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Design and Analysis of Car Disc Brake by Using FEM

C. Venkatesh[1], B. Anjaneyulu[2], K. Kiran Kumar Rao[3]
Department of Mechanical Engineering, GATES Institute of Technology, Gooty .JNTUA

Abstract -Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. The disc brake is a device for deaccelerating or stopping the rotation of a wheel. A brake disc (or rotor) usually made of cast iron or ceramic composites, is connected to the wheel and/or the axle. Friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc to stop the wheel. The present research is basically deals with the modelling and analysis of solid and ventilated disc brake using Pro-E and Ansys. Finite element (FE) models of the brake-disc are created using Pro-E and simulated using ANSYS which is based on the finite element method (FEM). In this research Coupled Analysis (Structural & Thermal analysis) is performed in order to find the strength of the disc brake. In structural analysis displacement, ultimate stress limit for the design is found and in thermal analysis thermal gradients, heat flow rates, and heat fluxes to be calculates by varying the different cross sections, materials of the disc. Comparison can be done for displacement, stresses, nodal temperatures, etc. for the three materials to suggest the best material for FSAE car.
Keywords—Maraging steel, Coupled analysis, finite element methods, ANSYS, PRO-ENGINEERING

I. INTRODUCTION

A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine.
In the process of performing this function, the brakes absorb either kinetic energy of the moving member or the potential energy given up by objects being lowered by hoists, elevators etc. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in to the surrounding atmosphere to stop the vehicle, so the brake system should have the following requirements:

A. The brakes must be strong enough to stop the vehicle with in a minimum Distance in an emergency.
B. The driver must have proper control over the vehicle during braking and the vehicle must not skid.
C. The brakes must have good ant fade characteristics i.e. their effectiveness should not decrease with constant prolonged application.
D. The brakes should have good anti wear properties

Based on mode of operation brakes are classified as follows:
Hydraulic brakes
Electric brakes
Mechanical brakes
The mechanical brakes according to the direction of acting force may be sub divided into the following two groups:

1) *Radial brakes:* In these brakes the force acting on the brake drum is in radial direction. The radial brake may be subdivided into external brakes and internal brakes.
2) Axial brakes: In these brakes the force acting on the brake drum is only in the axial direction. e.g. Disc brakes, Cone brakes.

A disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle, like the axle casing or the stub axle and is cast in two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid to enter or leave each housing.
These passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston. A schematic diagram is shown in the figure 1.

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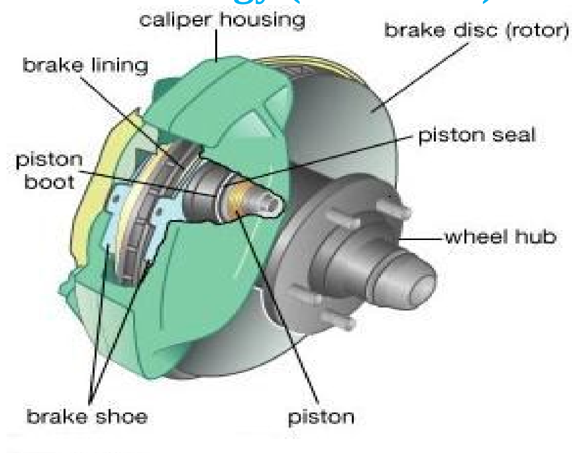


Figure.1

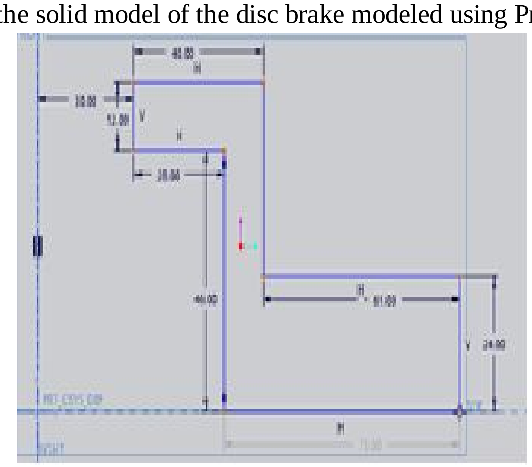
The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. The brake disc (or rotor in American English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade.

