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REVIEW ON DESIGN AND DEVELOPMENT OF 50 TON POWER PRESS MACHINE FLYWHEEL

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ABSTRACT

This study solely focuses on exploring the effects of flywheel geometry on its energy storage/deliver capability per unit mass, further defined as specific energy. In this paper we are studying various profiles of flywheel and the stored kinetic energy is calculated for the respective flywheel .Various profiles designed are solid disk, disk rim, webbed/section cut, arm/spoke flywheel. It shows 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. Efficient flywheel design used to maximize the inertia of moment for minimum material used and guarantee high reliability and long life. FE analysis is carried out loading on the flywheel and maximum von mises stresses and total deformation are determined. A flywheel is the heavy rotating mass which is placed between the power source and the driven machine to act as a reservoir of energy. It is used to store the energy when the demand of energy of energy is less and deliver it when the demand of energy is high. The current paper is focused on the analytical design of arm type of flywheel which is used for power press operation. Now in regard to the design of flywheel it is required to decide the mean diameter of the flywheel rim, which depends upon two factors such as availability of space and the limiting value of peripheral velocity of the fly wheel. However the current design problem is formulated for power press machine which has to be perform the various operations and space limitation that is the diameter of flywheel should not exceed 790 mm, hence it can be observed that the design of the flywheel is to be carried out (based) on the reduction ratio of motor and flywheel and accordingly the fluctuation of energy, dimensions of the flywheel, stresses induced in the flywheel are determined. Finally after detail analysis it is observed that the induced diameter of the flywheel is less than the allowable/permissible diameter and hence it can be concluded that the design is safe from operational features.

Keywords: Unigraphics , Ansys ,Taguchi Method

I. INTRODUCTION

1.1 Flywheel Origins

The origins and use of flywheel technology for mechanical energy storage begun several hundred years ago and developed throughout the Industrial Revolution. One of the first modern dissertations on the theoretical stress limitations of rotational disks is the work by Dr.A.Stodola, whose first translation to English was made in 1917. Development of advanced flywheel begins in the 1970s.

A flywheel acts as an energy reservoir, which stores energy during the period when the supply of energy is more than the requirement and releases energy during the period when the requirement is more than the supply. The energy-storage capacity of a flywheel is determined from its polar moment of inertia *J* and its maximum safe running speed. The necessary inertia depends on the cyclic torque variation and the allowable speed variation or, in the case of energy storage flywheels, the maximum energy requirements. The safe running speed depends on the geometry and material properties of the flywheel.

The function of flywheel is as follows,

- 1. To store & release energy when needed during the work cycle.
- 2. To reduce the power capacity of the electric motor or engine.
- 3. To reduce the amplitude of speed fluctuations.

The current paper is focused on the analytical design of flywheel which is used for power press operation. Now in regard to the design of flywheel it is required to decide the mean diameter of the flywheel rim, which depends upon two factors such as availability of space and the limiting value of peripheral velocity of the fly wheel. However the current design problem is formulated for power press machine which has to be perform the punching operations and maintaining the reduction ration having diameter of flywheel should not exceed 790mm, hence it can be observed that the design of the flywheel is to be carried out (based) on the availability of space limitation i.e. reduction ratio 5.20.

1.2 Problem Definition

Study of existing flywheel and calculation of energy requirement for the operations carried out on the 50 ton power press. The existing flywheel is more bulky and it the material cost is high. Hence in this paper we are optimizing the flywheel design by reducing the moment of inertia i.e. the reduction of weight of flywheel by keeping the reduction ratio constant.

1.3 Solution

Flywheel profiles for 50ton power press are designed such as solid disk, disk rim, webbed/section cut, arm/spoke flywheel. It shows 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. Efficient flywheel design used to maximize the inertia of moment for minimum material used and guarantee high reliability and long life.

