DESIGN EVALUATION OF FLYWHEEL USED IN DIESEL ENGINE CAR FOR VARIABLE TORQUE LOAD

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ABSTRACT: 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.Countering the requirement of smoothing out the large oscillations in velocity during the cycle of a mechanism system, a flywheel is designed and analyzed. Firstly, based on the dynamic function specifications of the system, the main features of the flywheel have been initially determined in a traditional way. Then, the finite element dynamic analysis of a flywheel have been carried out to get superior performances.The geometrical modeling is to done in Pro/E and Analysis is to done by using Ansys.

***Keywords*- PRO-E & ANSYS.**

I INTRODUCTION:

Modern technology has enabled a new application for the age old flywheel in advanced flywheel energy storage systems. Flywheel energy storage systems store kinetic energy in the form of a rotating flywheel typically made of composite materials. These systems are often called mechanical batteries since electrical energy is input, stored as rotational mechanical energy, and converted back to electrical energy to provide power on demand. The basic components of a typical system include a composite flywheel, vacuum and safety containment, magnetic bearings, motor / generator, and electronics for control and power conversion. Advances in magnetic bearings, power electronics, and composites have allowed flywheel energy storage systems to surpass electrochemical batteries in terms of achievable energy density, power density, and number of discharge cycles. This is crucial in space applications where weight and longevity is of great concern. Significant research has been performed to optimize and demonstrate the technology can work. However, when failure occurs in these flywheels the energy is released almost instantaneously and can be catastrophic. Containment and health monitoring has now become a significant issue as these energy storage units are being incorporated into other systems where a failure must be avoided, or at a minimum contained (Space station, hybrid vehicles, etc). The complete containment of a composite flywheel burst requires a heavy structure and eliminates any advantage of the flywheel unit in terms of energy density. Real time heath monitoring is a viable alternative that may allow reduction of the containment requirements.

NASA Glenn Research Center (NASA-GRC) expressed a need for a means to monitor the health of a composite flywheel constructed of concentric preloaded composite rings. In response, the University of Texas Center for Electromagnetic (UT-CEM) designed a flywheel that exhibits a change in mass eccentricity when fatigue, thermal expansion, or other phenomena cause a loss in preload of the outer ring. The design is such that the outer ring of the flywheel is only bonded to next inner ring on 180 degrees of the contact area. As a result, centripetal acceleration causes the outer ring to grow asymmetrically if the preload is lost. The existence of preload or compression between the rings is important since it provides the structural integrity of the flywheel. The outer ring preload is designed to be maintained to just above maximum operating speed. Therefore, the asymmetric growth would only be sensed in the operating speed range if the preload was reduced. The most notable factor that would cause a reduction in the preload is fatigue. Fatigue in the composite material causes a reduction in the ring hoop stiffness which in turn reduces the preload

II LITERATURE REVIEW:

Research regarding the health monitoring of composite flywheels is just beginning as energy storage units are beginning to be incorporated into practical applications. Most of the research conducted so far has focused on predicting and detecting the severity of flaws in the flywheel during operation. Fisher and Lesieutre [1] propose health monitoring by detecting small changes in the balance state due to various types of flaws that can occur in composite flywheels. An experimental apparatus was constructed consisting of a rotor supported by ball bearings and attached to the housing via an array of springs to provide a low stiffness. Initially, bench top experiments are conducted to characterize the unbalance response to each type of flaw. The flaws are simulated using tape and small masses that are released from the flywheel at speeds up to 10,000 Rpm. The resulting changes in unbalance are detected using position sensors that monitor the rotor hub and rim. Based on the data collected a controller was also developed to evaluate the severity of flaws and de-rate the maximum flywheel operating speed accordingly. Successful detection and operation of the controller was reported for changes in mass eccentricity as small as 10 microns. Shiue,

