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UNSTEADY STATE THERMAL ANALYSIS OF DISK BRAKE

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Abstract: The disk brakes are used in light weight and heavy motor vehicle which retards rotation of wheel and during this process the kinetic energy of vehicle is converted on thermal energy. The proper design of disk brakes enhances its heat dissipation capacity and is therefore necessary to improve design of disk brake to achieve optimal performance. The objective of current research is to investigate the effect of MMC material on thermal characteristics of disk brake. The thermal characteristics studied in the research is temperature and heat flux which gives necessary data on heat dissipation. The design optimization and transient thermal analysis of disk brake is conducted in ANSYS FE simulation package. The research finings have shown a linear relationship between the radius of disk brake and heat flux. The dimensions corresponding to maximum heat flux and maximum temperature is also obtained.

Key Words: Disk Brake, FEA, Design Optimization

1. INTRODUCTION:

The disk brake works by the effect of rubbing brake pads against the disc. The rubbing action generates heat due to friction. The kinetic energy of the vehicle gets converted in to thermal energy. This thermal energy is then dissipated in the atmosphere [1]. The disc brake assembly of front wheel is shown in figure 1 below.

Figure 1: Disc brake assembly mounted on front wheel [1]

2. LITERATURE REVIEW

According to Praveena S Lavakumar [2] has conducted numerical investigation on different materials and concluded that best material for disk brake application is cast iron. The low thermal conductivity of cast iron makes it best suited material for disk brake.

Venkatkumar R gurubaran [3] has contemplated the use of liners for disc brake rotor. The benefit of such liners is enhanced cooling characteristics of disc brake.

Ganesh P and Naresh C [4] has conducted numerical investigation of disc brake using Aluminium matrix composites and it possess better wear and thermal characteristics. They also come to conclusion that "Aluminum utilization for brake disc manufacturing can contribute to increase in acceleration and reduction in braking distance".

Hemraj nimhal et al. [5] has investigated the suitability of ceramic material for disc brake applications. The disk brake tested was "non ventilated" type and thermal analysis results have shown that disc brakes made of ceramic materials are better as compared to other cast iron materials.

Bhaskarasetupathi et al. [6] has studied the tribological characteristics of disc brake made of Aluminium matrix composite material and is better suited for disc brake applications.

Subhasis sarkar and Dr. Pravin Rathod [7] has conducted FEA analysis on disc brake made of AMMC and compared the results obtained from grey cast iron material. The design parameters of disc brake like vent hole diameter and vane thickness has important role in heat transfer characteristics of disc brake.

A. Belhocineet al. [8] has conducted FE thermal analysis on disc brake to determine heat generated due to friction. The results obtained from FE analysis has shown that cooling of disc brake is significantly affected by design of radial ventilation.

3. OBJECTIVE

The objective of current research is to investigate the effect of MMC material on thermal characteristics of disk brake. The thermal characteristics studied in the research is temperature and heat flux which gives necessary data on heat dissipation. The design optimization and transient thermal analysis of disk brake is conducted in ANSYS FE simulation package.

4. METHODOLOGY

The methodology of conducting FE analysis encompasses modeling, meshing, applying loads and boundary conditions, solution and postprocessing.

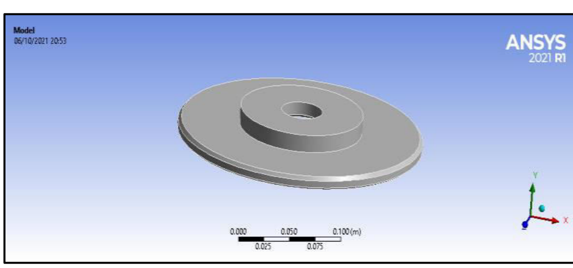

Figure 2: Disc brake CAD design

Using the data available from the literature [9], the disk brake model is designed using sketch and revolve tool. The model is then meshed using tetrahedral elements due to complexity of the geometry involving hard edges, sudden curvatures etc. The meshed model is shown in figure 3 below.

