

A Study of the Disc Scoring Generation Principle and Reduction

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ABSTRACT

Owing to the enhanced performance of engines these days, more heat should be dissipated in the braking system. Success of doing this properly causes more heat to the disc in the brake system which results in the deformation or scratches on the surface of it and a reduction in the appearance of the product. A study for detailed factors to aggravate this was done as a solution to prevent these from happening. In this paper, we present our work based on experiments to study MPU (Metal Pick Up) of the pad and the scoring (scratching) of the disc. MPU of which the main component is "Fe", is formed through the process of fusing the separated materials from the disc by friction with the pad, and by local heat generation to the pad. [1,2,3,4,5] The occurrence of MPU and the possibility of the disc scoring resulting from this were studied by noting "Fe" which was transferred to the surface of the pad to different extent and degree of segregation according to the roughness of the disc. For verification purposes, the vehicle and bench tests were conducted.

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INTRODUCTION

During braking, a disc plays an important role in generating braking force of vehicle together with calipers on the front or rear wheels of passenger car. In recent years, discs are getting more and more heat to convert greater kinetic energy into vehicle stopping energy due to higher vehicle performance especially by enhancing engine powers of normal cars. For this reason, a disc may be deformed or scratched and the appearance may be deteriorated. In general, scoring occurrence influencing factors are due to discs, friction materials, calipers, and external factors, and the Figure. 1 shows the influence factors in a diagrammatic representation.

In particular, a great body of research has been performed to solve these problems. Pietro[1] studied the factors, conditions, and mechanisms of occurrence of MPU by morphological characterization, to have an overview of the problem, both on a macroscopic and a microscopic scale. Oliver[1] examined the cause of the MPU through the surface component investigation of the friction material, before and after the dynamo test. Franco[2] suggested effective methods to reduce MPU like a disc slot or hole machining type, Semi-metal friction material to increase lubricant characteristics, assuming that it be easy to generate MPU because of non-maintenance of lubricant on friction material surface in wet environment condition. Kota[3] considered an influence factors of MPU generation. He dealt with Fe(iron) transfer according to a temperature, pressure, hardness and porosity of friction material, especially Cu component detected around the MPU. The higher temperature was, the lower pressure was, and the more porosities were, the much Fe transition was. Umberto, and Pietro[5] presented the mechanism of the occurrence of MPU again. They approached the main contents, the surface composition of the friction material before and after the test, the tuning of the component, and the effect of changing the disc design. They concluded that low steel friction material was disadvantageous in wet conditions and non-steel friction material was poor in dry environment and friction material Cu

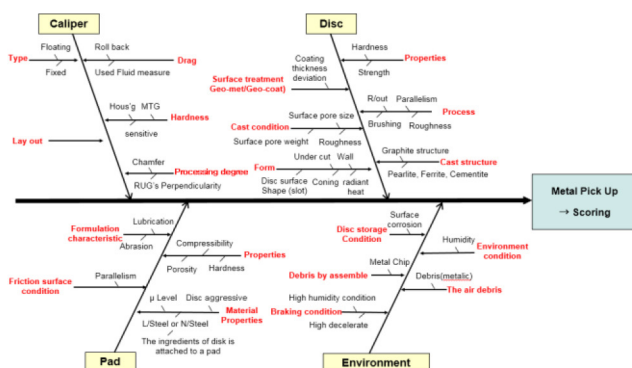


Figure 1. Influencing factors of scoring generation

content reduction, slot type disc was effective to reduce MPU. Georg[6,7,8] studied the general principles of friction and the effect of MPU to the friction interfaces.

In this study, we investigated the relationship between MPU of pad, or the possibility of the disc scoring and “Fe” transfer from the disc to pad or segregation degree according to the roughness of the disc. The procedure and method are as follows.

- Evaluation of scoring generation due to surface roughness (Stochastic approach)
- 1. Analysis of Fe content change and observing the degree of segregation in 1/5 scale disc by braking
- 2. Scoring stochastic evaluation according to the surface roughness of the same TARGET 1,2,3 discs

In order to verify the experimental results, Fe content transferred from disc to friction material by the number of braking was checked using a 1/5 scale disc, and chemical characteristics before scoring were analyzed quantitatively. It has been studied that the degree of MPU and scoring due to the surface roughness of the disc was proportional to the size thereof and scoring did not occur when surface roughness of the disc surface was H μm or less. [9] But, it was difficult to clearly distinguish between the cases where the scoring occurred when evaluating the same condition in the vehicle test and the case where it was not. Table 1 shows the parts of the same test conditions of the same TARGET 1,2,3 parts by making the roughness TARGET identical and the friction material making the same samples.

Table 1. Conditions of disc surface roughness

Subject	Roughness Range	Quantity
Non Steel Pad(Grinding)	1~4 μm (TARGET 1)	5ea
	4~10 μm (TARGET 2)	5ea
	More than 10 μm (TARGET3)	5ea
Low Steel Pad(Honing)	1~4 μm (TARGET 1)	5ea
	4~10 μm (TARGET 2)	5ea
	More than 10 μm (TARGET3)	5ea

Based on the evaluation results, it was possible to stochastically approach the degree of scoring caused by the surface roughness of the disc, and the premise of scoring was the MPU, and the disc rust had a possibility to accelerate it. In order to confirm this, the degree of rusting of the disc was controlled by a constant temperature / humidity corrosion test apparatus, and MPU and scoring occurrence degree were confirmed by 1/5 scale dynamo.

