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Design and Analysis of Composite of Aluminium, Coconut Shell Ash and SiC Based Clutch Plate Facing

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Abstract: - **Clutch plate liners are usually made up of luminium alloys or high carbon steels. One of the main advantage of aluminium alloy is that it is very ductile and it can be easily machined. Due to these reasons, it is suitable for the clutch plates. In order to reduce the weight of clutch plate material without affecting its life and effectiveness, we fabricated a new aluminium composite (Al-SiC-CSA) with Aluminium-92%, Silicon carbide-5% and coconut shell -3%. This composite is durable with low density and high strength. In this work aluminium composite is fabricated and wear test, hardness test and bending tests were conducted in order to compare it with the existing one. 3D model of the clutch plate is made in Creo 2.0 and analyzed with the help of ANSYS 15.0**

Index Terms— clutch plate liner, Aluminium, SiC, Coconut shell ash, composite , Creo, Ansys.

1. INTRODUCTION

A Clutch is a mechanism designed to disconnect and reconnect the driving and driven members. It is a device, which enables one rotary drive shaft to be coupled to another shaft, either when both the shafts are stationary or when there is a relative motion between them. The main function of the clutch is to enable smooth transmission of a rotary motion of an engine crankshaft to a stationary or slowly revolving output shaft(gearbox shaft) without snatch and it also enables rapid disengagement and re-engagement of the engine from the transmission while one or both in motion, for gear changing and emergency stops. The material which is used in this clutch plate is aluminium alloy. It can be easily machined. Hence, we use Al-SiC-CSA as optional material to aluminium alloy. These materials also have similar properties of aluminium alloy. We analyze these two materials then, we compare the materials and take out the best. The advantage of this project is to reduce the density of clutch plate without affecting the function and life of clutch plate.

A clutch is a mechanical device which engages and disengages power transmission especially from driving shaft to drive shaft. In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts). In these devices, one shaft is typically attached to an engine or other power unit (the driving member) while the other shaft (the driven member) provides output power for work. While typically the motions involved are rotary, linear clutches are also possible. In a torque-controlled drill, for instance, one shaft is driven by a motor and the other drives a drill chuck. The clutch connects the two shafts so they may be locked together and spin at the same speed (engaged), locked together but spinning at different speeds (slipping), or unlocked and spinning at different speeds (disengaged).Various materials have been used for the disc-friction facings, including asbestos in the past. Modern clutches typically use a compound organic resin with copper wire facing or a ceramic material. Ceramic materials are typically used in heavy applications such as racing or heavy-duty hauling, though the harder ceramic materials increase flywheel and pressure plate wear. In the case of "wet" clutches, composite paper materials are very common. Since these "wet" clutches typically use an oil bath or flow-through cooling method for keeping the disc pack lubricated and cooled, very little wear is seen when using composite paper material.

2. MATERIALS AND METHODS

2.1.MATERIALS

Coconut shell ash,Aluminium and silicon carbide are the required materials for the research.

2.2.METHODS

2.2.1.Carbonization of coconut shell

Coconut shell contains about 65 – 75% volatile matter and moisture which are removed largely during the carbonization process. The carbonization process involves converting the coconut shells to char (charcoal). The charring process (making of charcoal) is known as the Pyrolysis, which is chemical decomposition of the shell by heating in the absence of oxygen. During the carbonization of coconut shells, volatiles amounting to 70% of the mass of coconut shells on dry weight basis are released to the atmosphere, yielding 30% of coconut shell mass of charcoal. The volatile released during the carbonization process is Methane, CO2 and wide range of organic vapors. The carbonization temperature range between 400 and 850 degree Celsius sometimes reaches 1000 degree Celsius.