II. LITERATURE REVIEW

Literature review is an assignment which gives idea about previous work done by different authors & from the research paper published by them in different journals gives the data about their research work which are helpful in our project. It gives the guide line or path for progressing our task. Earlier many authors work on same. So we are collecting some useful information for our project for designing the flywheel following parameters has taken into consideration by reviewing literature review.

In 2012,Sushama G.bawane, A.P.Ninawe,& S.K.Choudhary [1] had proposed flywheel design .They study different types of flywheel & use different types of material for the analysis purpose. by using FEA analysis suggested the best material for the flywheel. S. M. Dhengle Dr. D. V. Bhope, S. D. Khamankar, [2] shows the comparison between analytical stresses and FE stresses in Rim by varying no. of arms& comparison between FE stresses on arm and analytical calculated bending stresses in arms. They also have seen that as a number of arms increases from 4 to 8, the stresses in the arms goes on reducing. This may be due to sharing of load by larger no. of arms shows the comparison of FE stresses and analytical bending stresses near the hub end of arm for 4, 6 and 8 arms flywheel under the influence of tangential forces on rim.

In 2013, Akshay P. Punde , G.K.Gattani [3],had proposed the flywheel design & study stress analysis of gray cast iron &S.Glass epoxy material by using FEA analysis.

A literature review of some relevant research work was conducted in related with the current study as stated below Akshay P. Punde, G.K.Gattani (2013) has presented the investigation of a flywheel, to counter the requirement of smoothing out the large oscillations in velocity during a cycle of an I.C. Engine, a flywheel is designed, and analyzed by using Finite Element Analysis method. Further it is used to calculate the Stresses inside the flywheel; finally the comparison study between the Design and analysis with existing flywheel is carried out. [1]

Bjorn Bolund, Hans Bernhoff, Mats Leijon (2007) the early models where purely mechanical consisting of only a stone wheel attached to an axle. Nowadays flywheels are complex constructions where energy is stored mechanically and transferred to and from the flywheel by an integrated motor/generator. The stone wheel has been replaced by a steel or composite. Rotor and magnetic bearings have been introduced. Today flywheels are used as supplementary UPS storage at several industries world over. Future applications span a wide range including electric vehicles, intermediate storage for renewable energy generation and direct grid applications from power quality issues to offering an alternative to strengthening transmission. One of the key issues for viable flywheel construction is a high overall efficiency, hence a reduction of the total losses. By increasing the voltage, current losses are decreased and otherwise necessary transformer steps become redundant. So far flywheels over 10kV have not been constructed, mainly due to isolation problems associated with high voltage, but also because of limitations in the power electronics. Recent progress in semi-conductor technology enables faster switching and lower costs. The predominant part of prior studies has been directed towards optimizing mechanical issues whereas the electro technical part now seems to show great potential for improvement. An overview of flywheel technology and previous projects are presented and moreover a 200kW flywheel using high voltage technology is simulated. [2]

SudiptaSaha, Abhik Bose, G. SaiTejesh, S.P. Srikanth (2013) the performance of a flywheel can be attributed to three factors, i.e., material strength, geometry (cross-section) and rotational speed. While material strength directly determines kinetic energy level that could be produced safely combined (coupled) with rotor speed, this study solely focuses on exploring the effects of flywheel geometry on its energy storage/deliver capability per unit mass, further defined as Specific Energy. 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. This paper specifically studies the most common five different geometries (i.e., straight/concave or convex shaped2D). [3]

M.lavakumar, R .prasannasrinivas (2013) this paper 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. [4]

Sushama G Bawane , A. P. Ninawe and S. K.Choudhary (2012) 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 are initially determined; the detail design study of flywheel is done. Then FEA analysis for more and more designs in diverse areas of engineering is 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 paper 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. [5]

