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Design and Analysis of Two Wheeler Clutch Inner Hub

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ABSTRACT : Clutch is an important part in the transmission system of the automobiles and transfers power to the driven shaft smoothly. The conventional design carried various flaws and was difficult to conceptualize from 2D drawings. But the use of solid modeling techniques made it very much simpler for the designer and the analysis software's are used to analyze the parts without actually fabricating the product which indirectly saves money and material as well as time improving the productivity of the working. We can analyze various products precisely in the software and improve the design as per the requirement and values obtained. This paper studies the design of the clutch hub using solid modeling static structural analysis of the clutch hub using ANSYS. The material used for the analysis purpose is ABS. As, to explore the working area of the ABS and due to its high strength to weight ratio and to test the performance of the clutch hub at the high torque. The study shows the efficient working of ABS made clutch hubs and its static structural analysis.

KEYWORDS: clutch, structural analysis, Ansys, inner hub

I. INTRODUCTION

Clutch is a machine part which is used to transfer the motion or torque from driving shaft to the driven shaft smoothly. In automobiles we can see the various examples of the clutches and its various types such as single plate clutch, multi plate clutch, centrifugal clutch and cone clutch likewise. As to increase the speed of the vehicle we need to change the gear according to the need and also idle gearing is required, at that time clutch plays an important role in the engine transmission. In the two wheeler SI engine vehicles we generally observe multi plate type wet clutch. The multi plate type wet clutch consists of various parts like clutch housing, pressure plate, friction plate, clutch plate, Clutch Hub, compression spring, etc. As the clutch is used to engage and disengage the flywheel, and undergoes a lot of torque and pressure it needs to be designed precisely. The smooth transfer of power is the main aim of the clutch. Various types of materials are used for the clutches like steel and its alloys. The material plays an important role in the performance of the clutch. In this work we have used ABS material due to its high strength to weight ratio and it can also be 3D printed. As we know Additive manufacturing is rapidly growing as the manufacturing technique. ABS is a thermoplastic material and has excellent engineering properties. From the analysis we will be able to check whether the material can substitute the metal alloy. An efficient and reliable analysis can also be done on mechanical clutches using computer modeling. Also, stress analysis and reduction of forces in the single plate type of clutch of automobiles can be done with the help of software approaches.

Based on such methodology an efficient and reliable design of clutch can be found and proper material also be selected from analysis approach Improved transmission efficiency can be obtained from the design changes and reducing error, such that whole assembly can be designed to improve the working efficiency again we can analyze various materials and composites in the interface .

In The Design and analysis process we can check various parameters which influence the performance of the product like equivalent stress, strain, deformations, etc and improve our design according to the need . The various studies show that design and analysis can be done on various kinds of transmission parts and from the data obtained we can optimize our design and save cost and time as well

II. LITERATURE REVIEW

AABHIJIT DEVARAJ [1] The aim of this work was to design a single disk friction clutch plate made of Kevlar 29 and optimize the design by changing the hub diameter and rivet diameter in the clutch, based on static analysis performed on the clutch using Ansys workbench analysis software.

GANESH RAUT et al [2] Objective of this paper is to design a multi plate clutch by using empirical formulae. A model of multi plate clutch has been generated in CATIA V5 and then imported in ANSYS workbench for Automobile Applications.

SAGAR OLEKAR et al [3] In this paper, the multi plate clutch is designed by using uniform wear theory. The 3D model of multi plate clutch has been prepared using modeling software pro/E. The structural analysis is carried out for friction plate by using analysis software Ansys Workbench 14.0. The results for stress, strain, total deformation and for strain energy are obtained.