2.3.FABRICATION PROCESS

2.3.1.stir casting process

It consist of cylindrical shaped GRAPHITE crucible is used for fabrication of AMCs, as it withstands high temperature which is much more than required temperature [680°C].Along that GRAPHITE will not react with aluminum at these temperature.This crucible is placed in muffle which is made up of high ceramic alumina. Stir casting process starts with placing empty crucible in the muffle. At first heater temperature is set to 500°C and then it is gradually increased up to 900°C.High temperature of the muffle helps to melt aluminum alloy quickly, reduces oxidation level, enhance the wetability of the reinforcement particles in the matrix metal. Aluminum alloy is used as Matrix material.The required quantity of aluminum alloy was taken in the form of rectangular pieces.Alumium alloy is cleaned to remove dust particles, weighed and then poured in the crucible along with coconut shell ash and SiC as the reinforcement.

The sand casting operation was then done and composite was formed.

3.TESTS AND ANALYSIS

3.1.HARDNESS TEST

The hardness value of the composite was determined as per ASTM E18-2014 using rockwell hardness tester on A scale on MSM model at an ambient temperature of 25.3oC with a 1.56 mm steel ball indenter with a minor load of 10kg and major load of 100kg.

3.2.WEAR TEST

A pin-on-disc test apparatus was used to investigate the dry sliding wear characteristics

of the composites as per ASTM G99- 95 standards . The disc used is En-32 steel hardened to 62 HRC, 80 mm track diameter and 8 mm thick, with surface roughness of 10 lm Ra. The wear test was conducted by varying applied load 1.5 kg with a constant speed of 3.0 m/s and sliding distance of 2000 mm at a speed of 716.5 rpm. The pin used here is the composite material.

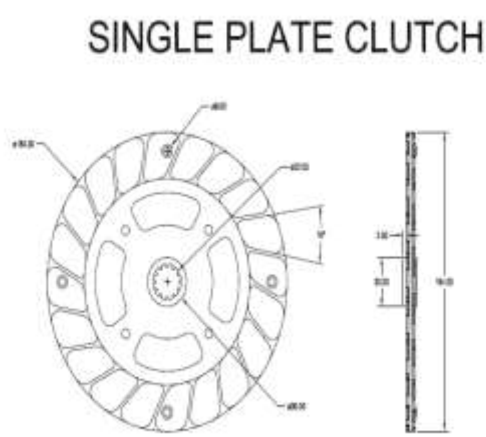
3.3.BENDING TEST

The experiment was done on the test file name CL L 0115.Utm based on the test standard IS 16008: 2005.A flat specimen of width 27.52 mm and thickness 8.23 mm and a CSA of 226.49 mm2 were taken.The load was applied from zero to find the peak load.And a graph was plotted against the load and cross head travel.

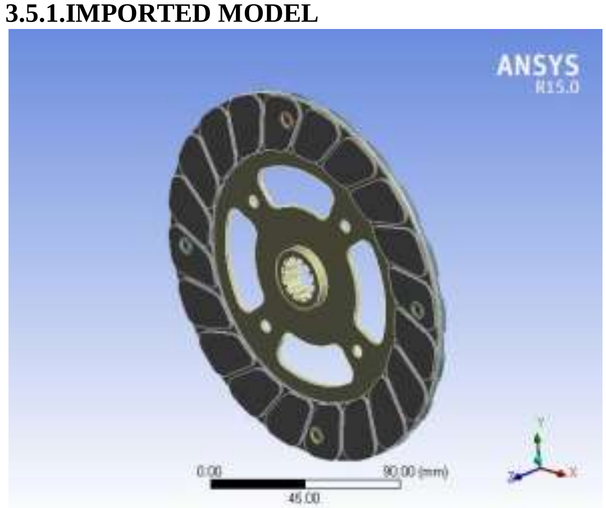
3.4.MICROSTRUCTURAL ANALYSIS

The microstructural analysis of the specimen prepared were carried out in the optical metallurgical microscope of model MVMS I 310 and machine number CL/ME/IMAG/15 at an ambient temperature of 25.7 Deg.The magnification was carried out in 100X and 500X.

