Optimization of Two Wheeler Brake Disc by Using Thermal Analysis

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Abstract— These day technologies go beyond us. For automotive field, the technology of engine develops very fast even the system of the car, luxury or comforts everything that develops by the innovation of engineer. Although the engineer gives priority for safety measure, but most consumers still have inadequate of knowledge in safety system. Thus safety is the first important thing we must focus. This paper is presented with "Thermal analysis of Disc Brake Rotor with slot shape optimization" which studies about on disc brake Rotor by analysis of different shapes of slots of different vehicle's Disc Brake Rotor. Therefore, we can optimize number of shapes of slots to estimate the good thermal conductivity of the disc brake Rotor. In this paper, Thermal analysis done on real model of Disc Brake Rotor of Bajaj Pulsar 220 and Thermal analysis of disc brake Rotor of different shapes of slots of different vehicle's in one Disc brake rotor. Different shapes of slots are because of to reduce the weight of disc rotor and for good thermal conductivity. Hopefully this paper will help everyone to understand Thermal analysis of disc brake rotor and how disc brake works more efficiently, which can help to reduce the accident that may happen in each day.

Keywords: Disc Brake, Thermal Analysis, shape Optimization

I. Introduction

A. Importance

While braking, most of the kinetic energy are converted into thermal energy and increase the disc temperature. This project consists of thermal stress analysis on pulsar brake disc rotor for steady state and transient condition. The heat dissipated along the brake disc surface during the periodic braking via conduction, convection and radiation. In order to get the stable and accurate result of element size, time step selection is very important and all of these aspects are discussed in this paper. The findings of this research provide a useful design tool to improve the brake performance of disc brake system.

B. Need

A problem in Disc Brake occurs because of uneven stress & heat dissipation during braking of two wheeler as scarring, cracking, rusting, poor stopping, noise, vibration, pulling, grabbing, dragging, and pulsation.

C. Principle Of Working

When hydraulic pressure is applied to the calliper piston, it forces the inside pad to contact the disc. As the pressure increases, the calliper moves to the right and cause the outside pad to contact the disc. Braking force is generated by friction between the disc pads as they are squeezed against the disc rotor. Since disc brakes do not use friction between the lining and rotor to increase braking power as drum brakes do, they are less likely to cause a pull. The friction surface is constantly exposed to the air, ensuring good heat dissipation, minimizing brake fade. It also allows for self-cleaning as dust and water is thrown off, reducing friction difference.

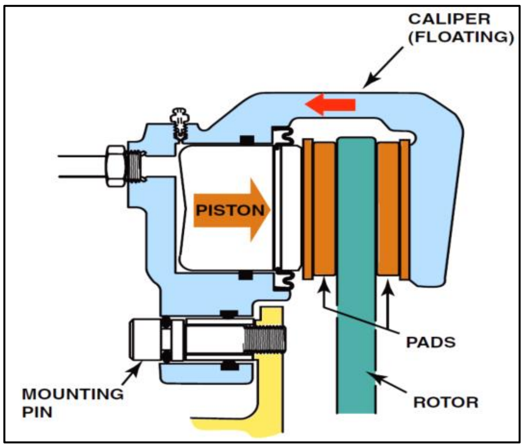

Fig. 1.1: single-piston floating caliper disc brakes

Unlike drum brakes, disc brakes have limited self-energizing action making it necessary to apply greater hydraulic pressure to obtain sufficient braking force. This is accomplished by increasing the size of the caliper piston. The simple design facilitates easy maintenance and pad replacement.

II. Literature Survey

Das.A et al.[1] investigated the temperature fields and also structural fields of the solid disc brake during short and emergency braking with four different materials. The distribution of the temperature depends on the various factors such as friction, surface roughness and speed. The effect of the angular velocity and the contact pressure induces the temperature rise of disc brake. The finite element simulation for two-dimensional model was preferred due to the heat flux ratio constantly distributed in circumferential direction. We will take down the value of temperature, and deformation for different pressure condition using analysis software with four materials .The Disc brakes are made up of cast iron.

