CHAPTER 3

FABRICATION AND TESTING OF BRAKE PADS

3.1 STEPS FOR MANUFACTURING A BRAKE PAD

The brake pads are fabricated in five steps which are mixing of the

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**Figure 3.1(a)** Flowchart for production of brake pad  
**Figure 3.1(b)** Schematic diagram showing steps for producing brake pad
Ingredients, preforming and curing in a compression molding machine, post baking and finishing.

### 3.1.1 Mixing of the Ingredients

Lodigee type shear mixer (Chopper Speed-2800 RPM, feeder – 300 RPM)

In order to obtain a homogeneous mixture, a sequential mixing procedure derived from the experience was adopted in a Lodigee type shear mixer (figure 3.2) as per the following procedure:

Fibers + barites (2800 r.p.m for 10 minutes) - fibrisation (Opening of fibre)

Friction modifier + friction additives, followed by resin (6 minutes) – mixing

Total time – 16 minutes

The mixture was then weighed as per the requirement in a weighing machine and sent for preforming.
3.1.2 Preforming Process

![Image](a)

![Image](b)

Figure 3.3(a) Cavity filled with powder  (b) brake pad

The brake pads are molded in a hydraulic press shown in figure 3.3(a) of 150 ton capacity. Mix weight of 620g is taken and put in a compaction die. A pressure of 15 to 16 MPa is applied for around 8 minutes.

3.1.3 Curing Process

![Image](a)
The preform is then placed in the compaction die of the compression moulding machine. The top and bottom temperature of the die is maintained between 150°C and 160°C depending upon the curing temperature of the binder in the formulation. A pressure of 15 to 16 MPa is applied. The press curing cycle is maintained for 8 minutes. Five breathings are followed by final curing. The breathing cycles help to remove entrapped gases evolved during cross linking reaction of the resin.

### 3.1.4 Post Curing Process

The molded components are post baked at different temperatures for different periods as per the schedule below:

<table>
<thead>
<tr>
<th>Post baking schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ambient to 140°C</strong></td>
</tr>
<tr>
<td><strong>Between 140°C and 145°C</strong></td>
</tr>
<tr>
<td><strong>Raise 150°C</strong></td>
</tr>
<tr>
<td><strong>Between 150°C and 155°C</strong></td>
</tr>
</tbody>
</table>
3.1.5 Finishing Process

The surfaces of the pads are then ground with the grinding wheel to attain the desired thickness and remove the resinous skin. Visual appearance characteristics like gapping (between material and plate), splits, and material flash, un-ground material surface and surface blisters are checked.

The properties required by the friction material as well as their different constituents along with the fabrication methods were described. The evaluation methods used for measurement of different properties of friction materials are detailed in the forthcoming sections.

3.2 CHARACTERIZATION OF BRAKE PADS

Evaluation of physical, thermal and mechanical properties of brake pads is important as it helps in study of friction and wear behaviour. Keeping this in mind, in this investigation, physical property such as specific gravity, thermal property such as decomposition temperature, heat swell, mechanical properties such as hardness, shear strength and tribological properties were measured. The details are given in this section.
3.3 EVALUATION OF PHYSICAL PROPERTIES

3.3.1 Specific Gravity

It is a nondestructive test used as a quality control check of the consistency of formulation and processing of brake lining. Normally, the theoretical and actual specific gravity should not differ by more than 2%. The specific gravity and the range of specific gravity are peculiar to each formulation and, therefore, the acceptable values or range must be established for each formulation.

Suspend the specimen from a balance pan hook by means of a thin thread and determine the weight of the specimen in air within an accuracy of 0.1 grams. Immerse the specimen in water at the ambient temperature in such a way that it is freely suspended and does not touch the surface of the water or the walls of the water container, and re-weigh within an accuracy of 0.1 grams.

The specimen shall be weighed as quickly as possible, within three minutes after immersing in water. The specific gravity of the specimen shall be computed as follows:

\[
\text{Specific gravity} = \frac{W_a}{W_a - W_b}
\]  

(3.1)

Where \(W_a\) is the weight of sample in air and \(W_b\) is the weight of sample in water.
3.3.2 Water Swell Test

The blanks of size 50 mm x 25 mm shall be cut from the brake pad and soaked fully in water at room temperature for 30 minutes. The blanks shall be measured for thickness before and after soaking in water at five points equally spaced along the length of the blank and at the centre position across the width. The mean of these five readings shall be used to determine swell.