Lesieutre, and Bakis [2] propose a similar health monitoring scheme in which the balance state is monitored for changes due to small flaws in the flywheel. The influence coefficient method typically used for balancing rotors is employed to describe the balance state. This method essentially relies on an assumption of a linear relationship, described by the influence coefficients, between the rotor vibration measurement and rotor unbalance. The authors propose the use of normalized or speed independent influence coefficients since the flaws are elastic. The relationship between flaw sizes and level of unbalance are derived from a finite element analysis. Test rigs were constructed and small brass pieces used to simulate the predicted levels of unbalance and determine if they could be detected. Mass eccentricity changes as small as 80 microns were successfully detected. Further research by the authors includes the use of fracture mechanics to determine the growth rate and severity of flaws [3]. The research presented here is differentiated from prior research by the mechanism that generates the unbalance. In this case, the UT-CEM flywheel generates an unbalance due to degraded material properties that could lead to the flaws described above in prior research.

III METALS AND ALLOYS:

3.1: Metals:

A metal is a material that is typically hard, opaque, shiny, and has good electrical and thermal conductivity. Metals are generally malleable that is, they can be hammered or pressed permanently out of shape without breaking or cracking as well as fusible and ductile. Metals in general have high electrical conductivity, high thermal conductivity and high density. Mechanical properties of metals include ductility, i.e. their capacity for plastic deformation. Reversible elastic deformation in metals can be described by Hooke's Law for restoring forces, where the stress is linearly proportional to the strain. Forces larger than the elastic limit, or heat, may cause a permanent (irreversible) deformation of the object, known as plastic deformation or plasticity.

3.2 Alloys:

An alloy is a mixture of two or more elements in which the main component is a metal. Most pure metals are either too soft, brittle or chemically reactive for practical use. Combining different ratios of metals as alloys modifies the properties of pure metals to produce desirable characteristics. The aim of making alloys is generally to make them less brittle, harder, resistant to corrosion, or have a more desirable color and luster of all the metallic alloys in use today, the alloys of iron make up the largest proportion both by quantity and commercial value. Iron alloyed with various proportions of carbon gives low, mid and high carbon steels, with increasing carbon levels reducing ductility and toughness. The addition of silicon will produce cast irons, while the addition of chromium, nickel and molybdenum to carbon steels results in stainless steels. Other significant metallic alloys are those of aluminium, titanium, copper and magnesium. Copper alloys have been known since prehistory bronze gave the Bronze Age its name and have many applications today, most importantly in electrical wiring. The alloys of the other three metals have been developed relatively recently; due to their chemical reactivity they require electrolytic extraction processes. The alloys of aluminium, titanium and magnesium are valued for their high strength-to-weight ratios; magnesium can also provide electromagnetic shielding. These materials are ideal for situations where high strength toweight ratio is more important than material cost, such as in aerospace and some automotive applications.Alloys specially designed for highly demanding applications, such as jet engines, may contain more than ten elements.

IV MODELLING

4.1 Introduction to CAD

Computer Aided Design (CAD) is the use of wide range of computer based tools that assist engineering, architects and other design professionals in their design activities. It is the main geometry authoring tool within the product life cycle management process and involves both software and sometimes special purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design modeless.

4.2 Introduction to Pro/E:

PRO/E is the industry's de facto standard 3D mechanical design suit. It is the world's leading **CAD/CAM /CAE** software, gives a broad range of integrated solutions to cover all aspects of product design and manufacturing. Much of its success can be attributed to its technology which spurs its customer's to more quickly and consistently innovate a new robust, parametric, feature based model. Because that ***PRO/E*** is unmatched in this field, in all processes, in all countries, in all kind of companies along the supply chains.***PRO/E*** is also the perfect solution for the manufacturing enterprise, with associative applications, robust responsiveness and web connectivity that make it the ideal flexible engineering solution to accelerate innovations. ***PRO/E*** provides easy to use solution tailored to the needs of small medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly. Electrical and electronics goods, automotive, aerospace, shipbuilding and plant design. It is user friendly solid and surface modeling can be done easily.

