Design and Static Structural Analysis of Fly Wheel using with Differnt Composite Materials

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Abstract: A flywheel is an inertial energy-storage device. It absorbs mechanical energy and serves as a reservoir, storing energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than the supply. A flywheel used in machines serves as a reservoir which stores energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than supply. Countering the requirement of smoothing out the large oscillations in velocity during the cycle of an I.C engine a flywheel is used. As the load on flywheel increases deformation and stresses also increases. The structural analysis of flywheel had done for two materials. In first flywheel with Gray Cast Iron (Ultimate stress-214Mpa density-7510 Poisons ratio-0.23) is analyzed and stress inside the flywheel are estimated. In second composite material S-glass-Epoxy (ultimate stress- 4800Mpa density-2000 Poisons ratio-0.25) is analyzed and the stress inside the flywheel are estimated and compared the results of both materials The structural analysis on various geometric forms of Flywheel such as solid type, rim type, web type & spoke type of flywheel has been carried out Using modeling package such as CATIA& ANSYS & appropriate results have been extracted & moreover analysis has been carried out on the specific rotation of fly wheel & appropriate Speed can be determined,

KEYWORDS: Flywheel, structural analysis, Composite materials, CATIA, ANSYS,

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INTRODUCTION

A flywheel is a rotating mechanical device that is used to store Rotational Energy. Flywheels have a significant moment of inertia and thus resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by applying torque to it, thereby increasing its rotational speed, and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing its rotational speed.

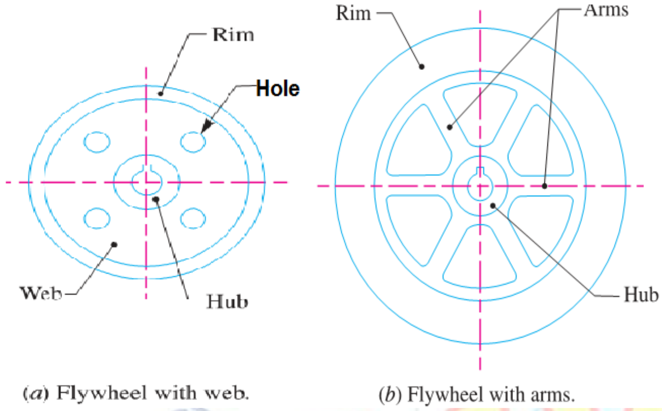


Figure 1: Types of Flywheel

Composite materials have both high strength and low density and are ideal for flywheel rotors used for energy storage. A composite material allows a higher rotational speed and this result in flywheel rotors with high specific energy. Composite materials are therefore a better choice than metals when designing flywheel rotors. The theoretical specific energy of composite rotors is around five times higher than metallic ones. The high-speed flywheel concept originated in the early 1970s. A researcher at Lawrence Livermore National Laboratory presented an article in Scientific American proposing a new approach to rotor design, recommending the use of composite materials instead of metal. Composite materials also have safety advantage over metallic material.

Common uses of a flywheel include:

Providing continuous energy when the energy source is discontinuous. For example, flywheels are used in reciprocating engines because the energy source, torque from the engine, is intermittent.

Delivering energy at rates beyond the ability of a continuous energy source. This is achieved by collecting energy in the flywheel over time and then releasing the energy quickly, at rates that exceed the abilities of the energy source.

Controlling the orientation of a mechanical system. In such applications, the angular momentum of a flywheel is purposely transferred to a load when energy is transferred to or from the flywheel.

Flywheels are typically made of steel and rotate on conventional bearings; these are generally limited to a revolution rate of a few thousand RPM.Some modern flywheels are made of carbon fiber materials and employ magnetic bearings, enabling them to revolve at speeds up to 60,000 RPM.

Carbon-composite flywheel batteries have recently been manufactured and are proving to be viable in real-world tests on mainstream cars. Additionally, they are more eco-friendly, as it is not necessary to take special measures in the disposal of them.