Disc-style brakes development and use began in England in the 1890s. The first caliper-type automobile disc brake was patented by Frederick William Lanchester in his Birmingham, UK factory in 1902 and used successfully on

Lanchester cars. Compared to drum brakes, disc brakes offer better stopping performance, because the disc is more readily cooled. As a consequence discs are less prone to the "brake fade"; and disc brakes recover more quickly from immersion (wet brakes are less effective). Most drum brake designs have at least one leading shoe, which gives a servo-effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal or lever, this tends to give the driver better "feel" to avoid impending lockup. Drums are also prone to "bell mouthing", and trap worn lining material within the assembly, both causes of various braking problems.

II. MODELING USING PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products. The figure 2 shows the solid model of the disc brake modeled using Pro-E.



Dimensions of 24mm Disc Brake

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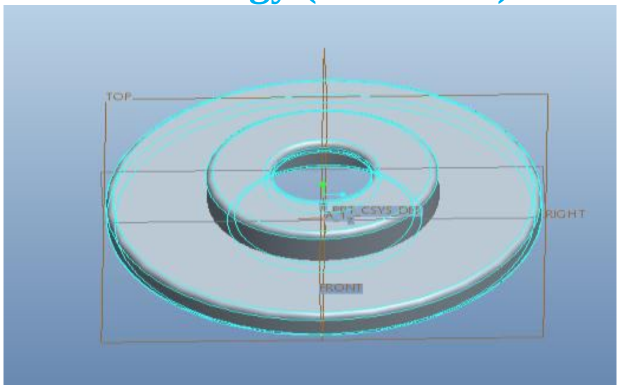

Model of Disc Brake

Dr. John Swanson founded ANSYS. Inc in 1970 with a vision to commercialize the concept of computer simulated engineering, establishing himself as one of the pioneers of Finite Element Analysis (FEA). ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of userdesignated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms.

A. Steps in ANSYS

To solve any problem in ANSYS it mainly follows the following steps. These are common steps to all problems except material properties and type of analysis used.

1) Preliminary decisions

a) Analysis type

b) Model

c) Element type

2) Pre processing

a) Material

b) Create or import the model geometry

c) Mesh the geometry

3) Solution

a) Apply loads

b) Solve

4) Post processing

a) Review results

b) Check the validity of the solution

B. Elements considered for Structural and Thermal analysis

According to the given specifications the element type chosen for Structural Analysis is solid 20node 95. Solid90 is a higher order version of the three dimensional, eight node thermal element. The element is defined by 20 nodes having three degrees of freedom per node. The element may have any spatial orientation.

According to the given specifications the element type chosen for Thermal Analysis is solid 20node 90. The element is defined by 20 nodes having three degrees of freedom per node. Solid90 is a higher order version of the three dimensional, eight node thermal element. The element has one degree of freedom, temperature at each node. The 20-node elements have compatible temperature shapes and are well suited to model curved boundaries. The 20-node thermal element is applicable to a three dimensional, steady state or transient thermal analysis.

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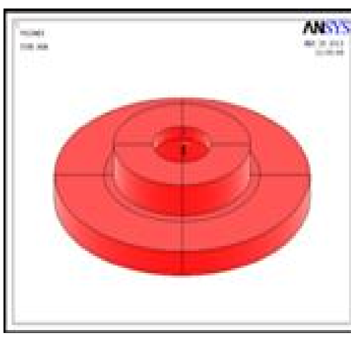
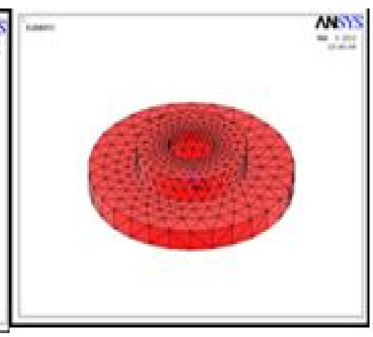
III. MATERIAL PROPERTIES

Properties	Carbon-Carbon Composites	Maraging Steels	Cast Iron
Density (Kg/M3)	1800	8100	7100
Young's Modulus (GPa)	95	210	125
Poisson Ratio	0.31	0.3	0.25
Thermal Conductivity (W/M-K)	40	25.5	54.5
Specific Heat (J/Kg-K)	755	813	586
Coefficient of Friction	0.3	0.8	0.2