Nouby M et al. [2]presented brake squeal is widely accepted by scientists and engineers as a noise which is caused by friction-induced vibrations and it frequently occurs at frequency above 1 kHz. It is one of the most difficult problems and is a big issue in the automobile industry. In recent years, squeal noise prediction methodologies using finite element analysis (FEA) have widely been investigated. Extensive research effort has been undertaken on understanding of brake squeal generation. This paper is concerned with the FEA and modal testing of a commercial disc brake assembly. The goal is to study squeal noise prediction at early stage of design development using a more realistic FE model. Firstly, the FE model of the disc brake was developed using a 3D solid element. Modal testing using hammer excitation measuring techniques was used to measure the physical vibration properties of the disc brake. The FE model is validated by comparing experimental results of the brake components and assembly with the results obtained from simulation.

Karuppaet al.[3] attempted a study of ventilated brake discs are used in high speed vehicles especially the effect of vane-shape on the flow-field and heat transfer characteristics for different configurations of vanes and at different speeds numerically. Three types of rotor configurations circular pillared, modified taper radial and diamond pillar vanes were considered for the numerical analysis. A rotor segment of 20° was considered for the numerical analysis due to its rotational symmetry. The preprocessing is carried out with the help of ICEM-CFD and analysis is carried out using ANSYS CFX 12.1. The three dimensional flow through the brake rotor vanes has been simulated by solving the appropriate governing equations viz. conservation of mass, momentum and energy using the commercial CFD tool, ANSYS CFX 12. The predicted results have been validated with the results available in the literature.

Nathi et al.[4] evaluated the performance under severe braking conditions and there by assist in disc rotor design and analysis. In this study is of disc brake used for cars, ANSYS package is a dedicated finite element package used for determining the temperature distribution, variation of stresses and deformation across the disc brake profile. An attempt has been made to investigate the effect of stiffness, strength and variations in disc brake rotor design on the predicted stress and temperature distributions. A transient thermal analysis has been carried out to investigate the temperature variation across the disc. An attempt is also made to suggest a best combination of material and flange width used for disc brake rotor, which yields a low temperature variation across the rotor, less deformation, and minimum von-mises stress possible.

Transient thermal analysis is carried out using the direct time integration technique for the application of braking force due to friction for time duration of 4,5 and 6 seconds. The maximum temperature obtained in the disc is at the contact surface and is observed to be 240°C. The Brake disc design is safe based on the Strength and Rigidity Criteria. To arrive at a best combination of parameters of the Disc Brake like Flange width and Material, Transient Thermal and Structural Analysis for three different combinations in each of the three different analyses were carried out separately and the results were compared. Comparing the different results obtained from the analysis, material Cast Iron is the Best possible combination for the present application.

Akop et al.[5]presented thermal stress analysis on heavy truck brake disc rotor for steady state and transient condition. The heat dissipated along the brake disc surface during the periodic braking via conduction, convection and radiation. In order to get the stable and accurate result of element size, time step selection is very important and all of these aspects are discussed in this paper. The findings of this research provide a useful design tool to improve the brake performance of disc brake system.

A. Gaps and Scope of the Present Work

In recent decades the improvement of the braking performances are required as the two wheelers run at high speeds. The generated frictional heat, during braking operation causes several negative effects on the brake system such as brake fade, premature wear, thermal cracks and disc thickness variation. It is then important to determine the temperature field of the brake disc which will be in the safe range The brake disc manufacturing industries are in need of a suitable test setup to test the brake disc temperature with selected braking cycle and a selected braking force including related instrumentation. It is proposed to fulfill this need.

