# MODELLING AND STATIC THERMAL ANALYSIS OF MULTI CLUTCH PALTE BY USING DIFFERENT MATERIALS

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**ABSTRACT**

A clutch is a mechanical device which provides for the transmission of power motion from one component to another component .The opposite component of the clutch is the brake. A multi plate clutch may be used when a large torque is to be transmitted. The multi disc clutches are extensively used in motor cars, motorbikes, machine tools etc. The aim of the project is to design a multi plate clutch by using theoretical values. A 2D drawing is drafted for multi plate clutch from the calculations and a 3D model is created in the SOLIDWORKS modelling software took for pulsar 150cc bike Existing vehicle. We have done FEM analysis by varying friction materials with some non metals By extracting the result we are going to find out which material is best for the multi clutch plate by using Structural analysis and thermal analysis using these material properties of the Four materials, Grey cast iron, SF001,Zamak,AL7075,etc....,

***Index Terms— ANSYS, SOLIDWORKS, Grey cast iron, ZAMAK, AL7075, SF-001, Wet-Clutch plate, Von-misses stress, Total Deformation, temperature distribution and heat flux.***

## I. INTRODUCTION

Clutch is a device used in the transmission system of a vehicle to engage and disengage the transmission system from the engine. Thus, the clutch is located between the engine and the transmission system. In a vehicle, the clutch is always in the engaged position. The clutch is disengaged when starting the engine, when shifting gears, when stopping the vehicle and when idling the engine. It is disengaged by operating the clutch pedal i.e. by pressing the pedal towards the floor of the vehicle. The clutch is engaged when the vehicle has to move and is kept in the engaged position when the vehicle is moving. The clutch also permits the gradual taking up of the load, when properly operated; it prevents jerky motion of the vehicle and thus avoids putting undue strain on the remaining parts of the power transmission.

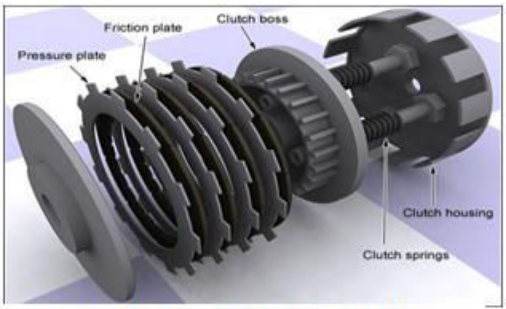


**Figure 1 multi clutch nomenclature**

The energy necessary for the motion of a vehicle is transmitted by the engine to the wheels through the flywheel, the clutch system and the driveline. The clutch takes the energy from the flywheel and transmits it to the driveline. During the engagement process, the friction torque acts upon the friction surfaces of the clutch as an engaging force for the driveline. A part of the energy transmitted through the driveline is transformed in to other forms of energy by positive damping effects. It is disengaged by operating the clutch pedal i.e. by pressing the pedal towards the floor of the vehicle. The clutch is engaged when the vehicle has to move and is kept in the engaged position when the vehicle is moving. The clutch also permits the gradual taking up of the load, when properly operated; it prevents jerky motion of the vehicle and thus avoids putting undue strain on the remaining parts of the power transmission. Single plate friction clutch the parts of a single plate clutch can be seen below .It has only one clutch plate, mounted on the splines of the clutch shaft. This is the most commonly used type. The flywheel is mounted on the crankshaft, and rotates with it. The pressure plate is fixed on the flywheel through the pressure plate is fixed on the flywheel through the clutch springs. The plate rotates freely on the clutch shaft. It can also be moved axially along the clutch shaft. The axial movement of the pressure plate is effected by pressing the clutch pedal. The end of the clutch shaft rests and rotates freely in the pilot bearing housed at the centre of the flywheel. The splined portion of the clutch shaft carries the clutch plate whose details

**Figure 2 clutch plates**

**TYPES OF CLUTCH:**

•Single plate clutch.

•Diaphragm type clutch.

•Multi plate clutch.

•Helical type single plate clutch.

•Centrifugal clutch.