4.3 MODELLING :

Modeling of roller conveyor system is done in Pro/E :

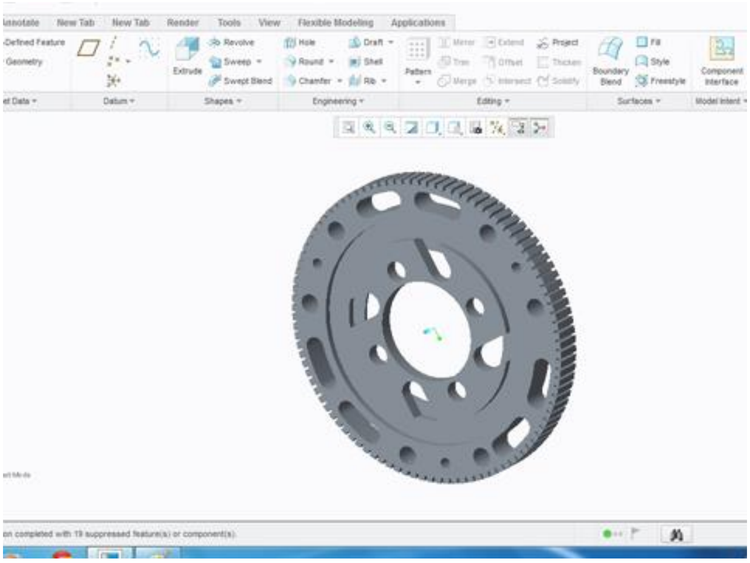

Fig 4.1 Fly wheel-3D

V ANALYSIS

The finite element method is numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in almost every industry. In more and more engineering situations today, we find that it is necessary to obtain approximate solutions to problem rather than exact closed form solution. It is not possible to obtain analytical mathematical solutions for many engineering problems. The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has been developed simultaneously with the increasing use of the high- speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problem, started in terms of different equations

Static Structural Analysis:

A structural model which created can be use 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 non linear. Nonlinearities can include plasticity, stress stiffening, large deflection, large strain, contact surfaces, and creep.

Procedure of static analysis consists of these tasks:

1. Build the model
2. Set Solution Controls
3. Set Additional solution options
4. Apply Loads
5. Solve the Analysis
6. Review the Results

Structural Analysis:

Importing the Model:

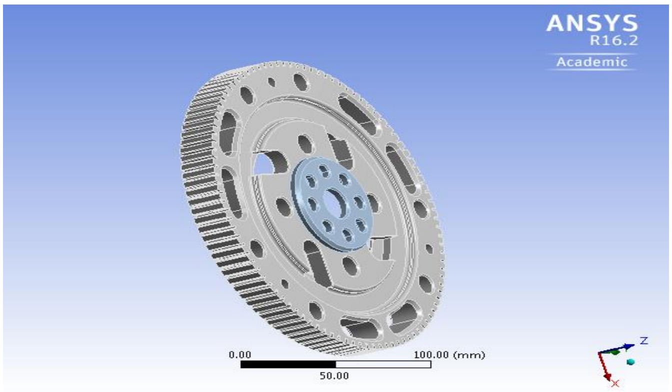

Fig 5.1 Importing Geometry

Meshing the model

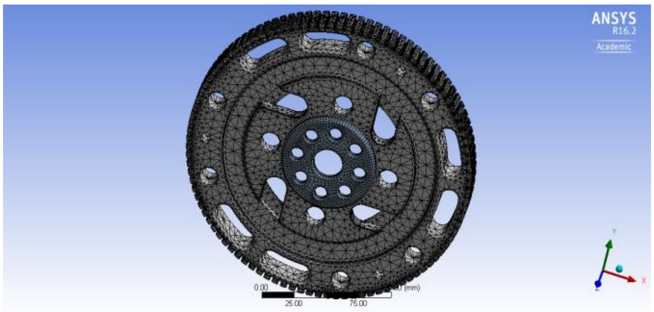

Fig 5.2 Mesh generation

Structural Analysis Results:

CASE1: STRUCTURAL STEEL

Young's Modulus : 2×10^{005} Mpa
Poisson's Ratio : 0.3
Density : 7.85×10^{-006} Kg/mm3
Tensile Ultimate Strength : 460 Mpa

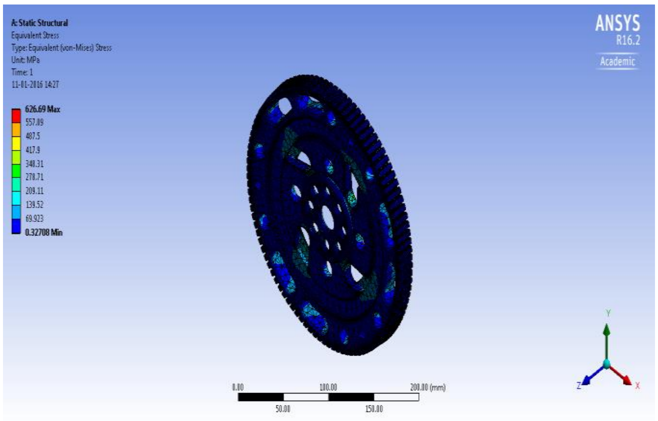

Fig 5.3 Equivalent Stress

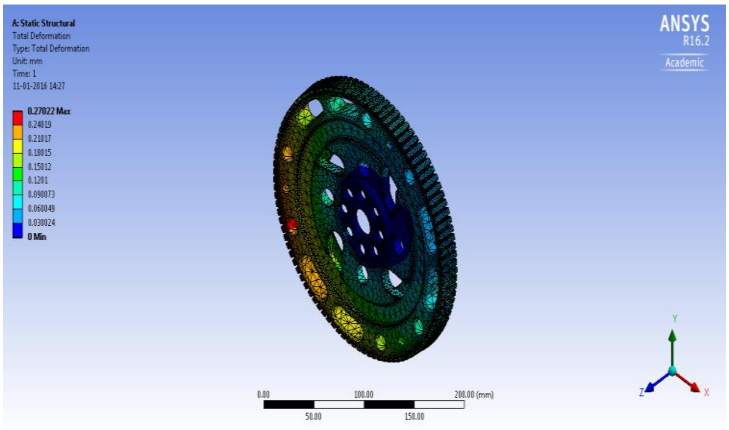

Fig 5.4 Total Deformation

Case2: Magnesium Alloy

Young's Modulus : 45000 MPa
Poisson's Ratio : 0.35
Density : 1.85×10^{-006} Kg/mm3
Tensile Ultimate Strength : 255 Mpa

