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Research Paper

ANALYSIS AND OPTIMIZATION OF FLYWHEEL

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In present investigation, to counter the requirement of smoothing out the large oscillations in velocity during a cycle of a mechanism system, a flywheel is designed, optimized and analyzed. By using optimization technique various parameter like material, cost for flywheel can be optimized and by applying an approach for modification of various working parameter like efficiency, output, energy storing capacity, we can compare the result with existing flywheel result. Based on the dynamic functions, specifications of the system the main features of the flywheel is initially determined, the detail design study of flywheel is done. Then FEA ANALYSIS for more and more designs in diverse areas of engineering are being analyzed through the software. FEA provides the ability to analyze the stresses and displacements of a part or assembly, as well as the reaction forces other elements are to impose. This thesis guides the path through flywheel design, and analysis the material selection process. The FEA model is described to achieve a better understanding of the mesh type, mesh size and boundary conditions applied to complete an effective FEA model. At last the design objective could be simply to minimize cost of flywheel by reducing material.

Keywords: Flywheel, Optimization design, Analysis, Finite Element Analysis (FEA)

INTRODUCTION

The concept of a flywheel is as old as the axe grinder's wheel, but could very well hold the key to tomorrow's problems of efficient energy storage. The flywheel has a bright outlook because of the recent achievement of high specific energy densities. A simple example of a flywheel is a solid, flat rotating disk. David Eby, R. C. Averill explained the term shape optimization with the help of genetic algorithm.

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 fly wheel is to smoothen out variations in the speed of a shaft caused by torque fluctuations. If the source of the driving torque or load

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torque is fluctuating in nature, then a flywheel is usually called for. Many machines have load patterns that cause the torque time function to vary over the cycle. 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 fly wheel.

This chapter steps through various approaches that have been designed to analyze and optimize flywheels. The flywheel is modeled as a series of concentric rings through the software. The thickness within each ring varies linearly in the radial direction. A diverse set of material choices is provided for each ring. A planar finite element model used to represent a flywheel, in which symmetry about the transverse normal direction and about the axis of rotation is used to increase computational efficiency. The structural analysis and shape optimization through ANSYS software is done.

MATERIALS AND METHODS

Material Properties

Due to its high density, low cost and excellent machinability, gray cast iron ASTM 30 is used to make the flywheel, whose properties are listed in Table 1.

Table 1: Material Properties

Material, class, specification	Gray cast iron, ASTM 30, SAE 111
Ultimate strength	Tension, Sut = 214 Mpa; Shear sut = 303 MPa
Torsional/Shear strength	276 MPa
Modulus of elasticity	Tension, E = 101 GPa; Shear, G = 41 GPa
Density	7510 kg/m^3
Poisson's ratio	0.23

Research Methodology

- Modelling (Figure 1)

  Modelling in CATIA software

  Flywheel is constructed in CATIA software

  Assembly-flywheel of MARUTI-Omni

- Analysis

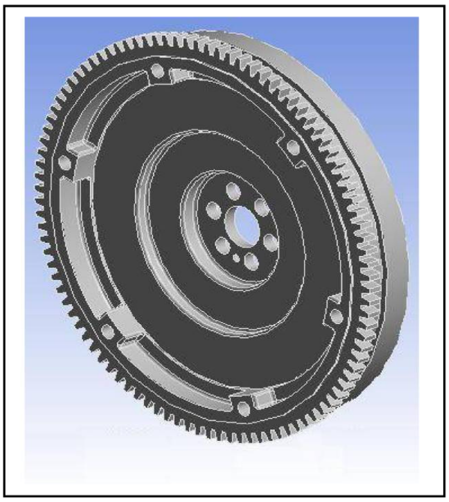
  ANSYS-structural analysis

  FEA analysis is done in ANSYS

  Stresses and Total deformation is shown in this software.