•Cone clutch

**FUNCTION OF CLUTCH:**

1. Clutch is use the function of clutch to engage and disengage the engine power from gear box or wheel.

2. Effortless operation.

3. Minimum size.

4. Minimum mass.

5. Torque transmission will be more.

6. Friction capacity will be more.

7. Heat dissipation will be more.

8. Minimum vibration.

9. Well balance.

**MULTI DISC CLUTCH ADVANTAGES:**

1. Increase the amount of torque able to be transmitted.
2. Decrease the pedal effort to operate the clutch.
3. Decrease the weight of the clutch
4. Decrease the M.O.I. (Moment of Inertia) of the clutch.
   The amount of torque that a clutch transmits is critical to the ultimate performance of a vehicle .Multi disc clutches increase the available torque capacity by 2 for twin disc and 3 for triple disc.

## II. LITERATURE REVIEW

Structural Analysis of Multi-Plate Clutch In this paper, we design a multi plate clutch by using empirical formulas. A 2D drawing is drafted for multi plate clutch from the calculations & a 3D model is created in the modelling Software Pro/E for Automobile Applications. We have conducted structural analysis by varying the friction surfaces material. By extracting the results Comparison is done for both materials to validate better lining material for multi plate clutch to find out which material is best for the lining of friction surfaces. Analysis is done in ANSYS software.

The Friction plate used in this Project is part of a Wet Multi-Plate clutch System which is normally used in commercial Motor vehicles. The clutch Friction plate is located between the Clutch Centre and the Pressure plate. The clutch cushioning spring is a plate where is acts to absorb the vibration effect during clutch engagement as well as linking the clutch counter mate disc and the clutch disc base together.

**GORIN AND SHILYAEV (1976)[1]** studied the analytical solutions between two rotating annular disks having small gaps. Since the analytical solutions were derived from the Navier-Stokes equations using an integral approach, i.e. the Slezkin-Targ method, the inertial terms were not considered. The study was limited to laminar flow between a rotating and a stationary disk, and computed exactly the radial, axial and tangential velocity components.

**LI AND TAO[2] (1994)** compared three types of outflow boundary conditions for recirculating flows with experiment data for convective heat transfer of a two-dimensional jet impinging on a rectangular cavity. They tried a local mass conservation method, a local one-way method and a fully-developed flow assumption. They concluded that, if possible, the area of the outflow boundary should be located far enough from the re circulating area in order to obtain a realistic numerical solution and avoid significant errors. Of the three methods that Li and Tao studied, the mass conservation method for the outflow boundary model having is circulating flow at the boundaries had the best agreement with the experimental data.

**NATSUMEDA AND MIYOSHI[3] (1994)** developed a numerical solution for the clutch 15 engagement process including the permeability of the friction plate, the compressive strain and the asperity contact of the friction material. In addition, they solved the equations of heat conduction to model the heat generated by the asperity contact. Furthermore, the conducted experiments with multi-friction plates to measure the torque and temperature variation in the system. They found that during engagement the temperature at the centreline of the separator plates begins to rise from its initial state. Also, it was observed that during the engagement process the temperature at the end of clutch pack was much lower than that between the friction plates although the temperature at the both locations was almost identical prior to engagement. Since the friction material insulates the separator area surrounded by the friction plates, it achieves a higher temperature than that of the separator area, whose one side is in contact with the piston.

**BERGER ET AL.[4] (1996)** developed a Finite-Element Model (FEM) model to simulate the engagement of rough, grooved, paper-based permeable wet clutches. A modified 16 Reynolds equation was adopted from the Patir and Cheng flow model using average flow factors to include surface roughness effects. The Reynolds equation and force balance equations were discredited using the Galerkin approach. The simulation results indicate that increasing the applied force increases the torque peak and decreases the engagement time. Furthermore, the permeability of the friction material affects the magnitude of the increase in torque peak and the corresponding decrease in engagement time. The FEM model radial grooves on the friction material and the computational results showed that an increase in groove width results in a decrease of the torque peak while groove depth only slightly affects the torque. Furthermore, the film thickness decay was shown to be related to increasing the torque peak. However, no comparison between the simulation and available experimental measurements were made. In 1997, to obtain a more efficient solution to the problem, the modified Reynolds equation.

**BERGER ET AL.[5] (1997)** was simplified assuming axis symmetric flow, and neglecting the compressive strain of the friction material. The system of Reynolds and force balance equations was reduced to a single, first-order differential equation that resulted in a fast executing model.

