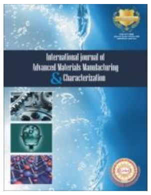

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Design Optimization of Flywheel of Thresher using FEM

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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 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 maximizes 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.

Introduction

Flywheel acts as a reservoir by storing energy during the period when the supply of energy is more than the requirement and releasing it during the period when the requirement of the energy is more than the supply. Flywheel provides an effective way to smooth out the fluctuation of speed. The stored kinetic energy relies on the mass moment of inertia and rotational speed. . A flywheel is a mechanical device with a significant moment of inertia used as a storage device for rotational energy. Flywheels resist changes in their rotational speed, which helps steady the rotation of the shaft. Flywheels have become the subject of extensive research as power storage devices for uses in vehicles. Flywheel energy storage systems are considered to be an attractive alternative to electrochemical batteries due to higher stored energy density, higher life term, and deterministic state of charge and ecologically clean nature. The performance of a flywheel can be attributed to three factors, i.e., material strength, geometry (cross- section) and rotational speed.

Material strength:

Stronger materials could undertake large operating stresses, hence could be run at high rotational speeds allowing to store more energy. Hencecould be run at high rotational speeds allow wing to store more energy.

Rotational speed:

It directly controls the energy stored, higher speeds desired for more energy storage, but high speeds assert excessive loads on both flywheel and bearings during the shaft design.

Geometry:

It controls the Specific Energy, in other words, kinetic energy storage capability of the flywheel. Any optimization effort of flywheel cross-section may contribute substantial improvements in kinetic energy storage capability thus reducing both overall shaft/bearing loads and material failure occurrences. Flywheel efficiency includes the amount of specific kinetic energy (energy per unit mass) and mechanical losses.
To improve the quality of the product and in order to have safe and reliable design, it is necessary to investigate the stresses induced in the component during working condition. When the flywheel rotates, centrifugal forces acts on the flywheel due to which tensile and bending stress are induced in a rim of flywheel. To counter the requirement of smoothing out the large oscillations in velocity during a cycle of a mechanism system, a flywheel is designed, optimized and analyzed. 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.

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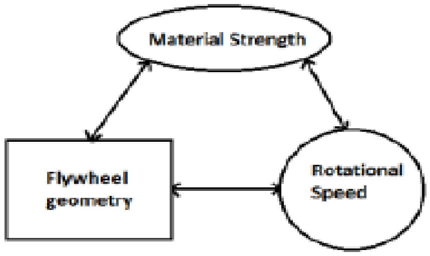

Fig.1 Factors affecting flywheel performance

Geometrical dimentions of flywheel :

Flywheel used in the thresher machine is solid disk. Dimensions of flywheel are provided below. this flywheel is designed and analyzed.
Mass of flywheel (m)=60kg.
Outer diameter of flywheel(do)=500mm.
Inner diameter of flywheel(di)=50mm.
Rpm(n)=750.

Material of flywheel :

CAST IRON, ASTM 30, SAE 111
Density=7510 kg/m3.
Poisons ratio(υ)=0.23.
Modullus of elasticity = 101 Gpa
Modullus of rigidity = 41 Gpa
Torsional/shear strength=276 mpa.

Table 1.functional values of solid flywheel

Type	Moment of inertia(I) Kg-m2	Kinetic energy stored (ΔE)kJ	Spe. Energy Kj/kg	Spe. Density Kj/m3
Solid	*1.893*	*5.837*	*0.097*	*728.47*

Tθ diagram

Tθdiagrm for the solid flywheel used is given below.
Tmax = 51.15 Nm
Tmin= 44.76 Nm

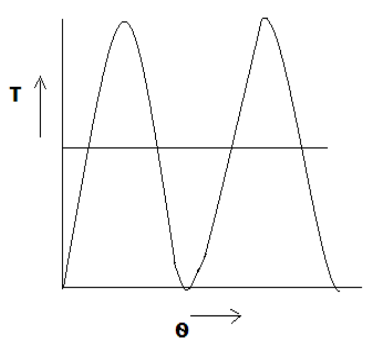

Fig 2 Tθ diagram

Work done per cycle = 20.074 Nm

Maximum fluctuation of energy = 2.631 Nm
Coefficient of fluctuation of energy(CE) = 0.13

Other flywheel geometries:

Other flywheel geometries taken under study are rim disk, webbed/ section cut, arm/spoke type .keeping mass constant as 60 kg and outside diameter 500 mm,stored kinetic energy is calculated for these profiles. This study clearly depicts the importance of flywheel geometry design selection and its contribution in the energy storage performance. Although this improvement is to be thought small, it still could be crucial for mission critical operations .other profiles of flywheel given below are designed and analyzed.

