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Analysis of Flywheel Used in Petrol Engine Car

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Abstract: - **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. For example, in I.C. engines, the energy is developed only in the *power* stroke which is much more than engine load, and no energy is being developed during the suction, compression and exhaust strokes in case of four stroke engines. The excess energy is developed during power stroke is absorbed by the flywheel and releases its to the crank shaft during the other strokes in which no energy is developed, thus rotating the crankshaft at a uniform speed. The flywheel is located on one end of the crankshaft and serves two purposes. First, through its inertia, it reduces vibration by smoothing out the power stroke as each cylinder fires. Second, it is the mounting surface used to bolt the engine up to its load. The aim of the project is to design a flywheel for a multi cylinder petrol engine flywheel using the empirical formulas. A 2D drawing is drafted using the calculations. A parametric model of the flywheel is designed using 3D modeling software Pro/Engineer. The forces acting on the flywheel are also calculated. The strength of the flywheel is validated by applying the forces on the flywheel in analysis software ANSYS. Structural analysis, modal analysis and fatigue analysis are done on the flywheel. Structural analysis is used to determine whether flywheel withstands under working conditions. Fatigue analysis is done for finding the life of the component. Modal analysis is done to determine the number of mode shapes for flywheel Analysis is done for two materials Cast Iron and Aluminum Alloy A360 to compare the results. Pro/ENGINEER is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design. ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements.**

INTRODUCTION:

A flywheel is a mechanical device with a significant moment of inertia used as a storage device for rotational energy. Flywheels resist changes in their rotational speed, which helps steady the rotation of the shaft when a fluctuating torque is exerted on it by its power source such as a piston-based (reciprocating) engine, or when an intermittent load, such as a piston pump, is placed on it. Flywheels can be used to produce very high power pulses for experiments, where drawing the power from the public network would produce unacceptable spikes. A small motor can accelerate the flywheel between the pulses. Recently, flywheels have become the subject of extensive research as power storage devices for uses in vehicles and power plants.

Akshay P. Punde & G.K.Gattani [1] have proposed, to counter the requirement of smoothing out the large oscillations in velocity during a cycle of a I.C. Engine, a flywheel is designed, and analyzed by using FEA technique and also calculated the stresses inside the flywheel and compared the Design and analysis result with existing flywheel

JohnA.Akpobi & ImafidonA.Lawani [2] have proposed, a computer-aided-designs of software for flywheels using object-oriented programming approach of Visual Basic. The various configurations of flywheels (rimmed or solid) formed the basis for the development of the software. The software's graphical features were used to give a visual interpretation of the solutions. The software's effectiveness was tested on a number of numerical examples, some of which are outlined in this work.

Sushama G Bawane, A P Ninawe and S K Choudhary have proposed [3] flywheel design, and analysis of 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.

Saeed Shojaei , Seyyed Mostafa Hossein Ali Pour Mehdi Tajdari Hamid Reza Chamani [4] have proposed algorithms based on dynamic analysis of crank shaft for designing flywheel for I.C.engine , torsional vibration analysis result by AVL\EXCITE is compared with the angular displacement of a desire free haed of crank shaft ,also consideration of fatigue for fatigue analysis of flywheel are given.

Sudipta Saha, Abhik Bose, G. SaiTejesh, S.P. Srikanth have propose [5] the importance of the flywheel geometry design selection and its contribution in the energy storage performance. This contribution is demonstrated on example cross-sections using computer aided analysis and optimization procedure. Proposed Computer aided analysis and optimization procedure results show that smart design of flywheel geometry could both have a significant effect on the Specific Energy performance and reduce the operational loads exerted on the shaft/bearings due to reduced mass at high rotational speeds.

Bedier B. EL-Naggar and Ismail A. Kholeif [6] had suggested the disk-rim flywheel for light weight. The mass of the flywheel is minimized subject to constraints of required moment of inertia and admissible stresses. The theory of the rotating disks of uniform thickness and density is applied to each the disk and the rim independently with suitable matching condition at the junction. Suitable boundary conditions on the centrifugal stresses are applied and the dimensional ratios are obtained for minimum weight. It is proved that the required design is very close to the disk with uniform thickness.

Problem Modelling:

The flywheel of the car was modeled using Pro/ENGINEER version through reverse engineering technique. The flywheel was discredited using hexahedral dominant elements. The 3D CAD model was imported into ANSYS 11.0 in and meshed using 3D solid element

SPECIFICATIONS OF SELECTED ENGINE:

Model: maruti zen estilo L× I
Displacement = 1061CC
Power = 64@ 10000 (ps @rpm)= 64ps=64× 735.4988 = 47071.9232watts
Torque = 84 23500 (N m @ rpm)
Number of cylinder = 4
Bore = 68.5mm
Stroke = 72mm
Compression ratio = 9:1
Volume per cylinder = 265.25CC
Expression for rotational energy is

$$E_k = \frac{1}{2} I \omega^2$$

Where

ω is the angular velocity, and
I is the moment of inertia of the mass about the center of rotation