**YUAN ET AL. [6] (2007)** proposed an improved hydrodynamic model for open, wet-clutch behaviour. This theoretical model includes not only the effects of trapped air bubbles, but also surface tension and wall adhesion. The surface tension between fluid and air at outer interface is assumed and the relation between the surface tension and the pressure jump is formulated. With the formulation, an equivalent radius assumption was made. The drag torque for the equivalent radius was validated with experiment results and the computed drag torque from this model was proven to be more accurate than previous models at high rpm. The analytical solution of Yan et al. agreed well with the experimental results, however the need for adjustment of the oil viscosity was rather problematic. Also, since the model corresponded to a non-grooved open wet clutch, there were limitations to any potential applications to a realistic wet clutch having a grooved friction plate and undergoing dynamic engagement

**OBJECTIVE OF PROJECT:**

The objectives of this project are:

1. To study the static and thermal capacity of the clutch disc.

2. To determine the structural analysis and temperature distribution, heat flux on the clutch counter mate disc in transient state condition by using different materials.

**SCOPE OF PROJECT:**

The scopes of this proposed project are:

1. To generate 3-dimensional geometry model of the commercial clutch disc component.

2. To perform steady state thermal analysis on the model to determine the temperature distribution and heat flux of the component under transient thermal Analysis component using ANSYS.

3. To compare thermal analysis between four materials of clutch disc.

## III. PROBLEM STATEMENT:

Improper material leads the Clutch failure and damage due to excessive frictional heat and heat fluctuations to the clutch counter mate disc often happens to any type of automotive clutches. This situation contributes to thermal fatigue to the component which causes the clutch counter mate disc to crack and deform. This later will create problems such as clutch slip, clutch drag or failure of clutch to disengage properly and clutch rattling as well as shortening the lifecycle of the component.

**Figure 3 problems in multi clutch**

The objective of this project is to make a 3D model of the multi plate clutch and study the static and thermal behaviour of the multi plate clutch by performing the finite element analysis.3D modelling software (SOLIDWORK) was used for designing and analysis software (ANSYS) was used for analysis.

**THE METHODOLOGY FOLLOWED IN THE PROJECT IS AS FOLLOWS:**

- Create a 3D model of the multi plate clutch assembly using parametric software SOLIDWORKS.
- Convert the surface model into IGS and import the model into ANSYS to do analysis.
- Perform static analysis and thermal analysis on the multi plate clutch assembly for thermal loads.
- Finally it was concluded which material is the suitable for multi clutch plate

**COMPUTATIONAL MODELLING**

1. Power produced in Bike = 9000 rpm

2. Twisting Moment = 12.45 N-m @ 6500rpm

3. Co-efficient of friction in between the friction plates, μ = 0.3

4. Operating temperature in between plates = 150 – 250

5. Maximum pressure applied N/mm2 = 0.4

6. r1 and r2 outer and inner radius of friction faces r1 =109mm and r2 = 90 mm

7. Average Uniform Pressure=0.0045867Mpa.

8. Generation of Heat Q g=2187.5 Joules.

9. Area=11878.361mm$^2$.

10. Heat flux per plate=7.3663*10-3W/mm$^2$.

**MODELING OF WET CLUTCH:**

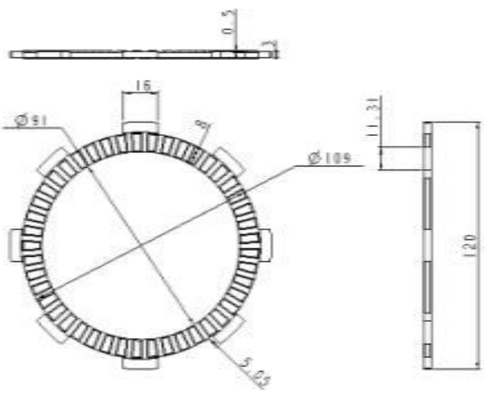


**Figure 4 modelling and dimensions of multi clutch**

SOLIDWORKS is software which is used for creation and modifications of the objects. In SOLIDWORKS and design and modelling feature is available. Design means the process of creating a new object or modifying the existing one. Drafting means the representation or idea of the object. Modelling means converting 2D to 3D. This is most progressive geometric demonstrating in three measurements. This regularly utilizes strong geometry shapes called picture to build the article. Another element of the SOLIDWORKS framework is shading design capacity. By method for shading, it is conceivable to show more data on the representation screen hued pictures help to illuminate parts is a gathering or highlight measurements or host of different purposes. By utilizing the basic capacities of the product as to the single information source standard, it gives a rich arrangement of apparatuses in the assembling environment as tooling plan and recreated CNC machining and yield. Tooling choices spread forte instruments for embellishment; pass on throwing and dynamic tooling outline