- Optimization

Figure 1: Modelling of Flywheel



MODELLING OF FLYWHEEL

Specification

Model-MARUTI SUZUKI OMNI

Maximum power – 33.3 ps@5000 rpm

Maximum torque – 57 Nm@2500 rpm

Capacity – 796 cc

STRUCTURAL ANALYSIS

Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behavior of structures. From a theoretical perspective the primary goal of structural analysis is the computation of deformations, internal forces and stresses. In practice, structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

It includes the following methods,

- Analytical methods
- Strength of materials methods (classical methods)
- Elastic methods
- Finite Element Methods (FEM)

FEA

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively.

The ANSYS CAE (Computer-Aided Engineering) software program was used in conjunction with 3-D CAD (Computer-Aided Design) solid geometry to simulate the behavior of mechanical bodies under thermal/ structural loading conditions.

Element Type

Based on the consideration of rotational deformations in the flywheel, the element Soilid72, a 3-D 4-node tetrahedral structural solid with rotations, is used to model meshes. The element is defined by 4-nodes with 6 DOFs at each node and well suitable to create irregular meshes. It also has stress stiffening capability.

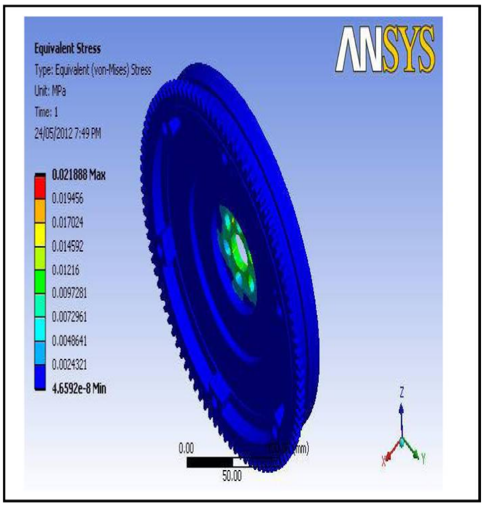
Meshing Method

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.

RESULTS AND DISCUSSION

With the help of ANSYS Software flywheel is descretized into 50658 nodes and

Figure 2: Meshing and Equivalent Stresses in Flywheel



28038 elements with free meshing. Then in the structural analysis the maximum equivalent (von-mises) stresses, normal stresses, shear stresses and total deformation at loading conditions are shown in Figure 2.

SHAPE OPTIMIZATION

At last through the software for reduction of 1kg weight 20% material can be removed from the periphery of the flywheel (Table 2).

CONCLUSION

After completion of the analysis in CAE software i.e. ANSYS 11.0 based on the values of Equivalent stresses for material loading conditions it is clearly seen that these are less than the allowable stresses for that particular material under applied conditions the part not going to yield and hence the design is safe.

Table 2: Model > Shape Optimization > Solution > Results

Object Name	Shape Finder
State	Solved
Scope	
Geometry	All Bodies
Definition	
Target Reduction	20%
Results	
Original Mass	5.5006 kg
Optimized Mass	4.4004 kg
Marginal Mass	0.0000 kg

Table 3: Comparison of Result by ANSYS

Quantity	Gray Cast iron	Aluminium Alloy
Equivalent (von-mises) stress, MPa	0.02189	0.02164
Normal stress, MPa	0.003073	0.003591
Shear stress, MPa	0.001474	0.001556
Total deformation, mm	1.419×10^{-5} mm	2.24×10^{-5} mm

The result occurred are quiet favourable which was expected. The stresses as well as deformation clear the idea about what parameter should have been taken into account while defining the flywheel.

The result observed carefully, the normal stress obtained for the gray cast iron is 0.003073 MPa similarly for the Aluminium Alloy it is 0.003591 MPa.Similarly the shear stresses obtained for the gray cast iron is 0.001474 MPa and for the Aluminium Alloy it is 0.001556 MPa, which shows that the Gray Cast Iron is the more suitable one (Table 3).

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