B. Objectives of the Present Work

1) Toanalyse given set of disk brake rotors for load, stress and thermal conditions in ANSYS and select the best one on the basis of ANSYS results.
2) To design and develop new disc brake rotor and analyse the same for load, stress and thermal condition.
3) Tocompare the performance of transient thermal analysis of selected disc rotor and new disc brake rotor.
4) To design and development of brake disc test rig for monitoring and analyzing the conditions of disc brake rotor experimentally in laboratory environment.
5) To investigate performance of new designed brake disc experimentally on developed brake disc test rig under frequent braking and un-braking conditions.
6) To comparethe performance of experimental results in relation to ANSYS analysis to show physical agreement of the approach.

III. 3D MODELLING OF ALL SHAPE

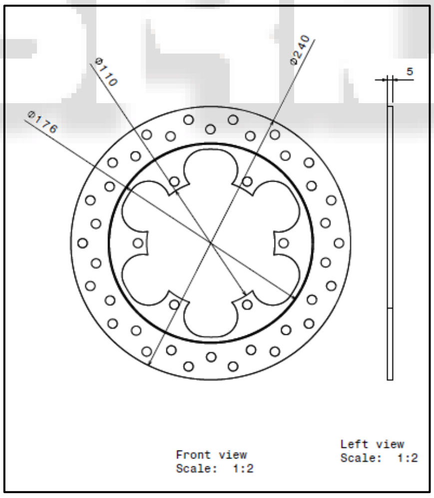

Fig. 3.1: Drafting of sample disc 1

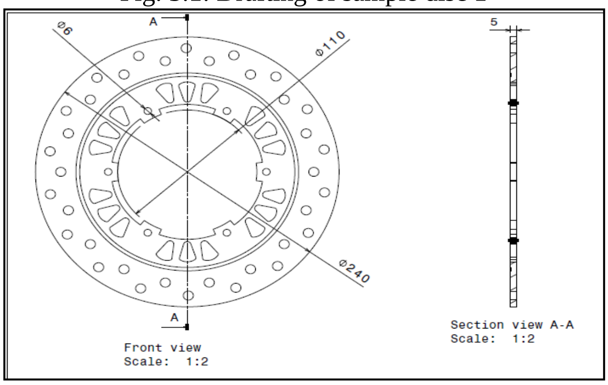

Fig. 3.2: Drafting of sample disc 2

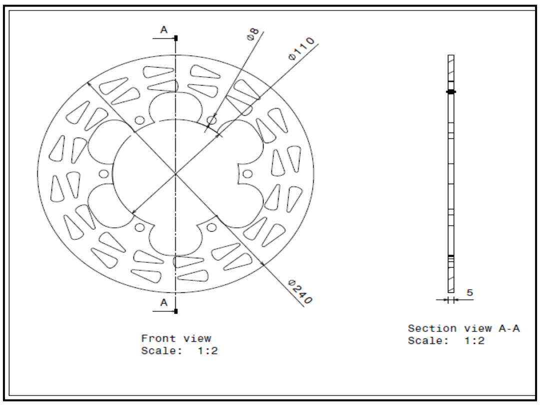

Fig. 3.3: Drafting of sample disc 3

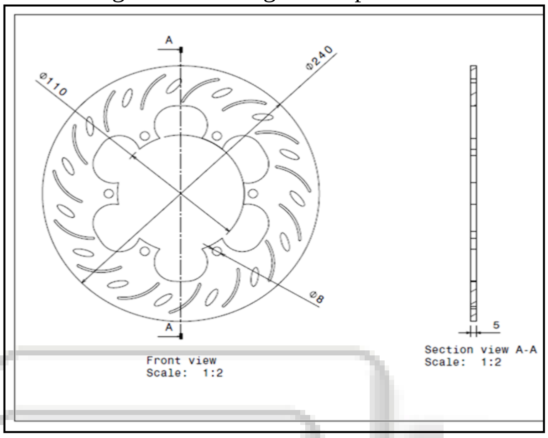

Fig. 3.4: Draftingof sample disc 4

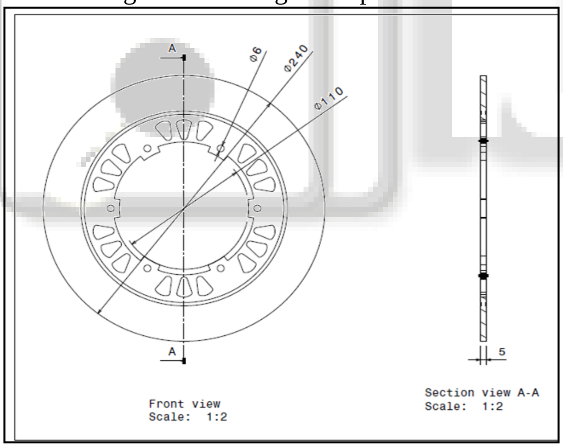

Fig. 3.5: Drafting of sample disc 5

IV. THERMAL ANALYSIS RESULT-ANSYS

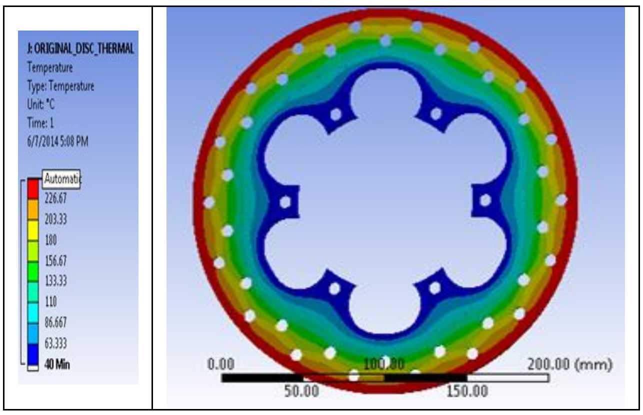

Fig. 4.1: Thermal Analysis of sample disc 1

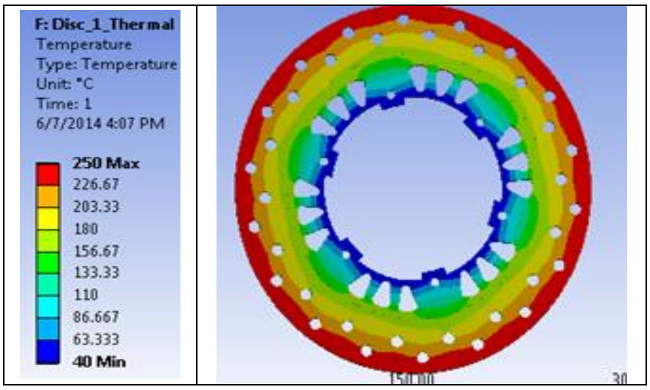

Fig. 4.2: Thermal Analysis of sample disc 2

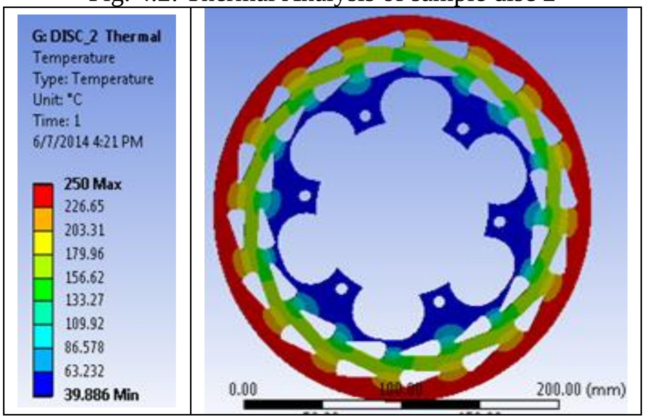

Fig. 4.3: Thermal Analysis of sample disc 3

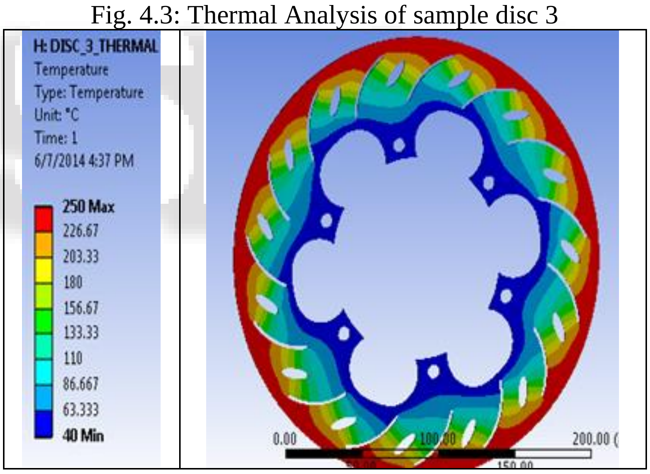

