Analysis of Different Geometry of Flywheel used in Punching Press

Mr. Rahul Berani 1 Jayvir Shah 2

1 Department of Machine Design 2 Department of Mechanical Engineering

1,2 VGI(FOE & FOM), Jankhenia, Kutch

Abstract— 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. Mainly, 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 finite element analysis and optimization procedure is used to find out smart design of flywheel geometry that have a significant effect on the Specific Energy performance. This paper specifically studies the most common five different geometries.

Key words: Flywheel, Specific Energy, Rotational Speed, Material Strength, Geometry

I. INTRODUCTION

A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels have a significant moment of inertia and thus resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by applying torque to it, thereby increasing its rotational speed, and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing its rotational speed.

Flywheel is basically a rechargeable battery. It is used to absorb electric energy from a source, store it as kinetic energy of rotation, and then deliver it to a load at the appropriate time, in the form that meets the load needs. As shown in Fig1, a typical system consists of a flywheel, a motor/generator, and controlled electronics for connection to a larger electric power system.

Basic component of flywheel system:

![Flywheel System](image)

The input power may differ from the output power in its temporal profile, frequency, or other attributes. It is converted by the input electronics into a form appropriate for efficiently driving a variable-speed motor. The motor spins the flywheel, which stores energy mechanically, slowing down as it delivers energy to a load. That decrease in mechanical energy is converted into electrical form by the generator. A challenge facing the motor and the generator designer is to size the system for the amount of storage (energy) and delivery rate (power) required and also to minimize losses. The output electronics convert the variable-frequency output from the generator into the electric power required by the load. Since the input and output are typically separated in a timely manner, many approaches combine the motor and generator into a single machine, and place the input and output electronics into a single module, to reduce weight and cost.

A. Flywheel Origins

The origins and use of flywheel technology for mechanical energy storage began 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.

B. Common Uses of a Flywheel:

- Providing continuous energy when the energy source is discontinuous. For example, flywheels are used in reciprocating engines because the energy source, torque from the engine, is intermittent.
- Delivering energy at rates beyond the ability of a continuous energy source. This is achieved by collecting energy in the flywheel over time and then releasing the energy quickly, at rates that exceed the abilities of the energy source.
- Controlling the orientation of a mechanical system. In such applications, the angular momentum of a flywheel is purposely transferred to a load when energy is transferred to or from the flywheel.

II. LITERATURE SURVEY

Snehal.R.Raut, Prof .N.P.Doshi ,Prof .U.D.Gulhane has published paper in this they focused on the analytical design of flywheel and FEM analysis of flywheel used in Press. Different types of forces acting on flywheel & design parameters has taken into consideration for optimizing design of flywheel. In present investigation more focus is given to energy storing capacity of flywheel during a cycle of mechanical system, flywheel is designed & analyzed .During this they study different parameters like material stress acting on flywheel, efficiency, cost of flywheel ,output, energy storing capacity & compare these parameters with existing flywheel.

S.M.Chodhary,D.Y.Sahare has published paper in this paper they mainly focus on effect of flywheel geometry on energy storage capacity. 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.

Nilesh V. Rana, Brijesh K. Gotawala they mainly focus on optimizing the design of flywheel in terms of energy storage capacity and release on requirement. They made different design of flywheel and FEM analysis of flywheel used in punching press. During analysis they consider different force acting on flywheel and design parameter for optimizing design of flywheel. By using ANSYS stresses obtained and compared with analytical calculation and also weight is compared.

S. M. Dhengle, Dr. D. V. Bhope, S. D. Khamankar has published paper. In this work they evaluate 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.

Kishor D. Farde, Dr. Dheeraj S. Deshmukh has published paper. In this Project Work taking Flywheel as an Automobile component and applying FEA analysis using ANSYS to optimize weight and strength of flywheel. Here Performing Analysis on metal flywheel, carbon fiber flywheel and composite i.e. metal and carbon fiber flywheel. By using ANSYS stresses obtained & compared with analytical calculations, also weight is compared. Composite flywheel made from steel rim & carbon fiber body will be safe for automobile applications like F1 car. From analysis & analytical results composite flywheel for automobile can be selected.