S. M. Dhengle, Dr. D. V. Bhope, S. D. Khamankar (2012) there is many causes of flywheel failure. Among them, maximum tensile and bending stresses induced in the rim and tensile stresses induced in the arm under the action of centrifugal forces are the main causes of flywheel failure. Hence in this work evaluation of stresses in the rim and arm are studied using finite element method and results are validated by analytical calculations .The models of flywheel having four, six and eight no. arms are developed for FE analysis. The FE analysis is carried out for different cases of loading applied on the flywheel and the maximum Von mises stresses and deflection in the rim are determined. From this analysis it is found that Maximum stresses induced are in the rim and arm junction. Due to tangential forces, maximum bending stresses occurs near the hub end of the arm. It is also observed that for low angular velocity the effect gravity on stresses and deflection of rim and arm is predominant. [6]

D.Y. Shahare, S. M. Choudhary (2013) This study solely focuses on exploring the effects of flywheel geometry on its energy storage/deliver capability per unit mass, further defined as specific energy. In this paper we have studied various profiles of flywheel and the stored kinetic energy is calculated for the respective flywheel .various profiles designed are solid disk, disk rim ,webbed/section cut, arm/spoke flywheel. It shows 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. Efficient flywheel design used to maximize the inertia of moment for minimum material used and guarantee high reliability and long life. FE analysis is carried out for different cases of loading on the flywheel and maximum von-mises stresses and total deformation are determined. [7]

III. METHODOLOGY

3.1 Methodology of flowchart

Step Numbers	Process
1	Study Of Existing Flywheel
2	Calculation Of Physical Weight And Moment Of Inertia
3	Stress Calculations For Existing
4	Study Of Optimum Inertia Required
5	`Reduction Of Excess Weight By Calculations
6	Design New Optimized Flywheel Using Software
7	Stress Calculations for new flywheel by numerical with software & compare
8	Use Taguchi Method For Design Optimizations
9	Compare Results Of Existing & Modified Flywheel
10	Conclusion & Result

3.2 Mathematical calculation of existing Flywheel

Given data,

Motor specifications:-

5 HP Motor & Revolution1440 RPM,

Stroke length (L)=0.200 m =200mm.

Power consumption=5 x 786=3.930 x 10^3kwof motor.

$P=\frac{2\pi NT}{60}$

Therefore,

$Torque=\frac{3.930 \times 10^3 \times 60}{2\pi \times 1440}$=26.06Nm

Speed Ratio Calculation :-

Diameter of pulley (Motor)=150 mm

Diameter of flywheel=790 mm

∴Speed Reduction $=\frac{790}{150}$

=5.26

Work done per cycle,

w=2 x π x T x speed reduction x conversion factor

= 2 x π x 26.6 x 5.26x0.08

=927.37 x 0.08

=74.18Nm

Net Work done= power x stroke length conversion factor

= 50 x 10^3x 0.2 x 0.35

= 3500 (STD data from manufacturer)

K.E. stored in flywheel= 3500 – 74.1

= 3424.82 N-m

Flywheel Moment of Inertia actually required

K.E. = I x 2πN^2 x C_s,

where C_s=0.02 &ω = 2πN

$$I=\frac{K.E}{\omega^2}\frac{1}{C_s}$$

$$=\frac{3424.82}{\left(\frac{2\pi X\ 1440}{60}\right)^2 X\ 0.02}$$

=7.53 Kgm²

Now, practically used flywheel Moment of Inertia

∴ Weight of flywheel=127 Kg

Radius of shaft R1=63.5 mm

Outer diameter of flywheel=790

Radius=395 mm

∴ I = mk^2,

Where $k^2=\frac{(R2^2+R1^2)}{2}$

$$=127\ X\frac{(395^2+63.5^2)}{2}$$

=10.16 kg -m²

Hence

Excess Moment of Inertia=10.16 – 7.53

= 2.63 kg- m²

Hence keeping all dimension same,

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The net mass reduction in existing flywheel will be given as below

As calculated

$$Mk^2 = 2.63 \text{ kg-m}^2$$

Therefore,

$$m = \frac{2.63}{\left(\frac{0.895^2 + 0.685^2}{2}\right)}$$

Mass of Reduction=32.85 kg

But considering (factor of safety)FOS= 1.2

Net mass reduction= $\frac{32.85}{1.2}$

= 27.38 kg

Net mass reduction=27.38 kg from existing flywheel.

