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DESIGN EVALUATION AND OPTIMIZATION OF DISK BRAKE

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ABSTRACT

Brake disk rotor paperwork pan of a foundation brake and rotates with the wheel hub meeting. The principal characteristic of a basis brake is to generate a retarding torque through converting mechanical energy to thermal electricity through distinctive feature of the frictional paintings achieved in relative sliding at the rotor-pad interface. Braking performance of a automobile can be significantly stricken by the temperature upward thrust inside the brake additives.

In this thesis, a disc brake is analyzed for its energy and temperature distributions while subjected to internal pressure and temperature the use of functionally graded material. Two models of the disc brake are considered without holes and with holes.

In this thesis, assessment is done by way of varying materials with conventional substances and functionally graded materials, conventional substances are Cast Iron, Aluminum Alloy 6061. The Functionally Graded Material with metallic Aluminum alloy 6061 using Ceramic as interface sector is taken for analysis. FGM's are considered for extent fractions of K=2. Theoretical calculations are executed to calculate the fabric residences for each layer up to 10 layers.

Structural and Thermal evaluation are executed on the two fashions by various materials. 3D modeling is to be executed in Pro/Engineer and evaluation is executed in ANSYS.

1. INTRODUCTION

A brake is a device which inhibits motion. Its opposite factor is a take keep off. The relaxation of this e-newsletter is dedicated to various forms of vehicular brakes.

Most regularly brakes use friction to convert kinetic strength into warmness, although other methods of electrical energy conversion could also be hired. For illustration regenerative braking converts plenty of the power to electric force, which may be saved for later use. Other methods convert kinetic force into capacity vigor in such stored paperwork as pressurized air or pressurized oil. Still different braking tactics even remodel kinetic electrical power into extraordinary varieties, for example via using shifting the power to a rotating flywheel.

DISC BRAKES

The disc brake or disk brake is a instrument for slowing or stopping the rotation of a wheel even as it is a long way in motion. A brake disc (or rotor in U.S. English) is almost always manufactured from forged iron or ceramic composites (including carbon, Kevlar and silica). This is attached to the wheel and/or the axle. To discontinue the wheel, friction material within the form of brake pads (attached on a software known as a brake caliper) is pressured sometimes, hydraulically, pneumatically or electromagnetically in the direction of each facets of the disc. Friction causes the disc and hooked up wheel to gradual or prevent. Brakes (each disc and drum) convert friction to heat, but if the brakes get too heat, they will end to paintings due to the fact

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they can't deplete sufficient warmth. This condition of failure is referred to as brake fade.

FIG.1.1 DISC BRAKE OF A CAR

DISCS

FIG.1.2 A PASS-DRILLED DISC ON A TODAY'S MOTORCYCLE

The design of the disc varies alternatively. Some are without doubt powerful cast-iron, nevertheless others are hollowed out with fins or vanes becoming a member of together the disc's two contact surfaces (normally blanketed as part of a casting process). This "ventilated" disc design helps to fritter away the generated warmth and is usually used on the additional-closely-loaded the front discs.

FUNCTIONALLY GRADED MATERIALS (FGM)

Introduction

The reinforcement in composites used as structural materials in lots of aerospace and vehicle programs is traditionally disbursed uniformly. Functionally graded substances (FGMs) are getting used as interfacial zone to make stronger the bonding power of layered composites, to minimize the residual and thermal stresses in bonded specified materials and as put on resistant layers in gadget and engine components. They've as a result attracted colossal awareness in trendy years. Probably the most benefits of FGMs over laminates is that there isn't a stress build-up at sharp fabric barriers due to non-stop fabric property variant to get rid of capacity structural integrity inclusive of delimitation.

LITERATURE SURVEY

Thermal habits of full and ventilated disc brakes of cars by way of A. Belhocine, M. Bouchetara[1], Braking is a fashion which converts a automobile's kinetic strength into mechanical electrical power which must be dissipated within the form of warmness. In the course of the braking segment, the frictional warmness generated at the interface of the disc and pads can influence in excessive temperatures. This phenomenon is much more main than the tangential pressure. The relative sliding speeds for the duration of touch are additionally important. The prediction of floor temperature for a brake rotor is seemed as an crucial step in analyzing brake gadget efficiency. The frictional warmth generated on the rotor floor can affect immoderate temperature upward push which, in turn, outcome in unwanted consequences which involves thermal elastic instability (TEI), premature placed on, brake fluid vaporization (BFV) and thermally excited vibrations (TEV). The objective of this appear at is to investigate the thermal habits of the whole and ventilated brake discs of the cars the utilization of computing code ANSYS. The modeling of the temperature distribution within the disc brake is used to become aware of all of the explanations and the coming into parameters worried on the time of the braking operation, inclusive of the form of braking, the geometric design of the disc and the fabric used. The outcome obtained with the help of the simulation are excellent in comparison to the ones of the specialised literature.