Dimensions of the flywheel selected:

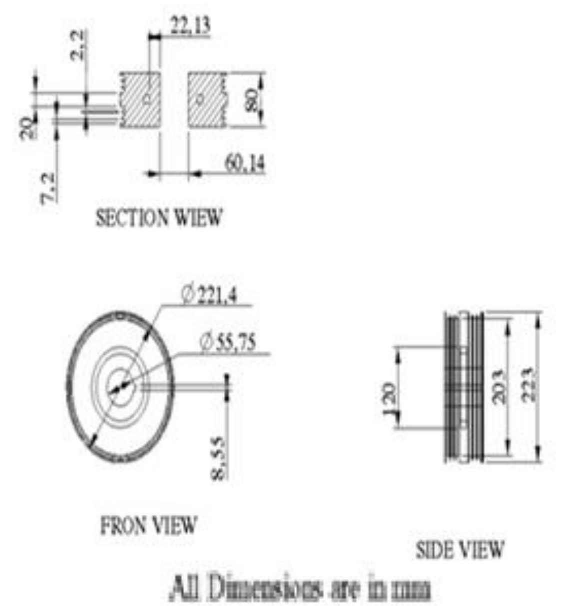

Fig-1: flywheel geometry

ELEMENT TYPE:

Linear Solid (Solid 20)
tetrahedral Dominant
No. of Nodes – 23950

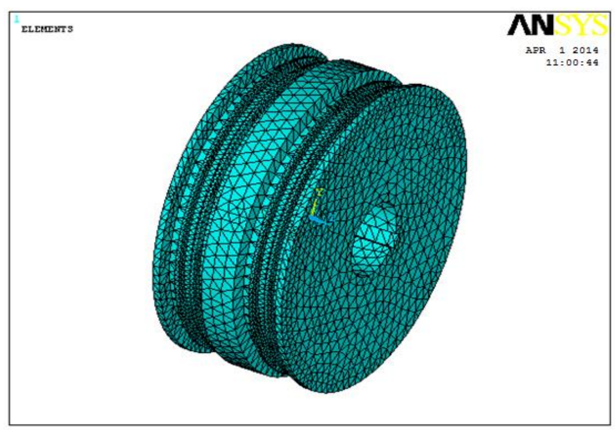

Fig-2:Full Meshed Model of flywheel

LOADING:

Pressures(N/mm^2): 0.64398e-01 ,0.86604e-01, 0.19221 ,0.25849 ,0.51714e-01, 0.69546e-01.

BOUNDARY CONDITIONS:

In order to carry out the static structural analysis the flywheel was constrained at the crankshaft end for all degrees of freedom. A frictional support was given at the keyways which subjected to both the crushing and shear loads. And the different pressures as given above were applied at the selected nodes in different areas.

MATERIAL PROPERTIES:

For Cast Iron
Young's Modulus (EX) : 103000N/mm^2
Poisson's Ratio (PRXY) : 0.211
Density : 0.0000071 kg/mm^3

For Aluminum Alloy(A360)
Young's Modulus : 80000N/mm^{2}Poissons Ratio (PRXY) : 0.33
Density : 0.00000268 kg/mm^3