3.5.DESIGN OF THE MODEL



3.5.1.IMPORTED MODEL



The clutchplate was modeled in creo 2.0 and then the file was converted in to iges file so the file can be uploaded to ansys and analyzed

3.5.2.MESHED VIEW OF THE MODEL

3.6.ANALYSIS

Static structural analysis and static thermal analysis of the composite made was done in ansys workbench.The analysis results were compared between the existing aluminum alloy and the Al-CSA-SiC composite.

4.RESULTS AND DISCUSSIONS

4.1.HARDNESS TEST RESULTS

Table 1: Hardness test results

S. No	Sample Id	Observed values, HRA			Average, HRA
		1	2	3	
1	Al5052 92%+SiC 5%+CSA3%	58	58	59	58

The hardness values of the developed composites increased with an increasing percentage of coconut shell ash particle additions. This is noteworthy that the hardness value of coconut shell ash composite was found to be 58 HRA and the presence of the hard ceramic phase in the ductile matrix has resulted into the increase in the hardness of the composite. These increments are attributed to increase of the weight percentage of hard and brittle phase of the coconut shell ash particles in the aluminium alloy. This hardness of the coconut shell particles are obtained from the SiC, Al_2O_3, Fe_2O_3 and SiO_2 of the chemical made up of the particles. Also the presence of coconut shell ash particles in the alloy increases the dislocation density at the particles matrix interfaces. This is as a results of differences in coefficient of thermal expansion (CTE) between the hard and brittle reinforced particles and soft and ductile metal matrix which results to elastic and plastic incompatibility between the matrix and the reinforcement.

4.2.WEAR TEST RESULTS

VELOCITY (m/s)	DISTANCE mm	TRACK DIA mm	SPEED rpm	TIME sec	TIME min
3	2000	80	716.5605096	666.6667	11.11111

TIME;	WEAR;	FF;	TEMP
661.6100;	54.90;	0.65;	287.64
662.5890;	55.12;	0.63;	287.59
663.5700;	54.77;	0.60;	287.63
664.5500;	54.95;	0.53;	287.72
665.5300;	54.72;	0.45;	287.62
666.5100;	54.55;	0.41;	287.46
667.4900;	54.51;	0.33;	287.53
668.4710;	54.76;	0.37;	287.73
669.4510;	55.35;	0.41;	287.71
670.4310;	55.70;	0.52;	287.63

Table 2: Wear test results

The test results showed that the wear rate was lower when compared to aluminium 5052 alloy due to the presence of ceramic particles in it ie., SiC.This was also proved in accordance with the work done by A.Apasi, Madakson on the wear behavior of Al-SiC The beneficial effect of the reinforcement on the wear resistance of the Al-Si-Fe alloy composites is observed to be the best at low load and reduces with increase in applied load applied. With higher load contact temperatures become high and plastic deformation occurs with consequence of very high wear. Also when applied load are increased seizure was accompanied by a sudden increase in wear rate, heavy noise and vibration were also noticed. This type of seizure has been referred to as galling seizure .The wear mechanism reported was oxidation at lower loads and adhesion and delamination at higher load .This observations are a part with the one observed by Aigbodion and Hassan , on bagasse ash reinforced aluminium alloy composites who reported that the beneficial effect of particle reinforcement was gradually reduced with increasing

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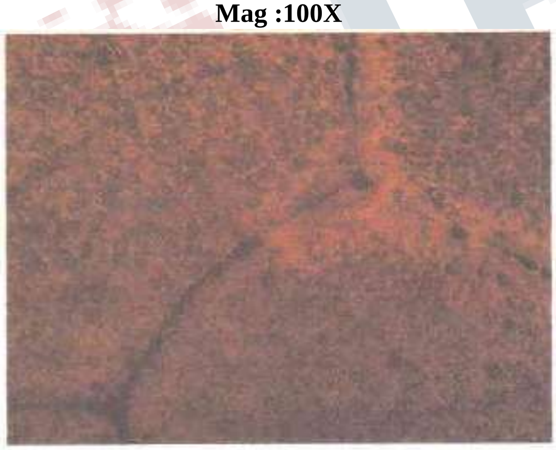
load. Also with increased load, the friction and wear will increase due to the critical surface energy of the MMCs. Furthermore, this is explained as the frictional heat raised the temperature of the friction surfaces. It is well known that wear process involve fracture, tribochemical effects and plastic flow. Transitions between regions dominated by each of these commonly give rise to changes in wear rate with load.

