DESIGN AND ANALYSIS OF FLY WHEEL WITH DIFFERNT LOAD CONDITIONS

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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. The fly wheel design was done by using NX 12.0 and analysis was done by using ANSYS in static structural analysis with different composite materials applied various load conditions (250 N,300N,) The structural analysis of flywheel had done for two materials. In first flywheel with Grey Cast iron, Epoxy E-Glass UD is analyzed and the deformation stress and strain.

Keywords: Flywheel, NX 12.0, Structural analysis

1.0 INTRODUCTION

A flywheel comprises a rotating mass that stores kinetic energy. When charging, a torque applied in the direction of rotation accelerates the rotor, increasing its speed and stored energy. When discharging, a braking torque decelerates the rotor, extracting energy while performing useful work. Since the invention of the potter's wheel, flywheels have been used as a component in machinery to smooth the flow of energy. In engines or industrial equipment, the purpose of the flywheel is to damp out changes in speed due to a pulsed motive source or a pulsed load. Here, the torque may vary significantly between pulses while the speed of the flywheel varies little. Many shapes of flywheel have been used ranging from the "wagon wheel" configuration found in stationary steam engines to the mass produced, multi-purpose disks found in modern automotive engines. Since the late 20th century, a new class of standalone flywheel systems has emerged. The modern flywheel, developed expressly for energy storage, is housed in an evacuated enclosure to reduce aerodynamic drag. The flywheel is charged and discharged electrically, using a dual function motor/generator connected to the rotor. Flywheel cycle life and calendar life are high in comparison to other energy storage solutions These modern flywheels are found in a variety of applications ranging from grid-connected energy management to electromagnetic aircraft launch. The prevalent rotor configurations comprise disks, solid cylinders, and thick-walled cylinders made from carbon and glass composite or high strength steel.

Flywheel:

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.

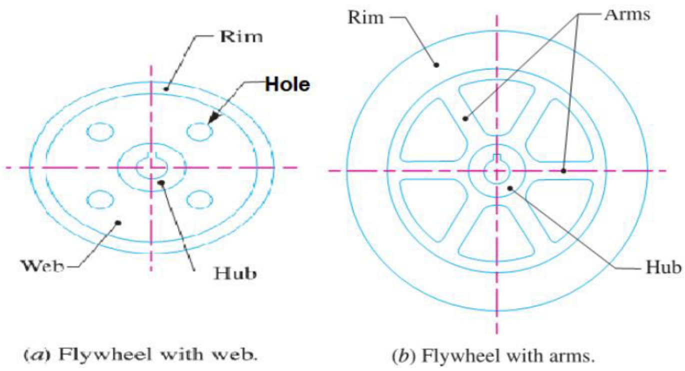

Figure 1: Types of fly wheel

Applications of Flywheel

Its purpose is to smooth the power generation of an energy source. Take an example, the flywheel is used in reciprocating engines because the active torque from the individual pistons is broken.

- Flywheel is usually applied in energy storage systems to maintain the energy in the system as rotational energy.
- Providing energy at rates higher than the capacity of the energy source. This is done by getting energy in a flywheel over time. Then releasing it quickly at rates that exceed the energy source's capabilities.
- It is useful in controlling the adjustment of a mechanical system, gyroscope, and reaction cycle. Flywheel is used with a motorized generator to store energy. Most of the time flywheel is used in wind turbines and automobile vehicle engines.
- Used in electric cars to boost the speed and in large power grids for protection from blockages. Moreover, the flywheel is employed in advanced locomotive propulsion systems and in technology transportation buses.

Objectives:

- To design was done by using NX 12.0
- The analysis is carried out for perforated flywheel by continuously changing the assigned material that is, S-glass-Epoxy, Grey cast iron and Carbon steel.
- The analysis is done to find the equivalent Von-Mises stress and total deformation for different materials and static condition

2.0 LITERATURE REVIEW

Chunming Xu and Du Jiang [1] Flywheel mechanism can effectively improve the mechanical performance of the system, and the flywheel's energy storage density can be significantly improved by optimizing the design. According to the optimal control design theory, the 3D model of the flywheel is established, and the structural analysis is carried out by with the Workbench. **Aswin Inbaraj Jaison [2]** 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. **Dai, X.J, Wei, H.G [3]** This work discusses performance analyses of a flywheel energy storage system rotor using ANSYS. Design of a rotor based on 3D modeling and simulation is presented, the flywheel theory is also studied. A basic static structure and modal analyzes were carried out to evaluate the performance of the model rotor under this condition and the results discussed. **Mofid Mahdi [4]** This study exclusively focuses on exploring the property of flywheel geometry on its energy storage/deliver ability per unit mass, further defined as specific energy. In this paper we have studied various profiles of flywheel and the stored kinetic energy is calculated for the respective flywheel various profiles designed are solid disk, disk rim webbed/section cut, arm/spoke flywheel. **B. Swetha1, Ch. Siva Kumar [5]** In machines where the procedure is intermittent like punching machines, shearing machines, riveting machines, crushers etc., the flywheel stores energy in the, source of energy throughout the greater portion, from the operating cycle and provides up throughout a small duration of the cycle. Thus the power in the source of energy to machines is provided practically in a constant rate through the operation. **Pérez-Aparicio JL, Ripoll L [6]** In the combustion engine, and specifically in one with a few cylinders, energy is imparted for the crankshaft from time to time, & to help keep it rotating inside a fairly uniform speed within substantially constant load, you need to supply it getting a flywheel. **Krack M, Secanell M, Mertiny P [7]** flywheel has unquestionably the best inertia during a multi cylinder engine Aside from its principal function, the fly wheel functions as a part of the friction clutch, & it always carries the ring gear in the electric starter. **Ha SK, Kim SJ, Nasir SU, Han SC [8]** The extra energy developed during power stroke is absorbed with the flywheel and releases it for the crankshaft during other strokes through which no energy is developed, thus rotating the crankshaft inside a uniform speed. Somewhat, consideration might have any time the flywheel absorbs energy, its speed increases then when it releases, the speed decreases. **Ha SK, Kim SJ [9]** ANSYS Professional software supplies a starting point into advanced straight-line dynamics and nonlinear abilities. Which contains the effectiveness of leading simulation technology inside an easy-to-use package, ANSYS Professional tools provide users wealthy in level simulation abilities without making use of high-level expertise. **Zu L, Xu H, Zhang Q, Zhang B [10]** The solution approach relies either on eliminating the differential equation completely (steady condition problems), or rendering the PDE into an approximating system of ordinary differential equations, which are then numerically integrated using standard approaches for example Euler's method, Runge-Kutta, etc.