RAJESH PUROHIT et al [4] This paper deals with designing a friction clutch assembly using Solid Works Office Premium software. The assembly comprises of the clutch plate, the pressure plate and a diaphragm spring

MAY THIN GYAN et al [5] This paper shows the difference in performance of clutch plates made of various materials. Design of single plate clutch 2D drawing is drafted by using theoretical calculations. The strength of the friction plate is done by using Solid Works. Friction materials used are cast iron, alloy steel and copper

III. WORKING PRINCIPLE

Clutch is used to attach two moving shafts that are moving at different speeds. This enables us to disengage the power of the engine and drive off smoothly with the engine. When we press the pedal the friction disc which is movable slides on the shaft. This is the disengaged condition in which the friction doesn't touch the Flywheel which means that the Axial load applied by the pressure plate is 0 and hence power/torque transmission is 0. The engine is still running but the vehicle will not move. When it is being pressed, the pressure plate moves back against the force of the springs, and the plate becomes free between the Flywheel and the pressure plate.

Thus the Flywheel remains rotating as long as an engine is running and the shaft speed reduces slowly and finally, it stops Rotating. As soon as the pedal is pressed the clutch is said to be disengaged. When we completely release the pedal the movable friction disc slides forward on that shaft.

IV. CLUTCH HUB

Clutch hub or clutch boss is a machine part on which the clutch plate and friction plate are mounted. The clutch hub rotates when the clutch gets engaged to the flywheel and due to spring force it starts rotating. The part we are designing is shown in the below figure 1. (Hero Splendor Clutch Hub). The vehicle transmits a torque around 8.05 Nm. So the clutch hub provides the motion to the friction and clutch plate and friction plate. While the clutch is an important part of the clutch assembly. While engaging and disengaging the clutch hub rotates with the same torque as that of the flywheel. And due to the friction plate and clutch plate being mounted on the hub, it undergoes the tensile force and continuous rotation may result in failure and fatigue. So, the clutch hub plays important role in transmission and does not let the plates slip out of the grooves

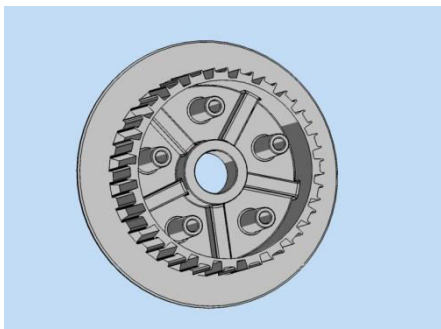


Fig:1 Two Wheeler Clutch Inner Hub

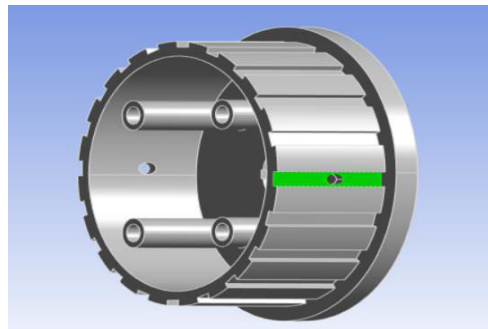


Fig 2 Modified Two Wheeler Clutch Inner Hub



V. FINITE ELEMENT ANALYSIS

INTRODUCTION TO ANSYS:

ANSYS is an engineering simulation software provider founded by software engineer John Swanson. It develops general-purpose finite element analysis and computational fluid dynamics software. While ANSYS has developed a range of computer-aided engineering (CAE) products, it is perhaps best known for its ANSYS Mechanical and ANSYS Multiple physics products. ANSYS Mechanical and ANSYS.

Multiple physics software are non-exportable analysis tools incorporating pre-processing (geometry creation, meshing), solver and post-processing modules in a graphical user interface. These are general-purpose finite element modeling packages for numerically solving mechanical problems, including static/ dynamic structural analysis (both linear and nonlinear), heat transfer and fluid problems, as well as acoustic and electro-magnetic problems. ANSYS Mechanical technology incorporates both structural and material non-linearity. ANSYS Multiphysics software includes solvers for thermal, structural, CFD, electromagnetic, and acoustics and sometimes couple these separate physics together to address multidisciplinary applications. ANSYS software can also be used in civil engineering, electrical engineering, physics and chemistry.