4.3.MICROSTRUCTURAL ANALYSIS RESULTS

Mag :100X



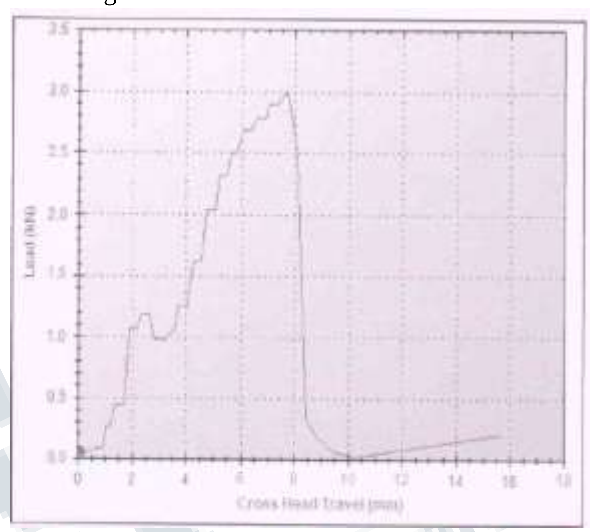
Mag:500X

Figure 1:Micrograph of the composite

The microstructure of the aluminum alloy and that of the aluminum alloy with 3wt% coconut shell ash were analysed using optical Electron Microscope. The structure reveals the eutectic phase containing Fe_3Si, Al_6Fe, in α- aluminum matrix. The microstructure of the composites reveals small discontinuities and a reasonably uniform distribution of coconut shell ash particles in the aluminum matrix. The ceramic phase is shown as dark phase, while the metal phase is light. Good retention of coconut shell ash particles was clearly seen in the microstructures of the composites.

4.4.BENDING TEST RESULTS

Load at peak : 2.980 KN
C.H.Travel at peak : 7.910 mm
Bend Strength : 13.157 N/mm2



Graph 1:load vs cross head travel

4.5.COEFFICIENT OF FRICTION

Friction force (F) = 0.52 N
Mass of the object (m) = 0.003568700 kg *9.81
= 0.035008947 N
External force (f_x) = 1.5 kg*9.8
= 14.715 N
Normal force (N) = m*g + f_x
=0.003568700*9.81+ 14.715
=14.750N
Co-efficient of friction = F/N
= 0.52 / 14.750
= 0.035

The co efficient of friction of the new material was found to be higher than the existing material of the value 0.028.This states that the material is good for a lining material.

4.6.DENSITY OF THE MATERIAL

The density of the composite was found to be 2.70 x 10^{-6} Kg/mm3 and that of the aluminium alloy used was found to be 2.77 x 10^{-6} kg/mm3.

4.7. ANALYSIS RESULTS

4.7.1.STATIC ANALYSIS RESULTS OF Al-CSA-SiC

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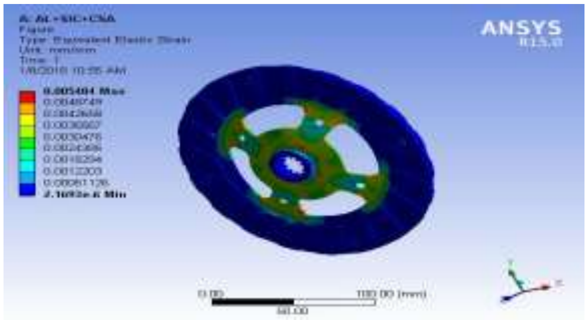