3.0 MATERIALS AND METHODS

- To start up the process of better selection of flywheel design and material allocation, it is necessary to follow a certain procedure.
- The parameters needed for the analysis are selected and their properties and effects on the experiments are taken into consideration.
- The FEA is carried out on the various combinations of the variables available and the results are analyzed.

Design Process:

Definition of problem

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Determine the output most critical to the present problem

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Selection of variables and parameters

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Creating a mathematical model

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Perform analysis on the various sets of variables at disposal

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Structural analysis and interpretation (total deformation, directional deformation, stress, strain

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Validate the results

Flywheel rotor design is the key of researching and developing flywheel energy storage system. The geometric parameters of flywheel rotor were affected by much restricted condition. This paper discussed the general design methodology of flywheel rotor base on analysing this influence, and given a practical method of deterring the geometric parameters. The foundation was laid for optimal design and analysis of flywheel rotor in the future. Flywheel energy storage system (FESS) mainly consists of a flywheel rotor, magnetic bearings, a motor/generator, a vacuum chamber, and power conversion system. The flywheel rotor was supported by non-contacting magnetic bearings that provide very low frictional losses, It stores energy in a kinetic form, the motor/generator converts mechanical energy to electric form, and vice versa. The flywheel rotor work in a high speed, must be high energy density, high mechanical strength, and dynamics properties. Therefore, the flywheel rotor was the key of FESS research and develop.

Design of a Flywheel

A flywheel acts as an energy reservoir, which stores energy during the period when the supply of energy is more than the requirement and releases energy during the period when the requirement is more than the supply.

- Selection of the engine ƒ Data tables will be provided and select the problem based on the serial number
- ƒ Calculation of Turning Moment ƒ calculation of torque due to inertia forces ƒ calculation of torque due to pressure forces the indicator diagram of the engine will be provided
- Obtain the turning moment and hence find the mean torque
- Calculation of the Moment of Inertia of the Flywheel to limit the speed fluctuation to given value
- Design of the flywheel with the required Moment of Inertia

The diameter of the shaft should be large enough to prevent from failure due to the torque on it. T/J +t/r r = distance from the centre

D = diameter of the shaft

τ = shear stress on the shaft at radius r
T = torque on the shaft
J = Polar second moment of area
J= 3.149*d*d/32

INTRODUCTION TO NX 12.0

The Introduction to NX for Experienced Users course provides an introduction to NX for those students who will be using NX on a daily basis. Upon completion of this course, accomplished 3D Parametric CAD users will have the capability to create and modify parts, assemblies, and products in NX, leveraging their years of parametric modeling experience. The pace and topics of this course have been carefully planned specifically for the experienced 3D Parametric CAD user.

Selection and Dimensions of Flywheel

Thresher machine is used in agriculture sector to separate the comb from grain. Flywheels used in Thresher Machine are made of single solid disk cast iron material and is selected in this project work.

- 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 $C S = N \; 2 - N \; 1 \; N = 410 - 400$
- N= average speed in RPM
- Coefficient of speed fluctuation =0.02469

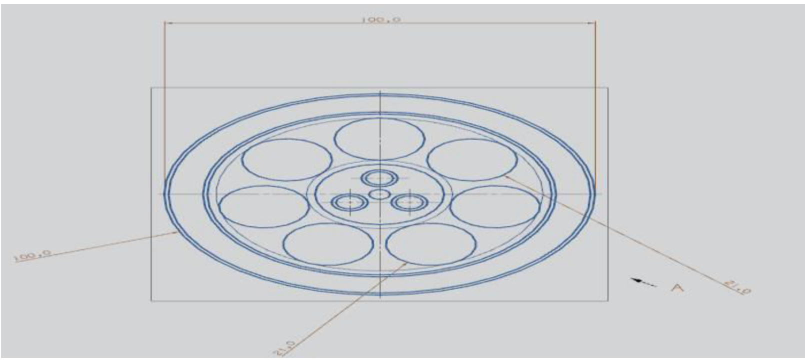

Figure 2: geometric view

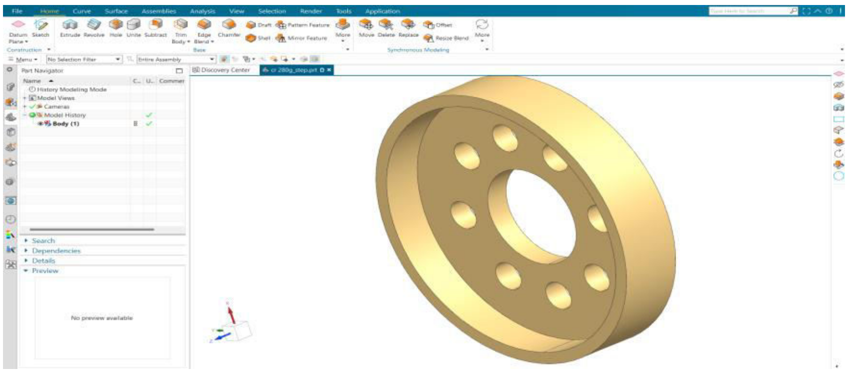

Figure 3: Design of flywheel NX 12.0

The geometry of a flywheel may be as simple as a cylindrical disc of solid material, or may be of spoke construction like conventional wheels with a hub and rim connected by spokes or arms Small fly wheels are solid discs of hollow circular cross section. As the energy requirements and size of the flywheel increases the geometry changes to disc of central hub and peripheral rim connected by webs and to hollow wheels with multiple arms.