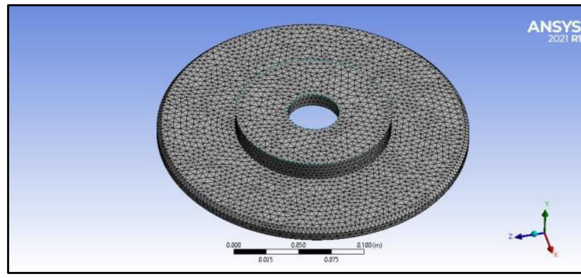

Figure 3: Meshed model of disc brake

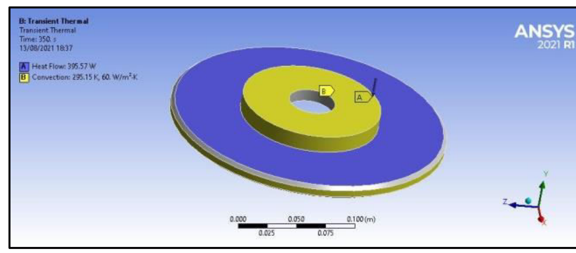

Figure 4: Loads and Boundary conditions

The disk brake is applied with heat flux on rubbing surface by brake pad. The magnitude of heat flux applied is 350 W/m^2 as and other surfaces are applied with convection of 60 W/m^2C. The ambient temperature is defined as 22^0C.

5. RESULTS AND DISCUSSION

From the transient thermal analysis conducted on MMC disc brake, the temperature and heat flux plots are obtained. The temperature plot at 3.5 counter secs is shown in figure 5 below. The temperature is higher at the corner edges as shown in red colored zone. The temperature at this region is more than 200^0 C. The temperature near the hub is nearly 150^0 C as shown in green color.

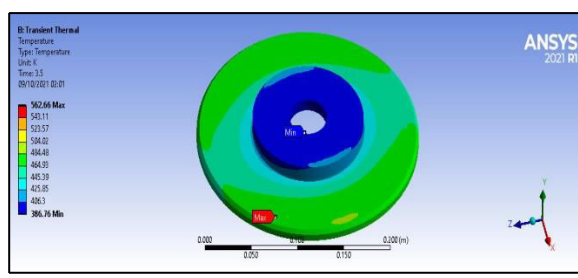

Figure 5: Temperature plot at 3.5 secs

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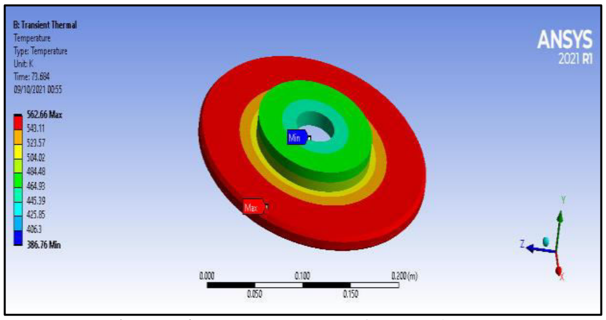

Figure 6: Temperature plot at 73 secs

The temperature plot at higher time interval i.e. 73 secs shows higher uniformity in temperature distribution as compared to earlier time intervals. The temperature at most of the regions (rubbing faces) is more than 278^0 C. The temperature is low near the edge of hub and minimum temperature is more than 189^0C.

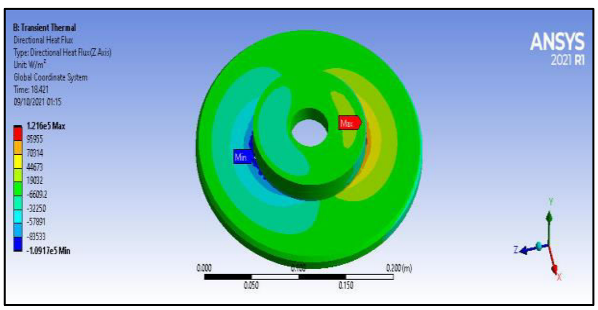

Figure 7: Heat flux plot at 18.4 secs

The directional heat flux is obtained from the thermal analysis shows maximum magnitude near the edges of hub and rubbing surface. The directional heat flux at this region is shown in dark blue and yellow colored region. The heat flows along both the directions i.e. along positive z direction and along negative z direction.