APPLICATIONS:

In the 1950s, flywheel-powered buses, known as gyro busses, were used in Yverdon, Switzerland and there is ongoing research to make flywheel systems that are smaller, lighter, cheaper and have a greater capacity. It is hoped that flywheel systems can replace conventional chemical batteries for mobile applications, such as for electric vehicles. Proposed flywheel systems would eliminate many of the disadvantages of existing battery power systems, such as low capacity, long charge times, heavy weight and short usable lifetimes. Flywheels may have been used in the experimental Chrysler Patriot, though that has been disputed.

Flywheels have also been proposed for use in continuously variable transmissions. Punch Power train is currently working on such a device.

During the 1990s, Rosen Motors developed a gas turbine powered series hybrid automotive power train using a 55,000 rpm flywheel to provide bursts of acceleration which the small gas turbine engine could not provide. The flywheel also stored energy through regenerative braking. The flywheel was composed of a titanium hub with a carbon fiber cylinder and was gimbal-mounted to minimize adverse gyroscopic effects on vehicle handling. The prototype vehicle was successfully road tested in 1997 but was never mass-produced.

In 2013, Volvo announced a flywheel system fitted to the rear axle of its S60 sedan. Braking action spins the flywheel at up to 60,000 rpm and stops the front-mounted engine. Flywheel energy is applied via a special transmission to partially or completely) carbon fiber power the vehicle. The 20 centimeters (7.9 in), 6 kilograms (13 lb flywheel spins in a vacuum to eliminate friction. When partnered with a four-cylinder engine, it offers up to a 25 percent reduction in fuel consumption versus a comparably performing turbo six-cylinder, providing an 80 hp boost and allowing it to reach 100 kilometers per hour (62 mph) in 5.5 seconds. The company did not announce specific plans to include the technology in its product line.

RAIL VEHICLES:

Flywheel systems have also been used experimentally in small electric locomotives for shunting or switching, e.g. the Sentinel-Oerlikon Gyro Locomotive. Larger electric locomotives, e.g. British Rail Class 70, have sometimes been fitted with flywheel boosters to carry them over gaps in the third rail. Advanced flywheels, such as the 133 kWh pack of University of Texas at Austin, can take a train from a standing start up to cruising speed.

The Parry People Mover is a railcar which is powered by a flywheel. It was trialled on Sundays for 12 months on the Stourbridge Town Branch Line in the West Midlands, England during 2006 and 2007 and was intended to be introduced as a full service by the train operator London Midland in December 2008 once two units had been ordered. In January 2010, both units are in operation.

RAIL ELECTRIFICATION:

FES can be used at the line side of electrified railways to help regulate the line voltage thus improving the acceleration of unmodified electric trains and the amount of energy recovered back to the line during regenerative breaking, thus lowering energy bills. Trials have taken place in London, New York, Lyon and Tokyo, and New York MTA 's Long Island rail road is now investing $5.2m in a pilot project on LIRR's West Hempstead Branch line.

LITRATURE REVIEW

Literature review is an assignment of previous task done by some authors and collection of information or data from research papers published in journals to progress our task. It is a way through which we can find new ideas, concept. There are lots of literatures published before on the same task; some papers are taken into consideration from which idea of the project is taken. Akshay P. Punde [1] built up the strategy to countering the necessity of smoothing out the expansive motions in speed amid a cycle of an I.C. Motor, a flywheel is planned, and analyzed and finished up Based on the above work of flywheel and its improvement techniques the accompanying end can be drawn. Unmistakably, cast iron flywheels are having higher Stress and disfigurement. Palak J. Patak [2] has done research on Reduction and Optimization of weight of vehicle flywheel and finished up Gray cast iron flywheel is exposed to increasingly add up to disfigurement contrasted with 5059 Al. Sushama G Bawane [3] on Optimization system different parameter like material, cost for flywheel can be upgraded, 1kg weight 20% material can be expelled from the fringe of the flywheel. Sudipta Saha [4] A technique was depicted by Exploring the impacts of flywheel geometry on its vitality stockpiling/convey capacity per unit mass and reasoned that In this plan of flywheels, there is still space for research, particularly when the execution is the essential goal. Prof. GayatriS.Patil [5] has done Evaluation of non-straight worries in the flywheel for various material, and discover the direct investigation was done on Aluminum composite, Cast Iron, Titanium and E-glass materials that is demonstrates the less pressure.