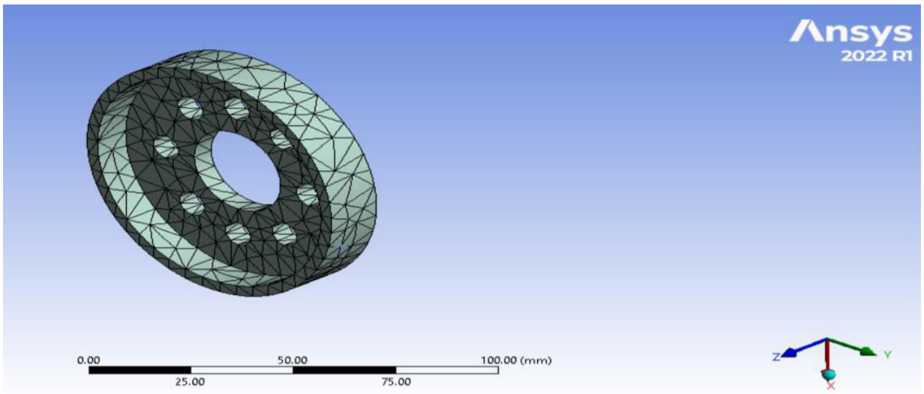

Figure 4: Meshed view

Free mesh with smart element sizing is adopted to automatically and flexibly mesh the model. Compared to mapped mesh, which is restricted to only quadrilateral (area) or only hexahedron (volume) elements; free mesh has no restrictions in terms of element shapes. Smart sizing gives the mesher a greater opportunity to create reasonably shaped element during automatic element generation.

4.0 RESULTS AND DISCUSSIONS

A structural model which created can be used to predict the behavior of their real structure, under the action of external forces. The response is usually measured in terms of deflection and stress. The response is static if the loads are steady. This analysis is called static analysis. A static analysis can be either linear or nonlinear. Static structural analysis of flywheel with different materials like Epoxy E-Glass UD, Structural Steel with 250 N, 300 N Load conditions

