088	0.067	0.034	0.382
2000	0	0.586	0.598	0.533	0.572	0.065	0.035	0.060
	20	0.461	0.446	0.438	0.448	0.023	0.012	0.026
	40	0.444	0.433	0.423	0.433	0.021	0.011	0.024
	60	0.403	0.389	0.380	0.391	0.023	0.012	0.030
	80	0.123	0.114	0.098	0.112	0.025	0.013	0.113
4000	0	0.494	0.521	0.498	0.504	0.027	0.015	0.029
	20	0.437	0.425	0.417	0.426	0.020	0.010	0.024
	40	0.404	0.393	0.392	0.396	0.012	0.007	0.017
	60	0.366	0.357	0.346	0.356	0.020	0.010	0.028
	80	0.094	0.107	0.064	0.088	0.043	0.022	0.250
8000	0	0.482	0.459	0.443	0.461	0.039	0.020	0.042
	20	0.424	0.418	0.417	0.420	0.007	0.004	0.009
	40	0.411	0.404	0.403	0.406	0.008	0.004	0.011
	60	0.386	0.376	0.378	0.380	0.010	0.005	0.014
	80	0.111	0.120	0.101	0.111	0.019	0.010	0.086
16000	0	0.429	0.433	0.486	0.449	0.057	0.032	0.071
	20	0.387	0.382	0.384	0.384	0.005	0.003	0.007
	40	0.359	0.356	0.356	0.357	0.003	0.002	0.005
	60	0.353	0.345	0.345	0.348	0.008	0.005	0.013
	80	0.105	0.073	0.122	0.100	0.049	0.025	0.249
32000	0	0.403	0.371	0.384	0.386	0.032	0.016	0.042
	20	0.372	0.358	0.359	0.363	0.014	0.008	0.022
	40	0.361	0.350	0.352	0.354	0.011	0.006	0.017
	60	0.340	0.325	0.326	0.330	0.015	0.008	0.025
	80	0.107	0.115	0.139	0.120	0.032	0.017	0.138
64000	0	0.372	0.339	0.344	0.352	0.033	0.018	0.051
	20	0.351	0.344	0.340	0.345	0.011	0.006	0.016
	40	0.344	0.340	0.336	0.340	0.008	0.004	0.012
	60	0.320	0.316	0.312	0.316	0.008	0.004	0.013
	80	0.054	0.104	0.103	0.087	0.050	0.029	0.329
100000	0	0.353	0.333	0.354	0.347	0.021	0.012	0.034
	20	0.326	0.330	0.333	0.330	0.007	0.004	0.011
	40	0.324	0.318	0.328	0.323	0.010	0.005	0.016
	60	0.307	0.303	0.308	0.306	0.005	0.003	0.009
	80	0.070	0.091	0.096	0.086	0.026	0.014	0.161
Outliers								

DFT plots (slab 3)

20 km/hr   40 km/hr   60 km/hr

Avg Fn

conditioning cycles