3.3.3 Porosity

Porosity is the relative volume of the proportion of cavities in the material. This includes pores, air pockets and any cavity in the material.

Porosity (for brake pads): The percentage of the volume of the absorbed oil relative to the volume of the test piece. (As per JIS-D 4118 standard)

\[
P = \left\{ \frac{m_2 - m_L}{\rho} \times \frac{1}{V} \times 100 \right\}
\]

(3.5)

Where, \( P \) : porosity (%)
m₁ : mass of the test piece (g)

m₂ : mass of the test piece after absorbing oil (g)

ρ : density of the test oil ( g/cm³)

V : volume of the test piece ( cm³)

The proportion of cavities must be lower than 5% of the surface of the pad and should not affect its profile if the pad is not to be rejected. High porosity may cause premature wear and low porosity may lead to squeal.

3.4 EVALUATION OF CHEMICAL PROPERTIES

3.4.1 Acetone Extract

It is a test which measures the amount of uncured resins in a material. It is an indication of the degree of cure. Readings above 1.5% can indicate a potential for swell.

A specimen of fine particles of the friction material shall be prepared by drilling with a 10 mm drill, using conditions which do not produce perceptible overheating. The samples shall be drilled perpendicular to the working face, but not nearer than 6 mm from the edges. The weight of drillings required for the specimen is 2 + 0.2g and sufficient holes shall be drilled to give this weight. The time between drilling the specimen and extracting shall not exceed 4 hours. The specimen is weighed to an accuracy of 0.001g, and shall be wrapped securely in a filter paper. The wrapped specimen is placed in an extraction thimble 25 x 80 mm thickness and transferred to Soxhlet extractions. (figure 3.7). Extraction shall proceed for six hours. On completion of the extraction period the flask shall be removed
at a stage when the extraction unit is nearly filled with acetone. This should leave about 15 ml of acetone in the extraction flask.

The contents of the flask shall be transferred to a pre-weighed silica crucible, the flask washed out with acetone and the washing transferred to the same crucible. The crucible is then placed in a water bath and the acetone evaporated. The crucible shall finally be dried for ten minutes in an oven at 80 to 85°C, and shall then be transferred to a dessicator, allowed to cool and reweighed.

The percentage of acetone extract = \( 100 \times \frac{(W_1 - W_2)}{W_1} \) \( (3.2) \)

Where

\[
W_1 = \text{weight of specimen, g} \\
W_2 = \text{weight of empty crucible, g} \\
W_3 = \text{Weight of crucible + extract, g}
\]

Figure 3.7 Soxhlet apparatus used for acetone extraction
3.4.2 Loss of Weight on Ignition (LOI)

![Figure 3.8 Muffle furnace](image)

**Procedure**

1. The sample is prepared in the same way as for the acetone extract test. A representative sample of one gram shall be weighed accurately (to a third decimal place) in a previously ignited, cooled and weighed silica crucible (without lid).

2. The crucible containing the sample is introduced into the muffle furnace (figure 3.8) maintained at 800 to 850°C and soaked for two hours. After ignition, remove the crucible and keep it in a desiccators and then re–weighed.

3. Calculate the %Ash / LOI as under

**Calculations**

\[
\frac{W_1-W_2}{W_2-W_1} \times 100
\]

Where
\[
\begin{align*}
W_1 &= \text{Weight of empty crucible.} \\
W_2 &= \text{Weight of crucible plus Specimen before ignition.} \\
W_3 &= \text{Weight of crucible and its Content after ignition.} \\
\% \text{ L.O.I.} &= 100 - \% \text{ Ash content}
\end{align*}
\]

### 3.5 EVALUATION OF MECHANICAL PROPERTIES

#### 3.5.1 Hardness

Hardness is calculated in ‘S’ Scale using a Rockwell testing machine with a minor load of 10 kgf and the major load applied is 100 kgf.

#### 3.5.2 Shear Strength

It is the ratio of the load at failure divided by the bond area. Brake pad shear strengths are conducted to determine the strength of the attachment of the friction material to the steel back plates of brake pads.

**Shear force**

The determination of the shear force of brake pads is used to assess the bonding strength of the friction material and the back plate. The shearing force is the maximum value of the force introduced via the outer diameter of the disc brake pad.