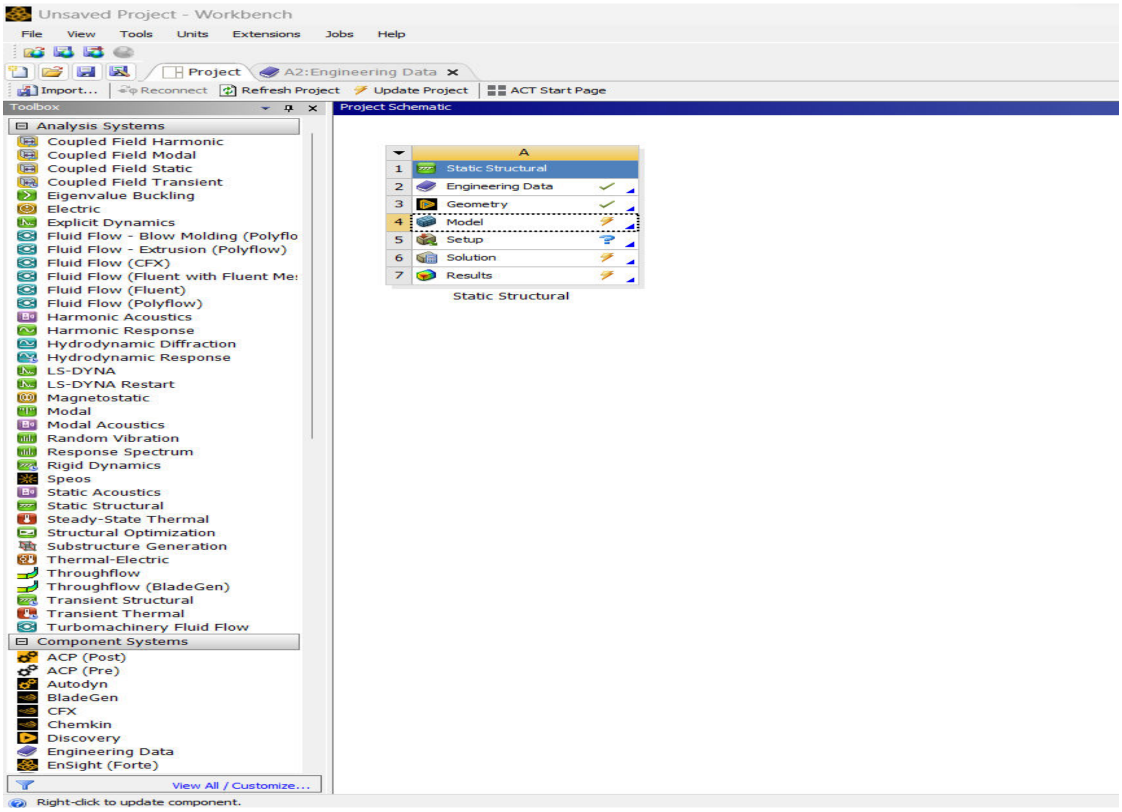

Figure 5: Ansys Layout

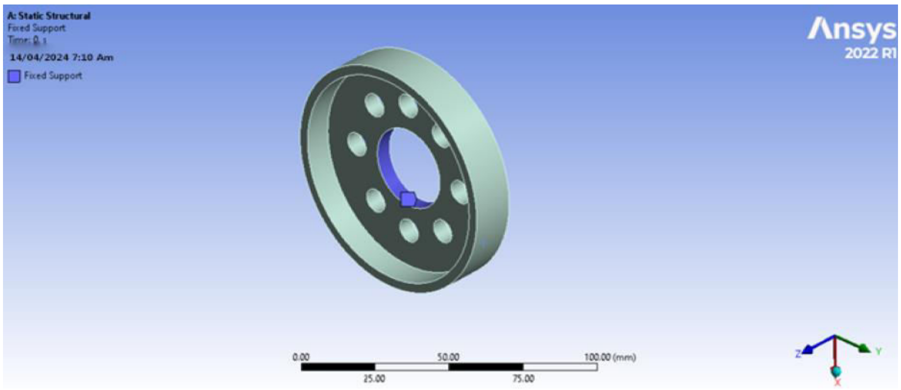

Figure 6: Fixed support

Static structural analysis of flywheel with Gray Cast Iron 250 N

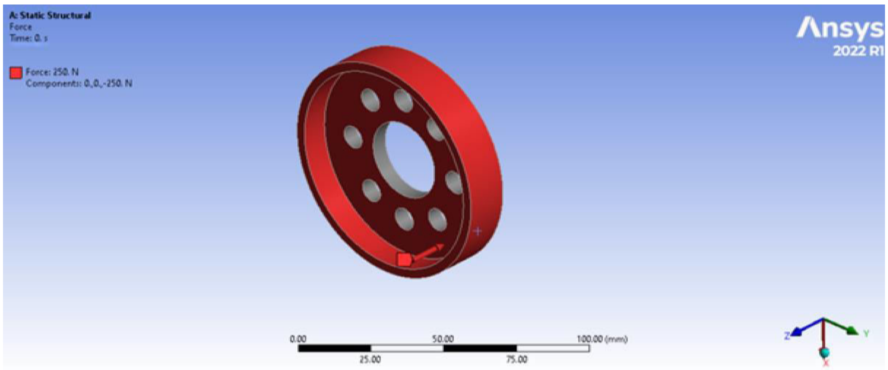

Figure 7: Force 250 N

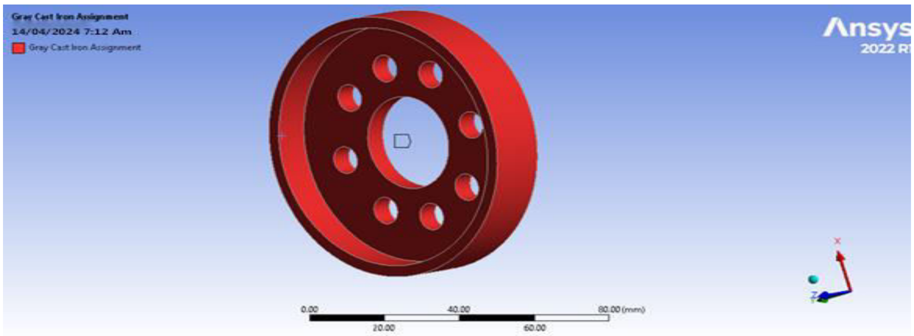

Figure 8: Material Assignment

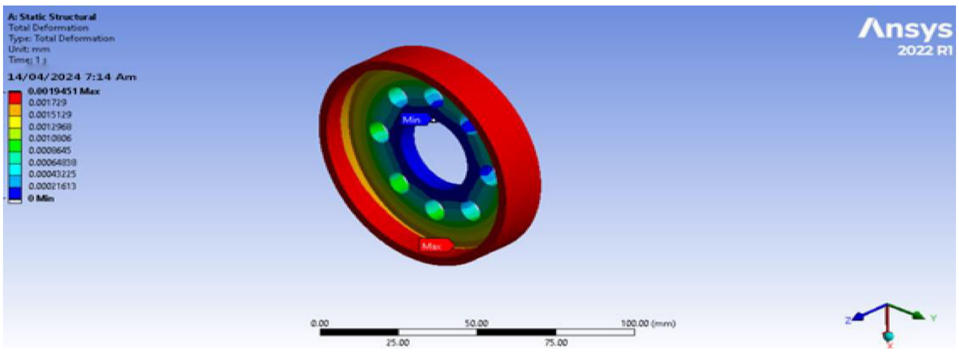

Figure 9: Total deformation

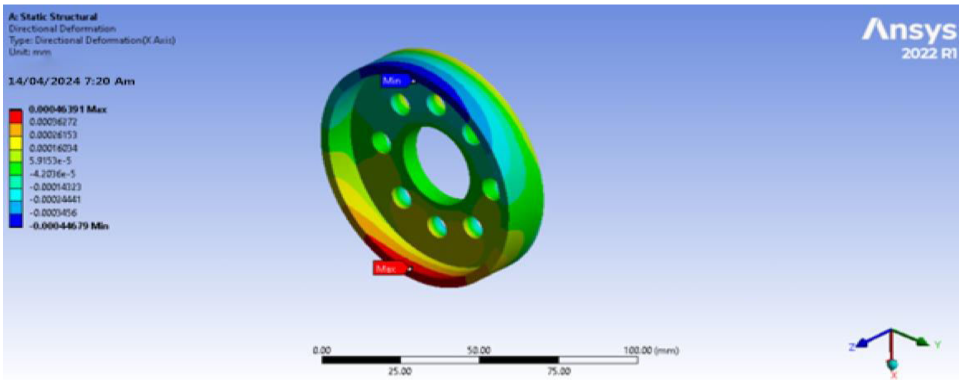

Figure 10: directional deformation

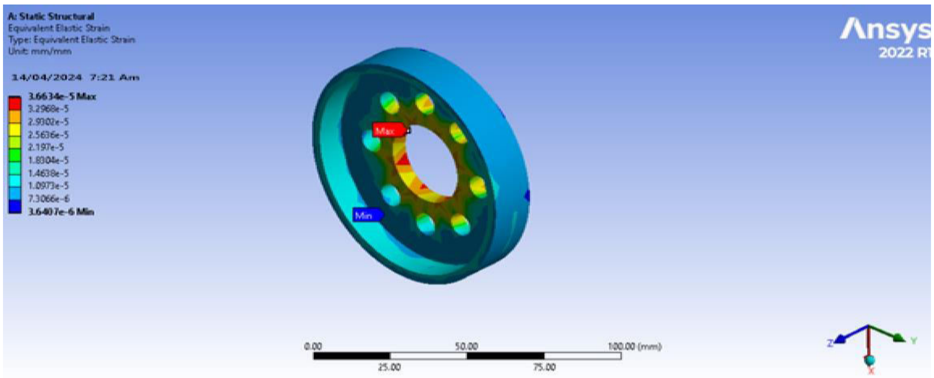

Figure 11: Elastic strain

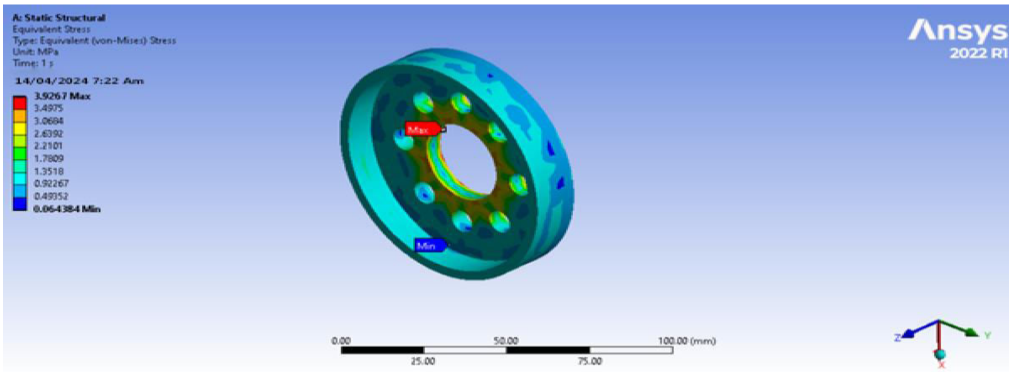

Figure 12: Equivalent stress

Static structural analysis of flywheel with Gray Cast Iron 300 N