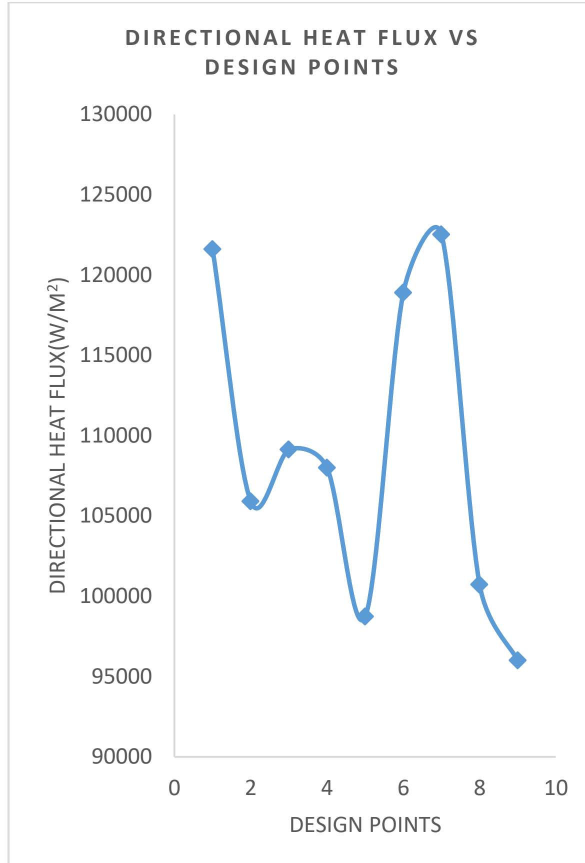

Figure 8: Heat flux plot vs design points

The design points are generated using Taguchi DOE and the graph of directional heat flux vs design points are generated as shown in figure 8 above. As it can be observed from design points curve that maximum heat flux is obtained for design point number 7 which signifies that disk brake modeled using this dimension will have maximum heat dissipation. The minimum heat flux is obtained for design point number 9 which signifies that minimum heat dissipation is observed for this design.