INTRODUCTION TO CAD

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Computer-aided design (CAD), additionally called laptop-aided layout and drafting (CADD), is the use of computer generation for the manner of design and design-documentation. Computer Aided Drafting describes the technique of drafting with a laptop. CADD software, or environments, offer the consumer with input-tools for the cause of streamlining layout strategies; drafting, documentation, and production processes. CADD output is often inside the form of digital files for print or machining operations.

INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3-D product design, featuring enterprise-leading productivity equipment that sell great practices in design at the same time as making sure compliance along with your industry and enterprise requirements. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to layout faster than ever, whilst maximizing innovation and nice to in the long run create extremely good merchandise.

MODEL OF DISC BRAKE

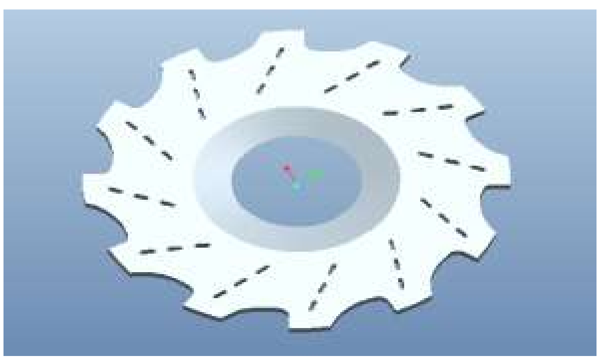

Fig.3.1 MODEL OF DISC BRAKE

3.5. 2D DRAWING OF DISC BRAKE

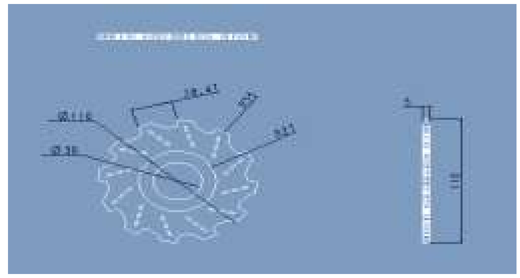

Fig. 3.5 2D DRAWING OF DISC BRAKE

WORKING ANALYSIS

INTRODUCTION TO FEA

Finite Element Analysis (FEA) become first evolved in 1943 via R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to achieve approximate solutions to vibration systems. Shortly thereafter, a paper posted in 1956 with the aid of M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp set up a broader definition of numerical analysis. The paper focused on the "stiffness and deflection of complicated systems".

By the early 70's, FEA turned into limited to steeply-priced mainframe computers generally owned with the aid of the aeronautics, automobile, defense, and nuclear industries. Since the fast decline within the price of computers and the exceptional growth in computing power, FEA has been advanced to an top notch precision. Present day supercomputers at the moment are able to produce accurate consequences for all varieties of parameters.

INTRODUCTION TO ANSYS

ANSYS is well-known-reason finite detail analysis (FEA) software program package deal. Finite Element Analysis is a numerical technique of deconstructing a complicated system into very small portions (of consumer-certain size) known as factors. The software implements equations that govern the behaviour of these factors and solves all of them; developing a complete clarification of the way the device acts as an entire. These consequences then may be supplied in tabulated, or graphical forms.

MATERIAL PROPERTY CALCULATIONS FOR FGM (K=2)

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FOR STRUCTURAL ANALYSIS

Material properties

Top material: ceramic (E=380000)

Bottom material: aluminium (E=70000)

For YOUNGS MODULUS:

$E(Z) = (E_t - E_b)(z/h+1/2)^K + E_b$

$\rho(Z) = (\rho_t - \rho_b)(z/h+1/2)^K + \rho_b$

$K(Z) = (K_t - K_b)(z/h+1/2)^K + K_b$

$C(Z) = (C_t - C_b)(z/h+1/2)^K + C_b$

WORKING ANALYSIS

STRUCTURAL ANALYSIS OF DISC BRAKE

USED MATERIALS

ALUMINUM 6061

Density=0.0000027kg/mm^3

Young's modulus=68900MPa

Poisson's ratio=0.33

CAST IRON

Density=0.0000071 kg/mm^3

Young's modulus=103000N/mm^2

Poisson's ratio=: 0.211

Imported model

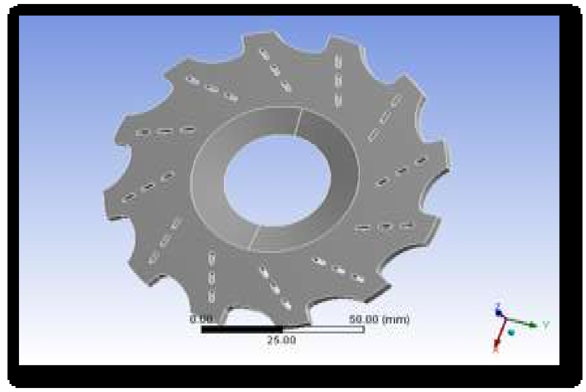

FIG.5.2 IMPORTED MODEL

Select model> right click on it>select edit>select mesh >right click on it > select generate mesh