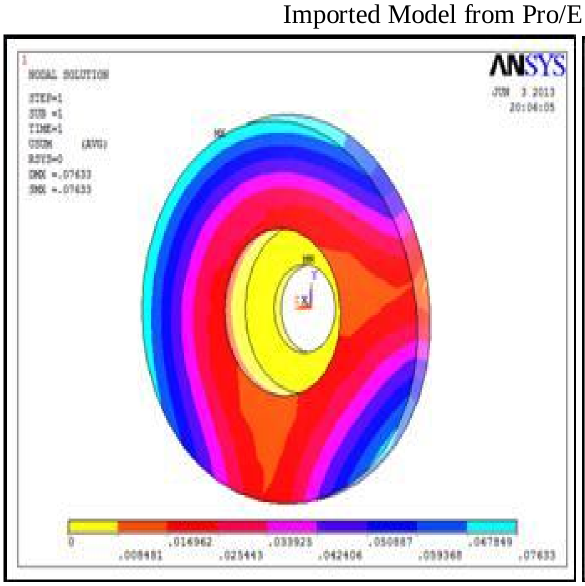
Structural Analysis of Solid Disc Brake: Carbon-Carbon Composites



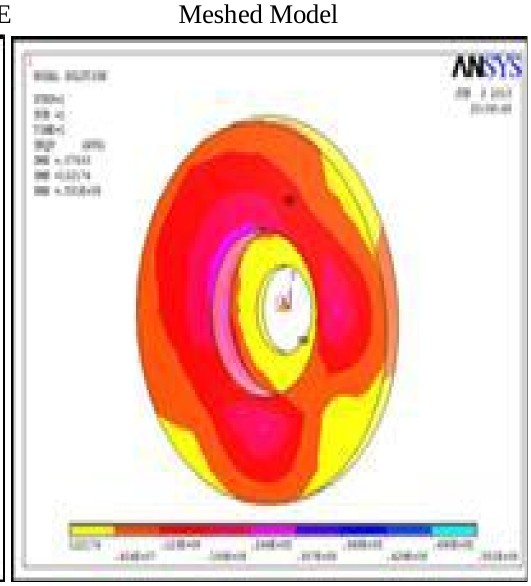
Imported Model from Pro/E



Meshed Model



Displacement Vector Sum



Von Mises Stress

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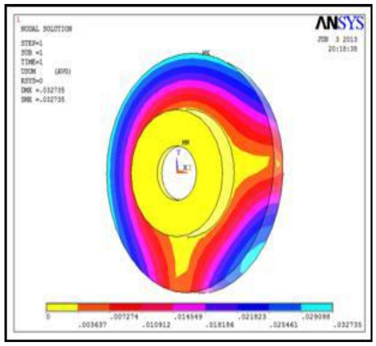
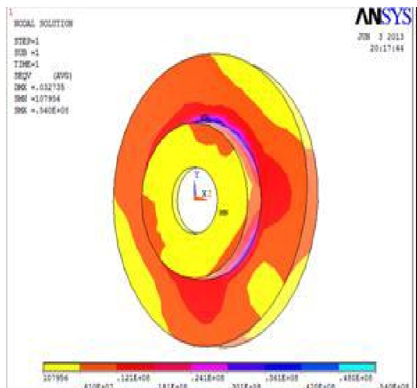
Maraging Steel