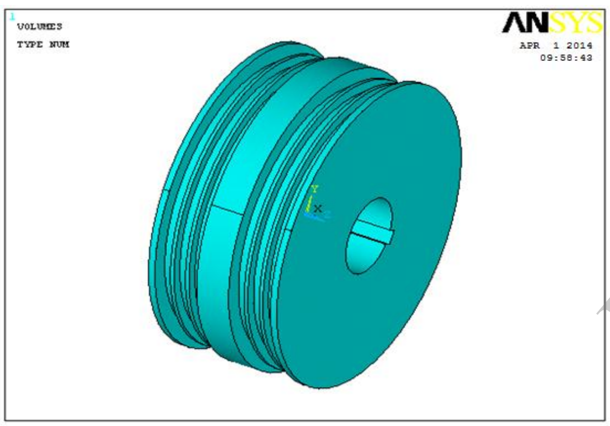

Fig-3: 3D model of the flywheel

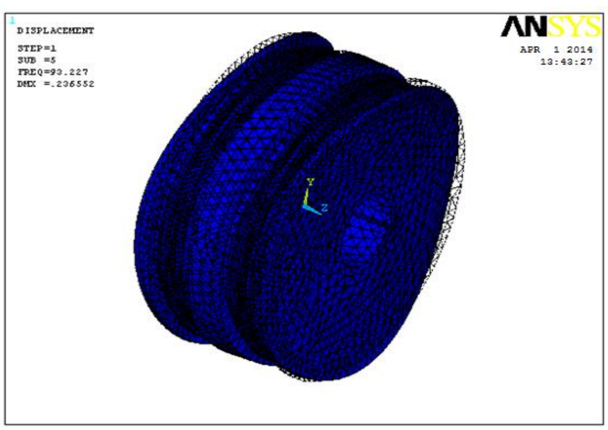

Fig-4: Deformation plot of the flywheel

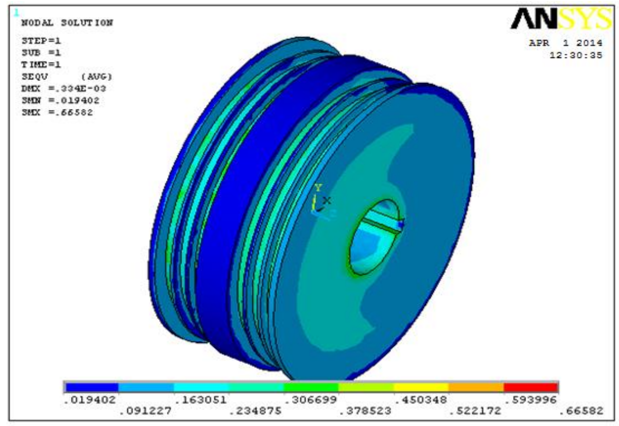

Fig-5: principle Stress plot

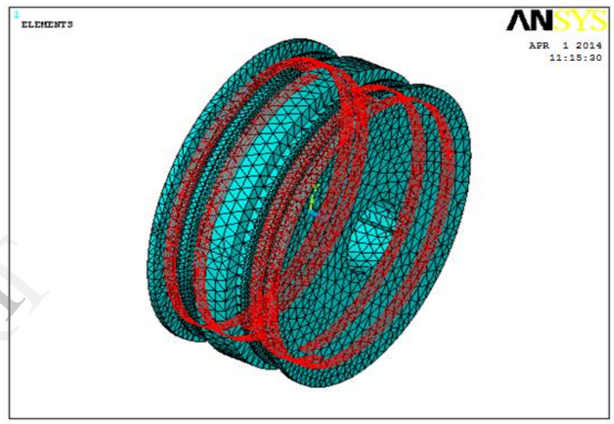

Fig-6:pressure applied regions

RESULTS AND DISCUSSIONS:

From the following tables we can observe that the deflection in the A360 alloy flywheel is less as compared to the existed Cast Iron flywheel as well as the vonmises stresses also decreased in the A360 alloy as compared to the existed Cast Iron flywheel. And also we got the frequencies and displacements at different nodes which gives different mode shapes.

STRUCTURAL ANALYSIS RESULTS:

	RESULTS	PERMISSIBLE
DISPLACEMENT (mm)	$0.300e^{-3}$	
VONMISES STRESS (N/mm^2)	0.602591	344
	Frequency	Displacement
MODE 01	62.993	0.183335
MODE 02	91.32	0.32203
MODE 03	92.659	0.290446
MODE 04	101.252	0.250101
MODE 05	130.887	0.374698

FOR CAST IRON

FOR A360 ALLOY

FATIGUE ANALYSIS RESULTS:

	Cast iron	A360 Alloy
Constrained area Event 1 Load1, Event 1 500000cycles Load 2 Event 2 Load1, Event 2 50000cycles Load 2	0.10417/mm^2 0.77463e-01 N/mm^2	0.86604e-01N/mm^2 0.64398e-01 N/mm^2
Pressure area Event 1 Load1, Event 1 500000Cycles Load 2 Event 2 Load1, Event 2 50000cyclesLoad 2	0.17499 N/mm^2 0.13012 N/mm^2	0.25849 N/mm^2 0.19221 N/mm^2

	RESULTS	PERMISSIBLE
DISPLACEMENT (mm)	$0.334e^{-3}$	
VONMISES STRESS (N/mm^2)	0.66582	620
	Frequency	Displacement
MODE 01	45.254	0.111115
MODE 02	63.595	0.20176
MODE 03	54.501	0.181312
MODE 04	69.819	0.159127
MODE 05	93.227	0.266552

Open area Event 1 Load1, Event 1 500000cycles Load 2 Event 2 Load1, Event 2 50000cyclesLoad 2	0.17018 N/mm^2 0.12654 N/mm^2	0.6954e-01 N/mm^2 0.51714e-01 N/mm^2

CONCLUSION:

In this paper we have designed a four wheeler flywheel used in a petrol engine using theoretical calculations. 2d drawing is created and modeling of flywheel is done using Pro/Engineer. We have done structural and modal analysis on flywheel using two materials Aluminum Alloy

A360 and Cast Iron to validate our design. By observing the results, for all the materials the stress values are less than their respective permissible yield stress values. So our design is safe. We have also done modal analysis for number of modes to see the displacement of flywheel for number of frequencies. By comparing the results for two materials, the stress value for Aluminum Alloy A360 is less than that of Cast Iron. So we conclude that for our design, Aluminum A360 is better material for flywheel. By using Aluminum A360 we can reduce Weight. Also it is rust free

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