INTRODUCTION TO CATIA CATIA

(Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Creo Elements/Pro and NX (Unigraphics).

SUPPORTED OPERATING SYSTEMS AND PLATFORMS: CATIA V6 runs only on Microsoft Windows and Mac OS with limited products. CATIA V5 runs on Microsoft Windows (both 32- bit and 64-bit), and as of Release 18 Service Pack 4 on Windows Vista 64.IBM AIX, Hewlett Packard HP-UX and Sun Microsystems Solaris are supported.

CATIA V4 is supported for those Unixes and IBM MVS and VM/CMS mainframe platforms up to release 1.7. CATIA V3 and earlier run on the mainframe platforms.

STARTING TO CATIA: To start CATIA there may be icon on the desktop or you may have to look in the Start menu at the bottom of left of the screen Windows taskbar. The program takes a while to load, so be patient. The start-up is complete when your screen looks like the following figure, which is a default CATIA screen.

DESIGN OF FLY WHEEL Diameter has chosen according to space requirement as 0.6 m Required power = 20 Kw and it is rotating from 400 RPM to 410 RPM. STORAGE OF ENERGY = 0.6 KN-M Speed fluctuation $CS = N\ 2 - N1\ N$ = 410 − 400 405 N= average speed in RPM Coefficient of speed fluctuation =0.02469 Energy storage $\Delta E = MV\ 2\ CS$ 600= M ($\Pi\ X$ 0.6 X 405 60) 2 X 0.02469 MASS M=150 KG MASS (M) = Π X D X B X t X ϱ 150 = Π X 0.6 X 0.118 X t X 7510

Required Thickness t = 0.089 m

Outer diameter of rim = D+t =0.6+0.089 Outer diameter of rim =0.6897 m

Inner diameter of rim = D-t = 0.6-0.089

Inner diameter of rim =0.511 m

Design of shaft hub and key

Power P= 2 $X\ \Pi\ X\ N\ X\ T$ 60

20000= 2 $X\ \Pi\ X$ 405 $X\ T$ 60 T=471.57 N-M

N= average speed in RPM Suppose max torque is equal to twice of mean torque THEN = 43.14 N-M Shear Stresses of for Shaft and Key

Material Is 40 N/mm2

$Tmax = \Pi$ 16 $X\ S\ X$ D 3 D= (16 X 943.14 X 103 $\Pi\ X$ 40) 1/3 diameter of shaft. (D)=49.5 mm diameter of shaft. (D)= 50 mm

Outside diameter of hub may be assumedas twice the diameter of shaft

Outside diameter of hub = 2 X D

Outside diameter of hub =100 mm

Suppose let we take Length of hub = width of rim

Length of hub for fly wheel L=0.07 m

Width of hub for fly wheel W = D 4 = 50

Width of hub for fly wheel =12.5 mm

Height of hub for fly wheel H= D 6 = 50 6

Height of hub for fly wheel =8.5 mm

RESULTS:

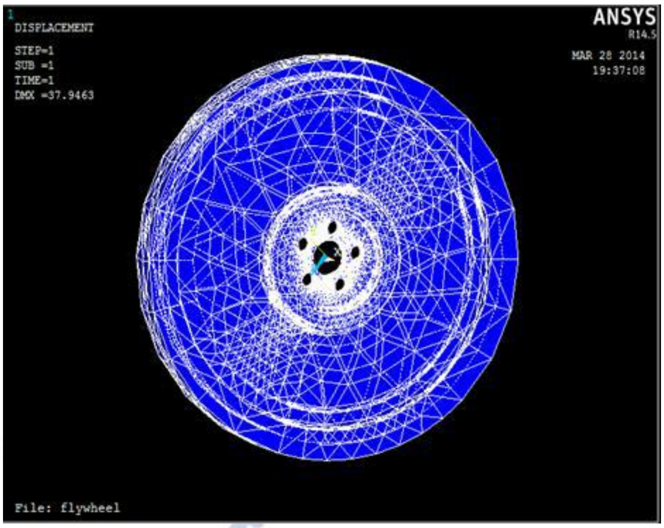


Figure 2: deformed shape for S – Glass Epoxy

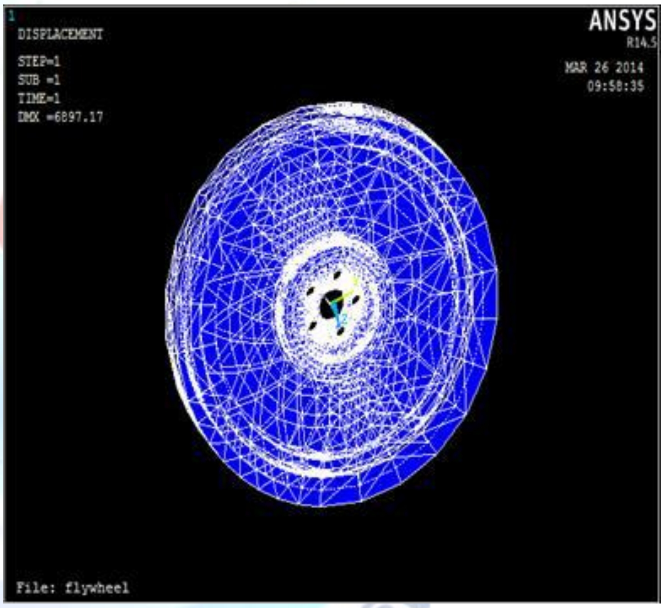


Figure 3: Deformed shape for Cast Iron

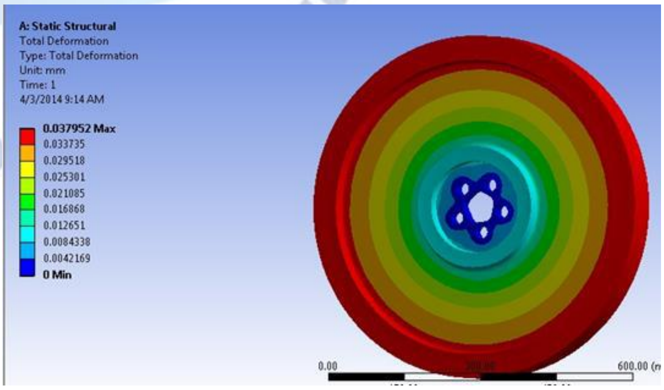


Figure 4: Total Deformation for S-Glass Epoxy

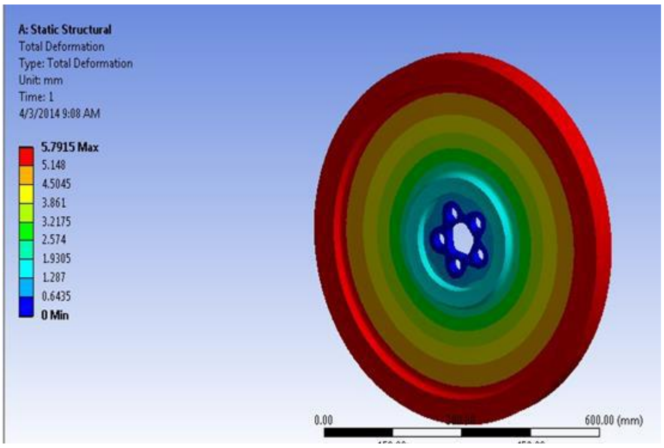


Figure 5: Total Deformation for Cast Iron

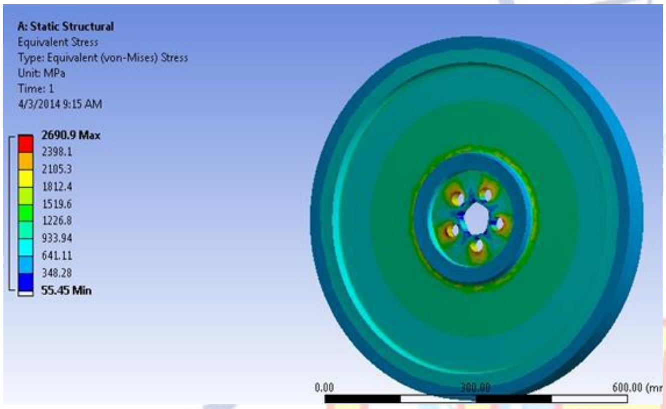


