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Design and Analysis of Single Plate Clutch for a Four Wheeler using Various Materials

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ABSTRACT

The clutch is one of the major components which can be seen in automobile. The clutch is used to transfer the maximum torque from the engine to the propulsionsystem. If a problem occurred in that crucial component it will halt the total system which occurs mostly because of deformations and strain .So a clutch plate has to be designed which has to be more heat resistant ,and results in less deformations and strain .The maximum structural stress technique should be implemented in design of clutches for increasing their durability and compactness .This project explains the static structural analysis and modal analysis of the single plate clutch and applying various types of materials .This project is used to find the stresses and deformations in failure region during the working of clutch and suggest the material changes to increase the life span of the clutch.

KEYWORDS: ANSYS,CATIA_V5,Friction_ Materials,SA92,SFMC2,30cr13,Tata Sumo gold

1. INTRODUCTION

Clutch is the mechanical component of generating power which is used on the transmission shafts. The main aim of a clutch is to engage and disengage the engine to the transmitting power whenever the user needs changing of gears. During the connecting position of clutch the power is passed from the engine to wheel and the power is not transmitted to wheel from the engine when it is disconnected. A Gearbox is placed in an automobile and is used in changing of the torque and speed of the four-wheelervehicle. If a gear is changed when the gearbox is engaged with the engine of the vehicle it can leads to wear and tear of the gear during its running position so to avoid this type of challenges clutch is introduced and are placed between the engine of the vehicle and gear box. Friction plates which are commonly known as clutch plates are placed in between the two units .The friction plays the huge role during the working of the clutch. If two surfaces containing friction comes in contact with each other and applied pressure then they became into a unit because of frictional forces acting in them . The area of surface, applied pressure and the acting frictional forces in them impact the friction between them. The flywheel which is placed on the engine crankshaft is the driving unit and the pressure plate placed on the driving shaft is the driven unit.

The clutch is commonly grouped into two types and they are Positive clutch and the Friction clutch. The clutches which are used during the requirement of a positive drive is said as the positive clutch. The jaw or claw clutch which is commonly used as the positive clutch and is called as the simplest type of clutch. The application of the friction clutch is seen in the transmitting of power to the shafts which are frequently start and frequently stall.

2.RELEATED WORK:

OBJECTIVE:

To analyze the performance of single plate clutch using different materials which is designed in Catia v5 and transferred to Ansys for static structural analysis and modal analysis to find the suitable material for heat resistance , less deformation and to expand life span.

LITERATURE REVIEW:

[1] B.Nivas,M.Nithiyanandam,had done research on the Design and analysis of clutch plate using a steel material published on 2014 and they had stated that cast iron has good properties of high compressive strength, low tensile strength and the cast iron has no ductility and the cast iron can be easily machined but the cost of a cast iron is too high so they have taken a low carbon steel material[EN GJS-400-15] to achieve the the properties of cast iron in a reasonable cost and after the analyzing of the clutch plate with the steel material they had concluded that the suitability of EN GJS-400-15 is better than the grey cast iron.

[2] Kedar Kishor Patil , Vinit Randive had done research on the Analysis ofsingle plate clutch by mathematical modelling and simulation which is published on 2020and their paper addresses analysis of single plate clutch which is used in a Tata Sumo vehicle and they have selected several materials processes good mechanical properties and a comparision was carried out for the selected materials to conclude better lining material for a single plate clutch and they had stated that ceramic material is best suitable for single plate clutch than the stainless steel,Kevlar 49,aluminium alloy and structuralsteelbasedon their total deformation,stress,strain and the modal frequencies of the materials .

[3] S.Gouse seema begum , A.Balaraju had done research on Design and analysis of Friction of clutch plate using Ansys which is published on 2015 and their paper addresses the analysis of clutch plate used in the Bajaj pulsar bike on several materials grey cast iron and Kevlar 49 for the uniform wear theory and the based on the parameters like equivalentstress and equivalent elastic strain and they had concluded that the Kevlar 49 material is more advantageous than the grey cast iron.

[4] Sunny Narayan , Ivan Gurujic had done their project on the Design and analysis of the automotive single plate clutch which is published on 2018 and their paper presents the deformations and stresses of the joining of the automotive single plate clutch based on the applied materials .They have taken a repressive four wheeler example of Toyota Helix kun25 using finite element method and they have selected some lining materials and finally concluded that the cermet material is more advantageous because of less heat generation and good contact pressure which are used to minimize the clutch wear during slippage time .