ANSYS, Inc. acquired the CFX computational fluid dynamics code in 2003 and fluent, Inc. in 2006. The CFX packages from ANSYS are used for engineering simulations.

In 2008, ANSYS acquired Ansoft Corporation, a leading developer of high-performance Electronic Design Automation (EDA) SOFTWARE and added a suite of products designed to simulate high-performance electronics designs found in mobile communication and interest devices, broadband networking components and systems, integrated circuits, printed circuits boards, and electromechanical systems. The acquisition allowed ANSYS to address the continuing convergence of the mechanical and electrical worlds across a whole range of industry sectors.

ANSYS WORKBENCH:

ANSYS Workbench is a new-generation solution from ANSYS that provides powerful methods for interacting with the ANSYS solver functionally. This environment provides a unique integration with CAD systems, and your design process, enabling the best CAE results.

ANSYS Workbench is comprised modules:

1. Design Modeler for generating a CFX-Pre-mesh for the CFX-5 Solver.
2. Design Xplorer and Xplorer VT for investigating the effect of variations input to the response of the system.
3. FE Modeler for translating a Nastran mesh for use in ANSYS

ANSYS WORKBENCH ANALYSIS:

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex metaphysics analyzes with drag-and-drop simplicity. With bi-directional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling simulation

The Workbench environment allows you to solve much more complex analyses, including :

1. Multi-part assemblies.
2. 3D solid elements, shell elements, and shell-solid assemblies.
3. Nonlinear contact with or without friction.
4. Small-displacement and large-displacement static analyses.
5. Modal, harmonic, and eigen value buckling analysis



STRUCTURAL ANALYSIS

Structural analysis is probably the most common application of the finite element method. The term structural (or structure) implies not only civil engineering structures such as bridges and buildings, but also naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools. Structural analysis is available in the following ANSYS programs.

- ANSYS/Multiphysics
- ANSYS/Mechanical
- ANSYS/Structural
- ANSYS/Professional

TYPES OF STRUCTURAL ANALYSIS

STATIC ANALYSIS

Used to determine displacements, stresses, etc under static loading conditions which includes both linear and nonlinear characteristics. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep.

STEPS IN A STRUCTURAL ANALYSIS

CREATION OF GEOMETRY

This can either be created within ANSYS or imported. The following points are to be carefully considered in model creation. Sufficiently model the stiffness of the structure. Add details to avoid stress singularities (e.g. fillets). Exclude details not in region of interest (e.g. exclude small holes) Add details to improve boundary conditions

ELEMENT TYPE

Most ANSYS element types are structural elements, ranging from simple spars and beams to more complex layered shells and large strain solids. The nodal DOF's may include: UX, UY, UZ, ROTX, ROTY, and ROTZ.

MATERIAL PROPERTIES

In certain 1D or 2D problems, the second or third parameters or both are specified through the Real Constants or Section properties command. For e.g. in a beam problem, we can specify the length in the model, but the cross section parameters are specified in the Sections properties, Similarly, thickness for a shell element is specified in the Real Constants dialog box. To define real constants Choose Preprocessor Real Constants from the main menu In the Real Constants dialog box click Add Then enter the specified real constant value of the material selected.

DEFINE LOADS

Structural loading conditions can be DOF Constraints - Regions of the model where displacements are known concentrated forces External forces that can be simplified as a point load. Pressures - Surfaces where forces on an area are known.

DISPLACEMENT CONSTRAINTS

This is used to specify where the model IS fixed (zero displacement locations) It can also be non-zero, to simulate a known deflection

To apply displacement constraints:

Choose Solution > Define Loads > Apply > Structural > Displacement

Pick the desired entities in the graphics window. Then choose the constraint direction. Value defaults to zero



CONCENTRATED FORCES

Force is a point load, applied on a node or key point, specifying the force magnitude and direction of force.