Meshed model

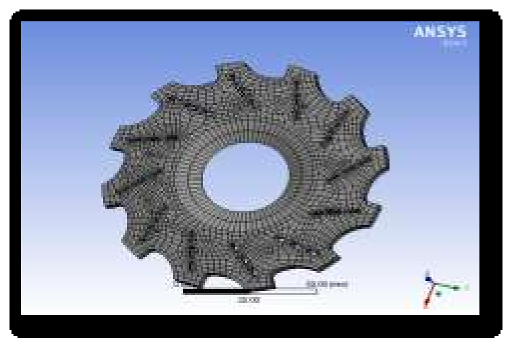

Fig 5.3 Meshed model

MATERIAL- ALUMINUM6061

TOTAL DEFORMATION

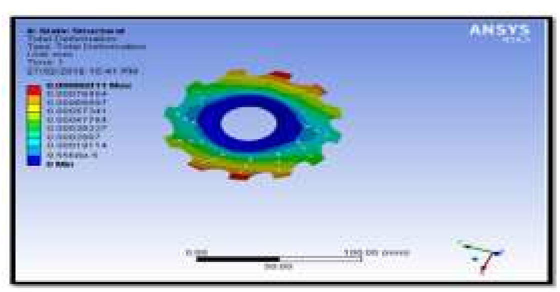

FIG 5.4 TOTAL DEFORMATION

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EQUIVALENT STRESS

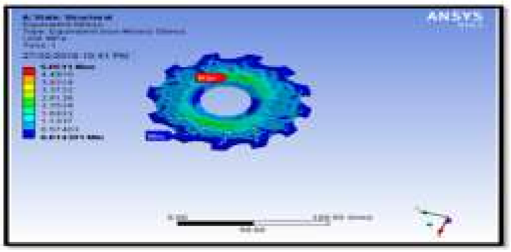

FIG.5.5 EQUIVALENT STRESS

STRAIN

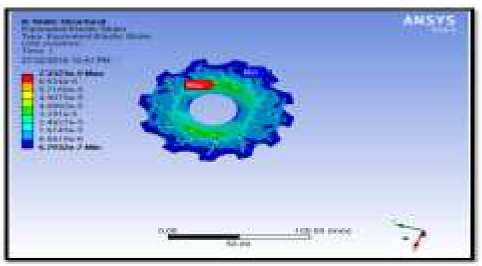

FIG.5.6 STRAIN

MATERIAL- CAST IRON

TOTAL DEFORMATION

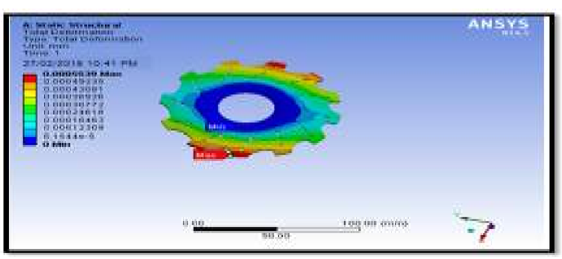

Fig.5.8 TOTAL DEFORMATION

EQUIVALENT STRESS

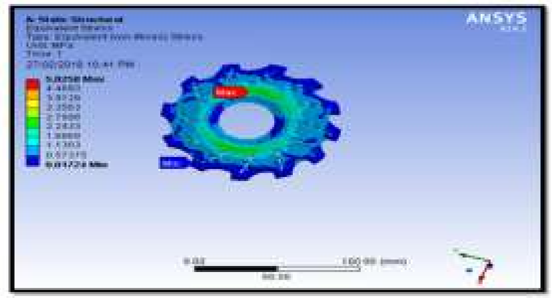

Fig.5.9 EQUIVALENT STRESS

STRAIN

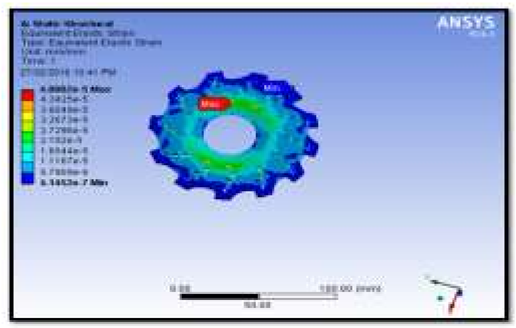

Fig.5.10 STRAIN

THERMAL ANALYSIS OF DISC BRAKE

ALUMINUM 6061

Density=0.0000027kg/mm^3

Thermal conductivity=18W/m-K

CAST IRON

Density=0.0000071 kg/mm^3

Thermal conductivity =50w/m-k

TEMPERATURE

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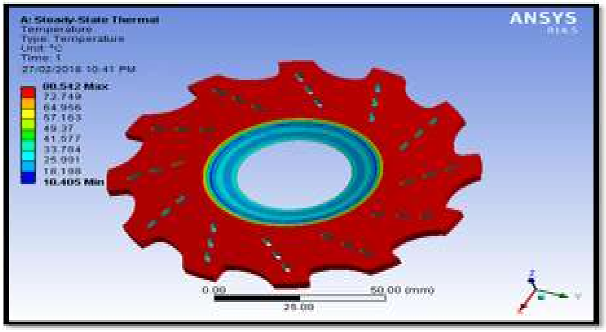