Figure 6: Equivalent Stress For S-Glass Epoxy

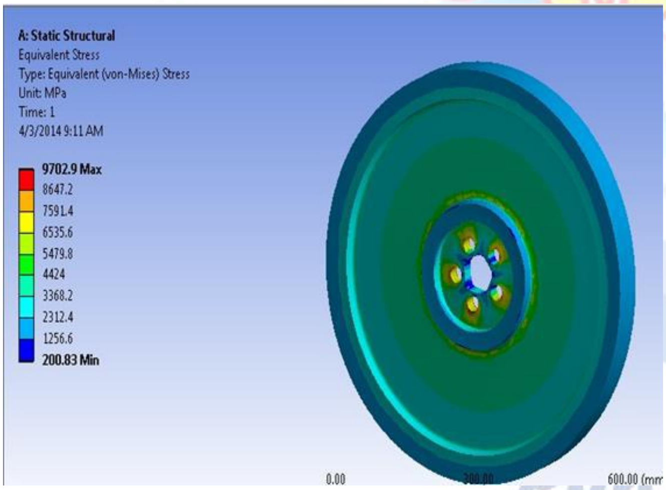


Figure 7: Equivalent Stress for Cast Iron

RESULTS AND COMPARISON

RESULTS FOR SOLID TYPE WHEEL BY USING CAST IRON:

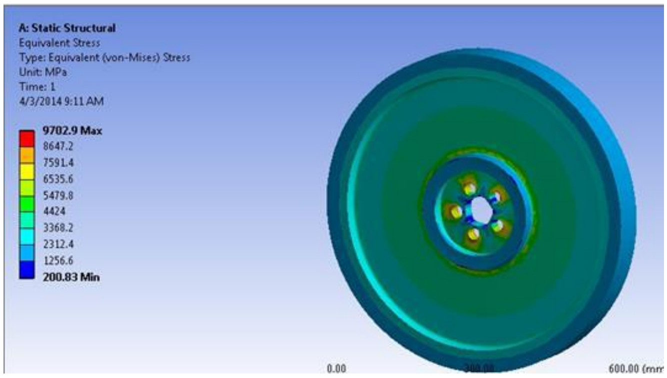


Fig 8: Equivalent Stress

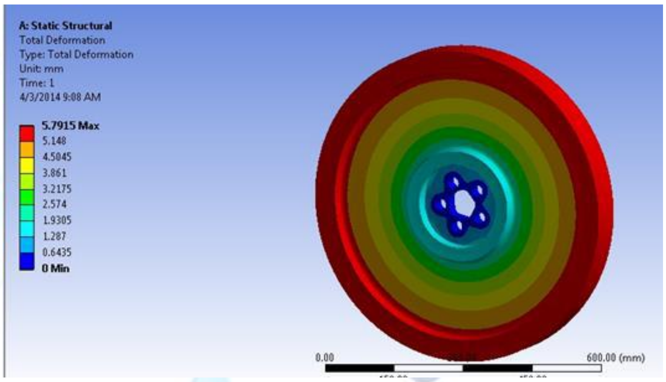


Fig 9: Total Deformation

	Total deformation (mm)	Equivalent Stresses (Mpa)
Maximum	5.7915	9702.9
Minimum	0	200.83