Choose Solution > Define Loads > Apply > Structural Force / Moment from Main Menu.

When we delete solid model loads, ANSYS also automatically deletes all corresponding finite element loads.

REVIEWING RESULTS

Gives a quick indication of whether the loads were applied in the correct direction. Legal column shows the maximum displacement, DMX. We can also animate the deformation. To plot the deformed shape. Choose General Postproc Plot Results Deformed Shape.

Choose PlotCtrls/EAnimate /EDeformed shape.

STRESSES

The following stresses are typically available for a 3-D solid model. Component Stresses - SX, SY, SZ, SXY, SXZ (global Cartesian direction by default. Principal

Stresses - S1, S2, S3, SEQV (von Mises), SINT (Stress intensity). Best viewed as contour plots, which allow us to quickly locate "hot spots" or trouble regions.

Nodal solution: Stresses are averaged at the nodes, showing smooth, continuous contours. Element solution: No averaging, resulting in

TO PLOT STRESS CONTOURS

General Postproc * Plot Results * Contour Plot Nodal Solu

General Postproc * Plot Results * Contour Plot * Element Solu

We Can also animate stress contours:

PlotCtrls> Animate> Deformed Results...

BENEFITS

- Reduce time and engineering analysis cost through high- performance finite element modeling and post-processing
- The industry's broadest and most comprehensive CAD and CAE solver direct interface support.
- Reduce overhead costs of maintaining multiple pre- and post- processing tools, minimize "new user" learning curves, and increase staff efficiency with a powerful, intuitive, consistent finite element analysis environment
- Open-architecture design and customization functionality allows Ansys to fit seamlessly in any environment.

VI. PROBLEMS IN MILD STEEL INNER HUB

Indicator:

Loss of drive/Noisy when operating the clutch pedal

Cause:

1. Clutch disc has been over torqued - example: down changing from 5th to 2nd gear at high speed
2. Severe engine to gearbox mis-alignment - Red dust will be present when alignment issues are present.
3. Clutch disc has been overloaded

Is this totally necessary – probably not. Now before I get hated on for this answer, let's think about things from an engineering standpoint for a minute. The steel plates make contact around 252 time with the clutch hub (assumed 7 steel plates with 36 teeth each; $7 * 36 = 252$). Now put your clutch pack in and count how many of those teeth do not



make contact with the hub because of the missing piece that broke off. Judging by the wear marks in the hub, it looks like your missing only one point of contact but to show just how negligible this can be, we'll just say it's 5 for this example. Assuming 5 points of contact are now lost, you now have 247 points of contact with the clutch hub, which results in a friction force reduction of just about 2%! If one point of contact was lost, your friction force reduction is just 0.39%. These are numbers so small you'll probably never notice them. A typical safety factor in design for a component like this could be upwards of 10-20% so I would argue that you're well within the acceptable range. Also, the loss in frictional force can easily be recovered by slightly increasing the torque on your hub bolts, although I wouldn't even think this is necessary.

VII. SELECTED MATERIAL FOR THE REPLACEMENT OF MILD STEEL

Aluminum alloy is a lightweight panel material which is designed for interior and exterior applications. The chemical composition of the aluminum alloy which is being taken into consideration for this particular study is stated as below. Alumina – 30 %, Magnesium – 1 %, Balance is Aluminum. Aluminum oxide is an amphoteric oxide with the chemical formula Al₂O₃. It is commonly referred to as alumina, Aluminum oxide is a chemical compound of aluminum and oxygen with the chemical formula Al₂O₃. Al₂O₃ is an electrical insulator but has a relatively high thermal conductivity (30 Wm⁻¹K⁻¹) for a ceramic material. The aluminum oxide generated by anodizing is typically amorphous, but discharge assisted oxidation processes such as plasma electrolytic oxidation result in a significant proportion of crystalline aluminum oxide in the coating, enhancing its hardness.