3.PROPOSED WORK:

MATERIAL SELECTION:

The following materials are selected for the friction clutch plate :

1.CERMET:

A Cermet is a composite material made from the ceramic [cer]and the metals[met].Generally the ceramic materials consist of Hardness and high Temperature Resistance . And the Metals are able to go under plastic deformation.The main aim of designing a cermet material is to implement combined properties of ceramic and metal.

2.AL7075:

Al7075 is an aluminum alloy done with the alloying of the aluminum with the zinc material which is used as the primary alloying elment.AL7075 exhibits very good mechanical properties like strength ,hardness,toughness,stiffness also provides good ductility and provides good fatigue resistance and heat resistance .

3.SA92:

SA92 is a Frenos standard formulation which is best known for its light medium duty . SA92 is a rigid material which provides the low wear and exhibits very good and stable friction performance . The material is made up of phenol resins with NBR bonding system,fillers,friction modifiers and short fibers .

4.SF MC2:

SF MC2 is a non-metal composite material which provides high performance ,high friction and avails many advantages MC2 is made from the high percentage of aramid fiber and it comes under the sintered metal materials and has high coefficient of friction. The SF MC2 material exhibits low wear rate at the high temperatures which is an additional merit of the material.

5.30cr13:

30cr13 is commonly said as Low end Chinese Martensitic stainless steel which is mainly seen in knife industry .30cr13 exhibits very high corrosion resistance and provides good wear resistance .the main advantage of this material is it is less price than the stainless steel.

Table 1. Comparision of materials based on their properties

Clutch plate was selected with repressive vehicle example Tata Sumo Gold for the modal and static structural analysis.

Table 2 Specifications of the Repressive vehicle example

Parameters	**Values**
Torque(T)	300N-m at 1000rpm
Outer Radius(R_o)	160mm
Inner Radius(R_i)	90mm
Maximum Power	64KW at 3000rpm
Maximum Pressure intensity(P)	0.5N/m²

Transmission of Torque under Uniform pressure

The theory of a torque transmission under uniform pressure is applicable to the new clutch. In the clutch pressure is pressure is identified to be distributed uniformly over the entire surface area and the intensity of pressure between disks is assumed to be constant.

Uniform Pressure Theory

$$P = F/\pi(R_o^2 - R_i^2)$$

$$T = \mu F \frac{2}{3} \times ((R_o^3 - R_i^3)/(R_o^2 - R_i^2))$$

Where,

P= normal pressure

F=axial force

μ=coefficient of friction between the surfaces

T=friction Torque

R_o =Outer radius

R_i =Inner radius

Transmission of Torque under Uniform Wear

The theory of torque transmission under uniform wear is applicable for the old clutches or worn out clutches.This is based on the reminder that the wear is distributed uniformly on the friction disk area.Uniiform wear plays a huge role in the life of friction lining and this is reason behind to use the uniform wear in the design of clutch.

Uniform Wear Theory

$$P = F/2\pi r(R_o - R_i)$$

$$T = \mu F \frac{1}{2}(R_o + R_i)$$

Where,

S. No	**Materials selected**	**Density [Kg/m³]**	**Poisson's Ratio**	**Friction coefficient**	**Young's Modulus [MPa]**
1	Cermet	5000	0.23	0.32	380000
2	AL7075	2810	0.33	0.4-0.6	71000
3	SA92	1800	0.27	0.3-0.4	3896
4	SF MC2	1350	0.27-0.3	0.45	7260
5	30cr13	7700	0.303	0.27-0.3	200000

r=constant

Calculation for Uniform Pressure Theory and Uniform Wear Theory:

Uniform wear effective mean radius is,

$$r = (R_i + R_o)/2$$
$$= (90+160)/2$$
$$= 125mm$$

Uniform Pressure effective mean radius is,

$$r = (2(R_o^3 - R_i^3))/(3(R_o^2 - R_i^2))$$
$$r = 128mm$$

Area of Friction Surface(A) = $\pi(R_o^2 - R_i^2)$

$$A = 54988mm^2$$

Angular Velocity (ω) = $2\pi N/60$

= 314.16 rad/sec

Table 3. Calculation Results:

Sr. No	**Materials**	**Friction Coefficient**	**Uniform Pressure**		**Uniform Wear**	
			Axial Force	**Pressure (N/m²)**	**Axial Force**	**Pressure**
1.	AL7075	0.23	3662.10	66.846e³	4000	52.04e³

2.	Cermet	0.32	5102.04	92.930e³	5200.43	72.63e³
3.	SA92	0.27	3906.25	71.152e³	4106.12	61.68e³
4.	SFMC2	0.45	4341.53	47.438e3	4571.32	81.09e³
5.	30cr13	0.30	2608.17	71.152e³	2812.8	79.82e³

Design of Clutch:

The design of clutch plate has completed in CATIA V5 using FEA analysis and is transferred to the ANSYS for performing static structural analysis and modal analysis using various materials and the modelling of clutch is seen below.

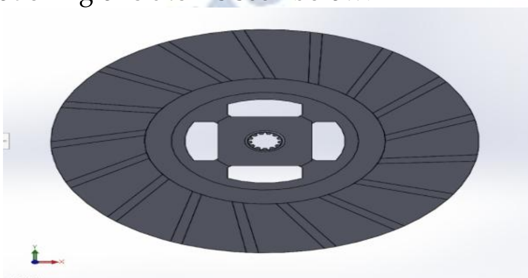


Figure 1

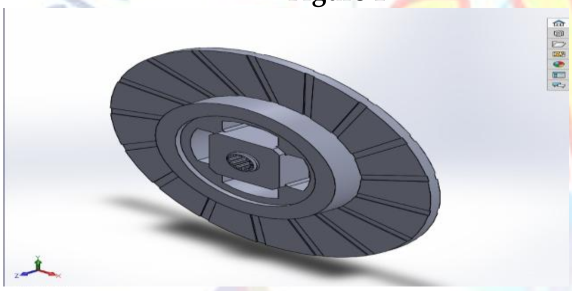


Figure 2

Figure1, Figure 2 Design Model of clutch

Boundary Conditions of clutch plate:

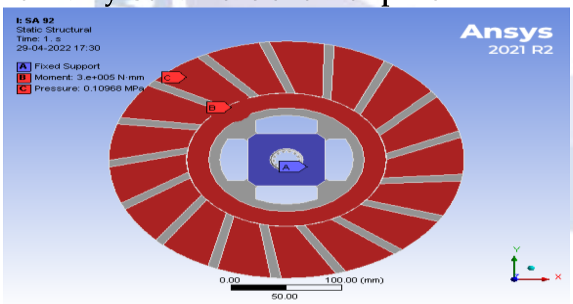
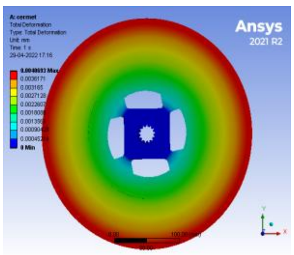


Figure 3:Boundary conditions

1.Material : CERMET



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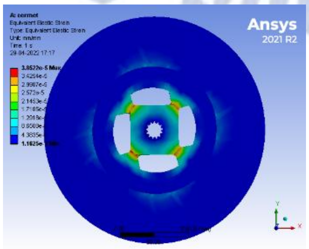

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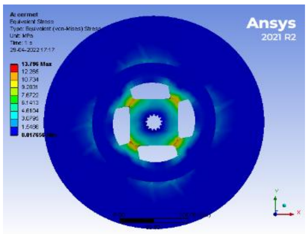
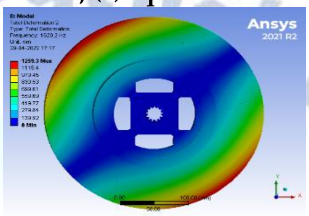


(c)

Figure 4: (a) Total deformation ,(b)Equivalent elastic strain , (c)Equivalent stress



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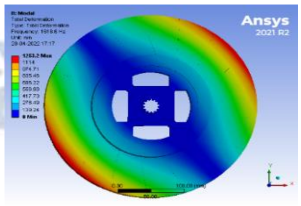

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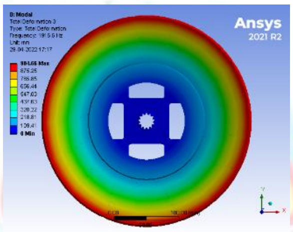