**MATERIAL PROPERTIES**:

- **Aluminium alloy 7075 material:**

Aluminium alloy 7075 is an aluminium alloy, with zinc as the primary alloying element. It is strong, with strength comparable to many steels, and has good fatigue strength and average machine ability. It has lower resistance to corrosion than many other Al alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use to applications where cheaper alloys are not suitable.

- **Grey Cast Iron Material**:

It is a type of cast iron that has a graphitic microstructure. It is named after the gray colour of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight. It is used for housings where the stiffness of the component is more important than its tensile strength, such as internal combustion engine cylinder blocks, pump housings, valve bodies, electrical boxes, and decorative castings. Grey cast iron's high thermal conductivity and specific heat capacity are often exploited to make cast iron cookware and disc brake rotors.

- **SF001MATERIAL**:

SF-001 is a high performance, high friction, non metallic composite material containing a high percentage of aramid fibre. Same family from SF-BU, but with less high Kevlar composition. It can be considered an alternative to sintered metallic materials and offers many advantages, it will withstand high energy inputs, is suitable for both dry and oil-immersed applications. It is not abrasive to the counter material, is silent in operation, it will withstand high pressures. The wear rate is low even at high temperatures is available in thicknesses from 0.6mm to 5mm.

- **ZAMAK MATERIAL:**

Zamak (formerly trademarked as ZAMAK and also known as Zamak) is a family of alloys with a base metal of zinc and alloying elements of aluminium, magnesium, and copper. Zamak alloys are part of the zinc aluminium alloy family; they are distinguished from the other ZA alloys because of their constant 5% aluminium composition.

**MODELING**

A fully parametric 3D model of multi plate clutch developed by using Profiles, Circular patterns using Sketch and applying extruded bosses and extruded cuts using features module as shown in below figure.

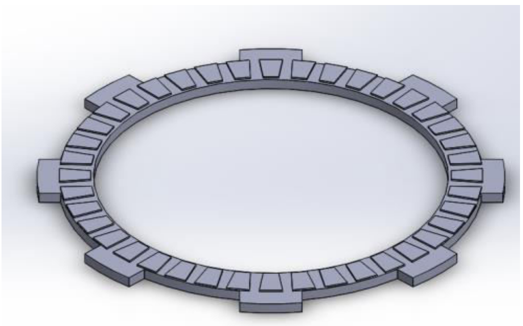

**Figure 5 multi plate clutches**

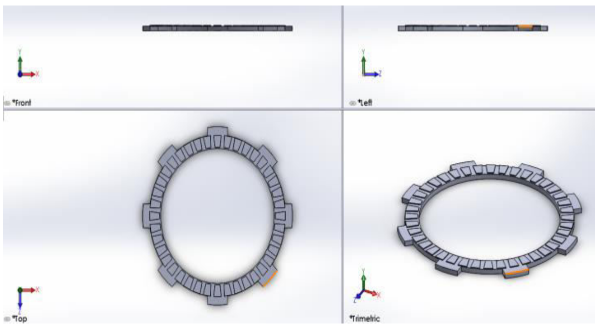

**Figure 6 multi sectional view of multi plate clutch**

**PROCEDURE OF STATIC ANALYSIS & THERMAL ANALYSIS:**

Create the geometry in SOLIDWORKS workbench and save the file in igs format and open ANSYS workbench apply engineering data (material properties), create or import the geometry, apply model (meshing),apply boundary conditions(setup) shown the results(stress, deformation, heat flux).meshing figure