VIII. ANALYSIS RESULT OF CLUTCH HUB

ALUMINUM ALLOY MATERIAL

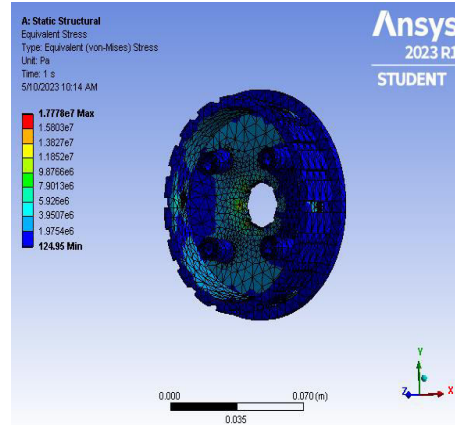
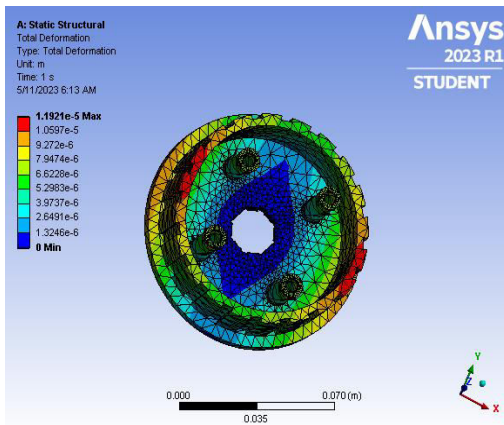


Fig:4 Total Deformation Of Aluminum Alloy Fig : 5 Von Mises Stress Of Aluminum Alloy

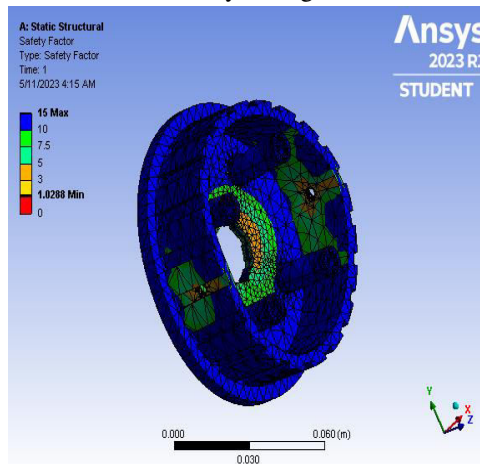


Fig: 6 Safety Factor Of Aluminum Alloy



GRAY CAST IRON

There are many unique benefits of using gray cast iron. One of the most notable is gray iron’s enhanced lubrication. The graphite flakes in gray iron allow for better lubrication creating less wear on the cast iron. This makes gray cast iron a great choice for parts like brake rotors. Gray cast iron also has the ability to dampen vibrations making it an excellent choice for housing applications or industrial applications such as machinery bases. Additionally, gray iron has high thermal conductivity allowing it to move heat more easily through the metal.

GREY CAST IRON MATERIALS:



Fig :7 Grey Cast iron Material

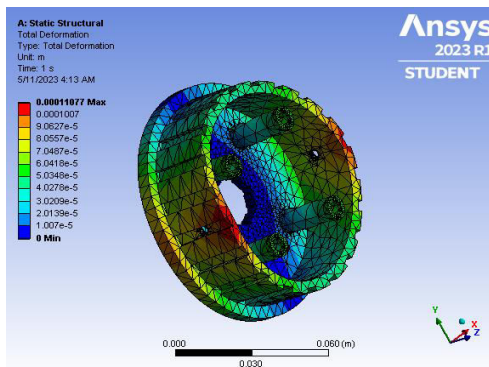


Fig: 8 Total Deformation of Grey Cast Iron

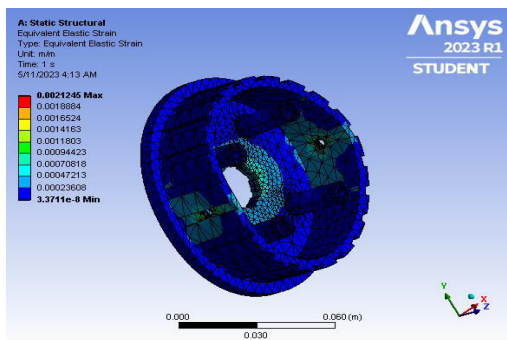


Fig:9 Equivalent Elastic Strain of Grey Cast

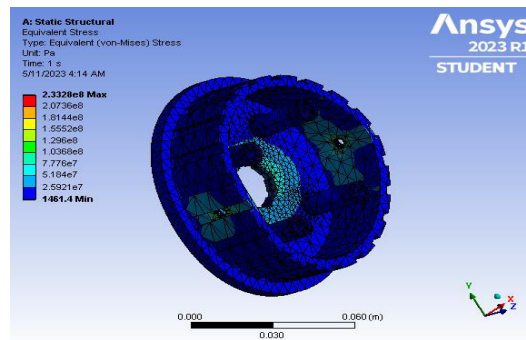


Fig: 10 Von Mises Stress of Grey Cast Iron

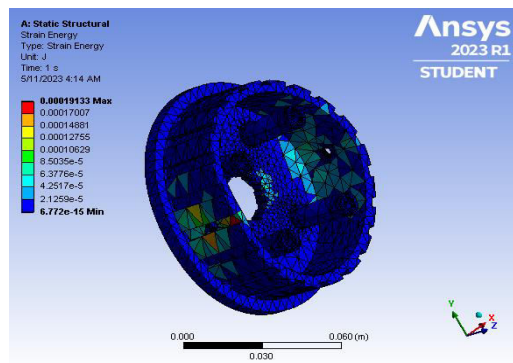


Fig: 11 Strain Energy of Grey Cast Iron

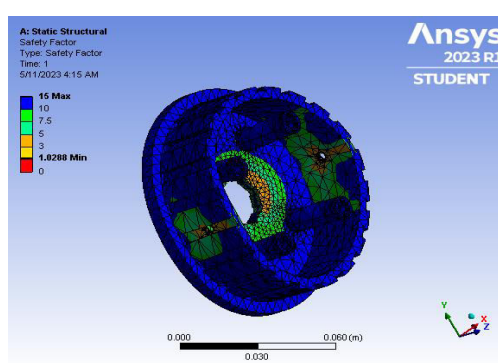


Fig: 12 Safety Factor of Grey Cast Iron

STRUCTURAL STEEL

Iron is commonly found in the Earth's crust in the form of an ore, usually an iron oxide, such as magnetite or hematite. Iron is extracted from iron ore by removing the oxygen through its combination with a preferred chemical partner such as carbon which is then lost to the atmosphere as carbon dioxide. This process, known as smelting, was first applied to metals with lower melting points, such as tin, which melts at about 250 °C (482 °F), and copper, which melts at about 1,100 °C (2,010 °F), and the combination, bronze, which has a melting point lower than 1,083 °C (1,981 °F). In comparison, cast iron melts at about 1,375 °C (2,507 °F). Small quantities of iron were smelted in ancient times, in the solid-state, by heating the ore in a charcoal fire and then welding the clumps together with a hammer and in the process squeezing out the impurities. With care, the carbon content could be controlled by moving it around in the fire. Unlike copper and tin, liquid or solid iron dissolves carbon quite readily.

