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FEM Analysis on Wet Multi- Plate Clutch by Varying Friction Lining Materials for Improved Mechanical Properties

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ABSTRACT

In this paper a multi plate clutch is designed by using empirical formulas. A 2D drawing is drafted for multi plate clutch from the calculations and a 3D model is created in the 3D modeling software Solid Works. We are conducting structural analysis for above design for validating design. We are conducting analysis by varying the friction surfaces material. By extracting the results we are going to find out which material is best for the lining of friction surfaces.

Structural analysis is going to perform for multi plate clutch using the properties of the two materials. Materials used for liner is Cork and Coconut coir+egg shell composite Material. Comparison is done for above all materials to validate better lining material for multi plate clutch under the different load conditions while changing the gears. Analysis is done in ANSYS software. Solid works is medium 3D Design Software featuring industry-leading productivity tools that promote best practices in design. 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 user-designated size) called elements.

KEYWORDS: *Ansys, CATIA, Copper, Cork, SF00, SF-BU, Wet-Clutch plate, Vonmises stress, Vonmises strain, Total Deformation.*

INTRODUCTION

It is a pin transmission tool, which can be locked and removed. Handles are valuable in devices that have two rotating shafts. In these devices, one pole is normally controlled by a motor or pulley and the other shaft drives another device. Let's take an event where a shaft is driven by a motor and the surrogate leads a piercing step. The handle relates the two axes so that they can be thrown together and bend at a similar speed (attracted) or disengage and rotate at different speeds (isolated). Depending on the presentation, speeds, material, torque finally achieved using the entire device, different types of fasteners are used. The handle itself is a tool, using various planes and unmistakable landmarks in various designs available. Following the lines, we have given the different types of open cellars.

Classification of Friction Clutches

Based on the application of the friction clutches in any automotive or machine they can be divided in different categories. The classification of friction clutches is done according to the design, working mechanism and shape of the mating surfaces.

- Flat Plate Friction Clutch
- Conical Friction Clutch

LITERATURE SURVEY

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 Center 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 are 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 centerline 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 simultate 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 discretized 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 of Berger et al.[5] (1997) was simplified assuming axisymmetric 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 behavior. 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.

MODELING OF WET CLUTCH

CATIA is software which is used for creation and modifications of the objects. In CATIA and design and modeling 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. Modeling 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 CATIA 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.

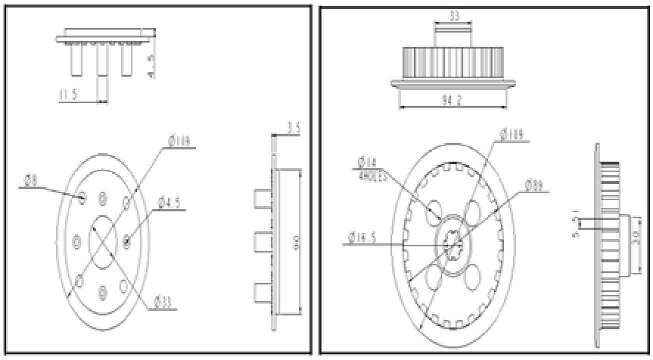

Fig.2. 2-D representation of Base-Part and Double plate.

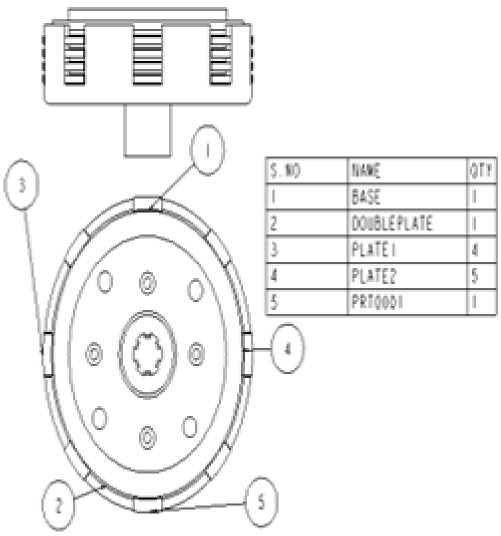

Fig.3.2-D representation of Friction-Plate and Assembly of Clutch.