Table 1: Results For Cast Iron

RESULTS FOR S-GLASS EPOXY

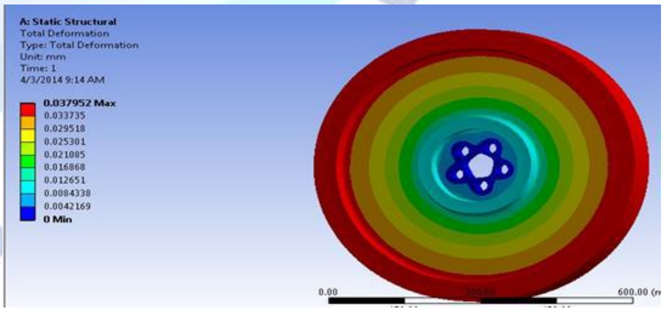


Fig 10: Total Deformation

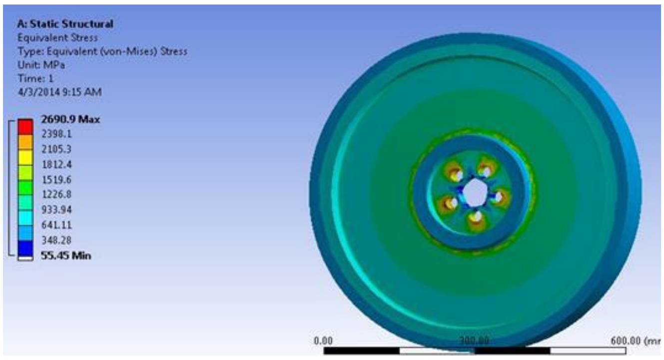


Fig 11: Equivalent Stress

	Total Deformation (mm)	Equivalent Stress (MPa)
Maximum	0.03795	2690.9
Minimum	0	55.5

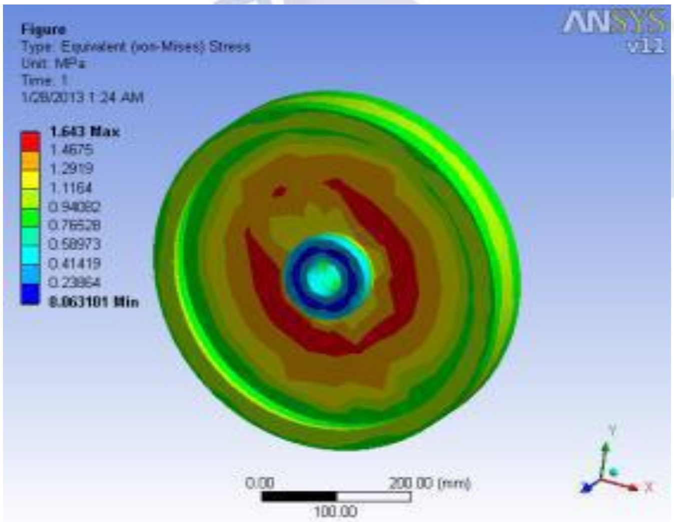
Table 2: Results for S-glass Epoxy

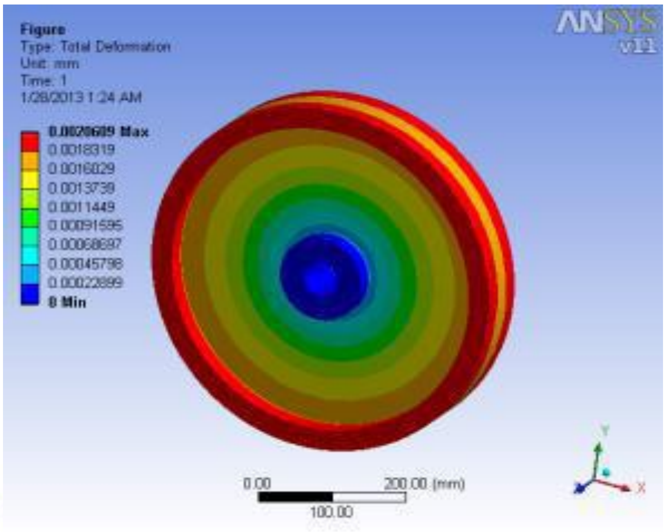
COMPARISON TABLE

	Cast Iron	S-glass Epoxy
Total Deformation (mm)	5.7595	9702.9
Equivalent Stress (MPa)	0.03795	2690.9