FIGURE 2:EQUIVALENT ELASTIC STRAIN

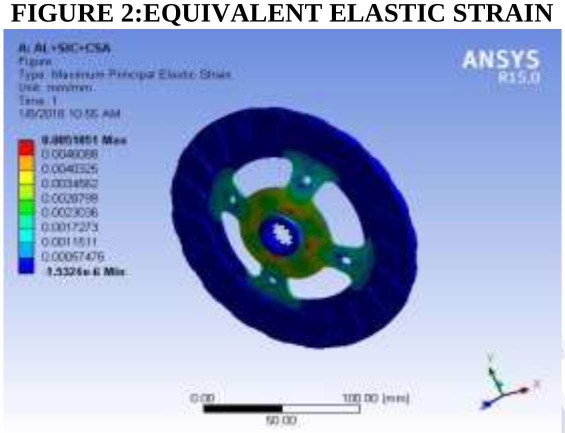

FIGURE 3:ELASTIC STRAIN INTENSITY

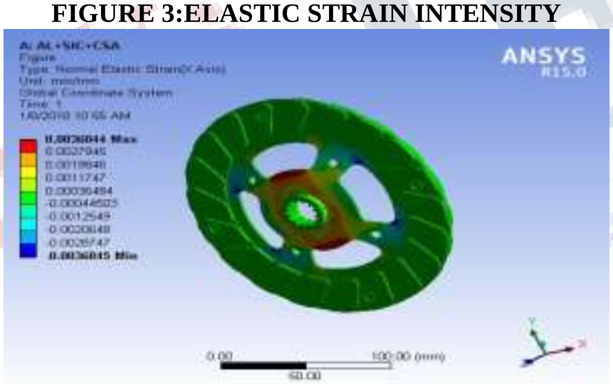

FIGURE 4:NORMAL ELASTIC STRAIN

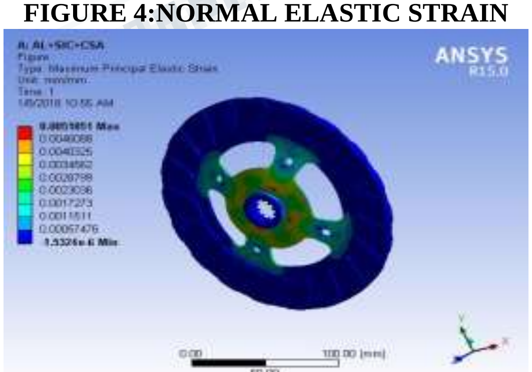

FIGURE 4:MAX PRINCIPAL ELASTIC STRAIN

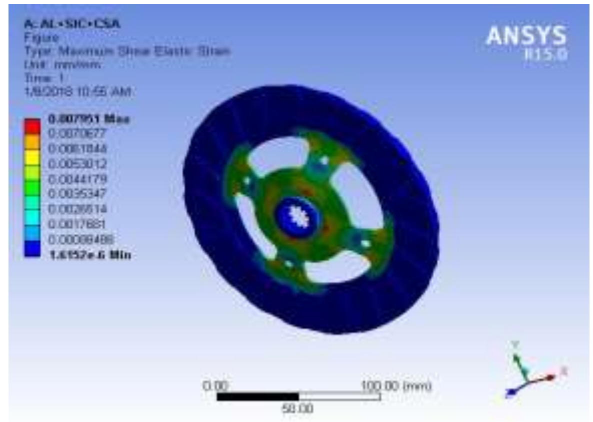

FIGURE 5:MAX SHEAR ELASTIC STRAIN

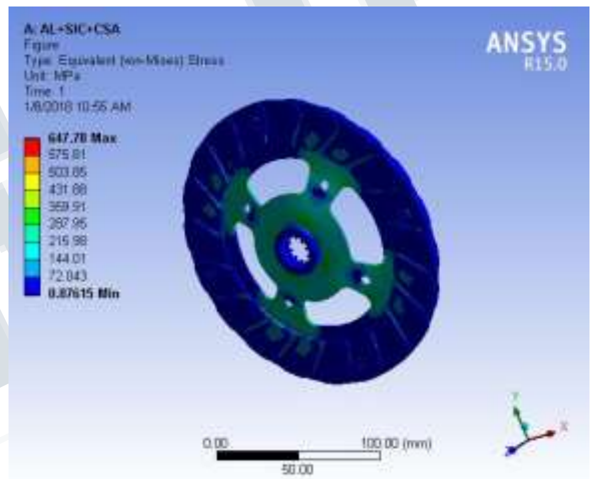

FIGURE 6:EQUIVALENT STRESS

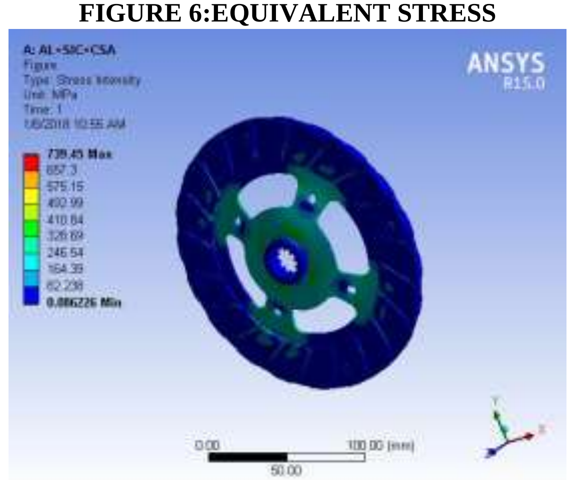

FIGURE 7:MAXIMUM PRINCIPAL STRESS

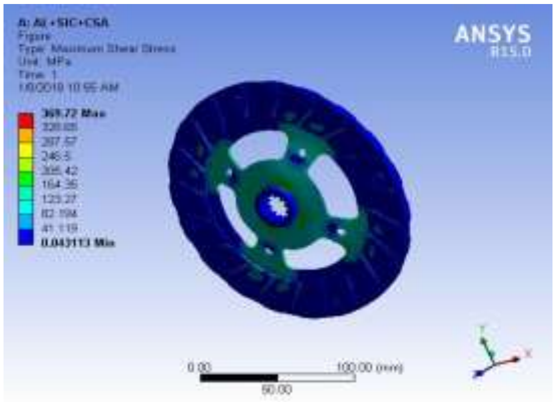

FIGURE 8:MAX SHEAR STRESS

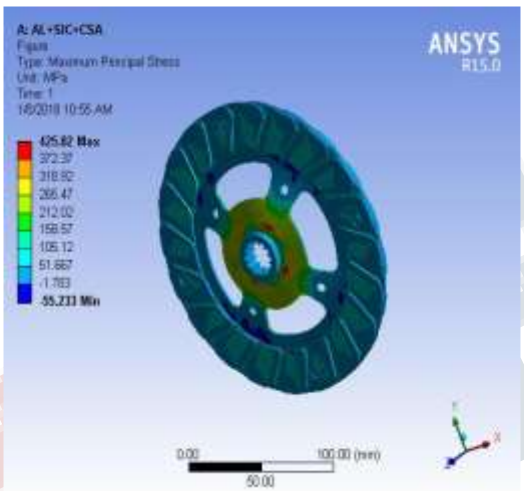

FIGURE 9: STRESS INTENSITY

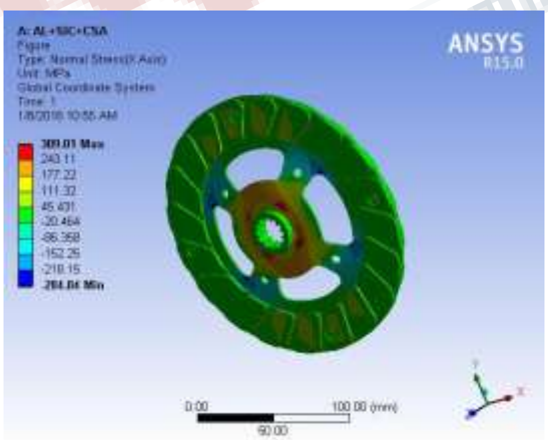

FIGURE 10: NORMAL STRESS