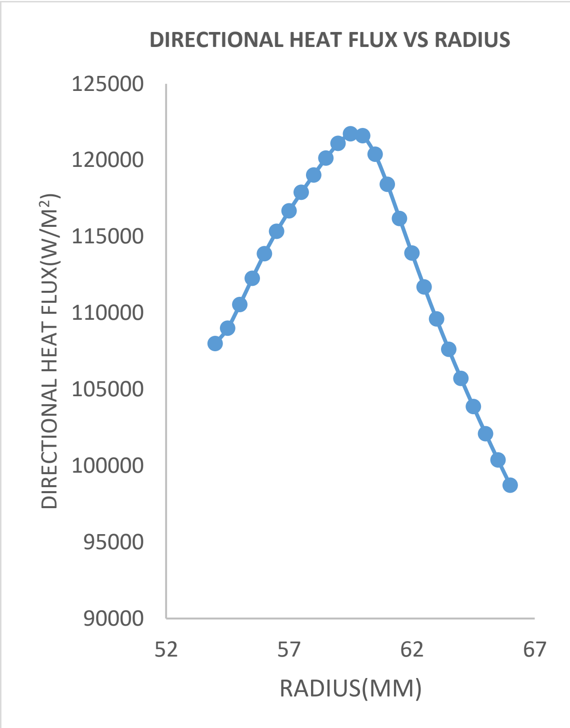

Figure 8: Heat flux plot vs radius

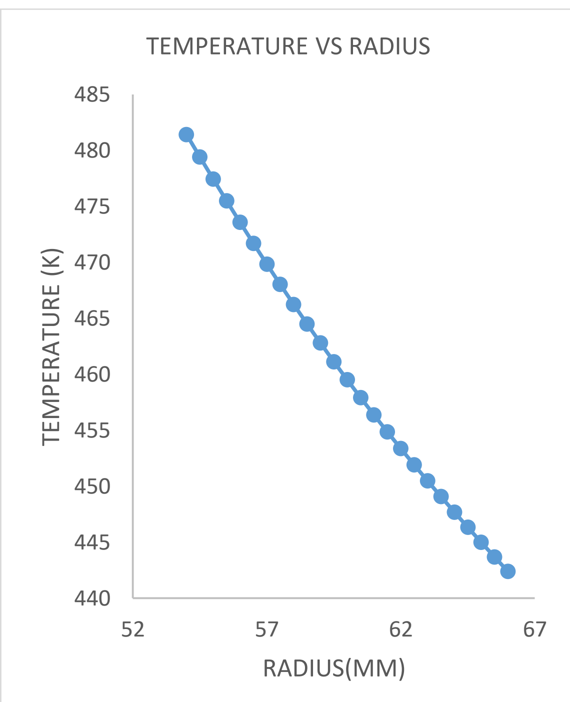

Figure 8: Temperature plot vs radius

The variation of heat flux vs radius (hub) is shown in figure 8 above. The plot shows increase in directional heat flux upto 59mm radius and then decreases linearly. The heat flux initially increases and then decreases with respect to radius. The variation of temperature vs radius is shown in figure 8 above. The variation of temperature vs radius is shown in figure 8 above where in the temperature initially high decreases linearly and reduces to minimum value of 445K.

6. CONCLUSION

The FE thermal analysis is conducted on disc brake using MMC material. The thermal analysis results have shown that material has significant effect on cooling characteristics of disc brake especially maximum temperature achieved and heat flux. The optimization results have shown that geometric design of brake hub has significant effect (linear variation) on directional heat flux.

REFERENCES

[1].C.Radhakrishnan, Yokeswaran.K, Naveen Kumar.M,Sarathkumar.Gopinath,Inbasekar.“Design and optimization of ventilated disc brake for heat dissipation” International Journal of Innovative Science, Engineering & Technology, Vol. 2 Issue 3, March 2015.

[2].Praveena S, Lava Kumar M, Kesavulu A “Modeling and Thermal Analysis of Disc Brake” Praveena S Int. Journal of Engineering Research and Applications Vol. 4, Issue 10(Part - 3), October 2014.

[3].Venkatramanan R, Kumaragurubaran SB, Vishnu Kumar C, Sivakumar S,Saravanan B. “Design and Analysis of Disc Brake Rotor”International Journal of Applied Engineering Research ,Volume 10, Number 19 (2015).

[4].Gnanesh P, Naresh C and Syed AltafHussain “ finite element analysis of normal and Vented disc brake rotor.”International journal of mechanical engineering and robotics research, Vol. 3, No. 1, January 2014.

[5].HemrajNimhal, ChitranjanAgarwal, S. Jindal, M. A. Saloda “Thermal Analysis of Disc Brake using Ansys Software” International Journal of Advance Engineering and Research Development Volume 3, Issue 3, March -2016

[6].BaskaraSethupathi P, Muthuvel A, Prakash N., Stanly Wilson Louis “Numerical Analysis of a Rotor Disc for Optimization of the Disc Materials” Journal of Mechanical Engineering and Automation 2015.

[7].SubhasisSarkar (Dr.) Pravin P. Rathod A. J. Modi “Research Paper on Modeling and Simulation of Disc Brake to Analyse

Temperature Distribution using FEA” IJSRD - International Journal for Scientific Research & Development| Vol. 2, Issue 03, 2014.

[8].A. Belhocine, C.-D. Cho, M. Nouby, Y. B.Y, A. R. Abu Bakar “Thermal analysis of both ventilated and full disc brake rotorswith frictional heat generation” Applied and Computational Mechanics 8 (2014) 5–24

[9]. A. Alnaqi, Abdulwahab, “Reduced scale thermal characterization of automotive disc brake” Applied Thermal Engineering (2014)