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Abstract. Flywheel is a mechanical device which acts as a saving bank account where one can deposit extra money and withdraws whenever required likewise flywheel also store the energy when the demand is less and deliver it when the demand is high. It is mounted in between driver and the follower. It act as a energy store. This paper is focused on the use of mathematical modeling of flywheel and space optimized design for punching press. Flywheel has to be designed for a punch which has to make 20 holes/minute in a plate of thickness 12 mm with constrained of space. 1200mm is the limiting value of diameter of flywheel. The flywheel design is based on the space limitations. The various parameters and stresses induced are determined. At the end it is seen that diameter of the flywheel is less than the permissible value therefore design is safe and optimized for available space.

Keywords- Rotor, fluctuation of energy, stresses, Flywheel, energy storage capacity, peripheral velocity.

1. INTRODUCTION

Flywheel is a very ancient device used for storing energy and this stored energy could be used for completion of desired task. Size of flywheel was used to design based upon energy storage capacity and the space available. Material was selected using trial and error concept and best option was given a prime importance. Later on it becomes most useful tool for many applications because of uniform and constant torque requirement. Many prime movers generate fluctuating or variable power so applications subjected to vibrations and leads to failure due to fatigue.

In this paper specific flywheel is designed for the space available and so called as space optimized design.

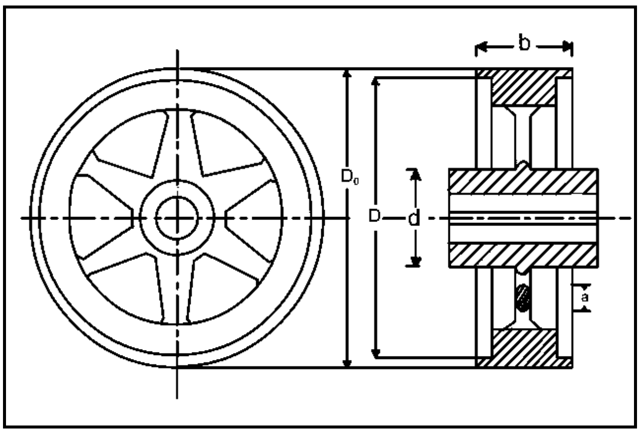

Figure 1 Arm type flywheel

1. LITERATURE REVIEW

G.K.Gattani and Akshay P. Punde, (2013) has used FEA method for analysis. Calculated the Stresses and compared with existing flywheel [1]. Hans Bernhoff, Mats Leijon and Bjorn Bolund.(2007)in this paper author has highlighted role of flywheel other than mechanical aspect that is electromechanical and power electronics .[2] Abhik Bose, Sudipta Saha and G. Sai Tejesh, S.P. Srikanth (2013) with the use of CAD one can optimize design of flywheel . Here it is analyzed for various geometry and best is selected for final application [3]
R. Prasanna Srinivas and M.lavakumar, (2013), in this paper it is suggested that design is can be done by using FEA and ANSYS software[4] A. P. Ninawe and Sushama G Bawane and S. K. Choudhary (2012), author suggested that using FEA technique one can reduce cost of flywheel and save material also.[5] Mofid Mahdi (2011), in this paper it is concluded that energy storage problem is can be solved by using well designed flywheel. Using FEA it can be achieved.[6] Dr. D. V. Bhope and S. M. Dhengle and S. D. Khamankar (2012) using FEA we can find stresses induced in flywheel in various parts like rim arm and hub [7] S. M. Choudhary and D.Y. Shahare, (2013), various geometries and their energy storage capacities are correlated and best geometry could be selected for a specific application. [8] Rathod Balasaheb S and Satish. M. Rajmane (2014), in this paper design of flywheel has been studied and designed for a specific case. A direction for constrained design has been explained in detail.[9]

2. PROBLEM DEFINITION

Design of arm type flywheel for punching press machine with the consideration of space or with the condition that the diameter of flywheel should not exceed 1200 mm. Design flywheel which is used to punch a hole of 28mm, in a 20 mm thickness steel plate .Punch capacity is 24 holes/minute and a speed ratio of 9:1. Dimension, function values and material of flywheel as follows

Dimensions and material condition:

- Diameter limit 1200mm
- Ks = speed fluctuation coefficient: 0.4
- Average speed : 216rpm
- Mass : 106.2kg
- Material : Grey cast iron with density, ρ= 7200kg/m^3

Flywheel design values.

Table: 1 Flywheel details

Flywheel	Total energy (N-m)	Fluctuation of energy (N-m)	Rim velocity (m/s)
Arm type	7139	5711.2	12.08

3. PROCEDURE

Analytical procedure is adapted for design of flywheel

Flywheel Average speed,

N= Number of strokes/min x 9

= 24 x 9 = 216 rpm= 22.6 rad/sec

shear strength (maximum) required to punch a hole

= resisting area x Shear stress

= π dt (2t/3) x f_s

= $\frac{304.5\times \pi\times 28\times 20\ (2x20/3)}{1000}$

=7139 Nm

7139= $\frac{1}{2} I w_m^2$

Therefore, I=27.95Kg m^2

Maximum 1200mm space is available , therefore taking D=1000mm

K=0.5 m

Assume rim supplies 95% of total mass

MK^2=0.95x27.95

M=106.2 Kg

M= πDmAρ

A=4.7x$10^{-3}m^2$

Assume b=h

Where, ρ=7200kg/$m^3$for C.I.

Therefore, h=68 mm, b=68mm

Flywheel outer diameter =D_o=D+h=1.068 m, this value is less than the maximum available space of 1.2m, therefore the designed dimensions are within range.

Surface speed V_s = πD x 216/60= 12.08 m/s

To find Shaft diameter:

Medium carbon steel is used for shaft, shear stress 40MPa, diameter of shaft is determined by torsion equation

f_s= $\frac{16T}{\pi d^3}$

$= 43mm$

diameter of shaft say,d= 45mm

D_h, Hub diameter = 2ds=90mm

Hub Length, L_h = 2ds=90mm

To find Stresses in the rim:

Stresses in rim (unstrained) =ρv^2

= 7200×12.08^2 =1.05MPa

- Stresses due to bending of rim = $\frac{\pi^2 \rho V_s^2 D_o}{hi^2}$

=4.2MPa

Total Stress

= 0.25 stresses in restrained rim + 0.75 stresses in unstrained rim

=1.84 MPa

Since this value of induced stress is less than the permissible stress of C.I, hence rim design is ok

To find stresses in arm, taking arm type flywheel with six arms

Stress in the arm (bending) = 8MPa

- Bending Moment on each arm = $\frac{T_{max}(D_m - D_h)}{6 D_m}$

= 95.77Nm

Assuming elliptical cross section and allowable stress for CI and sudden load as 8MPa

- Section modulus Z=$\frac{\pi h^3}{64}$

Where h= major axis and minor axis =h/2

h= 62.37mm say h= 62.5mm

Key cross section = 14 x 9 mm

4. CONCLUSIONS

Flywheel design is a very critical task for any application and it should be optimized for a particular parameter. In this case also we have tried to optimize it for space limitations. During trials we have tried many materials and factor of safety values and finally came to a conclusion that we could design a best flywheel for this space of 1.2 meter diameter and our flywheel satisfied it because in our case flywheel diameter is1.068 meter.

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