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DESIGN AND ANALYSIS OF LIGHT WEIGHT MOTOR VEHICLE FLYWHEEL

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ABSTRACT--- **The net torque imparted to the crankshaft during one complete cycle of operation of engine fluctuates causing a change in the angular velocity of shaft. In order to achieve a uniform torque, an inertia mass in the form of a wheel is attached to the out shaft and the wheel is called the flywheel. The finite element model of flywheel is considered and the analysis is done with the help of ANSYS package. ANSYS is general purpose software, which can be used for almost any type of finite elements analysis virtually in any industry – automobiles, aerospace, railways machinery, electronics, sporting goods, power generation, power transmission and bio-mechanics. General purpose also refers to the fact that software can be used in all disciplines of engineering-structural, mechanical, electrical, electromagnetic, thermal, fluid and bio-medical.**

The project involves the design and analysis of flywheel to minimize the fluctuation in torque, the flywheel is subjected to a constant rpm. The objective of present work is to design and optimize the flywheel for the best material. The flywheel is modeled with solid 95 (3-D element), the modeled analyses using free mesh.The FEM mesh is refined subject to convergence criteria. Preconditioned conjugate gradient method is adopted during the solution and for deflections. Von-misses stress for both materials (mild steel and mild steel alloy) are compared, the best material is suggested for manufacture of flywheel

KEY WORDS: Fly Wheel, PCG method, torque

I. INTRODUCTION

1.1 Introduction:

The Finite Element Method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Finite Element Modeling (FEM) and Analysis (FEA) are the two most popular mechanical engineering applications offered by existing CAD/CAM systems. This is attributed to the fact that the finite element method is perhaps most popular numerical technique for solving problems. The method is general enough to handle any complex shape or geometry, any material property, any boundary conditions, and any loading conditions.

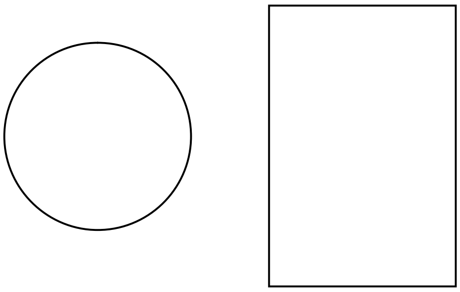
The present project deals with flywheel. A flywheel is generally attached to shaft in order to have uniform torque throughout the shaft. They store energy at some time and give up when desired. So flywheel can be considered as energy reservoir, which gives energy at desired time.

The flywheel is mounted on a shaft of 2-inch diameter. The flywheel is rotating with a mean angular velocity of 281 rpm. The flywheel is analyzed for two materials and compared for the best material.

II. DESIGN OF FLYWHEEL

2.1 Definition of Flywheel

The simple type of flywheel is a solid disk as shown in figure



The mass moment of inertia of the disk is given by

$$I = \frac{mr^2}{2} \text{........ (1)}$$

Where, I = mass moment of inertia of disk

M = mass of the disk

R = outer radius of the disk.

Mass of the disk is given by

$$M = \Pi r^2 t \text{ ...... (2)}$$

Where, t = thickness of the disk

ρ=Mass density of the fly wheel

From (1) & (2)

$$I = \Pi t r^4 \rho$$

There are two principles in the rotating disks. The tangential stress σ_t and radial stress σ_r. The general equations for these stresses at radius r are as follows

$$\sigma_t = \frac{\rho \vartheta^2}{1016(\mu + 3/8)\left[1 - 3\mu + 1/\mu + 3(r/R)^2\right]}$$

$$\sigma_t = \frac{\rho v^2}{106(\mu + 3/8)}\left[1 - (r/R)^2\right]$$

Where, σ_t= tangential stress at radius r

σ_r= radial stress at radius r

μ = Poisson's ratio

ν= Peripheral velocity

The maximum tangential stress & maximum radial stress are equal and both occur at r= 0

Therefore

$$(\sigma_t)_{Max} = (\sigma_r)_{max} = \rho v^2{}_{/106}(\mu+3/8)$$

In the case of disk with a circular hole of radius 'a' at the center. If there are no forces acting on these boundaries we have,

$$(\sigma_r)_{r=a} = 0$$

$$(\sigma_r)_{r=b} = 0$$

It can be seen from the definitions of that when they are independent of they must be equal at the center

Hence the equations are

$$\sigma_t = (3 + \nu/8)\rho\varpi^2(b^2 + a^2 - (a^2b^2/r^2) - r^2$$

$$\sigma_\theta =$$

$$[(3+\nu/8)\rho\varpi^2(b^2+a^2+(a^2b^2/r\ )-(1+3\nu/3+\nu)r^2]$$

III. ANALYSIS OF FLYWHEEL USING ANSYS

I. *Static Analysis For Mild Steel*

4.1.1 Displacements:

In x-direction: fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.126E-05 m and minimum deflection is -0.124E-04m.