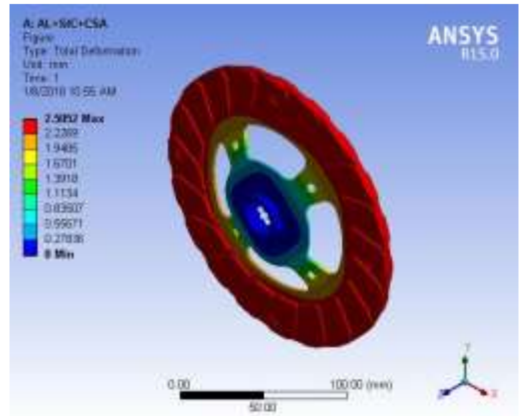

FIGURE 11:TOTAL DEFORMATION

4.7.2.STATIC THERMAL ANALYSIS RESULTS

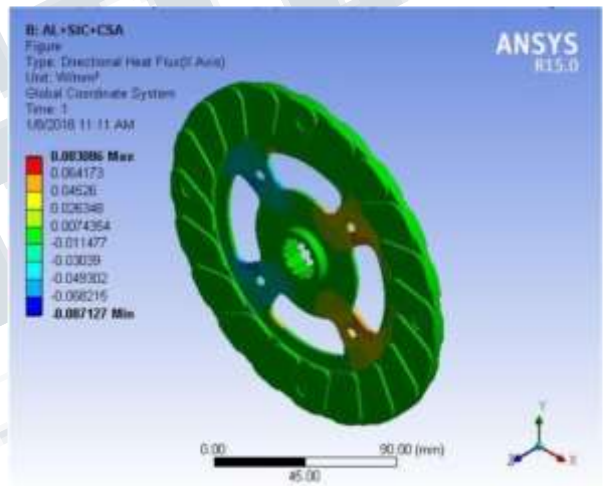

FIGURE 12:DIRECTIONAL HEAT FLUX

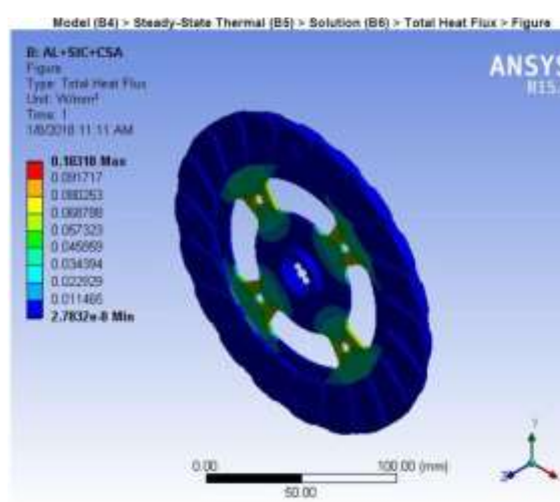

FIGURE 13:TOTAL HEAT FLUX

3. CONCLUSIONS

In this study paper we have done a static structural analysis and static thermal analysis on the clutch plate. We have done analysis to the both existing material and the new non existing material and the results are shown and we also have tested the mechanical characteristics of the material. As per the results the following were observed:

- Both material are same in the strength but different in the density. The old aluminium alloys density is higher than the new alloys density.
- The wear results showed that the wear characteristics of the new material was lower when compared to the aluminium alloy with no CSA addition.So the new material will live longer than the existing material.
- The hardness results showed that the Existing Aluminium alloy is having a lower hardness value compared to the new material.This states that the material will withstand higher forces than the existing material.
- The coefficient of friction of the new material was found to be higher.This states that the lining will provide good frictional characteristics.

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