

Design and Analysis of Flywheel for Different Geometries and Materials

Ankita Shinde¹, Kratika Singh Rawat¹, Ruchi Mahajan¹, Veeraj Pardeshi¹, Balbheem Kamanna² and Sachin Sheravi¹

¹Department Mechanical Engineering, A.C. Patil College of Engineering, Mumbai University, Mumbai, Maharashtra, India

²CAE Analyst, MATRIX CAD Academy, Navi Mumbai, Maharashtra, India

Abstract

Flywheel is a mechanical device used to store energy and utilize it whenever it required. Flywheels find its application in number of fields ranging from IC engine of 2-wheeler to more powerful jet engines. Increase in Kinetic Energy of flywheel is the most critical factor for the design engineers. The literature survey shows that flywheel can be redesign for mass optimization which results light weight and Increase in storage capacity. In this project work, an attempt is made to redesign the existing flywheel in terms of its geometry and different materials. Different cross sections of the flywheel are designed using 3D designing software Solidworks 2015. Finite Element analysis is used to calculate the Maximum Rotational speed the flywheel and the amount of Kinetic energy stored at that speed. 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 Geometries and materials. This New design of flywheel saves weight by 65.252kg compared to existing designs.

Keywords: Finite Element Analysis, Flywheel, Solidworks, S-glass Epoxy

Manuscript Accepted: 11-Jan-2017; **Originality Check:** 13-Jan-2017; **Peer Reviewers Comment:** 16-Jan-2017; **Double Blind Reviewers Comment:** 17-Feb-2017; **Author Revert:** 20-Feb-2017; **Camera-Ready-Copy:** 26-Feb-2017)

1. Introduction

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 main function of a flywheel is to smoothen out variations in the speed of a shaft caused by torque fluctuations. Generally used materials for manufacturing of flywheels are Steel, Cast Iron, Aluminum Alloy, and Titanium. Cast iron is most preferred because of long term durability and its design can be easily modified by avoiding cost of complete replacement. Internal combustion engines with one or two cylinders are a typical example. Piston compressors, punch presses, rock crushers etc. are the other systems that have flywheel. Rating of Flywheel Kinetic Energy is defined interns of Energy Density.

The Energy Density is defined as the Energy per unit mass,

Where, ω = Angular velocity of the flywheel, σ = Specific strength of a material, ρ = Density of the material.

2. 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. Specifications are mentioned in the Table no 1.

Table 1. Flywheel Dimensions

Mass of Flywheel (m)	72kg
Outer Diameter (D_o)	500mm
Inner Diameter (D_i)	50mm
Thickness (t)	50mm
RPM	750

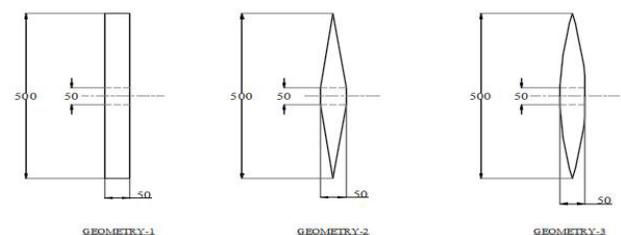


Figure 1. Different Cross sectional Flywheels.

3. Design of Flywheel Geometries

Single solid disk flywheels made of rectangular cross section is considered. Variation in cross section of the flywheel will results

in variation of Maximum rotational speed and kinetic energy storage capacity. In this project work existing rectangular cross section flywheel designs are compared with different cross sectional are of flywheels. The redesign of flywheel is done by changing the cross-section and reducing the material by keeping outer diameter, inner diameter and thickness to be constant. Three Different geometries are considered for design and analysis.

4. 3D Modelling of Different Geometries of Flywheel

Designing and modeling of flywheel is done using SOLIDWORKS 2015. Solidworks is a solid modeler that makes use of parametric feature-based approach for creating models and assemblies. The following figures show the present as well as re-designed geometries of flywheel.

ANSYS Workbench, one can generate 3D models, FEA models, perform analysis and generate results of analysis.

5. Material Selection

Flywheels Kinetic Energy is Depends upon the mass Moment of inertia of the Cross section which intern depends on the material of flywheel. Hence selection of Material to enhance the rotational speed and kinetic energy of the existing system is a critical task for the engineers. Different composite materials are short listed depending upon the Energy storage capacity of the materials. Weighted Residual Method (WRM) is used to find the best materials out of the number of shorted one. S-glass epoxy stands at the top to full fill all the requirement of flywheel. It has good inner strength and variety in surface textures. It is cost effective and

corrosion resistant. In this project work S- Glass Epoxy Flywheel is compared with Existing Cast Iron ASTM – 30 Flywheel.

