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FEM Analysis of Flywheel Used for Punching Press Operation

Snehal.R.Raut[1], Prof .N.P.Doshi[2],Prof .U.D.Gulhane[3]
Department of Mechanical Engineering, B.D.C.O.E, Sevagram

ABSTRACT

Flywheel is basically a energy storing device The current paper is focused on the analytical design of flywheel & FEM analysis 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 we study different parameters like material stress acting on flywheel , efficiency, cost of flywheel ,output, energy storing capacity & compare these parameters with existing flywheel.

Keywords :-flywheel , Analysis , Finite element analysis (FEA).

I. INTRODUCTION

A flywheel is a heavy rotating body act as reservoir of energy. The energy is stored in the flywheel in the form of kinetic energy. The flywheel act as an energy bank between the source of power & the driven machinery. Depending upon the source of power & the type of driven machinery, there are two distinct application of the flywheel.

In certain cases , the power is supplied at uniform rate , while the demand for power from the driven machinery is variable , e.g., a punch press is driven by an electric motor. In punching & shearing machines, maximum power is required only during a small part of the cycle, when actual punching or shearing takes place .During the remaining part of the cycle , negligible power is required to overcome the friction . If these machines are directly driven by an electric motor, a higher capacity motor corresponding to maximum power requirement during actual punching or shearing will be required. Such a motor will run almost idle during the remaining part of the cycle. It is obviously wasteful to provide such a large motor when its full capacity is needed but a small fraction of the time. Providing a flywheel to these machines allow a much smaller motor to be used. During the actual punching or shearing operations, energy will be taken from the flywheel , slowing it down .During the relatively long period between two punching or shearing operations, the motor will accelerate the flywheel back to its original speed. Thus the flywheel stores the kinetic energy during the idle portion of the work cycle by increasing its speed & delivers this kinetic energy during the peak-load period of punching or shearing. Therefore, when a flywheel is used between the motor & these machines , a smaller capacity motor is sufficient.

In other application , the power is supplied at variable rate , while the requirement of the driven machinery is at uniform rate,e.g., machinery driven by an internal combustion engine . In IC engines, the power is generated at a variable rate. The flywheel absorbs the excess energy during the expansion stroke , when power developed in cylinder exceeds the demand . This energy is delivered during suction , compression exhaust strokes. The flywheel , therefore , enables the engine to supply the power at a practically uniform rate.

The function of flywheel are 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 arm type of flywheel which is used for punching 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 punching machine which has to be make holes of 12 holes/minute in a steel plate of 4mm thickness.

I. 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 there research work which are helpful in our project. It gives the guideline or path for progressing our task.Earlier many authors work on same. So we are collecting some usefull 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 sugested the best mateial 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 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.

In,2013,M.LAVAKUMAR,R.PRASANNA SRINIVAS [4] had also proposed stress analysis & sugested that design is much safe for mild steel alloy than for mild based on strength point of view .

D.Y. Shahare and S. M. Choudhary (2013)[5] , had given main focus on various profiles of flywheel such as solid disk, disk rim ,webbed/section cut, arm/spoke flywheel. flywheel geometry has significant effect on its specific energy performance. Amount of kinetic energy stored by wheel –shaped structure flywheel is greater than any other flywheel. From the analysis it is found that maximum stresses induced are in the rim and arm junction.

II. 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 Mean Diameter of flywheel rim(Dm)
= 600mm 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) = 140
mm

III. DESIGN OF FLYWHEEL

Power = 2.25 KW.=2.25 x 10^3 W
Speed N =391 rpm.
Energy required
/Min ,
= Energy /stroke x No.of working stroke

= 2260.310 x 10^3x 12
=
27124 N-m.
Maximum Fluctuation of Energy,
E = 0.9 X 2260.31x 10^3
= 2034.3 N-m.
As Hub & spokes Provide 5% of rotational inertia of the wheel ,Therefore the maximum fluctuation of energy provided by flywheel rim will be 95 %.
E rim =0.95 x 2034.3
= 1932.585 N.m
N = 391 rpm.
$\omega = 2\pi N/60$
= (2π x391) /60
= 40.95 rad/sec.
We know that , Maximum Fluctuation of energy , $E = mk^2\omega^2Cs$
1932.585 = m x (0.30)^2 x 40.95 ^{2} x 0.132 m = 97 Kg.
Now ,
T = (P x 60) / 2πN
= (2.25x 10 ^{3} x60)/ 2π x391
=54.95N-m.

Dimension Mass of flywheel (m) = $A\pi D \varrho = 2t^2\pi$ X 0.66 X 7200 = 97 t = 60 mm
b = 120 mm
W= Rate of loading = $bt\varrho V^2/R$
= 0.06X 0.12 X7200 X13.51^2/0.330
= 8760 N

Stresses in Flywheel.