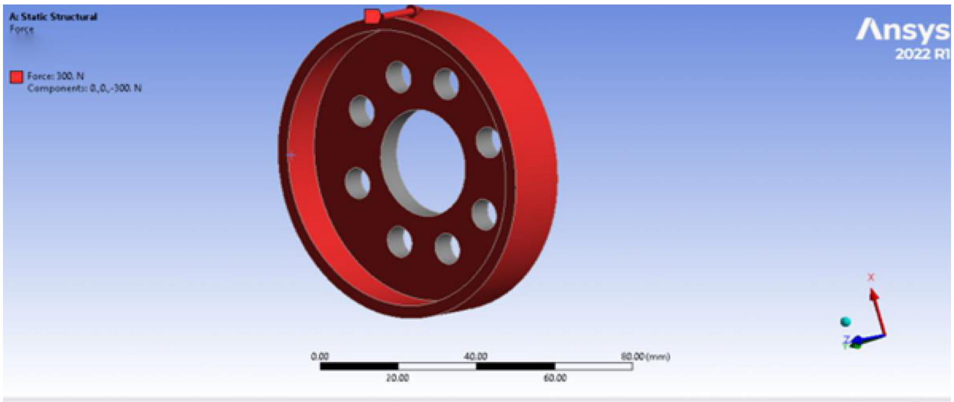

Figure 13: Force 300 N

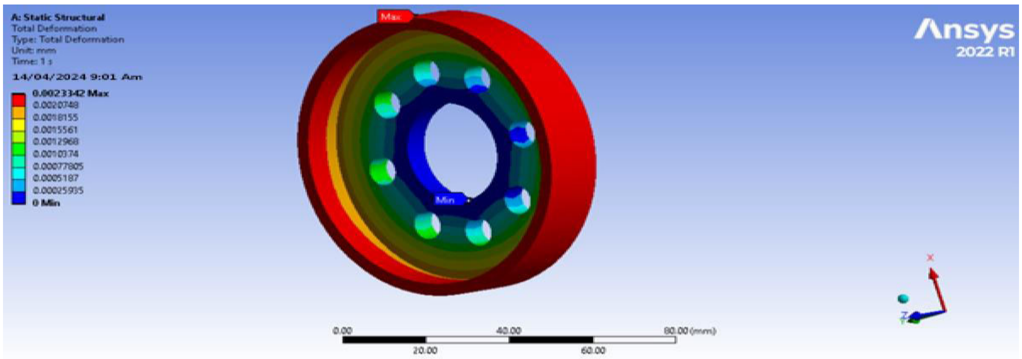

Figure 14: Total deformation

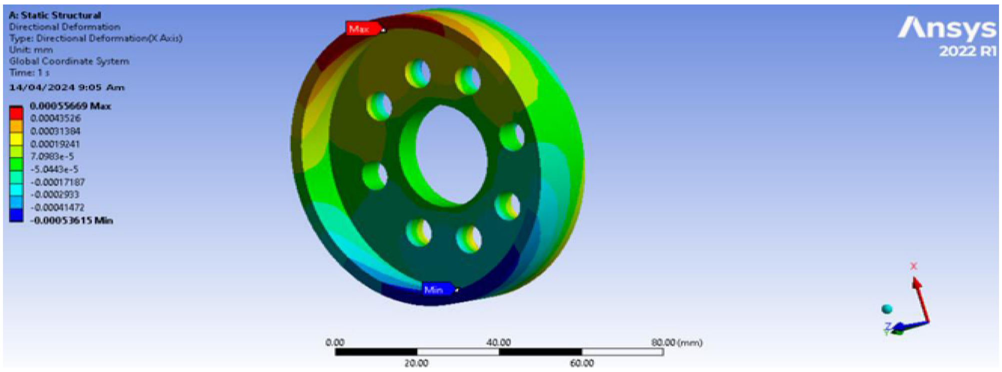

Figure 15: directional deformation

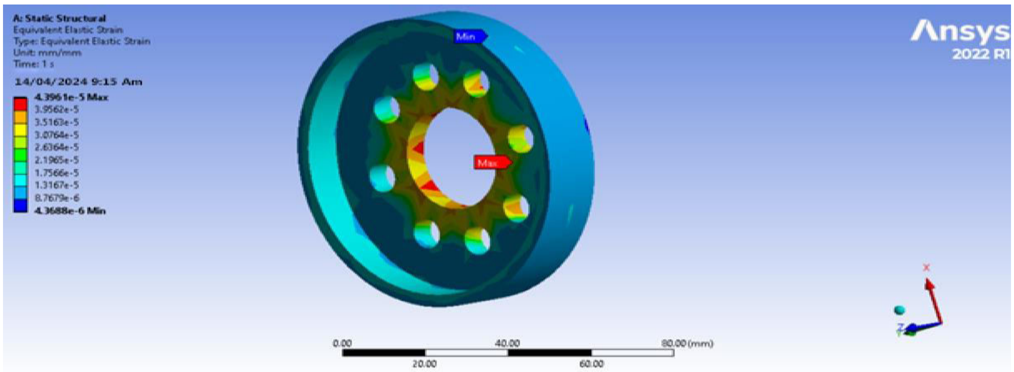

Figure 16: Elastic strain

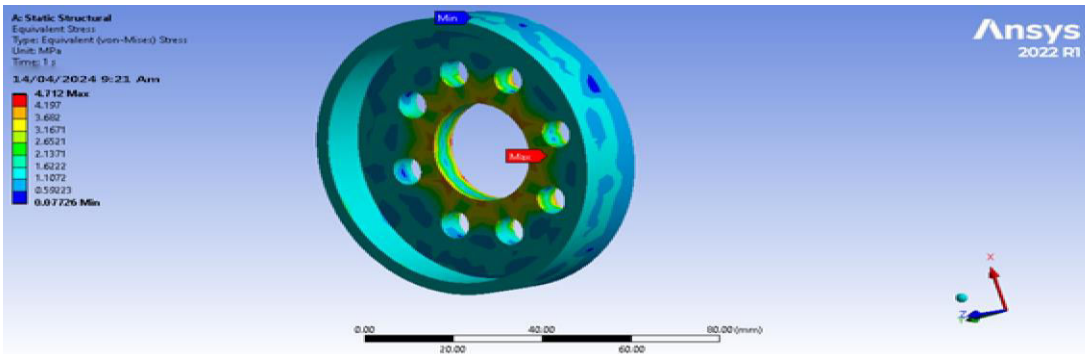

Figure 17: Equivalent stress

Static structural analysis of flywheel with Epoxy E-Glass UD 250 N

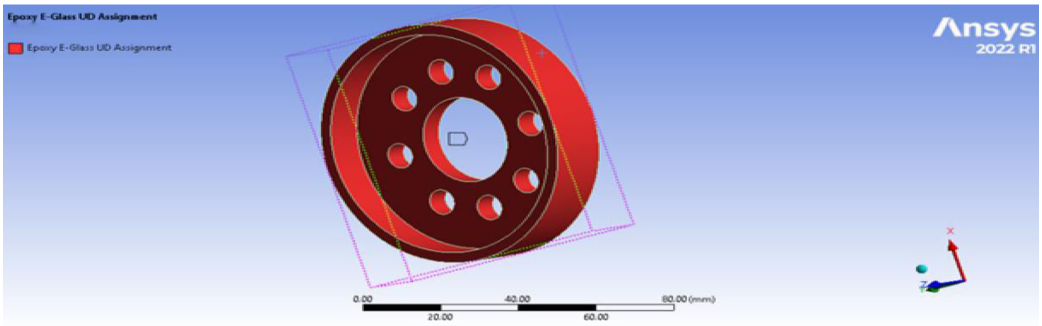

Figure 18: Material Assignment

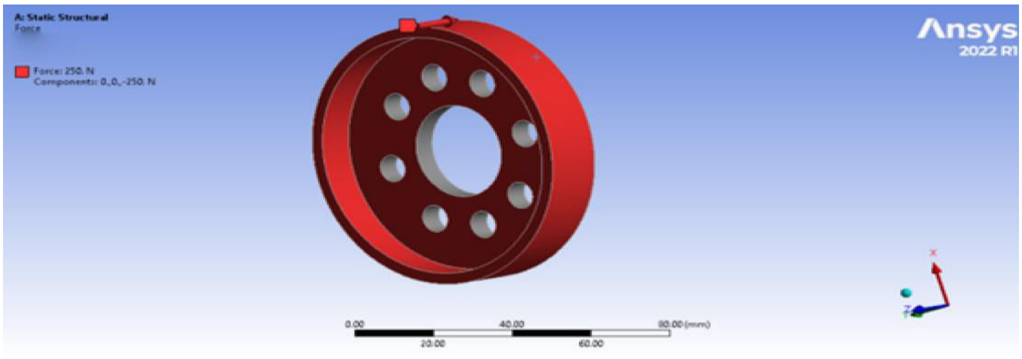

Figure 19: Force 250 N

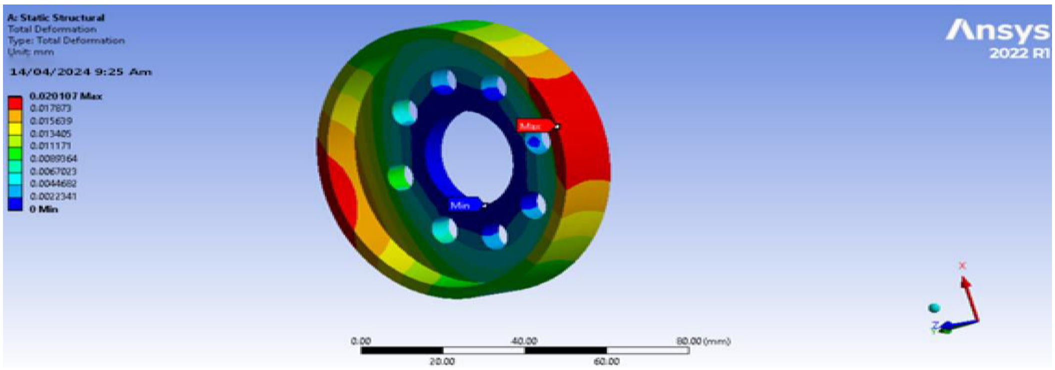

Figure 20: Total deformation