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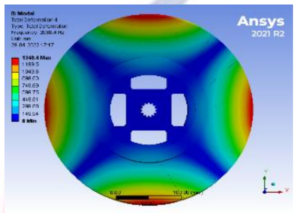

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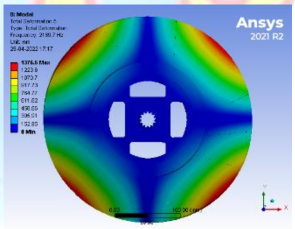

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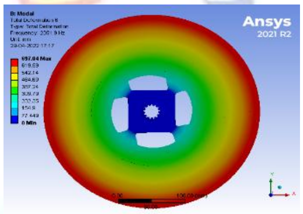
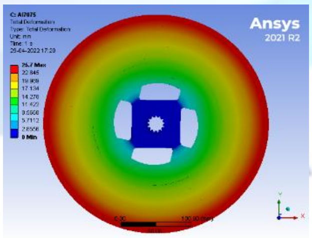


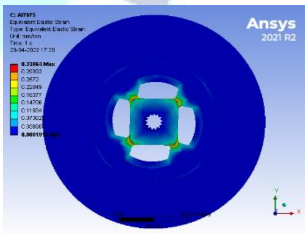
(f)

Figure 5: (a),(b),(c),(d),(e),(f) total deformation

2.Material : AL7075



(a)



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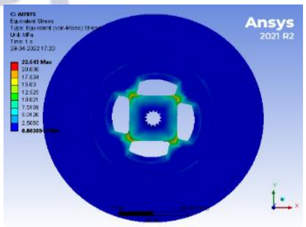
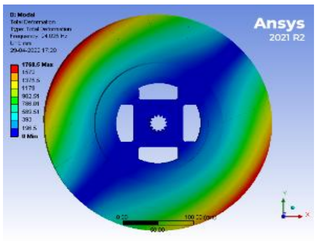
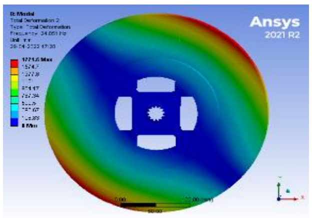


(c)

Figure 6: (a) Total deformation,(b)Equivalent elastic strain , (c)Equivalent stress



(a)



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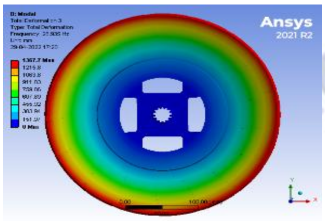

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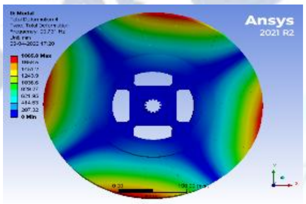

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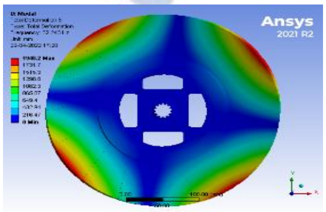

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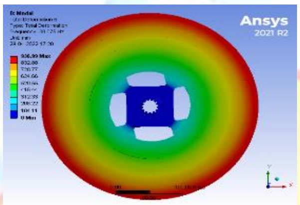
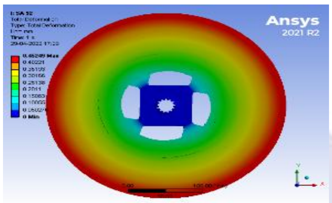


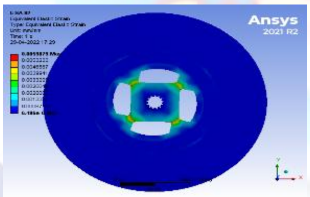
(f)

Figure 7: (a),(b),(c),(d),(e),(f) total deformation

3.Material :SA92



(a)



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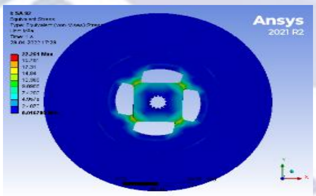

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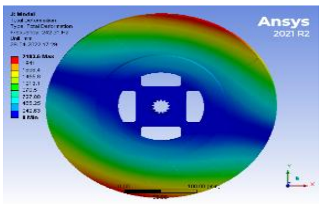
Figure 8: (a) Total deformation ,(b)Equivalent elastic strain , (c)Equivalent stress