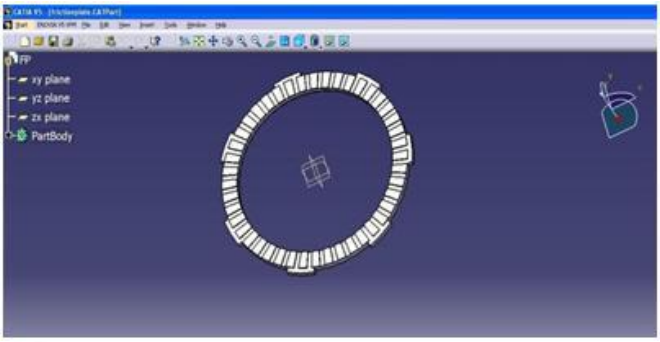

Fig.4. 3-D representation of Friction-Plate of Wet Clutch Plate.

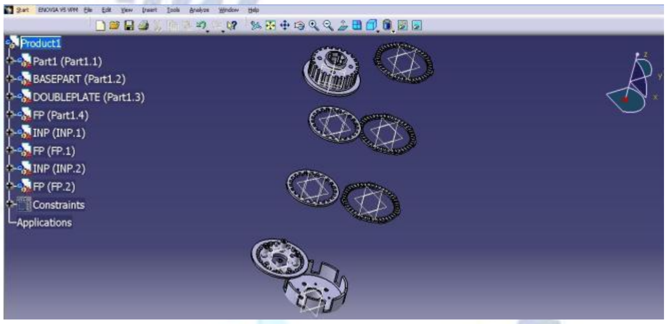

Fig.5.3-D representation of Exploded View of Wet Multi-plate Clutch.

ANALYSIS

The ANSYS software is a handy tool that has the capability to decide the type of elements that are required for the analysis purpose. The Finite Element Method is a mathematical tool used to compute ordinary equations and partial differential equations. Since it is a numerical tool, it has the ability to solve the complex problems that are represented in differential equations form.

Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results. ANSYS Meshing technology provides a means to balance these requirements and obtain the right mesh for each simulation in the most automated way possible. ANSYS Meshing technology has been built on the strengths of stand-alone, class-leading meshing tools. The strongest aspects of these separate tools have been brought together in a single environment to produce some of the most powerful meshing available. This helps in automatic choosing of elements and nodes and thus simplifies the job of FEM model creation. The meshing is performed by opening the ANSYS meshing application in workbench environment wherein the sizes of the elements are controlled.

Structural Analysis

Structural analysis is the process of determining the effects of loads on physical structures and their components. Structural analysis incorporates in the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. The results of the analysis are used to verify a structure's fitness for use, often saving physical tests. A structural model which created can be used to predict the behavior of their modal structure, under the action of external forces. The response is usually measured in terms of deflection and stress

Model Analysis

A Model Analysis is a Free Vibration Analysis it is find out The Maximum frequency generated within a product.

Thermal Analysis

In this Analysis we are going to find out how the Temperature Distribution is takes place and Heat flux of the product and Thermal gradient in the product.

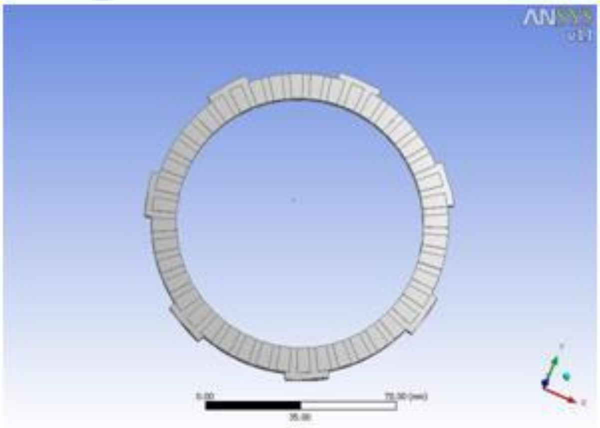

Fig.6.Clutch plate is imported into ANSYS-WORKBENCH.