EXPERIMENTAL SET UP

To carry out this study, the evaluation was carried out using the 1/5 scale dynamometer / vehicle scale dynamometer of Sangsin Brake and Myeonghwa-industry. In addition, quantitative analysis was carried out using a composite corrosion tester, a friction material analyzer, and a disc surface roughness tester for the generation of

rust. The final vehicle test condition confirmation was evaluated by Hyundai Proving Ground and confirmed to be correlated with dynamo conditions. The specifications and the shapes of each test equipment were as follows.

1/5 Scale Dynamo

1/5 scale Dynamo installs a caliper on a circular disc as shown in Figure 2 with a thermocouple installed at a depth of 1mm. It is equipped with a ventilation system to adjust the temperature, humidity and wind speed. It can perform basic performance test and wear test at arbitrary set temperature / humidity by caliper type input/output automatic control system. The test temperature can be controlled by KS R 4024, and the braking evaluation can be carried out according to the change of speed and deceleration in a certain environment.



Figure 2. (1) 1/5 Scale dynamometer external structure. -left (2) Internal structure. -right

As shown in Table 2, maximum inertia is 0.3 kgfm², maximum RPM is 3500rpm, maximum hydraulic pressure is 150 kg/cm², and maximum torque is 35 kgfm.

Table 2. Specifications of 1/5 Scale dynamometer

Category	Specification	Remarks
Maximum inertia (kgfms ²)	0.3	0.15 + 0.05 + 0.1
Maximum revolution (rpm)	3500	About 180km/h
Maximum torque (kgfm)	25.0	1.14g
Pad surface area (cm ²)	16.2	45mm × 18mm × 2
Disc size (Φ)	142.0	Φ142 × Φ × 8mm
Disc radius (mm)	55.0	-
Drive motor (kW)	7.5	Inverter motor

Brake dynamometer

The braking dynamo of vehicle scale used in the evaluation is shown in Figure 3 and the specifications of the tester are shown in Table 3.



Figure 3. The brake dynamometer of vehicle scale

Table 3. Dynamometer specifications of vehicle scale

Dynamometer specification		
Maker	LINK(USA)	
Inertial mass(kgms ²)	Self inertial mass	0.667
	Max.	13.167
	Quantity	3.0x3ea/0.6x5ea/0.1x5ea
	Auto/Manual	Manual
Drive Motor	Type	DC-Type
	Power	480V
	Driving Force	180HP
	Max. Rotation Speed	2400rpm
	Rotation Direction	CW/CCW
Torque	Sensor Type	Rotary torque sensor
	Max.	576kg*m
Pressure	Control Type	Hydraulic Servo
	Max.	210kg/cm ²
Cooling Air	Max. Speed	80m/s
	Test Speed	0 ~ 44 m/s
Water Spray	flux	Max. 10ℓ/min

Other Tester

The composite corrosion tester (Figure 4, Table 4), the XRF (X-ray Fluorescence Spectrometer) component analyzer (Figure 5), and the SEM (Scanning Electron Microscope) - EDS (Energy Dispersive Spectrometer) (Figure 6) used for preparing and analyzing parts before and after test are as follows.



Figure 4. Cyclic corrosion test chamber

Table 4. Specifications of cyclic corrosion test chamber

Salt solution reservoir capacity		115L
Chamber capacity		About 100ea
Condensing humidity mode	Temperature	ambient to +55℃
	Humidity	95% ~100% RH
Salt spray mode	Temperature	ambient to +50℃
	Salt spray fall-out rates	0.5 ~ 3.0ml/hour
	Air saturator temperature	ambient to +63℃
Air drying mode	Temperature	ambient to +70℃

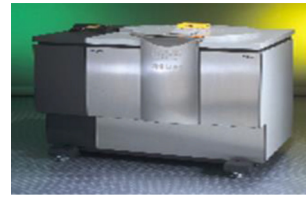


Figure 5. XRF Philips/PW2424



Figure 6. SEM-EDS Jeol & Oxford

The Test Procedure

Note) Many placeholder variables (such as A,B,C,...) will be shown from this and those are the policy of our company. Please excuse us for causing you inconvenience.

Changes in the Fe content during braking of the friction material are recognized as a major factor in MPU generations. In order to confirm the conditions of the disc surface roughness and braking conditions, it was carried out using 1/5 scale dynamo (Environmental conditions: 25°C temperature, 65% relative humidity, 13g absolute humidity). As shown in Table 5, the disc was prepared by changing the disc milling conditions to a surface roughness of 6.95 / 14.07 / 15.59 μm.

Table 5. Disc roughness at burnish mode

Disc	Friction material	Disc roughness
1/5 Scale	Low steel	6.95 μm
		14.07 μm
		15.59 μm

The friction material sample was prepared by using one set of two pads which were processed into 45(L)*18(W)*5(t) mm sizes using a low steel material. The evaluation mode was performed in the following Burnish mode / Dry mode / Wet mode / Corrosive dry-type MPU mode.

- Burnish mode: Test conditions were as shown in Table 6, and the initial disc roughness and XRF component analysis were performed, and disc roughness and XRF component analysis were performed at every 50 brakes. After final 200 brakes, Morphology and composition of the friction material surface were analyzed by SEMEDS to analyze Fe components strength.

Table 6. Burnish test procedure

Control	Velocity(kph)	Deceleration(g)	Temperature(℃)	Flow(m/s)
Temperature	E→1	0.35	120	11

- Dry MPU mode & Wet MPU mode: Test conditions were as shown in Table 8 (when wet mode, 0.5 L/h of water was sprayed