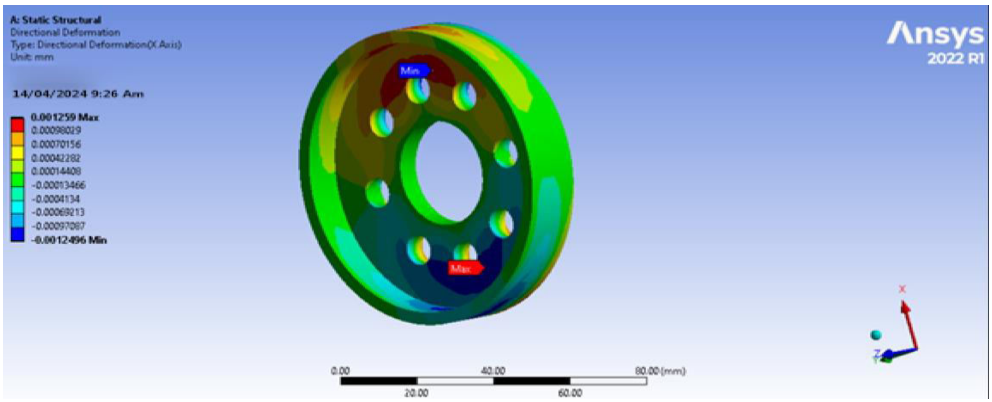

Figure 21: Directional deformation

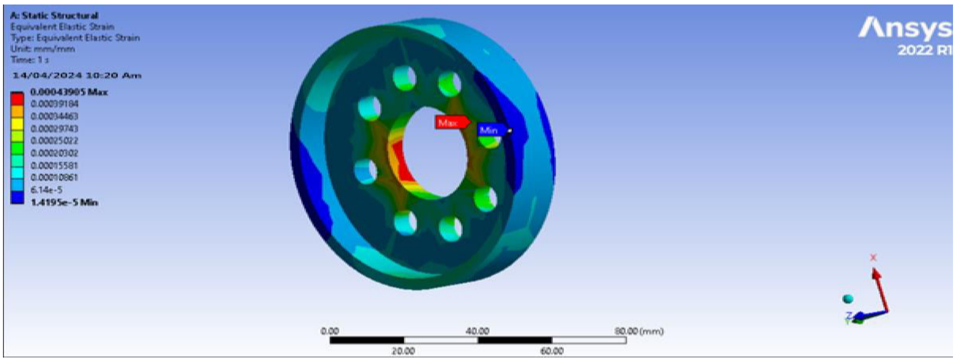

Figure 22: Elastic strain

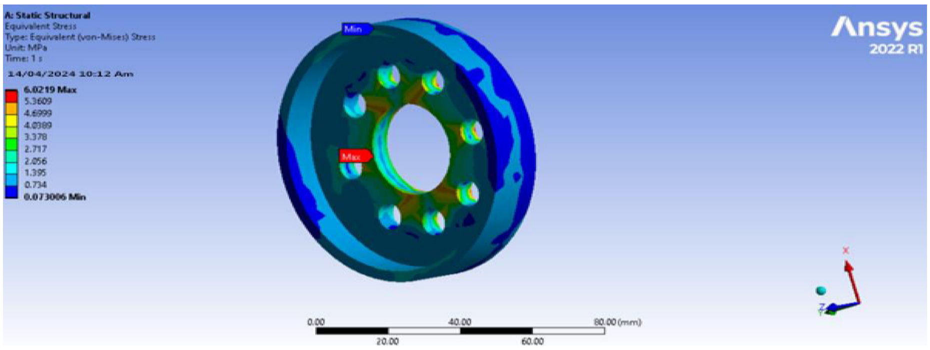

Figure 23: Equivalent stress

Static structural analysis of flywheel with Epoxy E-Glass UD 300 N

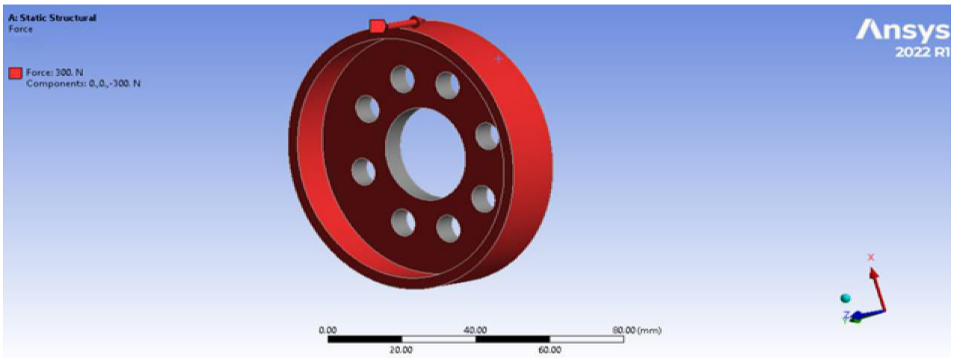

Figure 24: Force 300 N

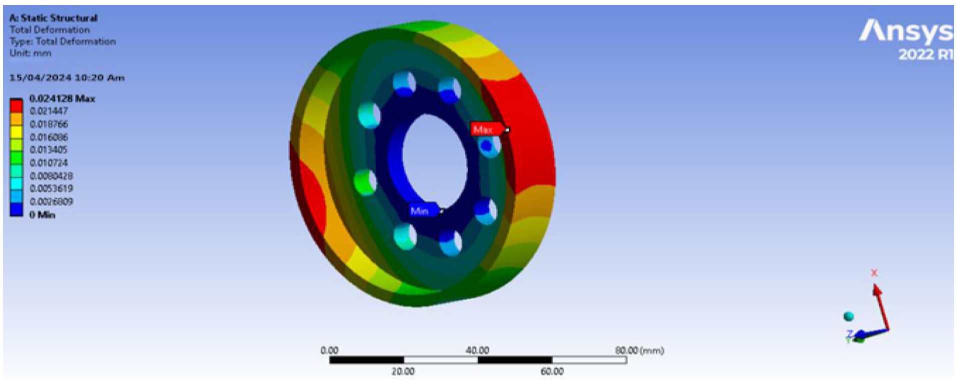

Figure 25: Total deformation

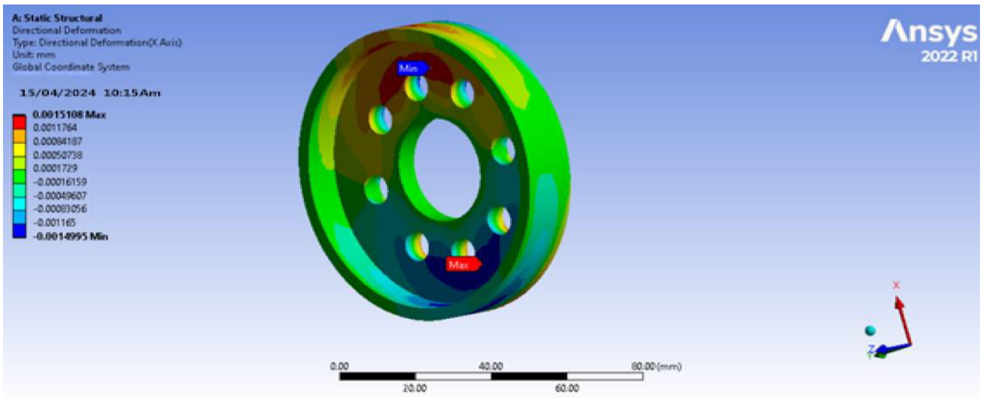

Figure 26: Directional deformation

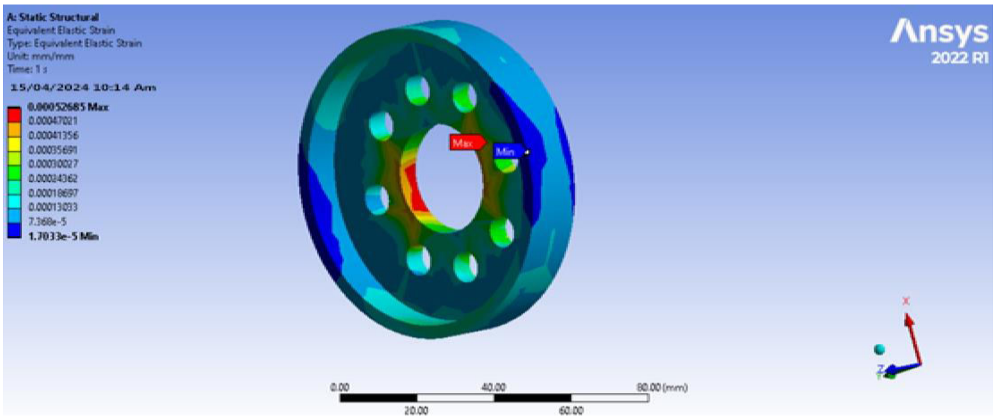

Figure 27: Elastic strain

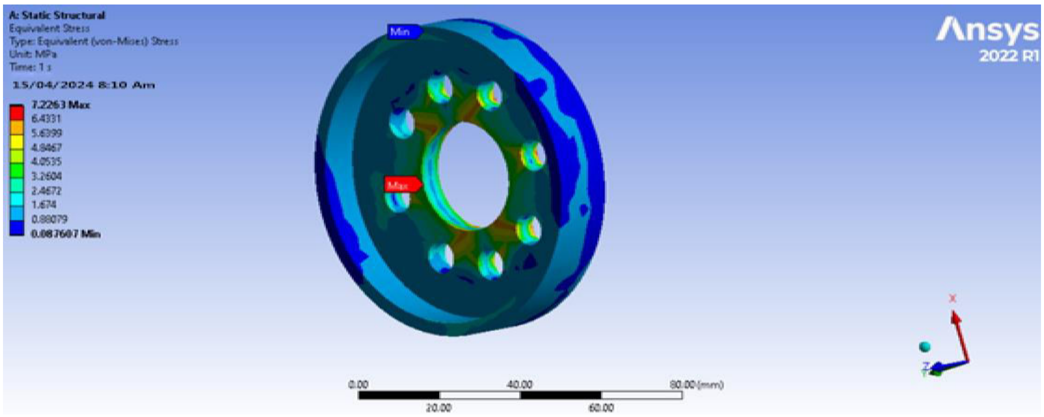

Figure 28: Equivalent stress