Fig.7. Meshing of Clutch plate in ANSYS-WORKBENCH.

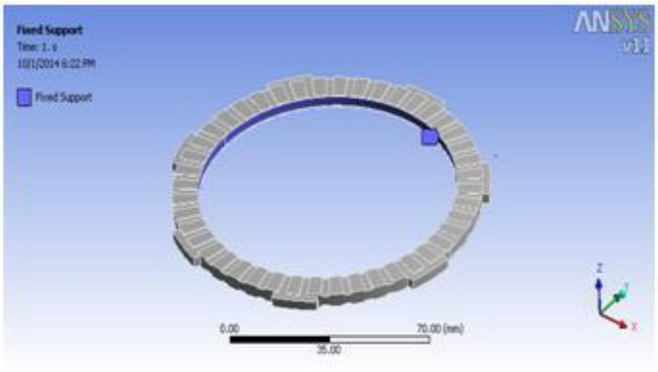

Fig.8. Boundary Condition's applied to Clutch plate

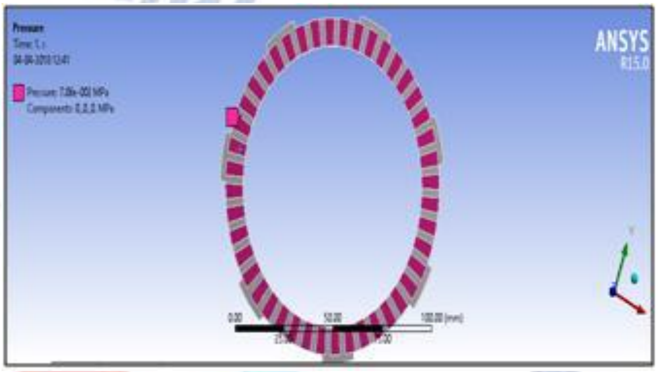

Fig.9. Loads applied on Wet-Multi plate clutch.

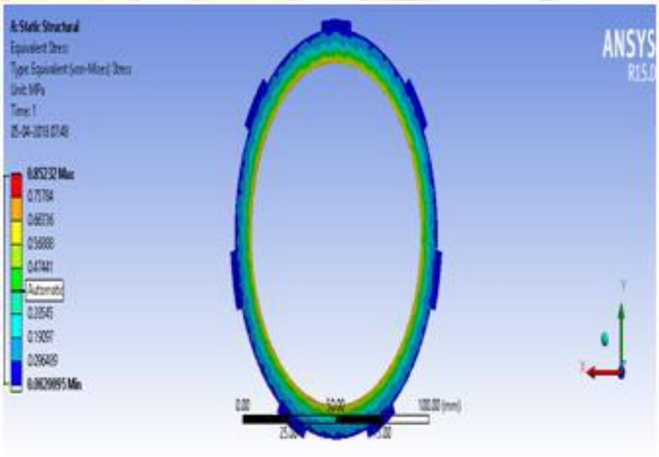

Fig.10. Vonmises stress acting on Cork Clutch plate.

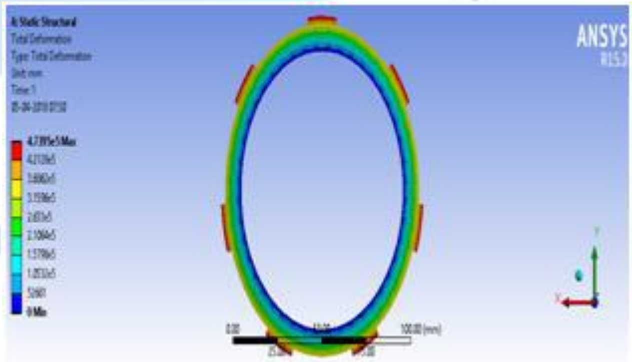

Fig.11. Total Deformation acting on Cork Clutch plate.