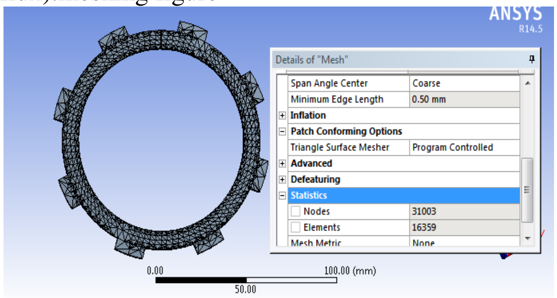

**Figure 7 Meshing of Clutch plate in ANSYS workbench**

Nodes: 31003

Elements: 16359

**Boundary conditions in static analysis**:
Static load that is applied on Wet-Multi plate clutch.0.0045867Mpa

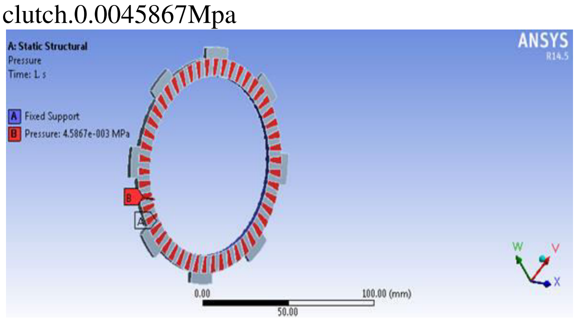

**Figure 8 static Loads applied on Wet-Multi plate clutch.**

**Boundary conditions in thermal analysis**:
thermal load applies on Wet-Multi plate clutch is temperature: 175 $^{0}$C AND HEAT FLUX: 7.3663e 003W/mm$^{2}$

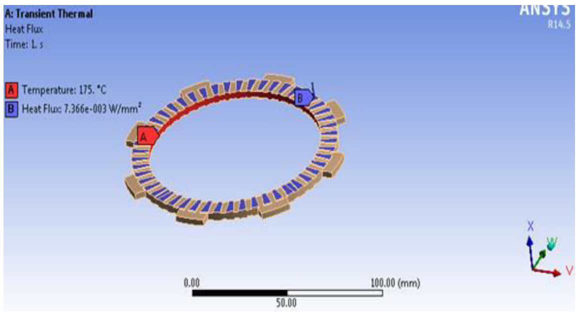

**Figure 9 Thermal loads applied on Wet-Multi plate clutch**

## IV. RESULTS AND DISCUSSION:

### STATIC ANALYSIS RESULTS:

This analysis is performed to find Structural parameters such as Stresses, Deformation.