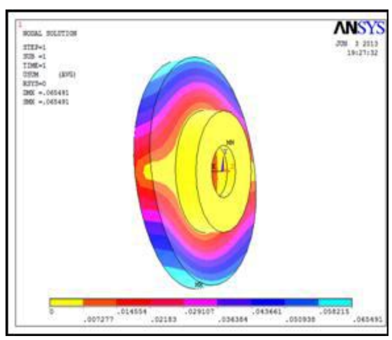


Displacement Vector Sum

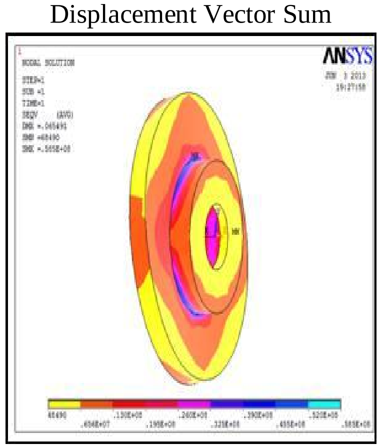


Von Mises Stress

Cast Iron



Displacement Vector Sum



Von Mises Stress

Table 1
Results Comparison

Material	Nodal Temperature		Thermal gradient vector sum		Thermal flux vector sum	
	Solid	Ventilated	Solid	Ventilated	Solid	Ventilat ed
Carbon-Carbon Composites	702.566	85.755	425.308	595.893	17012	29795
Maraging Steel	164.824	20	87.1	126.053	2221	3214
Cast Iron	240.79	28.069	134.961	198,297	7288	10708

The table 1 gives the results of the three materials Carbon-Carbon Composites, Maraging Steel and Cast Iron proposed and shows that Maraging Steel gives less deformation and stress when the loads are applied. Therefore Maraging Steel material is preferred over the existing materials

Material	Nodal Temperature		Thermal gradient vector sum		Thermal flux vector sum	
	Solid	Ventilated	Solid	Ventilated	Solid	Ventilated
Carbon-Carbon Composites	20	211.97	13.39	1009	699.3	54503
Maraging Steel	20	34.281	13.39	172.875	341.4	4408
Cast Iron	20	54.173	13.39	270.405	722.9	14602

The table 2 gives the results of the three materials Carbon-Carbon Composites, Maraging Steel and Cast Iron proposed and shows that Maraging Steel gives less nodal temperature value when the loads are applied. Therefore Maraging Steel material is preferred over the existing materials.