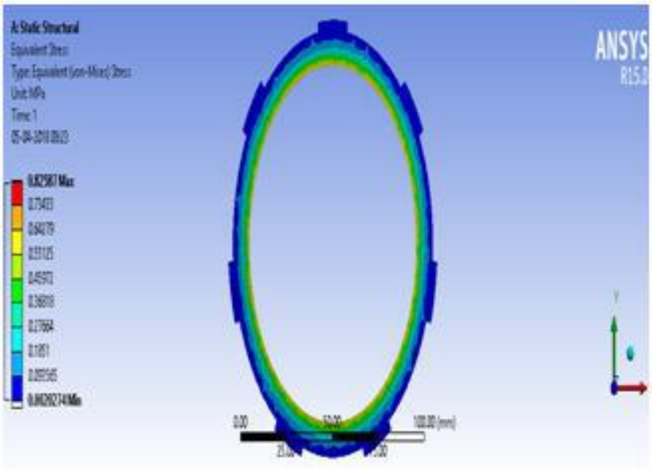

Fig.12. Vonmises stress acting on Coconut soir+ egg shell Clutch plate.

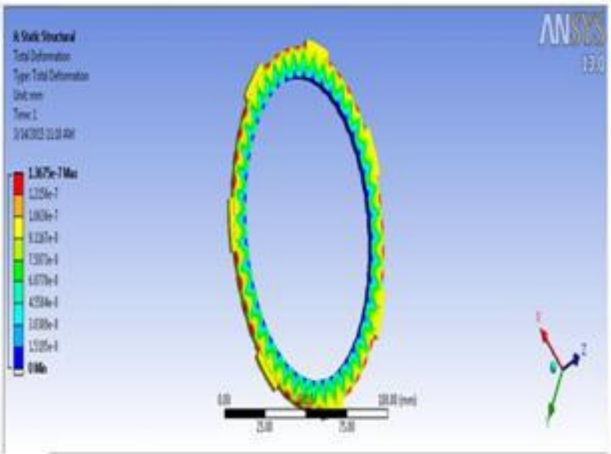

Fig.13. Total deformation acting Coconut coir+ egg shell Clutch plate

RESULTS& DISCUSSIONS

Results as per the Analysis Results

After the static structural analysis by ansys on frictionplate of a wet multi plate taking into account given limit conditions the acquired results are classified below.

Table No. 1: Results from Structural & Thermal Analysis

RESULTS		MATERIALS USED	
		CORK	COCONUT COIR & EGG SHELL
Von misses Stress (Mpa)	Maximum	0.85232	0.82587
	Minimum	0.0020095	0.0020274
Von misses Strain	Maximum	31074	25771
	Minimum	167.52	142.08
Total Deformation		4.7395e-5	3.9834e-5
Directional deformation	Maximum	90993	76622
	Minimum	-90986	-76514

The above properties are the most extreme results demonstrated by ANSYS.

The ANSYS workbench 15 for stress, strains, complete distortion, we acquire four qualities going from most extreme to least. In view of the qualities we plotted the charts as demonstrated as follows .Also in view of diagrams we propose best friction material for friction plate (clutch plate).