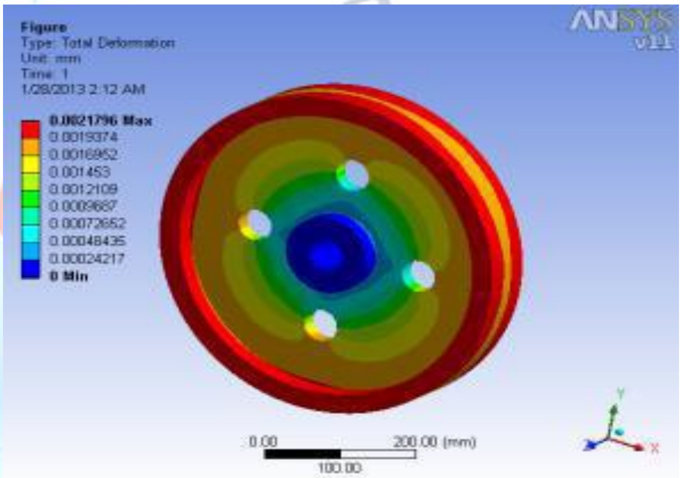
Table3: Comparison between Cast Iron and S-glass Epoxy

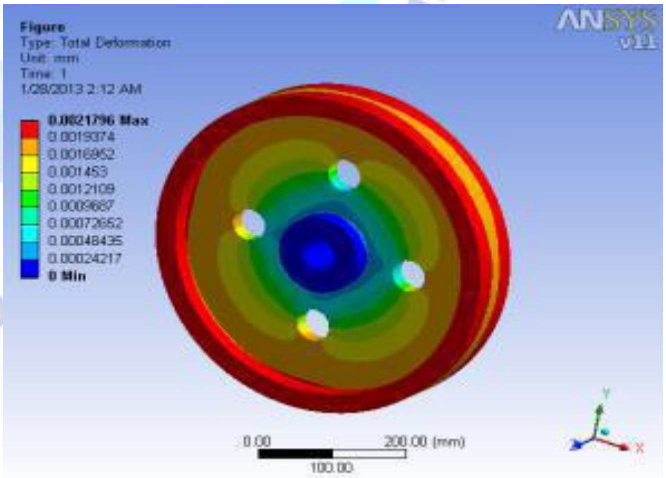
RESULTS FOR RIM TYPE WHEEL BY USING CAST IRON:



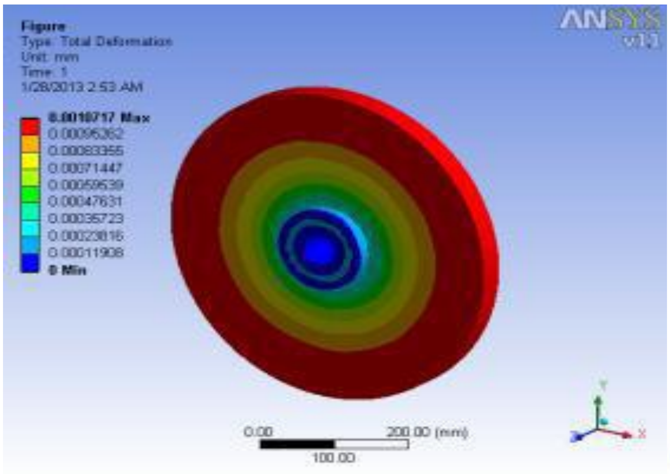


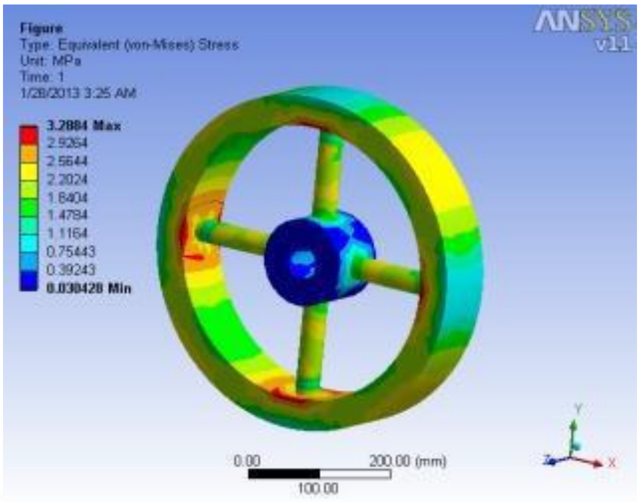
ANALYSIS FOR SECTION CUT TYPE

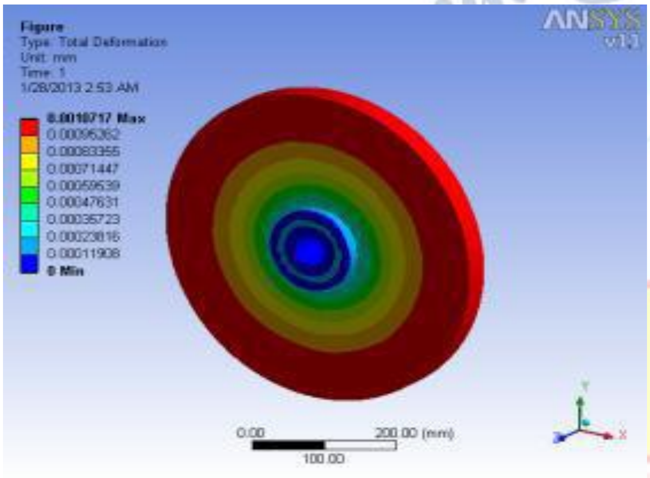




ANALYSIS FOR SOLID TYPE

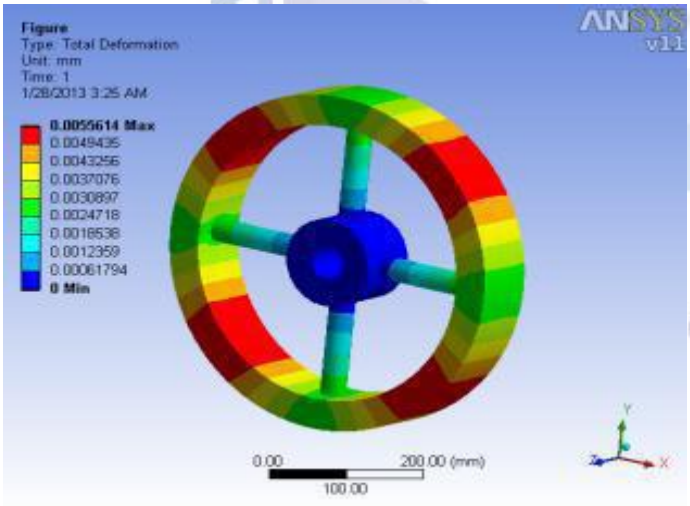






Results shows that efficient flywheel design maximizes the inertia of moment for minimum material used and guarantee high reliability and long life. Smart design of flywheel geometry has significant effect on its specific energy performance. Amount of kinetic energy stored by wheel –shaped structure flywheel is greater than any other flywheel. To obtain certain amount of energy stored; material induced in the spoke/arm flywheel is less than that of other flywheel, thus reduce the cost of the flywheel. From the analysis it is found that maximum stresses induced are in the rim and arm junction.

ANALYSIS FOR SPOKED TYPE



CONCLUSION

The subject of the flywheel is very extensive and is difficult to explain in few pages. This attempt is to summarize some important results by conducting the structural analysis on flywheel with Cast Iron and S-glass Epoxy. Conducted the structural analysis on flywheel stresses and deformation are founded and observed. By observed results concluded that the most effective material is S-glass Epoxy because Sglass Epoxy has less deformation and less Equivalent Stress when compared to the Cast Iron.

FUTURE SCOPE

- It is suggested that the analysisapproach could be successful approach applied to Cast Iron and Sglass Epoxy under different loads.
- The results show that the analysis of flywheel with different materials can be a simple way to find out the stress and deformation.

- The stress and deformation obtained by this method are for future use for more elaborate for structural analysis with different materials

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