In y-direction: fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.904E-04 m and minimum deflection is-0.363E-05m.

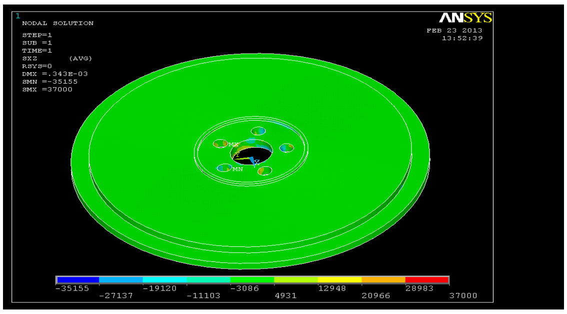
In z-direction: fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.335E-03 m and minimum deflection is -0.336E-03m.

4.3. shear stresses

In xy-plane: fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 126625 N/m^2 and minimum shear stress is-125660 N/m^2.

In yz-plane: fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 40212 N/m^2 and minimum shear stress is -59099 N/m^2

In xz-plane: fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 37000 N/m^2 and minimum shear stress is -35155N/m^2.



4.4 Static Analysis For Mild Steel Alloy

4.4.1 Displacements

In x-direction: fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.161E-06 m and minimum deflection is -0.163E-06m.

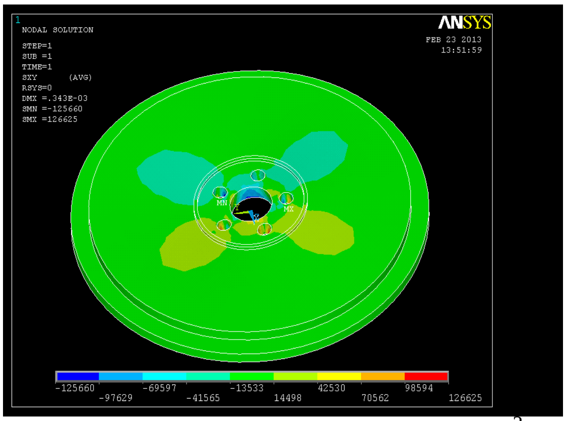
In y-direction: fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.470E-07 m and minimum deflection is -0.117E-05m.

In z-direction:fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.435E-05 m and minimum deflection is -0.434E-05 m.

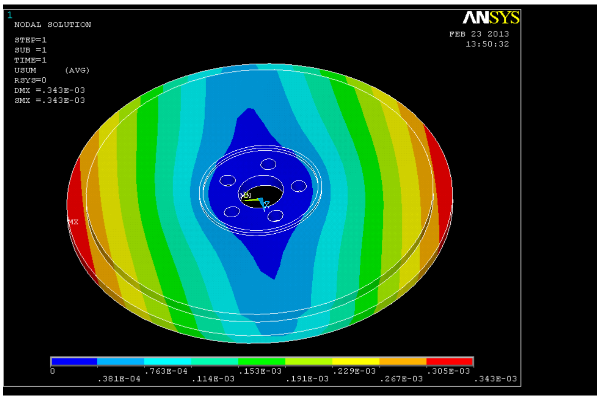
4.4.2 Shear Stresses

In xy-plane: fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 125660 N/m^2 and minimum shear stress is -126625 N/m^2.

In yz-plane: fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 59099 N/m^2 and minimum shear stress is -40212 N/m^2.



In xz-plane: fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 35155 N/m^2 and minimum shear stress is -37000 N/m^2.



4.5 VON MISSES STRESS:

The von misses stress variation in the flywheel is as shown in fig, the maximum von misses stress is found to be 332288 N/m^2 and minimum von misses stress is 688.154 N/m^2.

IV. RESULTS AND DISCUSSIONS

4.1 For Mild steel:

Fig 4.1 Displacement along X-Y-Z Directions

Fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.343E-05 m and minimum deflection is 0 m.

Fig 4.2 Shear Stress along XY- Direction

Fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 126625 N/m^2 and minimum shear stress is -125660 N/m^2.