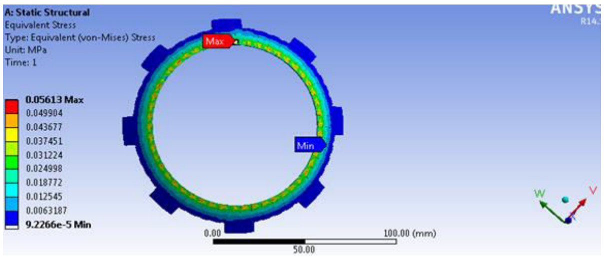

**Figure 10 Stresses in AL7075**

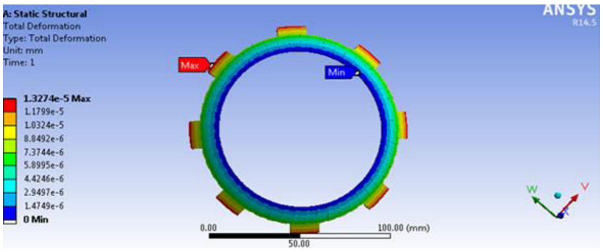

**Figure 11 Total deformations in AL7075**

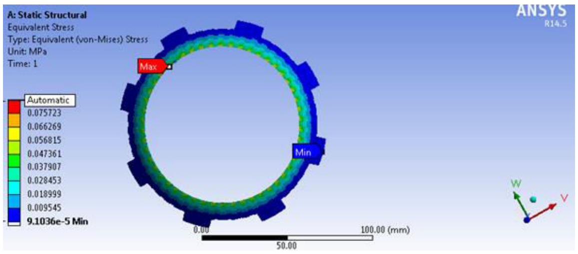

**Figure 12 stress in grey cast iron**

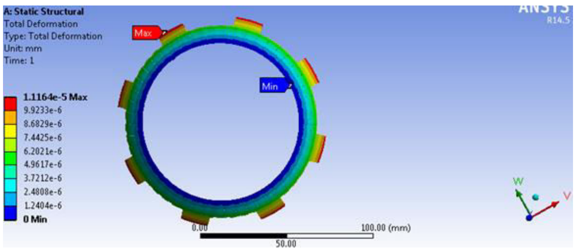

**Figure 13 total deformations in stress in grey cast iron**

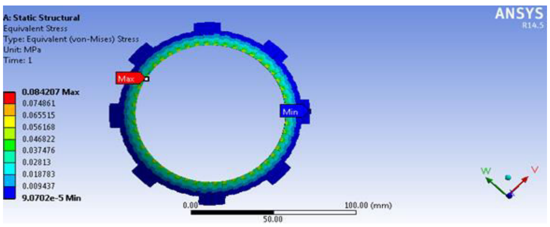

**Figure 14 stress in SF001**

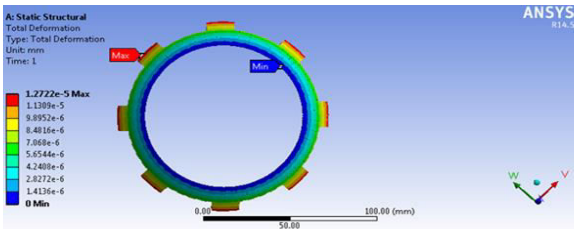

**Figure 15 total deformation in SF001**

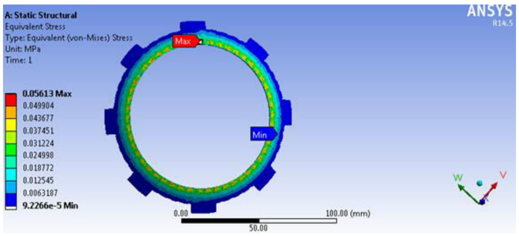

**Figure 16 stress in ZAMAK**

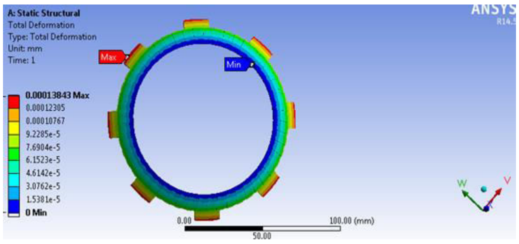

**Figure 17 total deformation in ZAMAK**

### STRUCTURAL ANALYSIS TABLE:

The values of stress strain and total deformation of each material is given in below table

| MATERIALS | AL 7075 | GREY CAST IRON | SF001 | ZAMAK |
|---|---|---|---|---|
| STRESS | 0.05613 | 0.08021 | 0.08427 | 0.05613 |
| TOTAL DEFORMATION | 1.3274 | 1.1164 | 1.2722 | 0.00013843 |

**Table 1 structural analysis table**

### THERMAL ANALYSIS:

The values of temperature distribution and heat flux of each material is given in below table