Table 2. Flywheel Material Properties

Material	Young's Modulus E, GPa	Poisson's Ratio,	Density, kg/m ³	Yield Strength, y MPa
Cast Iron ASTM-30	101	0.23	7510	260
S- Glass Epoxy	90	0.33	2190	190

6. Theoretical Calculation

For Flywheel Geometry 1 made of Cast Iron

1. Angular Velocity, <eq problem in MS Word>
2. Mass Moment of Inertia, $I = \frac{1}{2} mr^2 = \frac{1}{2} * 72.992 * (0.250)^2 = 2.281 \text{ kg} - \text{m}^2$
3. Maximum Kinetic Energy, $KE = \frac{1}{2} I\omega^2 = 760.14 \text{ KJ}$

7. Finite Element Analysis using ANSYS

Finite Element Method & Analysis is used to find the maximum Speed the flywheel can rotate without any failure and Amount of kinetic energy the flywheel can store at that maximum speed. Static structural analysis is used to find the Maximum Rotation speed and Explicit Dynamics is used to calculate the amount of kinetic Energy in the flywheel.

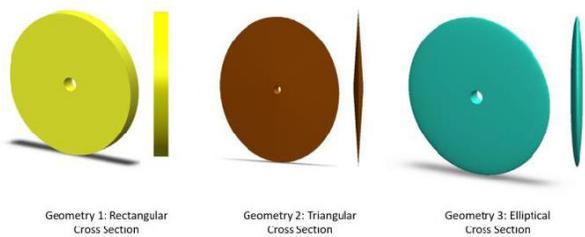
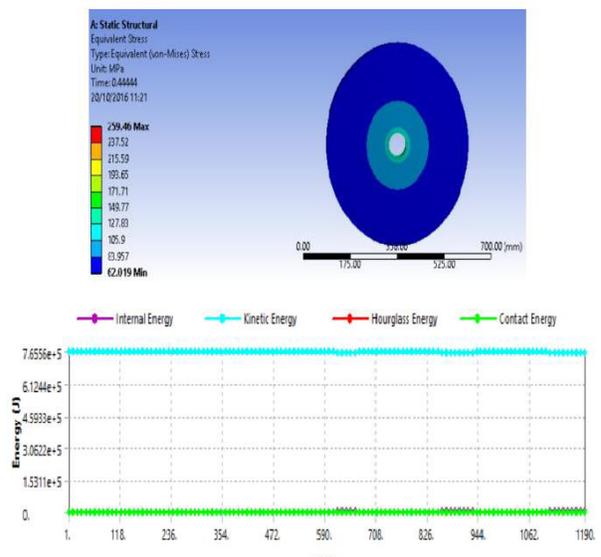


Figure 2. Different Cross sectional Flywheel Models.



ANSYS is a Computer Aided Finite Element Modeling (FEM) and Finite Element Analysis (FEA) tool developed by ANSYS Inc. In the Graphical User Interface (GUI) of

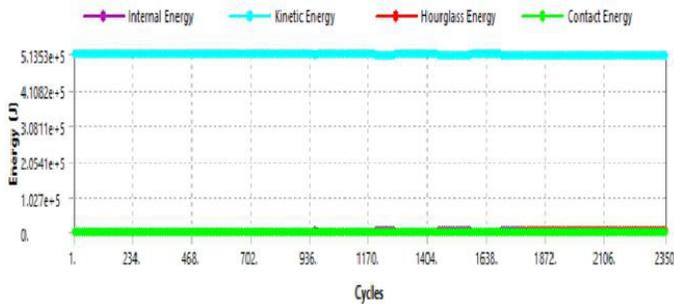
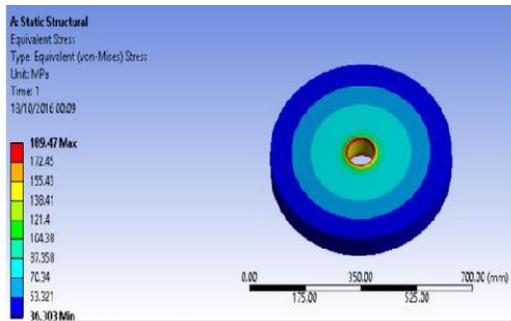


Figure 3. Stress distribution and KE of Geometry 1 with Cast Iron.