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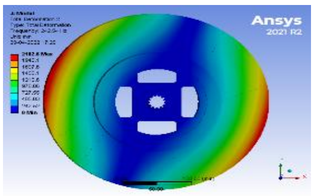

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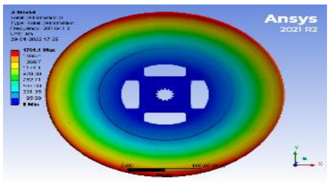

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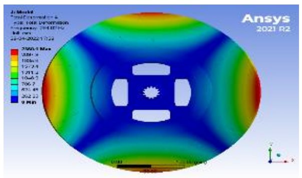

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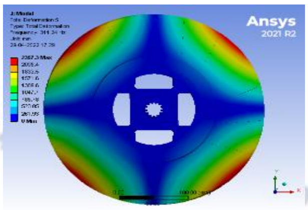

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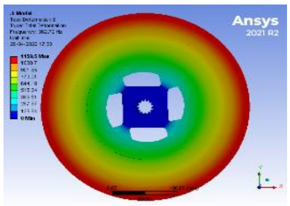
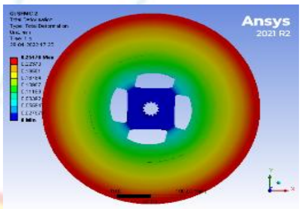


(f)

Figure 9: (a),(b),(c),(d),(e),(f) total deformation

4.Material:SFMC2



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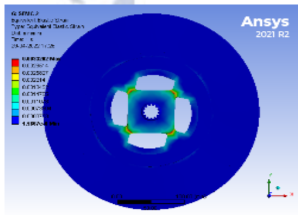

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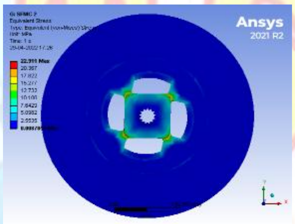
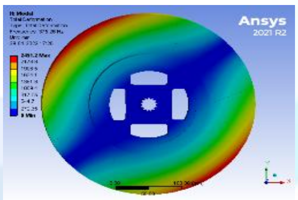


(c)

Figure 10: (a) Total deformation,(b)Equivalent elastic strain , (c)Equivalent stress



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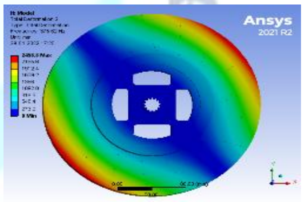

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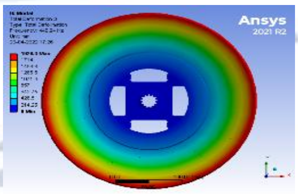

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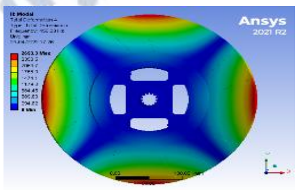

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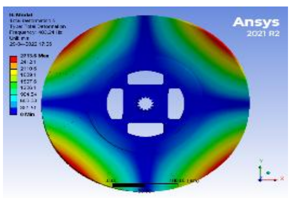

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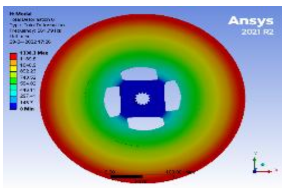
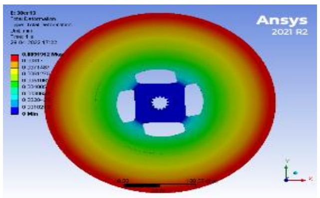


(f)

Figure 11:(a),(b),(c),(d),(e),(f) total deformation

5.material : 30cr13



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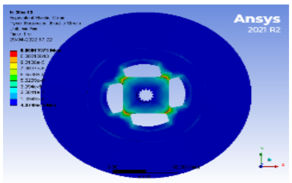

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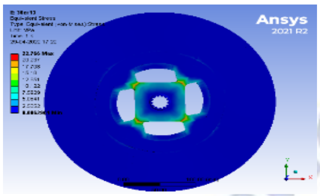

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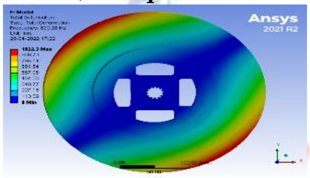
Figure 12: (a) Total deformation ,(b)Equivalent elastic strain , (c)Equivalent stress