Table: static structural analysis of flywheel with different materials maximum load conditions

Parameters	Grey Cast Iron		E-Glass Epoxy	
	250 N	300 N	250 N	300 N
Total deformation	1.9451e-003	0.0023342	0.020107	0.024128
directional deformation	0.00046391	0.00055669	0.001259	0.0015108
Elastic strain	3.6634E-5	4.3961e-5	0.00043905	0.0052685
Stress	3.9267	4.712	6.0219	7.2263

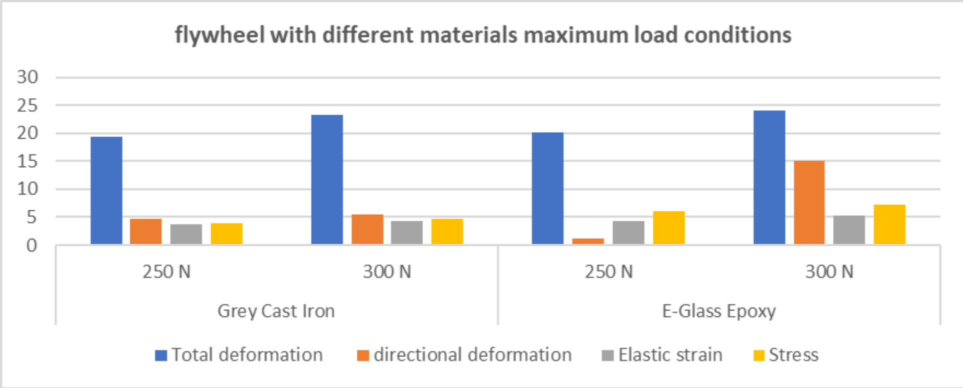

Figure 29: flywheel with different materials maximum load conditions

CONCLUSIONS

This work focus on the design and analysis of flywheel and Induction motor for automobile applications, usually instead of depending on gear system for multiplying speed of the vehicle flywheel can be use, flywheel not only increase the speed, it can also help to maintain stability of the vehicle and also it stores mechanical energy in the form rotation energy The results shows that flywheel with Triangular cross sectional geometry and made of S-glass epoxy composite material stores highest Kinetic Energy per unit mass compare to all other combination of Geometry and material. We can observe that the mass is going on decreasing from present geometry to modified geometry thus increasing flywheels maximum rotational speed, and hence maximum Kinetic Energy to corresponding rotational speed.

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