A REVIEW PAPER ON STUDY OF HOT SPOT ON PERFORMANCE OF BRAKE SYSTEM

SOYEB MULTANI[1], VINOD PATEL[2]

[1]*M.Tech in Thermal System & Design, Mechanical Engineering*
[2]*M.E Thermal Engineering, Mechanical Engineering*
Gujarat,India

---***---

Abstract - *Brake system of railway vehicle is very important role for safety. This Review article is based on performance and hot spot occurred in brake system. Brake dynamometer is used to measure the characteristics and data of brake while it is in running condition. In this paper we try to study the performance of brake with different working parameters and hot spot development in the railway disc brake. Hot spot classification is based on development of heat generation at high temperature. High temperature during breaking caused thermal crack, wear, bearing failure.*

Key Words**- hotspot, hot circle, pyrometer, hot bands, dynamometer**

1. INTRODUCTION

For several years, the increase of railway commercial speed and capacity requires the improvement of braking performances. Even if dynamic braking systems are often largely used in normal service braking, their performances are not sufficient to ensure an emergency braking at high speed. During braking different thermal phenomenon appear on the brake called hot spot or hot circle. Pyrometer is used to determine the surface temperature of the brake. Hotspot can be detected by pyrometer or IR camera. Disk brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. High decelerations typical of passenger vehicles are known to generate temperatures as high as 900°C in a fraction of a second. These large temperature excursions have two possible outcomes: thermal shock that generates surface cracks; and/or large amounts of plastic deformation in the brake rotor. In the absence of thermal shock, a relatively small number of high-g braking cycles are found to generate macroscopic cracks running through the rotor thickness and along the radius of the disk brake.

Dynamometer is a device for measuring the torque, force, or power available from a rotating shaft. The shaft speed is measured with a tachometer, while the turning force or torque of the shaft is measured with a scale or by another method.

1.1 Overview of brake performance

Hot spot occurs during brake system mainly classified into five categories. First type is called Asperity. During these types of hot spot temperature reached around 1200 °C. Second type is called gradients on hot bands. It is occurs during 650-1000°C and width is 5 to 20 mm at 800 °C. Third type is called hot bands. Forth type is called microscopic hot spot. It is occurs at 1100°C. Fifth type is called regional hot spots. It is occurs at 300 °C.

TABLE I

RAILWAY DISC HOT SPOT CLASSIFICATION

	Width (mm)	Temperature (°C)	Duration
Asperity (type 1)	<1	1200	<1 ms
Gradients on hot bands	5-20	650-1000	0.5-10S
Hot bands	5–50	800	>10 S
Macroscopic hot spots	40–110	1100	>10 s
Regional hot spots	80–200	20–300	>10 s

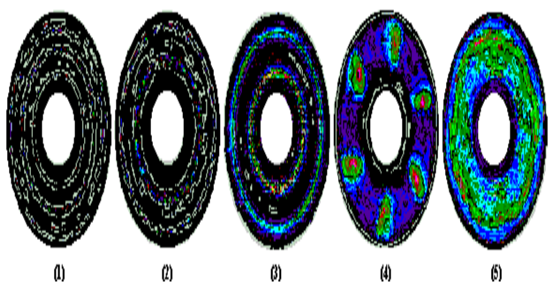

Fig-1. Thermal gradients classification illustrated by thermographs.

Three kinds of pad, respectively A, B and C, were tested. The pad A is a commercial standard model. Pad B has been specially developed for these tests. It is the same as pad A but with a softer substrate, with a Young's modulus of 30 MPa against 90 MPa for pad A. Pad C is the same as A with a reduced length (Fig. 4, on the right). Pads B and C allow to investigate respectively the influence of the pad stiffness and the contact length on hot spots development

2. RESULT

The infrared system was set to take temperature readings in snap shot mode precisely synchronized with the rotation of the disc. These experimental results illustrate the proposed classification five kinds of hot spots are considered: angular length. For pad A and pad B, tests were made at a constant dissipated energy of 15 MJ and 6.4 MJ respectively. For pad C, tests have been achieved with increased speed and energy. A new disc has been used for each pad.

The influence of contact length has been studied with a shorter pad called C. Its angular arc angle has been reduced from 66° to 44°, so that the contact angular length of pad C is two third of pad A. A series of braking actions have been done at increasing speeds and dissipated energy levels. For speed varying from 60 to 90 km/h with energy from 1, 39 to 6,25 MJ, only hot bands appeared. During the following braking (at 90 km/h and for 9.38 MJ), 9 macroscopic hot spots occurred on the friction surface, such investigation allows proposing correspondence between angular friction length of the pad and hot spots number. In the present case, the contact arc angle of pad C is one third less than pad A and the number of hot spots is one third higher. Even if the ratio of the disc perimeter with angular contact length is not exactly 9 or 6, it should be noticed that effective contact length is commonly less than the angular length of the pad due to thermal distortions and that hot spots number is the first higher whole number in order to ensure a way of continuity of the contact of the pad. 6 or 9, respectively for pad A and C, is close to the minimum number that at least one hot spot is located in the contact zone at all times.

3. CONCLUSION

A classical script of thermal gradients evolution has been defined. It was commonly observed firstly hot bands occurrence and then thermal gradients on hot bands and finally macroscopic hot spots. Analysis of the thermographs allows to give new highlights on the thermal gradients explanation. The focal type commonly called gradients on hot bands seems to be associated with thermoplastic instabilities according to the geometry of the pins of the pad. A model of the behavior of the pad under fretting loading with dynamical effects coupled with the thermo elastic response could be representative.

REFERENCES

[1] P. Dufrénoy, D. Weichert, "A thermomechanical model for the analysis of disc brakes fracture", Thermal Stresses 2001,Osaka,2001.
[2] A.E. Anderson, R.A. Knapp, "Hot spotting in automotive friction systems", Wear, 135, 319-337, 1990.
[3] P. Dufrénoy, G. Bodovillé, G. Degallaix, "Damage mechanisms and thermo mechanical loading in brake discs", Temperature-Fatigue interaction, L. Rémy & J. Petit, 167-176, 2001.
[4] T. Kao, J.W. Richmond, A. Douarre, "Brake disc hot spotting and thermal judder: an experimental and finite element study", Int. J. Of Vehicle Design, **23**, 276-296, 2001.
[5] X. Fan, H. Lippmann, "Elastic-Plastic Buckling of Plates under Residual Stress", Advances in Engineering Plasticity and its Applications, Pergamon Press, Amsterdam, 1996.
[6] K. Lee, J.R. Barber, "Frictionally excited thermo elastic instability in automotive disc brakes", J. of Tribology, 115, 607-614,1993.