The bonding is the residue remaining on the backing plate after the shear force test, which can consist of adhesive, under layer, friction material or a combination of these.

**Test components**
a) Original brake pads at room temperature
b) Brake pads after friction coefficient check

Test stand/equipment:

- Shear test stand with rams appropriate for the pad.
- The adapter should completely cover the surface of the friction pad.
- The radius and the inclination of the ram must match the geometry of the pad and must fully contact the surface.
- The ram has a radius of 1.5 mm.

Test setup

Figure 3.9 Shear strength testing fixture set up
Test Procedure

- Insert the test piece with the pad side toward the adapter
- Place a suitable ram in the device
- Apply a normal force to the friction surface corresponding to a pad pressure of 50 N/cm\(^2\) +5 N/cm\(^2\)
- Increase the shear force without shocks at a force increase rate of 4500+ 500N/s until the pad fractures.

The minimum acceptable value of a cold shear stress test is 40 Kg/cm\(^2\), in accordance with O.E specifications. This pressure is equivalent to developing a force of 1488 kgf in an average type pad, with an area of 37cm\(^2\).

Calculation of shear strength:

\[ \text{Shear strength } \tau = \frac{F}{A} \quad (3.4) \]

Where

\[ F = \text{ the shear force at failure (N)} \]
\[ A = \text{ Sample area (0.37m}^2\text{ of the brake pad)} \]

Sample calculation:

\[ \tau = \frac{14597}{37} = 3.95 \text{MPa} \]

If this characteristic is not fulfilled it is necessary to take corrective measures which achieve greater adherence between the back-plate and the friction material. The main actions aimed at correcting this defect are the use of a different adhesive, even varying the friction material in order to improve its flow through the holes in the backplate and for its adhesion to the backplate to be better. It is important to mention not only the breaking point
or shear stress maximum pressure withstood by the material but also its adhesion to the metal backplate, as once the friction material has been separated from the back-plate there must be material left attached to the back-plate which covers more than 80% of the surface of the backplate.

Cold and hot brake pad shear strength tests are conducted in accordance with the requirements of the International Standards Organization specification ISO 6312.

3.5.3 Compressibility

Compressibility is the change in thickness of the pads due to the application of a normal force to the surface of the pads. This test is carried out in two different conditions; initially at room temperature, which is known as cold compressibility, and subsequently by placing the pad on the side of the friction material for 10 minutes against a surface at 400ºC, or what is known as the hot compressibility test. When the cold compressibility is greater than 2% the friction material should be modified to ensure that such a large reduction in thickness does not occur in the material. During the hot test the maximum compressibility value must be less than 5%. If this value is exceeded corrective measures must again be taken as the maximum cold and hot limits are defined in Economic Commission for Europe Regulation 90. It should be pointed out that the compressibility of the brake pads is one of their fundamental characteristics as with a certain level of compressibility they absorb vibrations between the rotor and the pad, thereby reducing the damaging effects of vibrations on the brake system which normally result in noise. On the other hand, excessively high compressibility may lead to excess pedal play.
3.6 THERMAL ANALYSIS

3.6.1 Heat Swell

This test is designed to check the heat swell of the brake pads in the laboratory under controlled conditions. Obtain the initial thickness readings at room temperature to the nearest 0.02 mm, measuring the specimen at not less than six points located approximately between 12 and 20 mm from the pad edge.

Place the unconfined specimen in an oven at room temperature. Increase the oven temperature to $200 + 3^\circ$ C. The time taken to raise the temperature shall be between 30 and 60 minutes. Allow the specimen to remain in oven for 30 to 40 minutes at $200 + 3^\circ$ C. The clamping arrangement shall be such that the pressure exerted is same as that used in bonding. Remove the specimen from the oven and while still hot measure thickness at the same point used for obtaining initial thickness. The swell is recorded as increase in thickness.
3.6.2 Thermo Gravimetric Analysis (TGA)

Table 3.2 Details of TGA Instrument

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of Instrument / Equipment</th>
<th>Make</th>
<th>Machine Specification</th>
<th>Test Compliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thermo gravimetric Analyzer / Differential</td>
<td>Shimadzu</td>
<td>Testing of Thermal Stability of Raw and Finished Materials</td>
<td>As per IUPAC Standards</td>
</tr>
<tr>
<td></td>
<td>Thermo gravimetric (TGA / DTG)</td>
<td>Japan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Differential Thermo Gravimetric Analyzer for checking weight loss with respect to rise in temperature for raw material and finished product. TGA analysis will exactly point out decomposition temperature of individual raw material used in formulation and same can be extended to finished product analysis.

