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A Detail Review on Study of Flywheel

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Abstract: *A flywheel used in machines serves as a reservoir which stores 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 supply. For example, in I.C. engines, the energy is developed only in the power stroke which is much more than engine load, and no energy is being developed during the suction, compression and exhaust strokes in case of four stroke engines. The excess energy is developed during power stroke is absorbed by the flywheel and releases its to the crank shaft during the other strokes in which no energy is developed, thus rotating the crankshaft at a uniform speed. The flywheel is located on one end of the crankshaft and serves two purposes. First, through its inertia, it reduces vibration by smoothing out the power stroke as each cylinder fires. Second, it is the mounting surface used to bolt the engine up to its load.*

Keyword*: *Flywheel, Stresses, I.C. Engine.

I. Introduction

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 when a fluctuating torque is exerted on it by its power source such as a piston-based (reciprocating) engine, or when an intermittent load, such as a piston pump, is placed on it. Flywheels can be used to produce very high power pulses for experiments, where drawing the power from the public network would produce unacceptable spikes. A small motor can accelerate the flywheel between the pulses. Recently, flywheels have become the subject of extensive research as power storage devices for uses in vehicles and power plants.

In order to increase the performance of the flywheel rotor, it is thus crucial to prevent the delamination by decreasing the radial tensile stresses. Hybrid rotors of composite materials with different stiffness and density have been used to decrease the radial tensile stresses. Flywheels resist changes in their rotational speed, whichhelps steady the rotation of the shaft when a fluctuating torque is exerted on it by its power source. 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, deterministic state of charge and ecologically clean nature. 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.Modern high-speed flywheels differ from their forebears in being lighter and spinning much faster. Since the energy stored in a flywheel increases only linearly with its moment of inertia but goes up as the square of its rotational speed, the tradeoff is a good one. But it do raise two issues: flywheel strength and losses caused due to air friction. To keep from flying apart, modern flywheels are complex structures based on extremely strong materials like carbon fibers.

II. Literature Review

Literature review is an assignment of previous task done by some authors and collection of information or data from research papers published in journals to progress our task. It is a way through which we can find new ideas, concept. There are lot of literatures published before on the same task; some papers are taken into consideration from which idea of the project is taken. [1].

Sushama G.Bawane et al., 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.

Sagar M. Samshette works on design Solid, Rim, Section-cut and six arm type flywheel maintaining constant weight. And simultaneously we calculate moment of inertia and kinetic energy of respective flywheel. He conclude that six arm type flywheel store more amount of kinetic energy as compare to solid, rim and section cut flywheel. [2].

Yongjie Hana, Zhengyi Ren, Yongxiang Tong works on General Design Method of Flywheel Rotor for EnergyStorage System. This paper discussed the general design methodology of flywheel rotor base on analyzing these influence, and given a practical method of determine the geometric parameters. It was applied to determine flywheel rotor parameters of 600Wh flywheel energy storage system in developing.

Sung Kyu Ha, Dong-Jin Kim, Tae-Hyun Sung works on Optimum design of multi-ring composite flywheel rotor using a modified generalized plane strain assumption. The introduction of the modified generalized plane strain assumption which considers thermally induced residual stress is much more efficient and easier to use than the finite element approach.

K. Takahashi, S. Kitade, H. Morita works on Development of high speed composite flywheel rotorsfor energy storage systems. The rotor, whose outer circumference was re-wound, burst at a peripheral speed of1310 m/ s. The rotor stored energy of 354 Wh. The vibration in the spin test indicated good agreement with the stress in the analysis.

III. Material for Flywheel

Flywheels are made from many different materials, the application determines the choice of material Cast iron flywheels are used in old steam engines. Flywheels used in car engines are made of cast or nodular iron, steel or aluminum. Flywheels made from high-strength steel or composites have been proposed for use in vehicle energy storage and braking systems. The efficiency of a flywheel is determined by the maximum amount of energy it can store per unit weight. As the flywheel’s rotational speed or angular velocity is increased, the stored energy increases; however, the stresses also increase. Flywheels are made from many different materials, the application determines the choice of material Cast iron flywheels are used in old steam engines. Flywheels used in car engines are made of cast or nodular iron, steel or aluminum.

