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Suitability of Composite Material for Flywheel Analysis

Nagaraj.r.m
PG Scholar, The oxford college of engineering Bangalore, India

Abstract: *The paper deals with analysis of flywheel in which comparison of flywheel existing material and test material are done. There must be proper design and analysis of flywheel in order to meet the necessity to smooth out enormous oscillations in velocity that occur during a cycle of i.c.engine in a flywheel. So here some finite element analysis tools are used for design and analysis purpose. Then results are compared with existing material.*

Keywords:*Arm type flywheel, material properties, FE analysis.*

I. Introduction

In today's society energy storage plays a vital role, where almost all the things we use for our day –to-day life needs energy to work. Sometimes energy can be supplied directly or taken it from some kind of local energy storage. Flywheel technology is a very bright future for storing energy. As Flywheels are very "green" technology they have been widely used for a long time as mechanical energy storage devices.

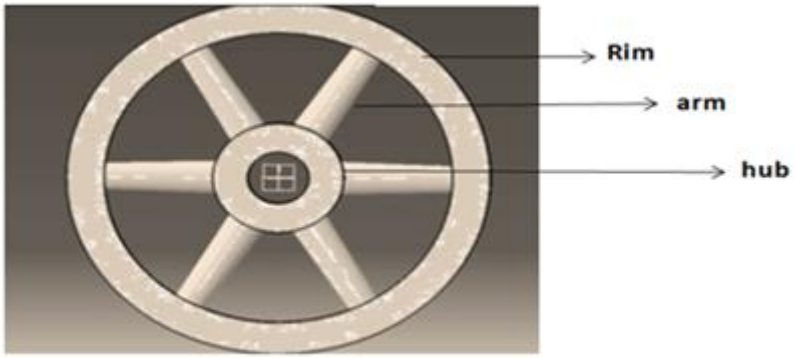

Fig 1 model of flywheel

It has rotating disk that stores energy as kinetic energy, spinning of flywheel decides how much amount of energy it stores. S.M.Choudhary1, D.Y.Shahare [1] has proposed the creation of various profiles of flywheel according to the geometry and calculation of stored kinetic energy with respective flywheel profile. Xingjian DAI, Kai ZHANG and Xiao-zhang[2] has given information regarding proper design of a flywheel energy storage prototype to get high energy density and low bearing loss. Mainly finite element analysis is subjected to analyse the different modes of the rim -hub- shaft system by using some tools. The testing of flywheel system is carried out where complex non-synchronous vibration was observed, analysed and suppressed. O.J. Fiske, M.R. Ricci[3] Figure out the comparison between materials used for flywheel as earlier days steel was widely used for its strength but less energy storage density .Akshay P. Punde[4], has proposed the design and analysis of flywheel which is a major part of an I.C.engine to bring the requirement for smoothing out the large asynchronous oscillations in velocity during a process. Some flywheels possess poor energy storage in their own therefore selection of material plays very important role. For energy storage we need low density materials so the best option is composite materials so here we are using aluminium metal matrix composite for flywheel Here we are using the test material properties for analysis purpose.

II. Evolution Of Tools

CATIA (Computer Aided Three-dimensional Interactive Application)**:**

Is one of the world's most developing key solutions for product design and innovation which is developed by dassault system. Mainly for advance structures it provides a better way to improve our ability to accomplish the design to manufacture process. The way it approaches to the market is based on 3D experience platform by providing a singular digital product experience as compared to the traditional 3D CAD software

tools.Catia is back up for various stages of product development which includes computer aided design, manufacturing, engineering etc. and also denoted to 3D product lifecycle management software suite. It provides all kinds of positive facilities in the fields like plant design, automotive, defence, aerospace and in some management areas. In catia we are creating 3D parts from sketches with respect to given dimensions.

ABAQUS:

Abaqus is a one of the most controlling engineering program which is centred by the finite element method, that have capability to solve all kind of problems ranging from modest linear analyses to the most interesting nonlinear analyses occurring in engineering field. It is combination of three main stages and they are pre-processing, simulation and post processing. Abaqus is able to model any geometry as well as can simulate the behaviour of any engineering materials. It is widely used to find solutions in the areas like structural, fluid dynamics, soil mechanics, heat transfer and thermal components etc. The role of abaqus in linear and non-linear analysis is very important especially in non-linear analysis it chooses an appropriate values of load and tolerance very neatly and automatically.

III. Modelling Of Flywheel

Modelling plays very important role in design and it's a first step to move to the analysis. Model of a flywheel is created based on geometry assigned and it is shown below. Mainly two types of models are used for analysis and they are 2-D modelling and 3-D modelling. These 2-D modelling and 3-D modelling are differ by memory they consume and accuracy. For the accurate results flywheel is given in 3-D model which is shown below.

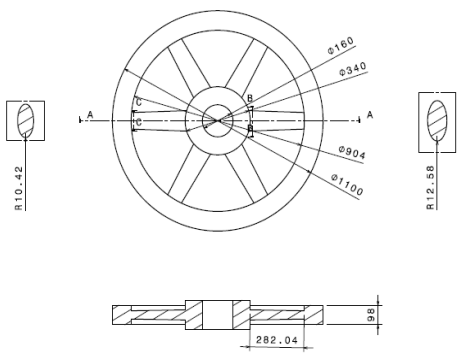

Fig 2: Geometry of flywheel

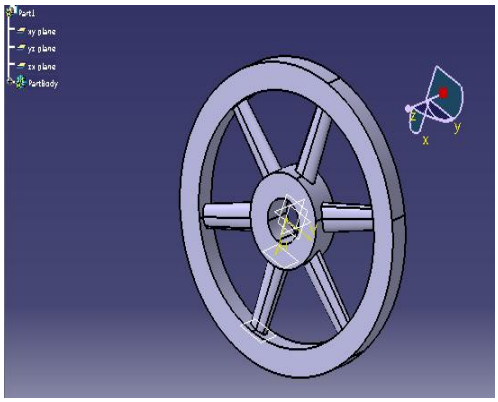

Fig 3: Flywheel 3-D model

IV. Flywheel Analysis

4.1. Material Properties

The properties of two materials are given below.