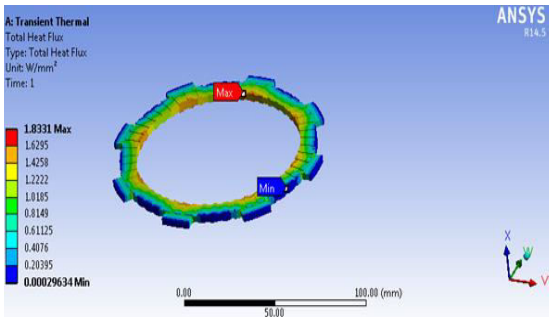

**Figure 18 heat flux in AL7075**

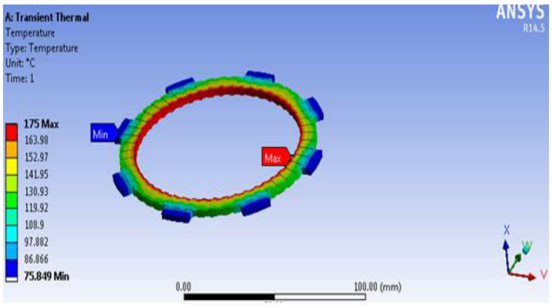


Figure 19 temperature distributions in AL7075

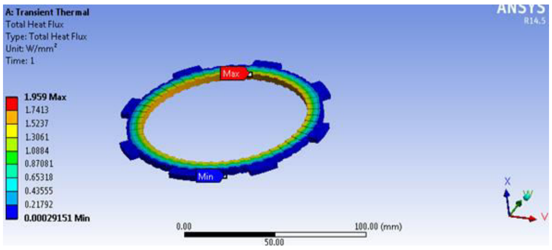


Figure 20 heat flux in grey cast iron

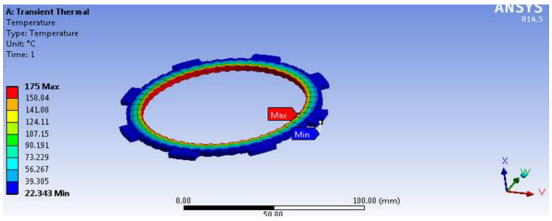


Figure 21 temperature distributions in grey cast iron

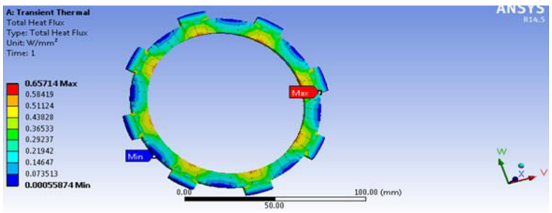


Figure 22 heat flux in SF001

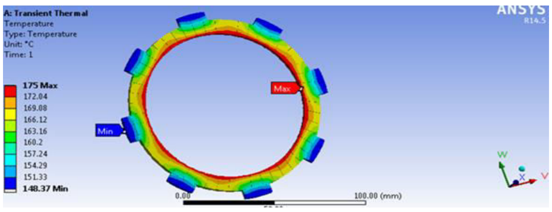


Figure 23 temperature distributions in SF001

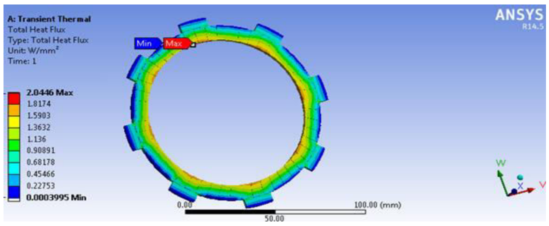


Figure 24 heat flux in ZAMAK

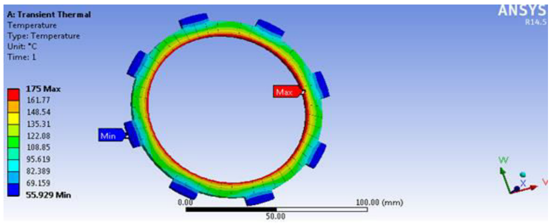


Figure 25 temperature distributions IN ZAMAK

| MATERIALS | AL7075 | GREY CAST IRON | SF001 | ZAMAK |
|---|---|---|---|---|
| TEMPERATURE DISTRIBUTION °C (MIN) | 75.849 | 22.343 | 148.37 | 55.929 |
| TOTAL HEAT FLUX (w/mm$^2$) | 1.8331 | 1.959 | 0.65714 | 2.0446 |

Table 2 thermal analysis table

## V. CONCLUSION

Modelling of Multi-plate clutch is done by using SOLIDWORKS Software and then the model is imported into ANSYS Software for Structural, Thermal analysis on the Multi plates to check the quality and temperature circulation of distinctive friction materials such as, Al7075, Grey cast iron, Zamak,SF001 composite material. From the investigation, the obtained Von-misses stresses ,strain, deformation for the materials, Al7075, Grey cast iron, ZAMAK (0.5613Mpa) respectively Compared to all materials these materials have less stresses, deformations also less in ZAMAK(0.00013843) and respectively Compared to all materials these two materials have less deformations. The results show that in case of temperature distribution , multi clutch plate of Minimum values are ZAMAK (55.929).The results show that in case of heat flux Maximum values of Multi clutch plate ZAMAK(2.0446) and is found to have highest heat flux in comparison with remaining materials. Finally structural and thermal analysis is done and concluded ZAMAK, as good materials for multi clutch plate.

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