III. DESIGN OF FLYWHEEL

In this thesis work we take a five different geometry of flywheel for analysis.

- Solid disk type
- Convex Type
- 8 Arm Type
- 4 Arm Type
- 8 Arm triangular rim Type

A. Geometrical Dimensions of Flywheel:

The major dimensions of flywheel considered for present analysis are as follows,

- Outer Diameter of flywheel rim (Do) = 660 mm
- Inner Diameter of flywheel rim (D) = 540 mm
- Thickness of rim (H) = 60 mm
- Width of rim (B) = 100 mm
- Diameter of shaft (d) = 70 mm
- Radius of Hub (Dh) = 76 mm
- Hub Length (L) = 110 mm

IV. FINITE ELEMENT ANALYSIS OF FLYWHEEL

These five geometry of flywheel is analysed using software ansys 14.5.

FE analysis is carried out for different geometry of flywheel and maximum Von-mises stresses and total deformation are determined.

Loading condition: Angular velocity
A. Total Deformation in Different Geometry of Flywheel:

![Solid Disk Type Flywheel](image1)
![Convex Type Flywheel](image2)
![8 Arm Type Flywheel](image3)
![4 Arm Type Flywheel](image4)
![8 Arms Triangular Rim Type Flywheel](image5)

B. Von-Mises Stress in Different Geometry of Flywheel:

![Solid Disk Type Flywheel](image6)
![Convex Type Flywheel](image7)
![8 Arm Type Flywheel](image8)
![4 Arm Type Flywheel](image9)
![8 Arms Triangular Rim Type Flywheel](image10)

C. Maximum Shear Stress in Different Geometry of Flywheel:

![Solid Disk Type Flywheel](image11)
![Convex Type Flywheel](image12)
![8 Arm Type Flywheel](image13)
![4 Arm Type Flywheel](image14)

V. COMPARISON TABLE

<table>
<thead>
<tr>
<th>Geometry type</th>
<th>Total(mm) deformation</th>
<th>Von-mises stress(MPa)</th>
<th>Maximum shear stress(Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid disk Type</td>
<td>0.7286e-6</td>
<td>2.6678</td>
<td>1.3531e6</td>
</tr>
<tr>
<td>4Arm Type</td>
<td>1.9771e-6</td>
<td>2.1046</td>
<td>1.1313e6</td>
</tr>
<tr>
<td>8Arm Type</td>
<td>1.8262e-6</td>
<td>2.593</td>
<td>1.4895e6</td>
</tr>
<tr>
<td>8Arm triangular rim Type</td>
<td>1.2565e-6</td>
<td>1.8305</td>
<td>1.0496e6</td>
</tr>
<tr>
<td>Convex Type</td>
<td>5.3767e-6</td>
<td>20.62</td>
<td>10.3746</td>
</tr>
</tbody>
</table>

Table 1:

<table>
<thead>
<tr>
<th>Geometry type</th>
<th>Mass(Kg)</th>
<th>Energy obtained(N.m.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Type</td>
<td>157.44</td>
<td>3521.6</td>
</tr>
<tr>
<td>4Arm Type</td>
<td>60.035</td>
<td>3964.72</td>
</tr>
<tr>
<td>8Arm Type</td>
<td>63.185</td>
<td>3880</td>
</tr>
<tr>
<td>8Arm triangular rim Type</td>
<td>30.23</td>
<td>4083.84</td>
</tr>
<tr>
<td>Convex Type</td>
<td>105.69</td>
<td>36.93.68</td>
</tr>
</tbody>
</table>

Table 2:

VI. CONCLUSION

After analysis of different geometry of flywheel we concluded that smart design of flywheel maximize the moment of inertia for minimum material used and also minimum stress acting on flywheel. After analysis of different geometry of flywheel we concluded that 8 arm triangular rim type flywheel and also its mass is less which reduce the cost of flywheel. also stress induced in 8 arm triangular rim type flywheel is less than other geometry of flywheel.

REFERENCES