Figure 3.10 Differential Thermo Gravimetric Analyzer

Principle :- The thermal analysis of Finished Product & Raw Material through DTG – 60A is based upon Weight Loss of the sample with respect to increase in temperature at a constant rate in a different atmosphere (Zero Air/ Nitrogen etc.).

**Operating Conditions**

1. Sample weight - 1 - 50 mg max.
2. Gas flow - 50 ml/min Gas flow type - Nitrogen or Air depending upon the material under test
3. Temperature rise - 10°C/min (or as required)
4. Max test temperature - 1100°C for Platinum Pan & 600°C for Aluminium Pan

### 3.6.3 Differential Scanning Calorimeter (D.S.C)

Differential scanning calorimeter is used for studying and analyzing exothermic and endothermic reactions using organic material like resins used in brake pads to analyze the exact curing point.

**Table 3.3 Details of D.S.C Instrument**

<table>
<thead>
<tr>
<th>S1. No</th>
<th>Name of Instrument / Equipment</th>
<th>Make</th>
<th>Machine Specification</th>
<th>Test Compliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Differential Scanning Calorimeter (DSC)</td>
<td>Shimadzu Japan</td>
<td>Testing of Exothermic and Endothermic Reaction</td>
<td>NA</td>
</tr>
</tbody>
</table>
Principle: - DSC – 60 is a Heat Flux type differential scanning calorimeter, Heat flow per unit time to the sample section and the reference material section is measured and deviation of the sample section temperature from a reference material section are detected and plotted against time or sample section temperature.


Operating Conditions

1. Sample weight - 1 -10 mg max.
2. Sample Form: - Solids or Liquids (Avoid Measuring sample possibly evolving toxic exhaust or generating corrosive degradation products)
3. Gas flow - 50 ml/min Gas flow type - Nitrogen or Air depending upon the material under test
4. Temperature rise - 10°C/min (or as required)
5. Max test temperature - 600°C.
3.6.4 Thermal Conductivity (TC)

Thermal conductivity assumes a critical role in the performance of materials in high temperature applications.

Thermal conductivity of a friction material is dependent on various factors including type and amount of fillers, processing technique etc and operating parameters such as temperature, method used for measurement sample size etc. With increase in temperature TC decreases. No two friction material can have identical thermo-physical characteristics.

Square samples of size (10 mm x10 mm) and thickness 2-2.5 mm were studied. Both surfaces of samples were coated, with graphite spray to improve the absorbity and emissivity of the material. Tests were done on Thermal conductivity analyzer (FL-3000) procured from Anter corporation, USA. All the measurements were carried out at 150°C and 400°C. Table 3.4 comprises the specifications of the instrument, while Fig 3.12 shows the photograph of the machine.

**Table 3.4 Specifications of TC instrument (FL-3000)**

<table>
<thead>
<tr>
<th>Principle of measurement</th>
<th>Pulse technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat source</td>
<td>Xenon flash lamp</td>
</tr>
<tr>
<td>Temperature range</td>
<td>Ambient to 400 °C</td>
</tr>
<tr>
<td>Sample dimensions</td>
<td>disc (31.75 &amp; 12.7 mm dia, square (10 mm)</td>
</tr>
<tr>
<td>Thickness</td>
<td>&gt;2-3 mm</td>
</tr>
<tr>
<td>Test- Materials range</td>
<td>Polymers, ceramic &amp; metals</td>
</tr>
<tr>
<td>Diffusivity range</td>
<td>0.001 - 1000 mm²/sec</td>
</tr>
<tr>
<td>Thermal conductivity range</td>
<td>0.1 – 2000 W/m K</td>
</tr>
</tbody>
</table>
3.7 TRIBOLOGICAL PROPERTIES:

3.7.1 Testing of Co-efficient of Friction as per SAE J661/IS 2742 Standards (Chase Testing Machine)

Table 3.5 Details of Chase Machine

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of Instrument / Equipment</th>
<th>Make</th>
<th>Machine Specification</th>
<th>Machine Utilization</th>
<th>Test Compliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chase Machine</td>
<td>Link USA</td>
<td>Testing of Co-efficient of Friction as per SAE J661 / IS 2742 1994 Std</td>
<td>To check friction Co-efficient and Wear properties of small samples</td>
<td>SAE – J661 IS 2742</td>
</tr>
</tbody>
</table>

Figure 3.12 Photograph of the TC instrument (FL-3000)
The Chase machine is well established as a means of determining friction levels. Automotive Association for Motor Vehicle Act (AAMVA) certification and edge codes are based on the results of this test. The figure 3.13 shows the chase type friction testing machine from Link Engineering, USA according to SAE J661a used in this study. It is fully computer controllable and involves data acquisition software. The test specimen is taken from the centre of the friction material (i.e. Brake pad) approximately equidistant from each end. The friction specimen is of size 25 x 25 mm square (625 mm$^2$) flat at the bottom and the radius of the working surface conform to the radius of the test drum. The drum surface is polished with an abrasive paper of grit size 320. The test specimen is burnished at 308
rev / min, 440N and at a maximum temperature of 199.40°F, for a minimum duration of 20 minutes, to obtain at least 95 percent contact.

The friction test used in this study consisted of three sequential stages which are repeated two times, namely (1) Baseline Run, (2) Fade Run and (3) Recovery run. The test procedure is given in the Table 3.6.

The wear test consists of 20s on, 10s off, at 660 N and 411 r.p.m for 100 applications. During the wear test, the drum temperature was adjusted between 379.4 and 399.2°F. The weight loss was determined from the corresponding measurements of the samples done before and after the wear test. The specific wear rate $W_s$ was calculated according to the following equation

$$W_s = \Delta m / L \rho F_n \text{ (mm}^3/\text{Nm}) \quad (3.6)$$

Where $\Delta m$ is the sample’s mass loss, $L$ is the total sliding distance; $\rho$ is the density of the sample during sliding. The wear resistance of the material is the inverse of the specific wear rate.

During the friction tests, the Coefficient of friction (COF) and the drum temperature were recorded continuously. At least 20 data points were recorded for each stage. Two types of friction values i.e Normal friction coefficient (average of four points in the second fade curve located at 199.4, 249.8, 300.2 and 401°F) and Hot friction coefficient (average of 10 points located at 402.8 and 300.2°F on the first recovery; 451.4, 501.8, 261, 289, 317 and 345°F on the second fade 501.2, 401 and 300.2°F on the second recovery) is calculated. Accordingly, first fade- $\mu$ percent, first recovery $\mu$ percent, second fade $\mu$ percent and second recovery $\mu$ percent are calculated which are defined as follows:
First fade $\mu$ (%) = \((\text{Initial } \mu - \text{Final } \mu) / \text{Initial } \mu\) x 100

(during I fade cycle)

First recovery $\mu$ (%) = \(\text{Final } \mu / \text{Initial } \mu\) x 100

(during I recovery cycle)

Second fade $\mu$ (%) = \((\text{Initial } \mu - \text{Final } \mu) / \text{Initial } \mu\) x 100

(during II fade cycle)

Second recovery $\mu$ (%) = \(\text{Final } \mu / \text{Initial } \mu\) x 100

(during II recovery cycle)

Table 3.6 Test procedure as per SAE J-661 Standard

<table>
<thead>
<tr>
<th>Stages</th>
<th>Speed (rpm)</th>
<th>Temperature ($^\circ$F)</th>
<th>Load (N)</th>
<th>On time min</th>
<th>Off Time min</th>
<th>Number of applications</th>
<th>Heater</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Increment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burnish</td>
<td>308</td>
<td>-</td>
<td>199.4</td>
<td>440</td>
<td>20</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Baseline-I</td>
<td>411</td>
<td>179.6</td>
<td>219.2</td>
<td>660</td>
<td>10</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>Fade-I</td>
<td>411</td>
<td>552.2</td>
<td>372.6</td>
<td>660</td>
<td>10</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Recovery -I</td>
<td>411</td>
<td>501.8</td>
<td>199.4</td>
<td>302.4</td>
<td>10</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Wear</td>
<td>411</td>
<td>399.2</td>
<td>379.4</td>
<td>660</td>
<td>20</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>Fade-II</td>
<td>411</td>
<td>653</td>
<td>179.6</td>
<td>473.4</td>
<td>10</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Recovery -II</td>
<td>411</td>
<td>403.2</td>
<td>602.6</td>
<td>403.2</td>
<td>10</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Baseline -II</td>
<td>411</td>
<td>219.2</td>
<td>179.6</td>
<td>660</td>
<td>10</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>
3.7.2 Testing of Friction And Wear as per JASO C-406 Schedule (LCV Cum Car Class Dynamometer for Disc Brake Pads)