Material	Young's modulus€	Density	Poisons ratio
Grey cast iron	101e3	7.5	0.23
Aluminium MMC's(test material)	80.23e3	2.56	0.33

Table 1: Material properties

4.2. Element Type

It is pertaining to the element solid 72, a 3dimension 8-noded tetrahedral structural solid with rotation is used for meshing, depends upon the attention for rotational deformations in the flywheel. Mainly the element is defined by 8 Nodes with 6 DOFs at each node which will be well proper solution to produce uneven meshes. Abaqus programme controls the problem occurring with elements.

Element type (# elements)
C3D8R : (57120),

Table 2: Element type

4.3. Meshing Method

Mainly in finite element methods there is a reduction of degrees of freedom from infinite to finite which is called as meshing. For structural analysis quad and hex are preferred over tetras, pentas. Here geometry size and shape have more values for meshing purpose. The meshing related diagrams are given below as per the nodes and elements chosen. Mesh is defined as a discrete representation of some spatial domain. We have structural, unstructural, conformal mesh and hanging nodes.

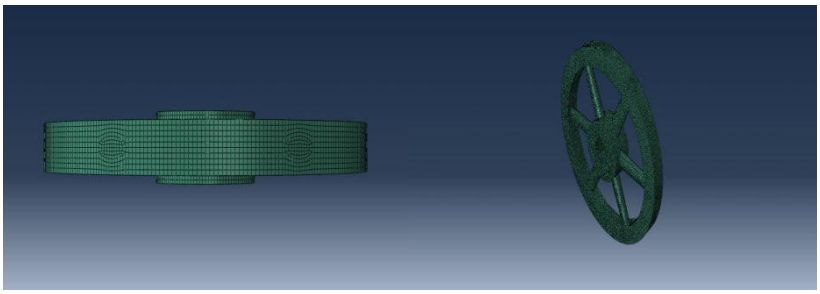

Fig 4: Top view

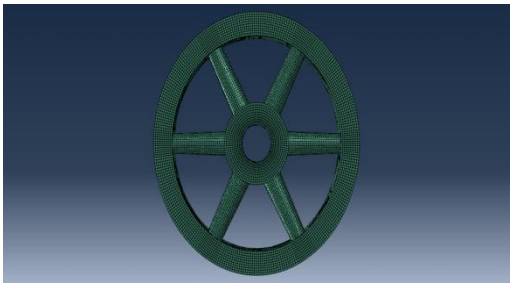

Fig 5: Isoview

Fig 6: Front view

4.4. Boundary Conditions and Loads

In boundary condition all the six degrees of freedom are taken into account as region of a part selected is based on angle and boundary condition type is displacement/rotation . As per the load consideration here rotational body force is selected with angular velocity.

V. Results And Discussions

A static analysis is performed on flywheel and determining stress and deformation. The below table shows the discretisation of Flywheel into 57120 elements and 68214 nodes.

Instance Name	# Elements	# Nodes
FLYWHEEL	57120	68214

Table 3: discretisation of Flywheel

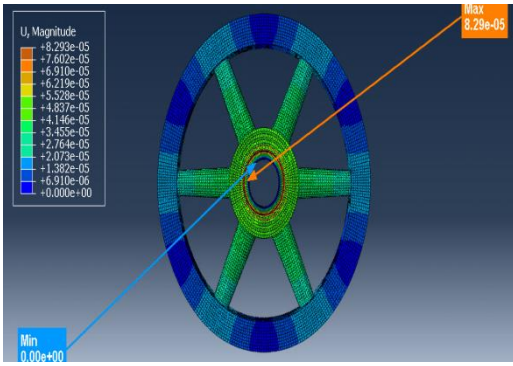

Fig 7: total deformation

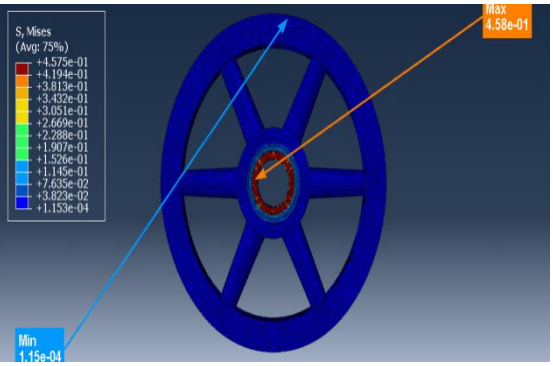

fig 8: normal stress

5.1. Comparison of Results by Abaqus

Material used	Normal stress (Mpa)	Total deformation (m)
Test material	4.58e-01	8.29e-05
Grey cast iron	44.07	5.3399*e-04

Table 4: result comparisons

VI. Conclusion

Thus we can conclude based on the work we carried out for a flywheel and the results what we got from design and analysis methods that for energy storage low density and high strength is required in turns stress and deformation should be low. So it is clear that, the existing grey cast iron flywheels are having more Stress and deformation whereas the test material is comparatively low. Therefore the test material (aluminium MMC's) can be used in flywheel for high energy storing purpose with low density and less mass.

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