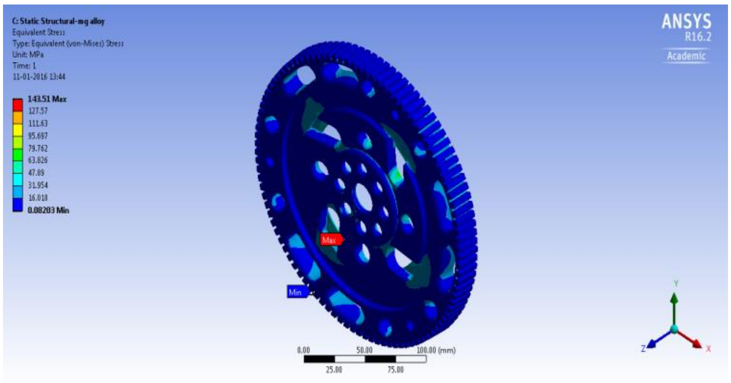

Fig 5.5 Equivalent Stress

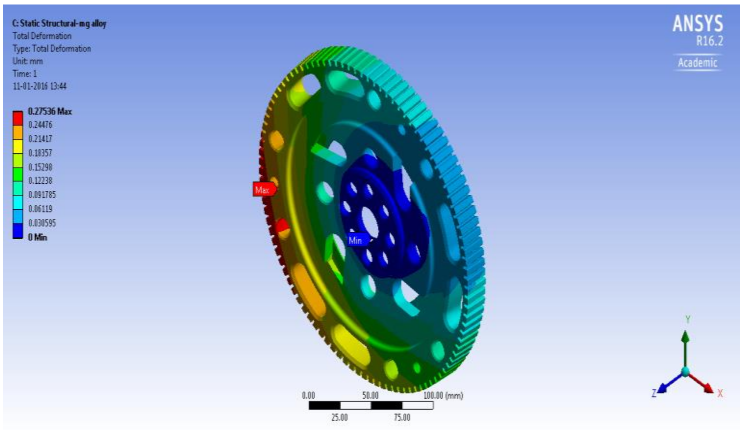

Fig 5.6 Total Deformation

Case3: Titanium Alloy

Young's Modulus	: 96000 MPa
Poisson's Ratio	: 0.36
Density	: 4.62×10^{-006} Kg/mm3
Tensile Ultimate Strength	: 1070 Mpa

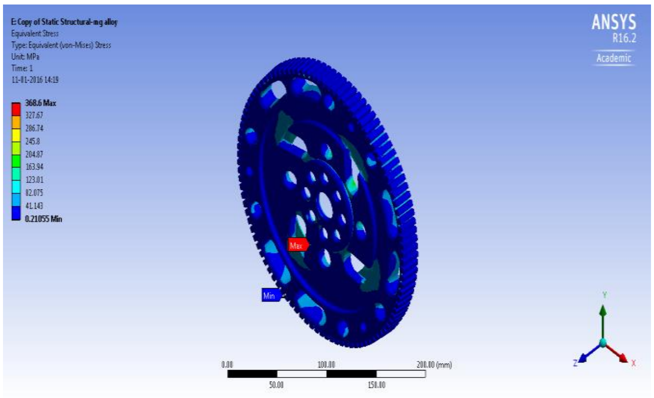

Fig 5.7 Equivalent Stress

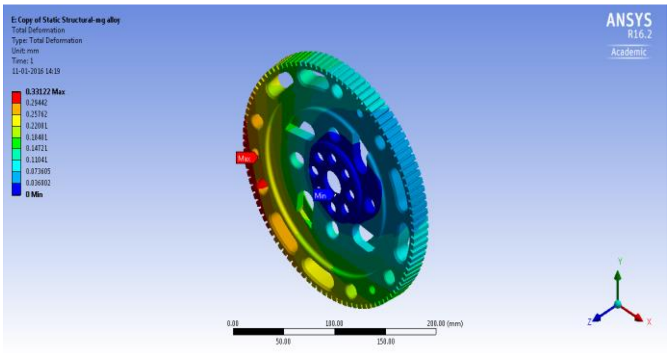

Fig 5.8 Total Deformation

VI RESULTS AND DISCUSSIONS

After conducting the static structural analysis on three different materials, the results of total deformation and von-mises stresses are given below:

- The stress and deformation for the material Structural Steel are 626.69 Mpa and 0.27822 mm.
- The stress and deformation for the material Magnesium Alloy are 143.51 Mpa and 0.27536 mm.
- The stress and deformation for the material Titanium Alloy are 368.6 Mpa and 0.33122 mm.

VII CONCLUSIONS

Based on the above work of flywheel the following conclusion can be drawn. It is clear that, Stain less steel and Titanium alloy flywheels are having higher Stress and deformation than Magnesium alloy. Therefore Magnesium alloy can be used in flywheels to store energy with less mass. It can be also used in high speed applications.

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