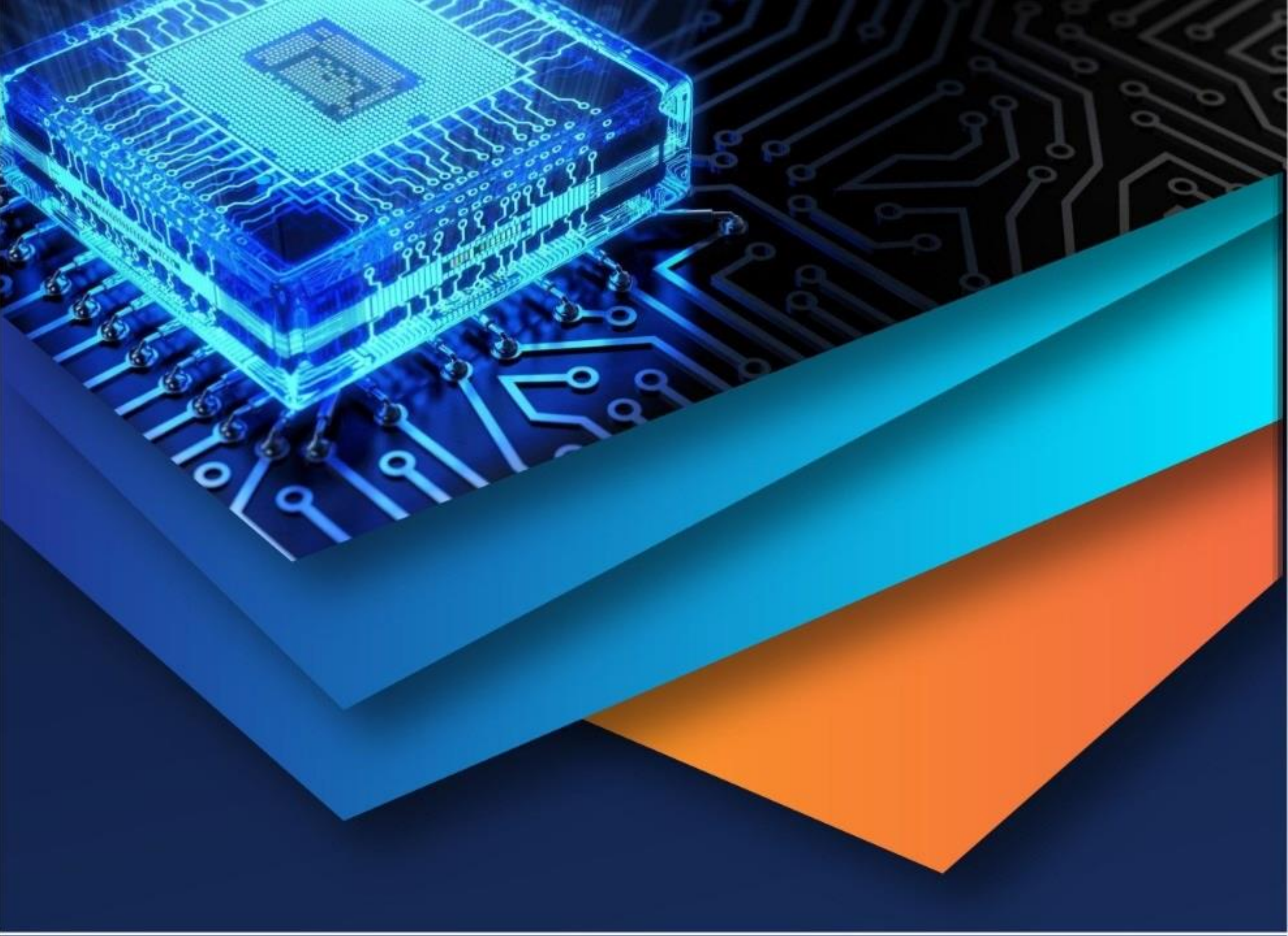
IV. CONCLUSIONS

The present study can provide a useful design tool and improve the brake performance of disk brake system. From the above Table we can say that all the values obtained from the analysis are less than their allowable values. Hence the brake disk design is safe based on the strength and rigidity criteria. Comparing the different results obtained from analysis. It is concluded that ventilated type disk brake is the best possible for the present application. By observing analysis results, maraging steel is best material for Disc Brake.

REFERENCES

[1] Finite Element Analysis for Engineering &Tech. Author, T. Chandrupatla. Edition, illustrated. Publisher, Universities Press, 2004.ISBN, 8173714274.
[2] ISBN-10: 1932709444 ISBN-13: 978- 1932709445 Pro/ENGINEER Wildfire 4.0 for Designers textbook is a comprehensive textbook that introduces the users to Pro/ENGINEER Wildfire 4.0,
[3] Machine Design Edition: 14th. Author: R.S. Khurmi& J.K. Gupta
[4] Analysis of Ventilated Disc Brake Squeal Using a 10 DOF Model," SAE Technical Paper 2012-01-1827, 2012.
[5] A Textbook of Machine Design by R S Khurmi and GUPTA.
[6] G. Babukanth & M. Vimal Teja. Transient Analysis of Disk Brake By using Ansys Software.
[7] Ali Belhocine, MostefaBouchetara. Thermal analysis of a solid brake disc, Applied Thermal Engineering 32 (2012) 59-67.
[8] V. M. M. Thilak, R. Krishnaraj, Dr. M.S akthivel, K. Kanthavel, Deepan Marudachalam M.G, R. Palani. Transient Thermal and Structural Analysis of the Rotor Disc of Disc Brake, International Journal of Scientific & Engineering Research Volume 2, Issue 8, August-2011.
[9] Ameer Fareed BashaShaik, Ch.LakshmiSrinivas. Structural and thermal analyses of disc brake with and without cross drilled rotar of race car, International

Journal of Advanced Engineering Research and Studies.
[10] GONSKA, H. W. AND KOLBINGER, H. J. Temperature and Deformation Calculation of Passenger Car Brake Disks, Proc. ABAQUS User.s Conference, Aachen, Germany, page 21- 232, (1993).
[11] AKIN, J. E. Application and Implementation of Finite Element Methods, Academic Press, Orlando, FL, page 318-323, (1982).
[12] ZAGRODZKI, P. Analysis of thermo mechanical phenomena in multi disk clutches and brakes, Wear 140, page 291-308, (1990).
[13] COOK, R. D. Concept and Applications of Finite Element Analysis, Wiley, Canada, (1981).
[14] ZIENKIEWICZ, O. C. The Finite Element method, McGraw-Hill, New York, (1977).
[15] BEEKER, A.A. The Boundary Element Method in Engineering, McGraw-Hill, New York, (1992).



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