Fig.5.13 TEMPERATURE

HEAT FLUX

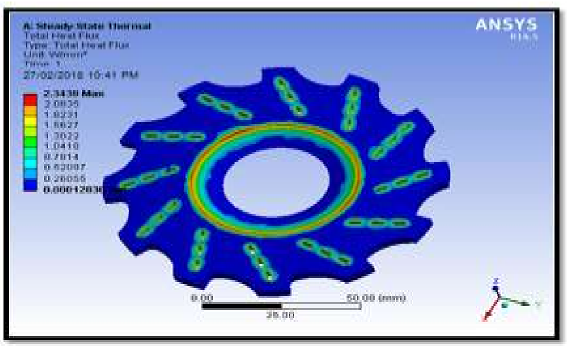

Fig.5.14 HEAT FLUX

MATERIAL- CAST IRON

TEMPERATURE

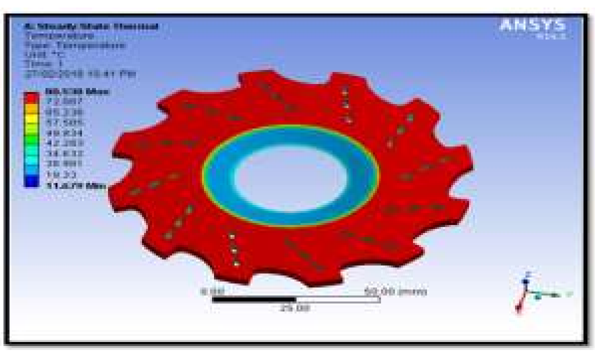

Fig.5.15 MATERIAL- CAST IRON TEMPERATURE

HEAT FLUX

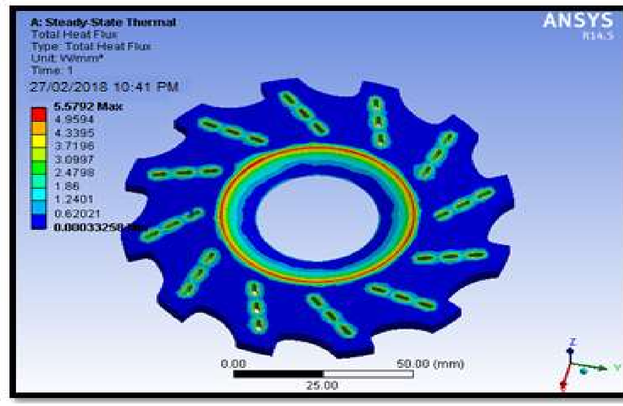

Fig.5.16 MATERIAL- CAST IRON HEAT FLUX

STRUCTURAL LINEAR LAYER ANALYSIS OF DISC BRAKE

Imported model

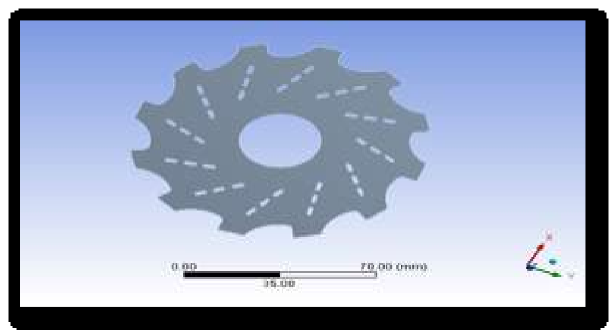

FIG.5.17IMPORTED MODEL

Select geometry> right click> select insert> select layered section>select co-ordinate system>select body co-ordinate system> select layers> select work sheet

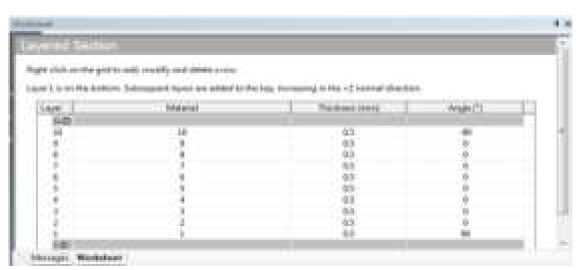

Fig.5.18 worksheet (layered section)

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Select model> right click on it>select edit>select mesh >right click on it > select generate mesh