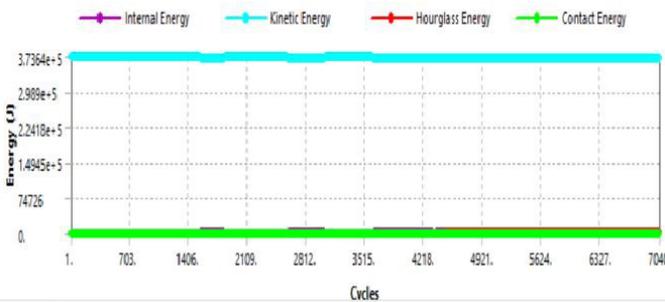
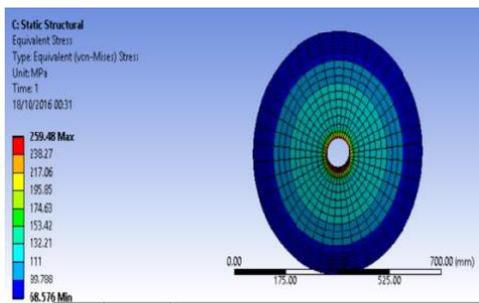


Figure 4. Stress distribution and KE of Geometry 1 with S-Glass Epoxy.

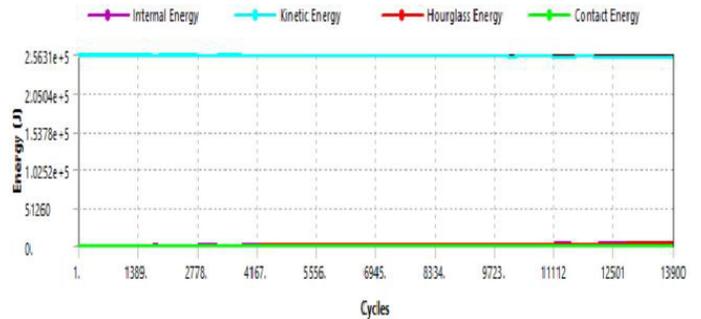
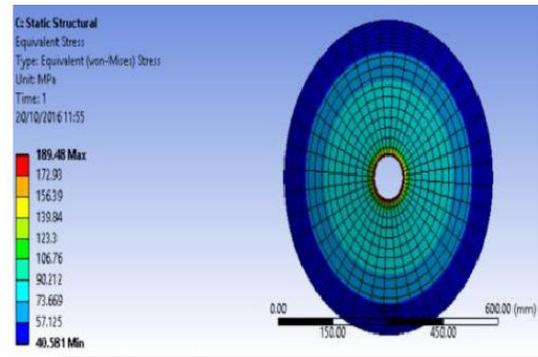


Figure 5. Stress distribution and KE of Geometry 2 with Cast Iron.

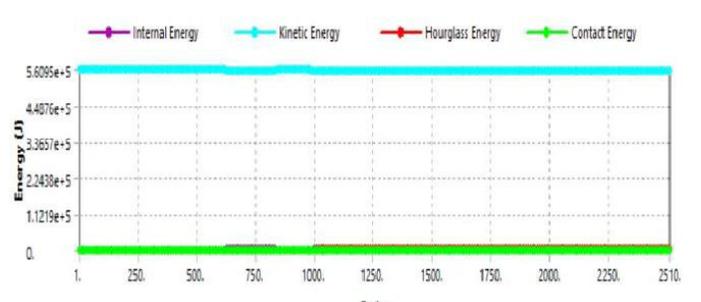
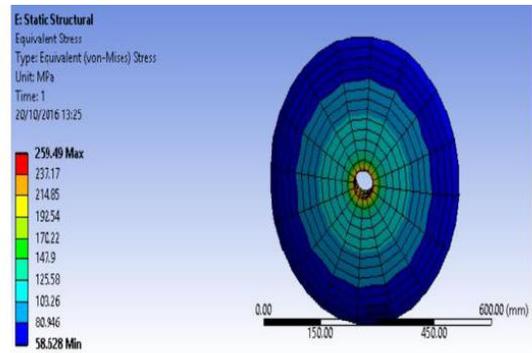


Figure 6. Stress distribution and KE of Geometry 2 with S-Glass Epoxy.

Table 3. Result table of ANSYS Simulation

Geometry	Material	Mass (kg)	Speed (RPM)	Stress (MPa)	Kinetic Energy (KJ)	Kinetic Energy perkg (KJ/kg)
1	Cast Iron	72.9	779	259.4	766	10.49
	ASTM 30	92	6	6		
	S-Glass	21.2	118	189.4	514	24.14
	Epoxy	85	24	7		
2	Cast Iron	26.5	115	259.4	374	14.09
	ASTM 30	43	43	8		
	S-Glass	7.74	177	189.4	256	33.07
	Epoxy		04	8		
3	Cast Iron	50.2	901	259.4	561	11.17
	ASTM 30	44	8	9		
	S-Glass	14.6	137	189.4	379	25.87
	Epoxy	52	43	9		