- ***Centrifugal Stress induced in the Flywheel***

$\sigma_1 = \varrho$ x Vs^2 ,ρ = 7200 kg/m^3
V = πDN /60 = (3.14 x 0.660 x 391) /60
= 13.51m/s.
σ_1 = 7200 x 13.51 x 13.51= 1.31 Mpa.

- ***Stress due to Bending of rim,***

$\sigma_2 = \pi^2 Vs^2 \varrho$ D/ i^2x h
= 3.96 Mpa.

- $\sigma_3 = 0.75\sigma_1 + 0.25\sigma_2$
= 1.9755 Mpa.

IV. MODELING OF FLYWHEEL

Modeling of flywheel for 3 different cases

- *Modeling of web type flywheel.*
- *Modeling of straight elliptical 4,6,8 arm flywheel.*
- *Modeling of tapper 4,6,8 arm flywheel.*

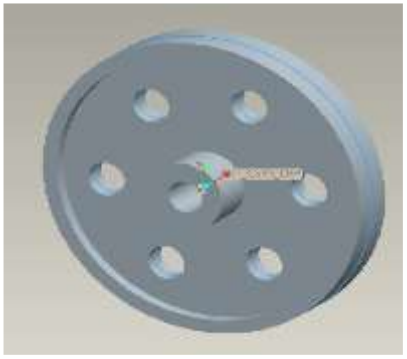


Fig.:- 5.1 ***web type flywheel***

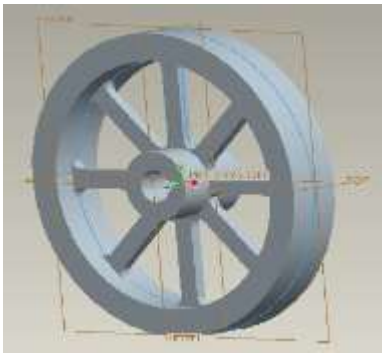


Fig.:- 5.2 ***straight elliptical 8 arm flywheel.***

Fig.:-.5.3 ***Tapper*** **8 arm flywheel.**

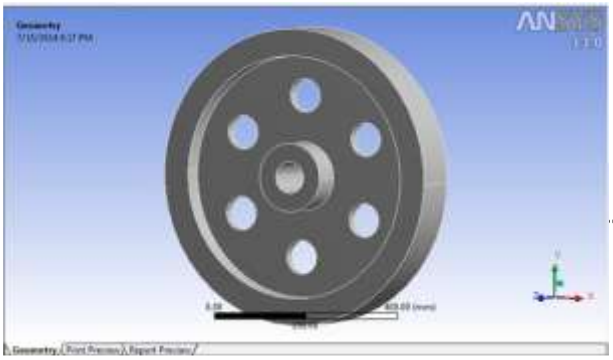
V. FINITE ELEMENT ANALYSIS

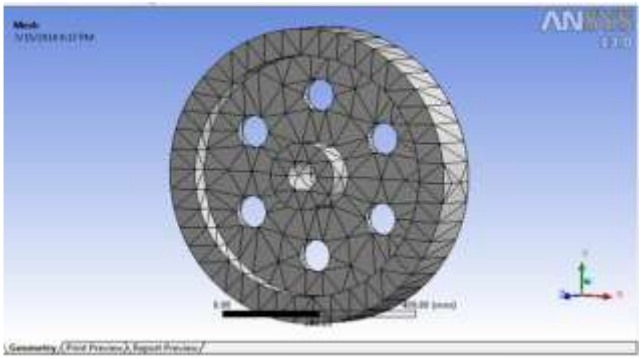
Finite Element Modeling (FEM), Finite Element Analysis (FEA) is two of the most popular mechanical engineering applications. This is attributed to the fact that the finite element method is perhaps the most popular numerical technique for solving engineering problems. The method is general enough to handle any complex shape or geometry, any material properties, any boundary conditions and any loading conditions. The generality of the finite element methods fits the analysis requirement of today's complex engineering systems and designs were closed from solutions of governing equilibrium equations arc usually not available. In addition, it is efficient design tool by which designers can perform parametric design studies by considering various design cases (different shapes, material, loads, etc) analysis them and choosing the optimum design.

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. The method originated in the aerospace industry as a tool to study stress in a complex airframe structures. It grew out of what was called the matrix analysis method used in aircraft design. The method has gained increased popularity among both researchers and practitioners.