Fig. 3.32: Thermal Analysis of sample disc 4

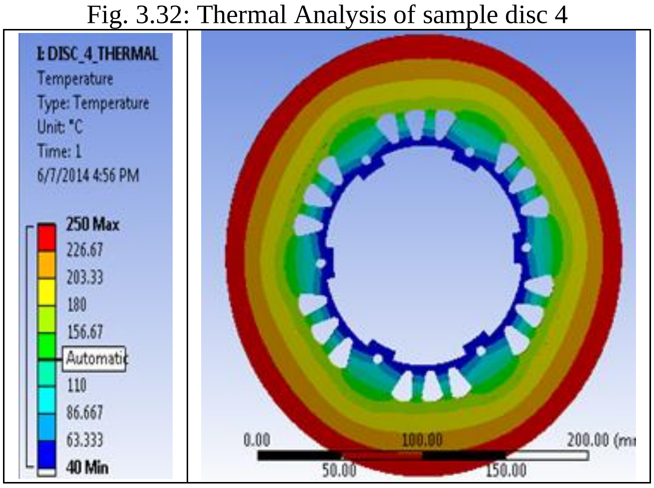

Fig. 3.33: Thermal Analysis of sample disc 5

V. COMPARISON OF ANSYS ANALYSIS AT LOAD, STRESS AND THERMAL CONDITION.

To select a better disc out of given set of disc rotors, a comparison of analysis of disc rotors perfumed at load, stress and thermal conditions is performed. The fig shows a comparison graph of all three analysis to select an optimized performance of a disc over all other, which is sample disc 1.

Disc	Stress in Pascal's,	Deformation in meter	Thermal Distribution (Red Hot Region) in cm^2
Sample Disc 1	2.309×10^7	3.99×10^6	2.3713
Sample Disc 2	1.967×10^7	3.82×10^6	3.5268
Sample Disc 3	2.991×10^7	5.68×10^6	3.4281
Sample Disc 4	2.745×10^7	5.34×10^6	3.5
Sample Disc 5	1.8×10^7	3.51×10^6	4.5