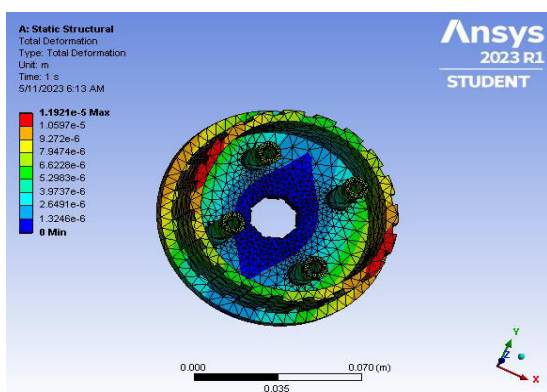


Fig:13 Total Deformation of Structural steel

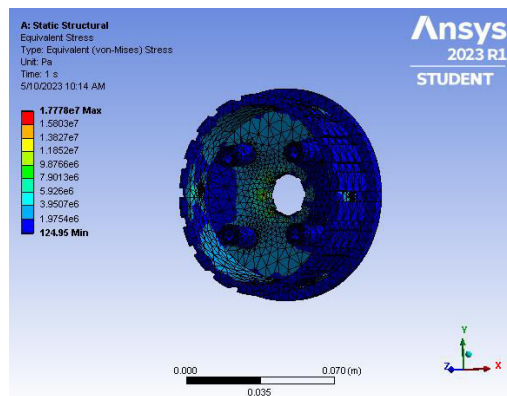


Fig : 14 Equivalent elastic strain of structural steel

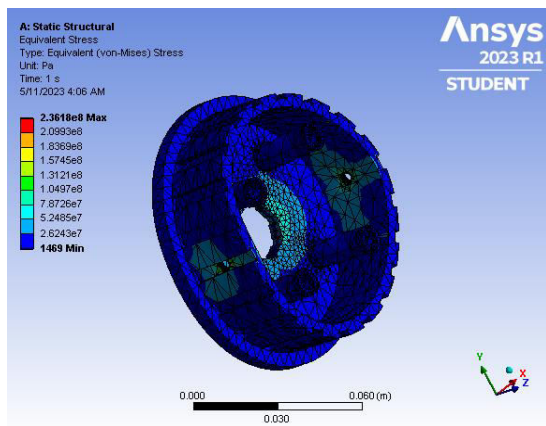


Fig : 15 Safety Factor Of Structural Steel

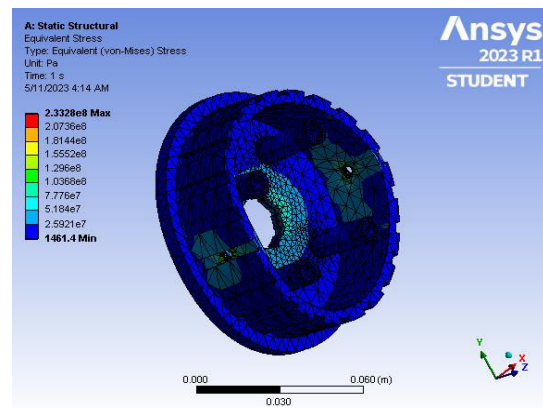


Fig : 16 Von Mises Stress of Structural Steel



IX. RESULTS

Table 1- Working parameters of clutch hub.

Materials	Total Deformation (Mm)	Elastic Strain	Von-Mises Stress (Mpa)
ALUMINIUM ALLOY (Mg,Si,Cu,Mn,Li)	0.0016913	0.00033323	2.3618e8
STEEL	1.1921	0.00022175	1.7778e7
GREY CAST IRON	0.0011077	0.00019133	1.3328e8

X. CONCLUSION

Until recently the primary analysis method had been hand calculations and empirical curves. New computer advances have made finite element analysis (FEA) a practical tool in the study of inner hub , especially in determining stresses.In this paper we have used Ansys software to do the analysis on the inner hub Performed design for inner hub for applied load of 2610N. Performed 3d modeling of the inner hub using SOLIDWORKS software.Performed Finite Element analysis of the inner hub for a Symmetric and Asymmetric loading. From the above results it is concluded that the inner hub structure is safe under the given operating conditions proved that the von-mises stress and deflection is less than the Design parameters.

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