% reduction in mass of flywheel = $\frac{27.38}{127}$ x 100

=21.55%

Hence it is proved that the existing flywheel have excess weight. The excess weight is 27.38 kg and it can be reduced without affecting the performance of flywheel and keeping the stress values same.

IV. EXISTING FLYWHEEL OF MACHINE IN UNIGRAPHICS

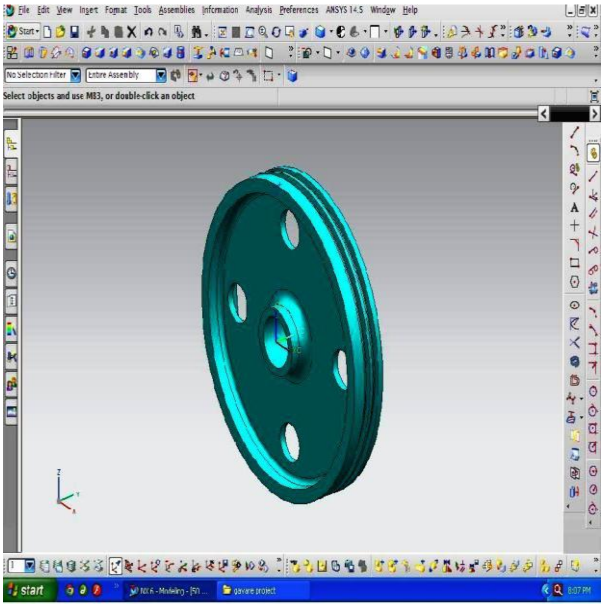

Fig. 1.Existing Flywheel of machine in unigraphics

V. EXISTING FLYWHEEL OF MACHINE

Fig.2. Existing Flywheel of machine

VI FUTURE WORK

6.1 Mathematical Model Development for optimized flywheel.

1) Mathematical model for calculations of stresses developed on flywheel.

2) Calculations of moment of inertia of existing flywheel

3) Energy Calculation for specific operation i.e. punching of part.

6.2 Modeling and analysis of existing flywheel.

1) With help of unigraphics software prepare model of existing flywheel

2) Export the file for analysis of model to ANSYS software

3) Apply all boundary conditions and forces for calculations of stresses develop in flywheel.

4) Compare it with mathematical model.

6.3 Optimize the flywheel

1) With comparison prepare new models and analyze with ANSYS software.

2) The flywheel which having minimum stresses is the result of optimization.

3) The proto type of optimized flywheel is manufactured with casting technique. With standard experimental set up the analysis of flywheel is done and the results are compared.

The two main tools used in this paper during the design of the flywheel are in Ansys and Unigraphics. Ansys is used for trying out different analytical results of shape in order to describe the different stresses acting on the flywheel and to reduce the weight of flywheel by comparing the results. Unigraphics is then used to verify the results from Ansys and fine tune the design using the built in FEM module. Additionally, Unigraphics was also used to make all computer generated pictures of the flywheel present in this paper, as well as all the drawings of the flywheel.

VII CONCLUSION

1. Flywheel design is based on energy requirement of various production processes to carry in power press machine.

- We modeled various components using Unigraphics Nx software.
- Energy calculated for all the product using manual design method (Mathematical)
- The product or operation which requires highest energy is selected for flywheel design.
- Flywheel is design manually & various stresses induced are calculated.

2. Design flywheel is modeled using Unigraphics NX-8 software& the same flywheel is analyzed by FEM using ANSYS (Workbench) Software.

3. The result comparison will be done in tabulated form.

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