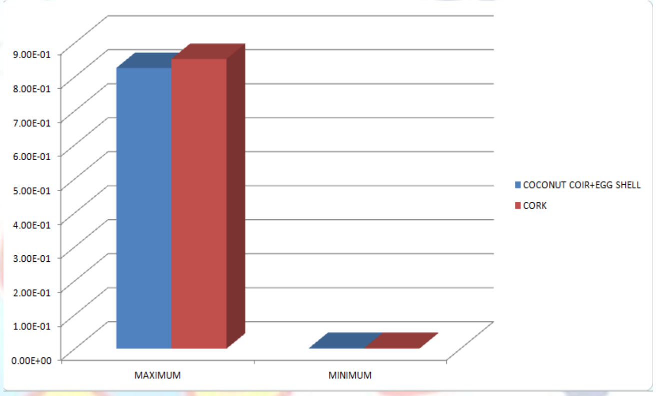

Fig.14 von mises stress

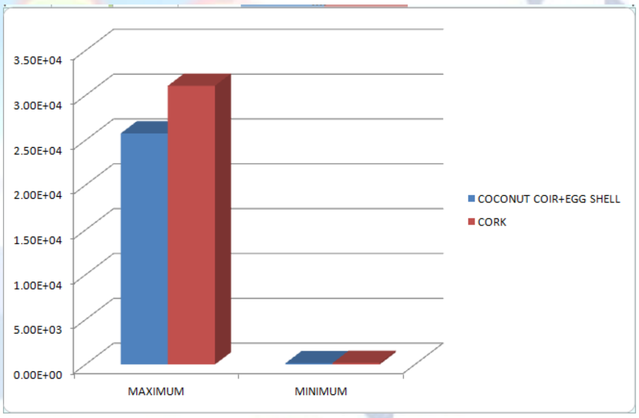

Fig.15 von mises strain

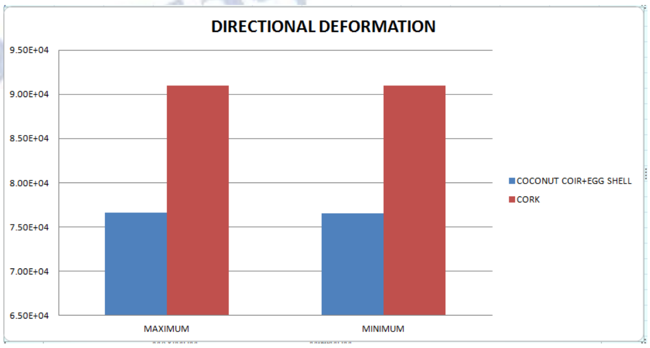

Fig.16 Directional Deformation

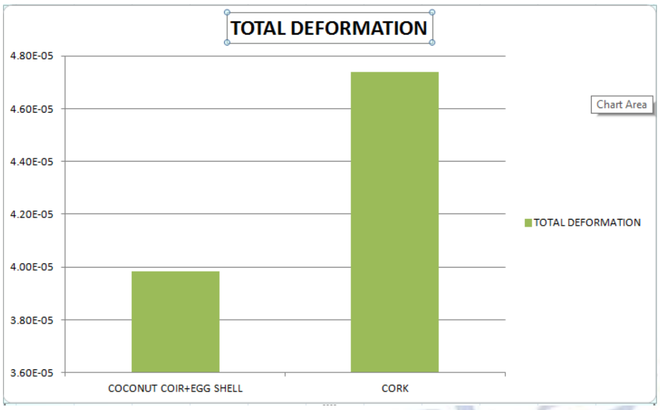

Fig.17 Total Deformation

CONCLUSION

Structural, Modal and Thermal analysis is done on the wet friction plates to verify the strength. Friction materials used are Cork and Copper Powder Metal. Material used for inner disc is steel and outer disc is bronze. By observing the analysis results, design is safe. Total Deformation and stress, Strain values are less for Copper Powder Metal. Copper powder metal is having capability to with stand high frequency up to 6.5231Htz. Temperature Distribution and Heat flux values for copper metal is moderate than cork Material usage of Copper powder Metal as surface lining is better than using cork. Hence we conclude that for multi plate clutches using Copper powder metal as friction material Strength is Improved, Deformation is reduced and Material Life of the Clutch is improved. To improve Performance of clutch Lubricant Oil is maintained and servicing of Automobile is done in Perfect Time

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