ANALYSIS OF FLYWHEEL

- ***Analysis of web type flywheel.***
- ***Analysis of straight elliptical 4,6,8 arm flywheel.***
- ***Analysis of tapper 4,6,8 arm flywheel*** .
- ***Analysis of web type flywheel.***





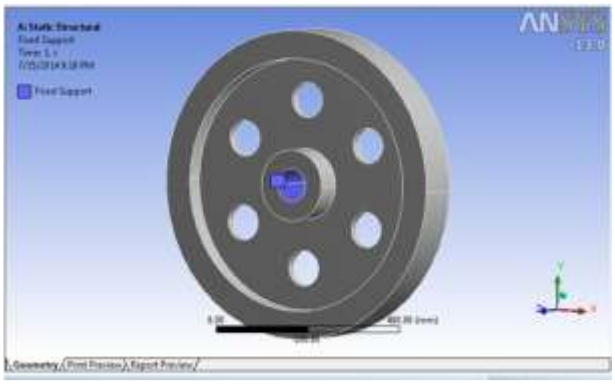


Fig.:-fixed support

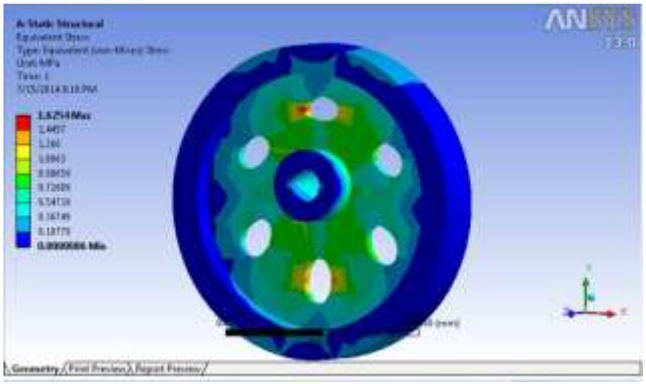


Fig.:-Equivalent von-mises stress

Fig.-Total Deformation

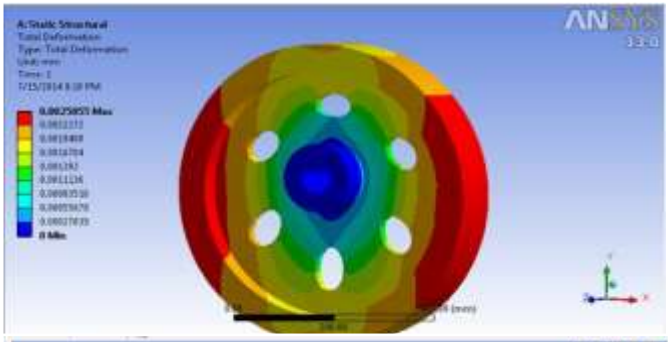
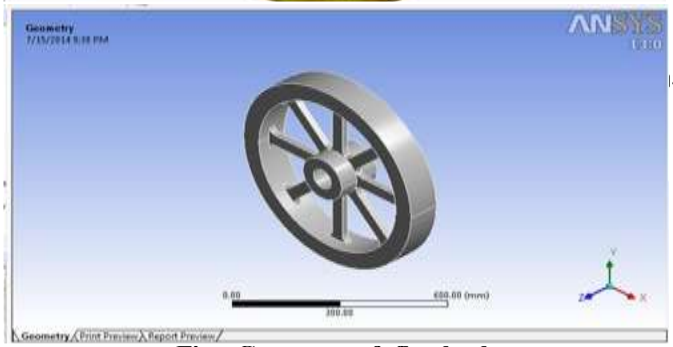


Fig.:- Shear Stress



heel.