Table 5.1: ANSYS analysis results of all sample discs

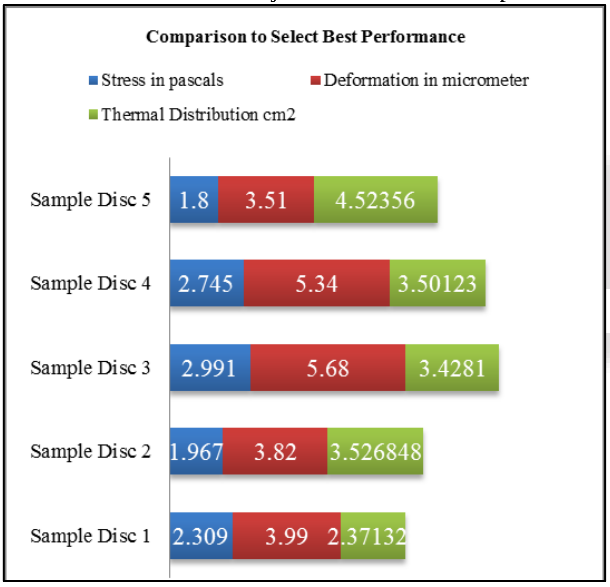

Fig. 5.2: Graph of acomparison to select optimized performance

VI. TRANSIENT THERMAL ANALYSIS:

A. Sample Disc 1: Nonlinear Transient Thermal Analysis Result

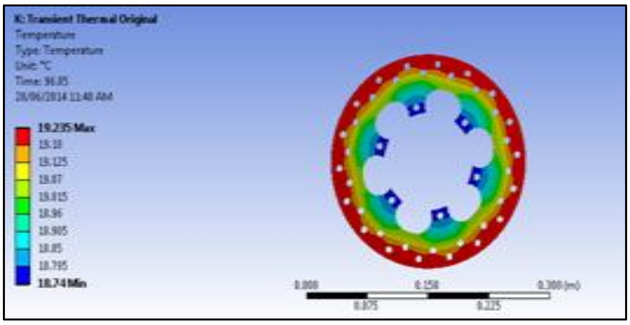

Fig. 6.1: Transient Thermal Analysis Result- Selected Disc (sample disc 1)

Nonlinear Transient Thermal Analysis Result of new disc

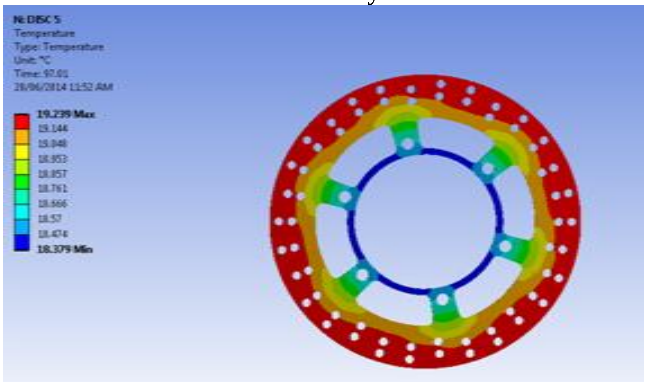

Fig. 6.2: Transient Thermal Analysis Result (ANSYS) of New Disc

VII. EXPERIMENTAL SET UP:

Experimental set up has various sub components as shown in schematic fig. 5.1. In this work, C channel angle frame base contains C channels of 80×40×5 and L channels of 35×35×5. This all frame structure is welded by arc welding and formed into predefined structure. The motor of 1.5Hp is selected directly from market. This motor has a starter i.e. ON/OFF switch fixed on a channel of 25×25×3. This is coupled to shaft of length 200mm and diameter 25 mm. On this shaft, ball bearings equipped in the bearing housing of the size 25×60×150.

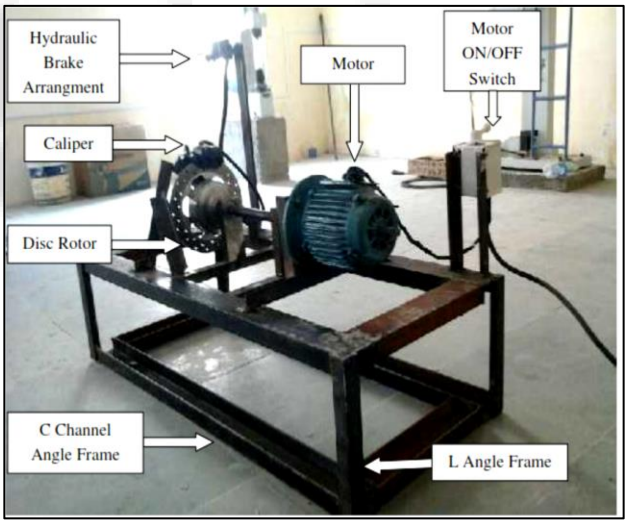

Fig. 7.1 Experimentation Setup

VIII. TEST RESULTS AND DISCUSSION

Time	Min Temp in ºC	Max Temp in ºC
600	24.1	24.8
1200	31	31.3
1800	36	37.4
2400	44.212	45.188
3000	51.5	52.151
3600	58.21	58.9