MESHED MODEL

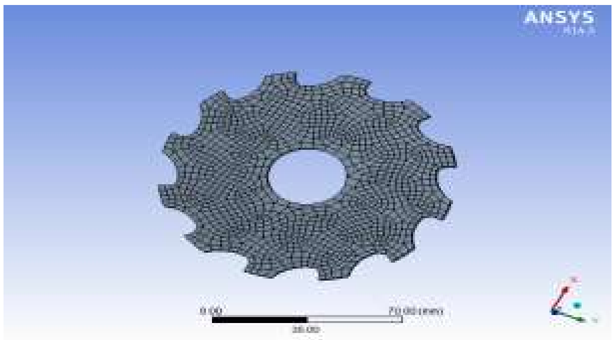

Fig.5.19 MESHED MODEL

TOTAL DEFORMATION

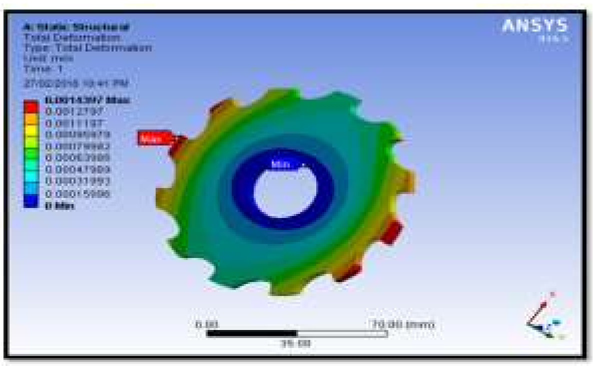

Fig.5.20 TOTAL DEFORMATION

EQUIVALENT STRESS

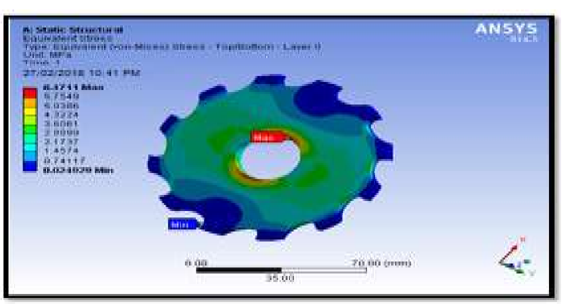

Fig.5.21 EQUIVALENT STRESS

STRAIN

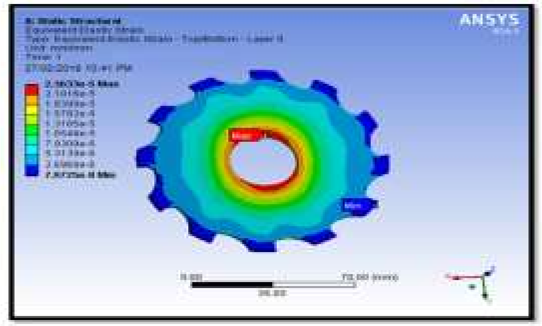

Fig.5.22 STRAIN

THERMAL LINEAR LAYER ANALYSIS OF DISC BRAKE

TEMPERATURE

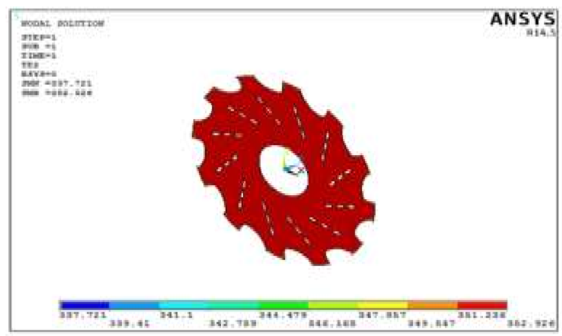

Fig. 5.23 THERMAL LINEAR LAYER ANALYSIS OF DISC BRAKE TEMPERATURE

HEAT FLUX

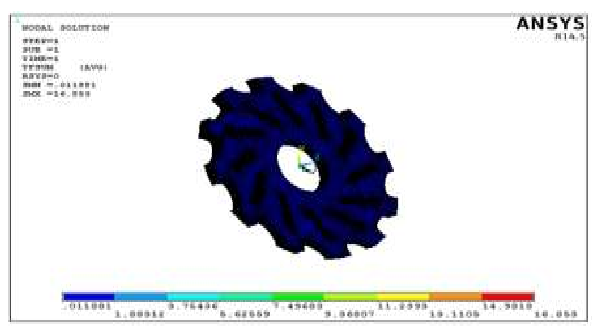

FIG. 5.24 THERMAL LINEAR LAYER ANALYSIS OF DISC BRAKE HEAT FLUX

FINAL RESULTS SUMMERY

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6.1 STRUCTURAL RESULTS

MATERIAL	DISPLACEMENT (mm)	STRESS (N/mm^2)	STRAIN
AL-6061	0.017289	104.821	0.153E-03
CAST IRON	0.068932	106.061	0.598E-03

STRUCTURAL LINEAR LAYER ANALYSIS

	RESULTS		
	DISPLACEMENT (mm)	**STRESS (N/mm^2)**	**STRAIN**
K=2	0.1598258	150.074	0.001091

THERMAL RESULTS

AT TEMPERATURE OF 393K

MATERIAL	NODAL TEMPERATURE (K)	THERMAL FLUX (W/mm^2)
AL-6061	393	55.2384
CAST IRON	393	21.0567

RESULTS OF FGM WITH HOLEs

MATERIAL	TEMPERATURES(K)	RESULTS	
		NODAL TEMPERATURE (K)	**HEAT FLUX (W/mm^2)**
K=2	**393K**	392.688	14.953

CONCLUSION

In this thesis, a disc brake is designed in three-D modeling software Pro/Engineer. The design is modified by specifying holes at the disc brake. In this thesis, contrast is carried out by using various materials for disc brake, the substances are Cast Iron, Aluminum Alloy 6061, Composite material Kevlar fiber and the Functionally Graded Material with metallic Aluminum alloy 6061 the usage of Ceramic as interface quarter is likewise taken for analysis.

By looking at the structural analysis results, the stresses and displacements are much less for Functionally Graded Material, so it's miles secure to use FGM and the stresses are much less for the disc brake with out hollow at extent fraction K=4..

By evaluating the models with out and with holes, the disc brake with holes fails early than disc brake without holes since the stresses are increasing.

By gazing the thermal analysis outcomes, the heat switch fee is more for disc brake with holes than without holes since thermal flux is more. Using FGM with quantity fraction of K=2 is higher given that warmth switch charge is greater.

So it could be concluded that the use of FGM with volume fraction of K=2 for disc brake is better with holes since the stresses are inside the permissible limit and extra heat transfer rate.

FUTURE SCOPE

Analytically using FGM is better, but investigations are to be done experimentally for better use of FGM for disc brake.

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3.Stress and Temperature Distribution Study in a Functionally Graded Brake Disk through P. Hosseini Tehrani, M.Talebi

four.Temperature in a disk brake, simulation and xperimental verification via Leszek Wawrzonek, (Institute of Thermal Technology, Silesian University of Technology, Gliwice, Poland), Ryszard A. Bialecki, (Institute of Thermal Technology, Silesian University of Technology, Gliwice, Poland)

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