Table 3.7 Details of Dynamometer for testing as per O.E standards

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of Instrument / Equipment</th>
<th>Make</th>
<th>Machine Specification</th>
<th>Machine Utilization</th>
<th>Test Compliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LCV cum Car Class Dynamometer</td>
<td>Pyramid Precision India</td>
<td>Double End Dynamometer for Drum Brake Lining and Disc Brake Pads for LCV and Passenger Cars</td>
<td>Inertia = Min 1.2 Kg-m-Sec², Max inertia 130 Kg-m-Sec², Speed = Max 220 KMPH</td>
<td>SAE, FMVSS, JASO, EES or any other tailor made schedule</td>
</tr>
</tbody>
</table>

Inertia Dynamometers are brake-testing equipment used to perform a variety of testing ranging from quick friction coefficient analysis for coated rotors to FMVSS 105 or 135 simulations. Performance, durability, capacity and noise tests are the most common tests performed. Single-ended Dynamometers utilize brake components from one corner of the vehicle in order to subject the components to a series of brake applications defined in the test procedure. The vast majority of Inertia Dynamometers procedures (SAE, JASO, ISO, FMVSS, JIS or proprietary) used by original equipment suppliers, friction vendors and component manufacturers are designed for single-ended Dynamometers.
The main components of an Inertia Dynamometer are: main drive, inertia section, brake enclosure, cooling air system, computer control console and fixture with brake components for testing. The main drive accelerates the mass inertia that simulates the vehicle’s kinetic energy and then the brake is applied to stop or reduce the speed of the mass. The motor can be also used to drag the brakes to simulate a constant downhill descent. If the brake is applied without rotation, parking brake forces can be measured.

Typical sensors and signal conditioning include channels for reading speed, torque, pressure, fluid displacement and temperature. Noise testing requires a noise enclosure and microphones for brake noise data collection. Modern Inertia dynamometers are controlled with Microsoft Widows based software and can simulate certain levels of inertia. Pressure profiles and complex control algorithms are also available.

Typical brake applications can be controlled by pressure, torque, deceleration or drag by pressure. The start of the brake application can be by initial temperature or cycle time. The release of the brake application can be by speed, torque, temperature or elapsed time.
The test may be summarized as follows.

(1) Preburnish effectiveness: at 200 °F (93 °C) and 483 rev/min (30 miles/hr or 50 km/hr); run stops at 150 - 750 lbf/in² in 100 lbf/in² increments (10.3 - 51.7 bar in 6.90 bar increments); repeat at 967 rev/min (60 miles/hr or 100 km/hr).

(2) Burnish: 200 stops at 644 rev/min (40 miles/hr or 65 km/hr) at 3.66 m/s² (12 ft/sec²) deceleration at 100 °C (212°F).

(3) Post-burnish effectiveness: same as above.

(4) First reburnish: 30 burnish stops.

(5) Recovery baseline: three stops at 644 rev/min (40 miles/hr or 65 km/hr) at 3.05 m/s² (10 ft/sec²) from 66 °C (150 °F).

(6) First fade: ten stops from 967 rev/min (60 miles/hr or 96.7 km/hr) at 4.57 m/s² (15 ft/sec²) deceleration with 35 s intervals, beginning at 66 °C (150 °F).

(7) First recovery: 12 stops at intervals of 120 s from 30 miles/hr (50 km/hr) at 3.05 m/s² (10 ft/s²).

(8) Second reburnish: 30 burnish stops.

(9) Recovery baseline: as above.

(10) Second fade: 15 stops from 967 rev/min (60 miles/hr or 96.7 km/hr) at 4.57 m/s (15 ft/s) deceleration with 35 s intervals, beginning at 66 °C (150 °F).

(11) Second recovery: same as first recovery.

(12) Third reburnish: 30 burnish stops.

(13) Final effectiveness: same as above.