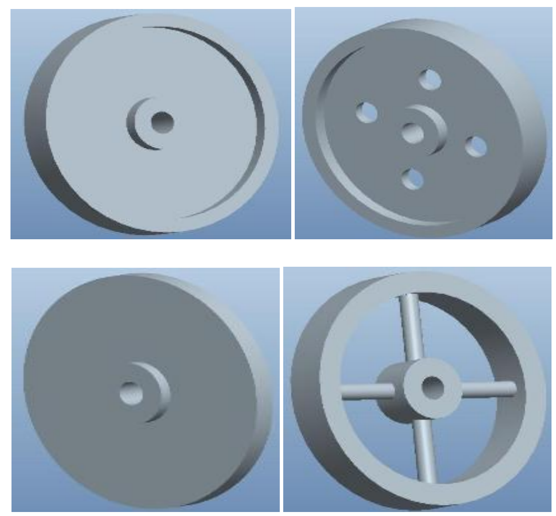

Fig3 Various profiles of flywheel

Table 2.comparison of functional values of flywheel

Functional values	Solid	Rim	Web	Arm
Moment of inertia(I) *Kg-m2*	1.893	2.283	2.337	3.784
Kinetic energy(ΔE) stored *kJ*	5.837	7.039	7.206	11.668
Spe. Energy *Kj/kg*	0.097	0.1173	0.1201	0.1944
Spe. Density *Kj/m3*	728.47	880.92	901.95	1459.94

Finite Element Analysis of Flywheel:

These four profiles of flywheel used are analyzed by FE software ie. ANSYS software. FE analysis is carried out for different cases of loading applied on flywheel and maximum von mises stresses and total deformation are determined.

[I]Loading condition:- Angular velocity

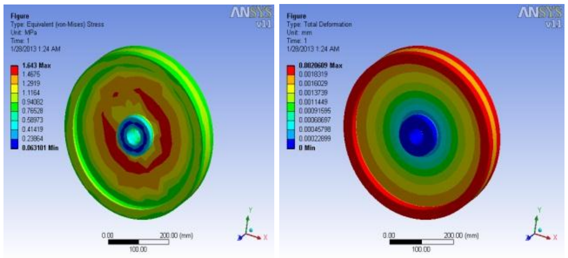

Fig 4 Analysis of rim type flywheel

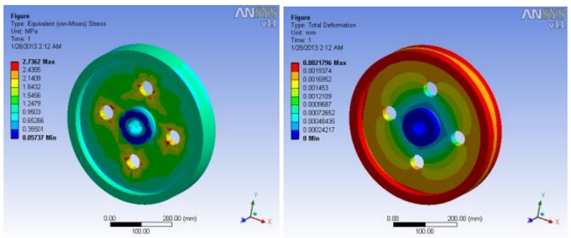

Fig 5 Analysis of section cut flywheel

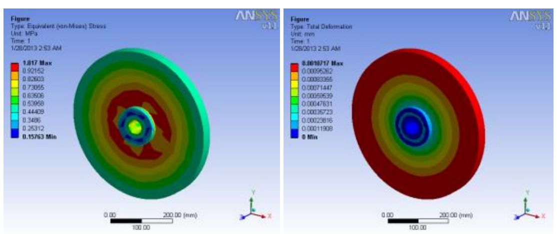

Fig 6 Analysis of solid flywheel

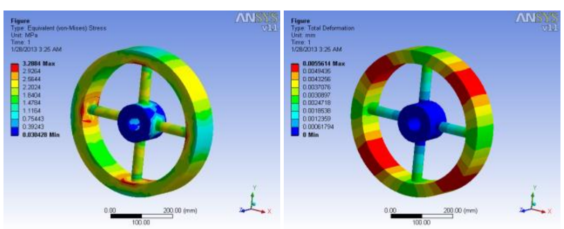

Fig 7 Analysis of spoke type flywheel

Conclusion

Results shows that efficient flywheel design maximizes the inertia of moment for minimum material used and guarantee high reliability and long life.smart design of 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. To obtain certain amount of energy stored; material induced in the spoke/arm flywheel is less than that of other flywheel, thus reduce the cost of the flywheel.From the analysis it is found that maximum stresses induced are in the rim and arm junction.

Table 3 comparison of analysis of flywheel

Type of Flywheel	Load	Equi.Vonmises stresses (mpa)	Total Deformation (mm)
Solid	ω=78.53 rad/sec	1.017	0.00107
Rim	ω=78.53 rad/sec	1.643	0.00206
Web	ω=78.53 rad/sec	2.736	0.00217
Arm	ω=78.53 rad/sec	3.228	0.00556

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