Fig :-Geometry of flywheel

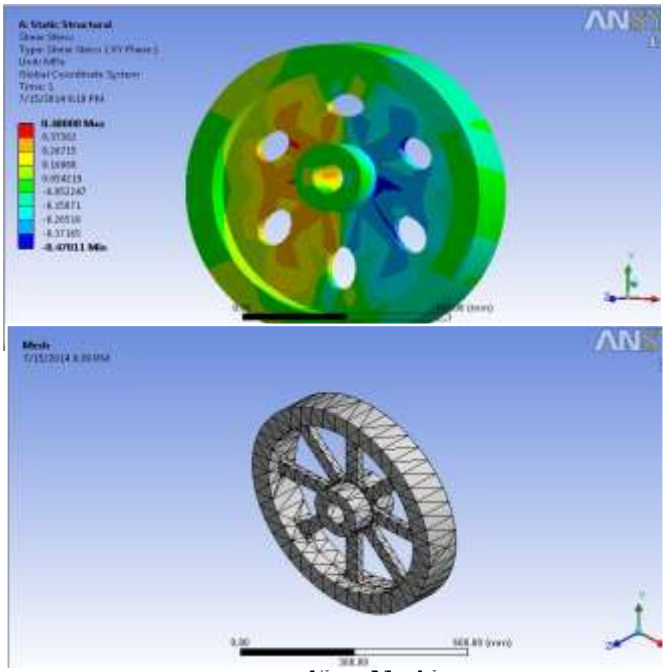


Fig.:-Meshing

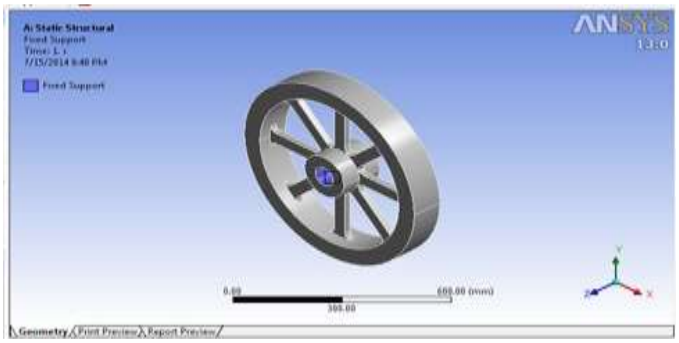


Fig:-fixed support

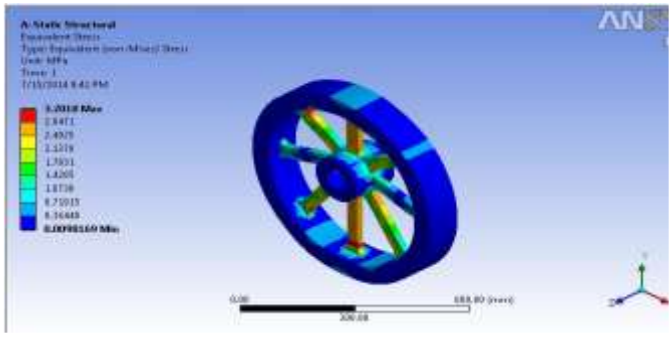


Fig:-Equivalent voin mises stress

In the similar way,for other profiles analysis is done.

VI. RESULT & DESCUSSION

1. Flywheel is design based on energy required of various product manufactured in punching machine.

- ❖ We modeled various components using PRO-E software.
- ❖ Energy calculated for all the product using manual design method.
- ❖ The product which require highest energy is selected for flywheel design.
- ❖ Flywheel is design manually & various stresses induced are calculated.

2. Design flywheel is modeled using PRO-E software & the same flywheel is analyze by FEM using ANSYS 13.0 (Workbench) Software.

Type	Equivalent (von-mises) stress (MPa)	Maximum shear stress (MPa)	Shear stress (MPa)	Normal stress (MPa)	Total Deformation (mm)
Web type Existing	1.6254	0.86588	0.48008	0.48878	2.5055e-3
Web type Modified	1.602	0.85994	0.4814	0.4689	2.54e-3
8 Arm Elliptical	3.2018	1.6562	1.4341	3.3021	5.9982e-3
8 Arm Taper	3.6603	1.8626	1.5777	1.4636	6.9883e-3

6 Arm Elliptical	3.9638	2.034	1.8277	2.4957	8.1573e-3
6Arm Taper	4.9445	2.5012	1.7199	2.537	9.6116e-3
4 Arm Elliptical	7.4058	3.7205	3.6734	6.1016	1.8134e-2
4 Arm Taper	7.4942	3.8419	1.1786	4.1487	2.1368e-2

- Various flywheel are modeled keeping diameter constant (4,6,8 arm straight elliptical & 4,6,8 taper arm flywheel).

3. All the flywheel are further analyzed by FEM using ANSYS13.0 (Workbench) software & the results obtained by analytically & FEM analysis are as per follows. With reference to the results shown above, the various findings are as follows,

Type	Mass (kg)	Energy obtain using weight of rim (97 Kg.) cross section (N.m)	Energy obtain from entire weight of flywheel (N.m)
WEB TYPE Existing	122.39	1932.585	2438.20
WEB TYPE Modified	123.13	1932.585	*2452.946*
8 Arm Elliptical	105.25	1932.585	*2096.74*
8 Arm Taper	103.68	1932.585	*2065.47*
6 Arm Elliptical	102.92	1932.585	*2050.33*
6Arm Taper	101.72	1932.585	*2022.839*
4 Arm Elliptical	100.54	1932.585	*2002.91*
4 Arm Taper	99.761	1932.585	1987.398

- It is observed that existing flywheel i.e. web construction is having maximum weight.
- It is observed that, all taper arm resp. 4,6,8 arm are having mass less than elliptical arm flywheel.
- It is observed that, stresses are greatest in 4 arm flywheel still it is less than its maximum stress value with minimum overall weight.

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