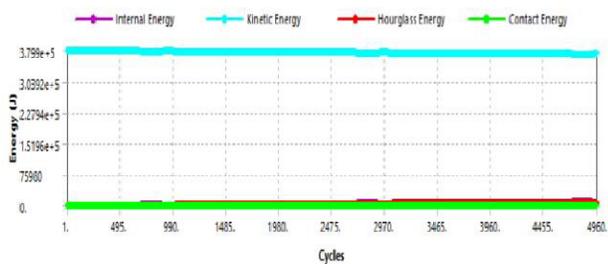
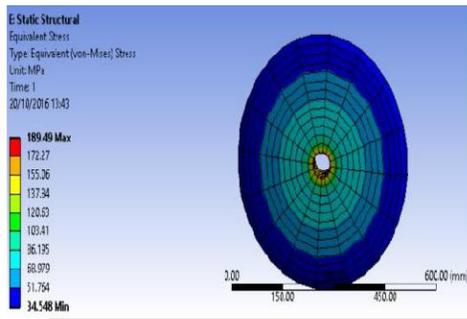


Figure 7. Stress distribution and KE of Geometry 3 with Cast Iron.

8. Result and Conclusion

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. This New design of flywheel saves weight by 65.252kg compared to existing design of flywheel made of Cast iron ASTM 30.

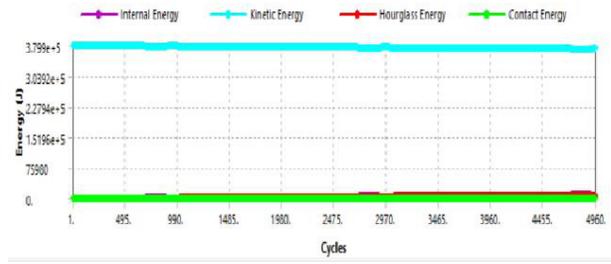
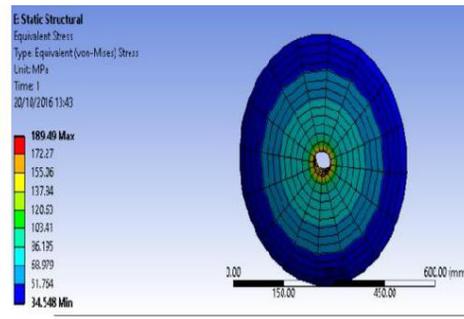


Figure 8. Stress distribution and KE of Geometry 3 with S-Glass Epoxy.

9. References

1. Punde AP, Gattani GK. Analysis of flywheel. International Journal of Modern Engineering Research (IJMER). 2013 Mar-Apr; 3(2):1097–9. ISSN: 2249-6645.
2. Choudhary SM, Shahare DY. Design Optimization of Flywheel of Thresher Using FEM. International Journal of Emerging Technology and Advanced Engineering Certified Journal. 2013 Feb; 3(2). ISSN 2250-2459, ISO 9001:2008.
3. Lokesh P, Ashok Kumar B. Design and Analysis of Fly Wheel and By Using CATIA and ANSYS Software. International Journal and Magazine of Engineering Technology, Management and Research.

- A Peer Reviewed Open Access International Journal . ISSN No: 2348-4845
4. Mathew M. Design of flywheel for improved energy storage using computer aided analysis. Department of Mechanical Engineering, National Institute of Technology, Rourkela. 769008 (2008-2009)
 5. Arslan MA. Flywheel Geometry Design For Improved Energy Storage Using Finite Element Analysis. Science Direct, Material and Design. 2008; 29:514–8.
 6. Danfelt EL, Hewes SA, Chou T-W. Optimization of Composite Flywheel Design. International Journal of Mechanical Science. 19:69–78
 7. Haung J, Fadel GM. Heterogenous Flywheel Modelling & Optimization. Materials & Design. 2000; 21:111–25.
 8. Tzeng J, Emerson R, Moy P. Composite Flywheels For Energy Storage. Composites Science and Technology. 2006; 66:2520–7
 9. Liu H, Jiang J. Flywheel Energy Storage-An Upswing Technology for Energy Sustainability. Science Direct Energy and Buildings. 2007; 39:599–604
 10. Wang B, Liu Z. Investigations on Deformation and Fracture Behavior of Workpiece Material During High Speed Machining Of T050-T7451 Aluminum. CIRP Journal of Manufacturing Science and Technology. 2016; 14:43–54.

Citation:

Ankita Shinde, Kratika Singh Rawat, Ruchi Mahajan, Veeraj Pardeshi, Balbheem Kamanna and Sachin Sheravi
“Design and Analysis of Flywheel for Different Geometries and Materials”,
Global Journal of Enterprise Information System. Volume-9, Issue-1, January-March, 2017. (<http://informaticsjournals.com/index.php/gjeis>)

Conflict of Interest:

Author of a Paper had no conflict neither financially nor academically.