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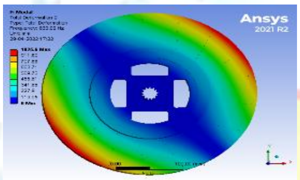

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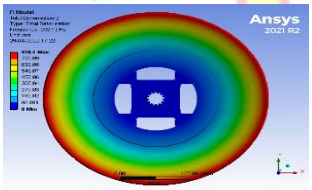
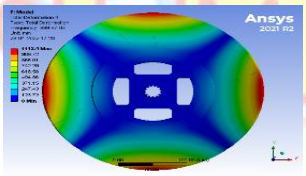
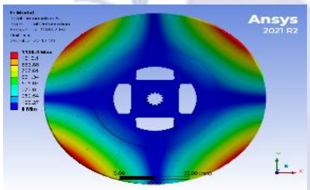


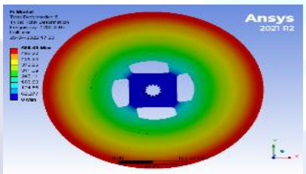
(c)



(d)



(e)



(f)

Figure 13: (a),(b),(c),(d),(e),(f) total deformation

Table 4. RESULT FROM STATIC STRUCTURAL ANALYSIS:

S.No	Materials	Total deformation(mm)	Equivalent stress(MPa)	Equivalent Strain
1	Cermet	0.0040693	13.796	3.8522×10^{-5}
2	AL7075	25.7	22.543	0.33064
3	SA92	0.45249	22.251	0.0059879
4	SFMC2	0.25176	22.911	0.33202
5	30cr13	0.0091912	22.766	0.000119

Table 5.RESULT FROM MODAL ANALYSIS: Total Deformations for first six frequencies

Frequency (Hz) No	Cermet	AL7075	SA92	SFMC2	30cr13
1	1253.2	1768.5	2183.6	2451.2	1022.3
2	1259.3	1711.5	2182.6	2458.8	1025.6
3	984.66	1367.7	1761.1	1928.3	810.1
4	1349.4	1865.8	2360.1	2653.3	1134.6
5	1376.6	1948.2	2357.3	2713.6	1136.4
6	697.04	936.99	1159.5	1338.3	560.9

CONCLUSION:

In this work, the clutch plate was designed with the repressive vehicle example-Tata Sumo Gold and imported to Ansys for the simulation. Total defamation, Equivalent stress, Equivalent strain has been observed by static structural analysis and the first six modal frequencies has been observed by Modal analysis. By the comparison of results, it is clear that the cermet material has less deformation, stress and strain than all others. This information assists the experimenters to choose proper material to reduce wear and extend life span of clutch

FUTURE SCOPE

Consider the following points when expanding on your thesis work. The modified condenser in modification 1 can be made with slots, which will increase the heat flux and efficiency of the condenser. Computational Fluid Dynamic (CFD) analysis can also be performed by changing the refrigerants.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] B. Nivas. M.E1, M. Nithiyanandam. M.E 2, S. Tharaknath. M Tech3, A. AvinashKumar. M Tech4,Design and Analysis of Clutch Plate Using Steel Material [En –Gjs-400 -15steel], IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 13, Issue 5 Ver. VI. (May. 2014)

[2] Kedar Kishor Patil, Vinit Randive, Sahil Mulla, Rajkumar Parit, Sagar Mane, Sunil Kadam , Design and analysis of single plate clutch by mathematical modelling and simulation , Volume 8 Issue 3 (2020) 248-252 ISSN 2347 – 3258 International Journal of Advance Research and Innovation

[3] S. Gouse seema begum1, A. Balaraju2,Design and Analysis of Friction Clutch Plate using Ansys,International Journal of Advanced Engineering Research and Science (IJAERS) [Vol-2, Issue-5, May- 2015]

[4] ISSN: 2349-6495

[5] Sunny Narayan 1*, Ivan Grujic 2, Nadica Stojanovic 3, Kaisan Muhammad Usman 4, Abubakar Shitu 5, Faisal O. Mahroogi ,Design and analysis of an automotive clutch plate ,MOBILITY & VEHICLE MECHANICS, DOI: 10.24874/mvm.2018.44.01.02UDC: 539.379(086.48)