Table 8.1: Test Results of Sample Disc 1

Time	Min Temp in ºC	Max Temp in ºC
600	23.15	23.9
1200	30	31.1
1800	36.44	36.952

2400	44.151	45.1
3000	51.433	52.15
3600	57.99	58.131

Table 8.2: Test Results of New Disc

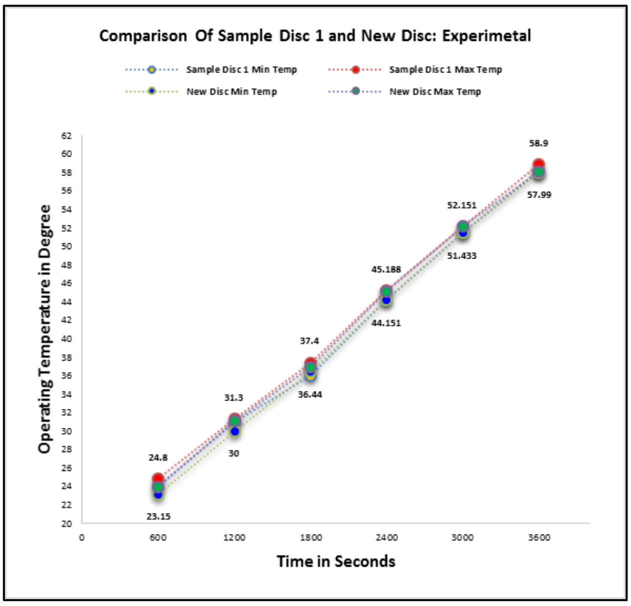

Fig. 8.1: Comparison of Sample Disc 1 and New Disc: Experimental

In this graph shows that the new disc has better results than sample disc 1.

Result of Discs	Mass(Kg)	Remark
Sample Disc	0.98541	Good
New disc	0.95155	Very Good

Table 8.3 Thermal analysis result

A. *Comparison of ANSYS and Experimental Results*

The ANSYS simulated analysis should be evidences or supported by empirical results.This is achieved by comparing ANSYS results with experimental results as shown in following graph.

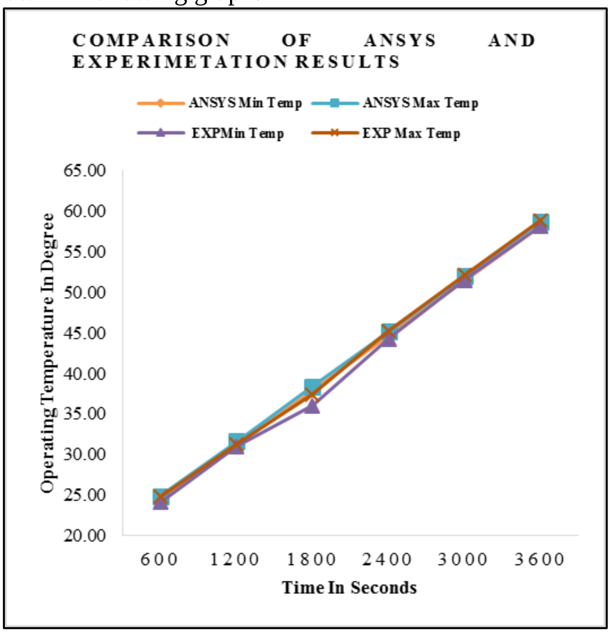

Fig. 8.2 Comparison of ANSYS and Experimental Results

Above graph shows a better fitment of ANSYS values with experimental observation. This shows that simulated approach is correct as compare to the practical experimentation. This shows the physical agreement to the simulation work.

IX. CONCLUSION

The present study can provide a useful design and improved the brake performance of disk brake system.

From the above results, it is clear that performance of new designed disc in transient thermal analysis is better and optimized in accordance with braking temperature and thermal distribution over the disc area in comparison with given set of discs.

For structural analysis, result of both computational & experimental analysis of the new brake disk evidences the safer design.

High brake force carrying capacity of new designed disc during running condition without any crakes is demonstrated well.

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