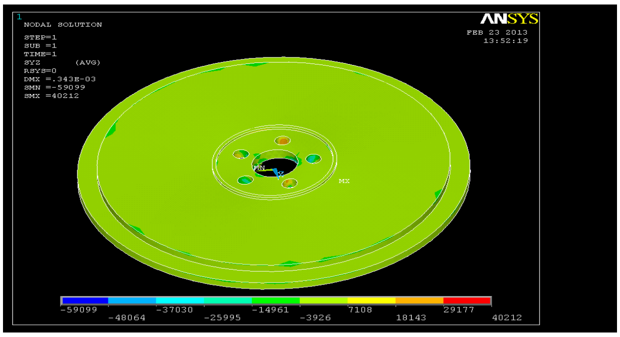


Fig 4.3 Shear Stress along YZ- Direction

Fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 40212 N/m^2 and minimum shear stress is -59099 N/m^2

Fig 4.4 Shear Stress along XZ- Direction

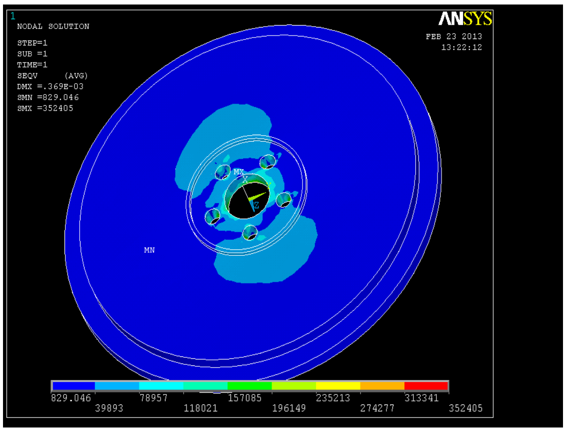


Fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 37000 N/m^2 and minimum shear stress is -35155 N/m^2.

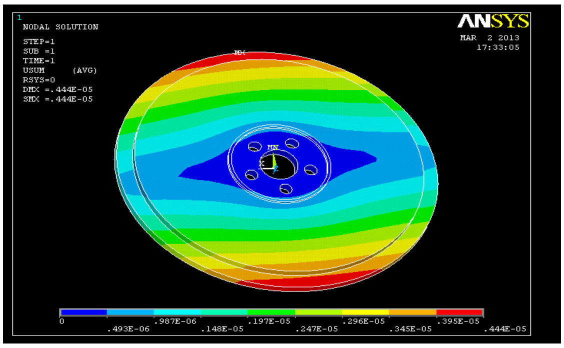


Fig 4.5 Von-Misses Stress developed in the Flywheel

The von misses stress variation in the flywheel is as shown in fig, the maximum von misses stress is found to be 352405 N/m^2 and minimum von misses stress is 829.406 N/m^2.

4.2 For Mild Steel Alloy:

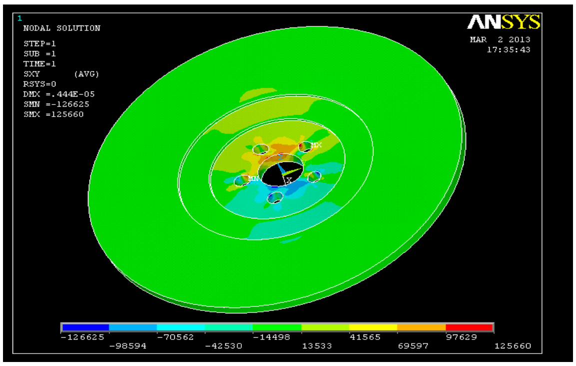


Fig 4.6 Displacements along X-Y-Z Directions

Fig shows the variation in displacement in the flywheel the maximum deflection is found to be 0.444E-05 m and minimum deflection is 0 m.

Fig 4.9 Shear Stress along X-Y Direction

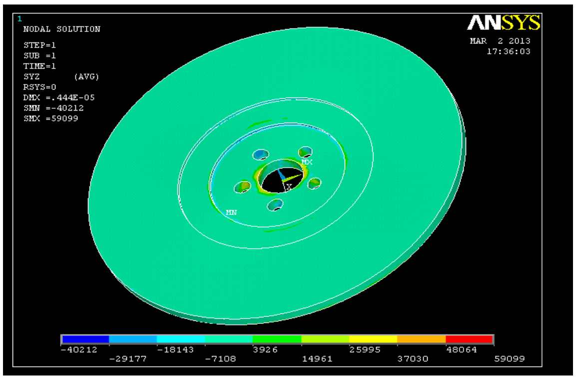


Fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 125660 N/m^2 and minimum shear stress is -126625 N/m^2.

Fig 4.8 Shear Stress along YZ – Direction

Fig shows the variation in the shear stress in the flywheel, the maximum shear stress is found to be 59099 N/m^2 and minimum shear stress is -40212 N/m^2.

V. CONCLUSION

1. The flywheel is modeled with solid elements.
2. To reduce stress and deflection flywheel 40% titanium element is added as alloying element to the mild steel.
3. The maximum deflection of mild steel alloy is 0.444E-05 meters which is less than maximum deflection of mild steel which is found to be 0.369E-03 meters. Thus mild steel alloy is best, from rigidity point of view.
4. Maximum von-misses stress in flywheel is 332288 N/m² for mild steel alloy which is less than the maximum von-misses stress of flywheel which is found to be 352405 N/m². Hence design is much safe based on strength point of view for mild steel alloy than for mild steel.

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