Carbon steel 1065, Alloy steel AISI 4340, Maraging steel 18ni, Alloy steel AISI E9310 and Stainless steel this material is also used for flywheel. In future more suitable materials and properties will be chosen for analysis which will provide more accurate results and the same method can be applied for selection of materials for other applications.A fuzzy number is a quantity whose value is imprecise. Any fuzzy number can be defined as a function whose domain is a specified set. In many situations, fuzzy numbers depict the physical world more realistically than any single valued numbers. Technique for orderof Preference by Similarity to Ideal Solution (TOPSIS) is one of the well-known methods in Multiple Attribute Decision-Making (MADM). TOPSIS in a fuzzy environment is where the vagueness and subjectivity are handled with linguistic terms and parameterized by triangular fuzzy number. A fuzzy multi-criteria decision analysis method based on the concepts of ideal and anti-ideal points used in mathematical model of linguistic variable.

Table 1:

Materials for Flywheels

Material	$\acute{M}$ (kJ/kg)	Comment
Ceramics	200 – 2000 (compression only)	Brittle and weak in tension — eliminate.
Composites: CFRP	200 – 500	The best performance — a good choice.
GFRP	100 – 400	Almost as good as CFRP and cheaper. Excellent choice.
Beryllium	300	Good but expensive, difficult to work and toxic.
High strength steel	100 – 200	All about equal in performance. Steel and Al-alloys cheaper than Mg- and Ti-alloys
High strength Al alloys	100 – 200	
High strength Mg Alloys	100 – 200	
Ti alloys	100 – 200	
Lead alloys	3	High density makes these a good (and traditional) selection when performance is velocity-limited, not strength-limited.
Cast iron	8 – 10	

IV. Turning Moment (Or Crank Effort) Diagram (TMD)

Turning moment diagram is a graphical representation of turning moment or torque (along Y-axis) versus crank angle (X-axis) for various positions of crank.

Uses of TMD

1.The area under the TMD gives the work done per cycle.
2. The work done per cycle when divided by the crank angle per cycle gives the mean torque Tm.

work done=Torque*crank angle

3. The mean torque Tm multiplied by the angular velocity of the crank gives the power consumed by the machine or developed by an engine.

power=Tm*ω

4. The area of the TMD above the mean torque line represents the excess energy that may be stored by the flywheel, which helps to design the dimensions & mass of the flywheel.

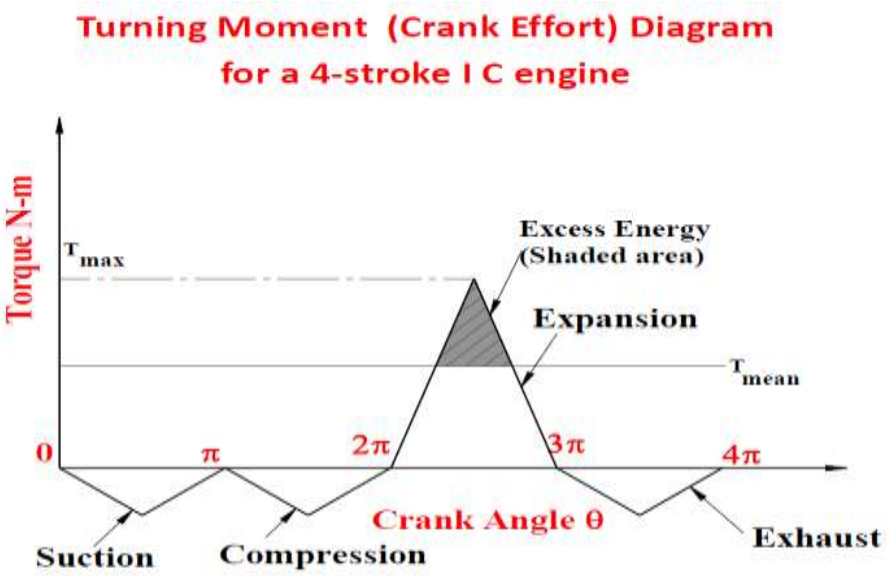


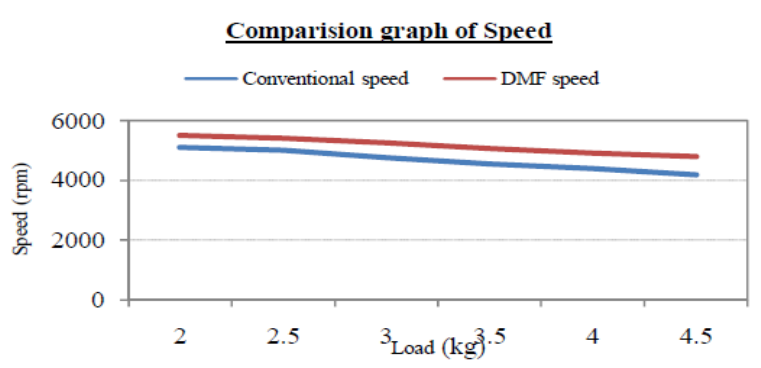
Fig. 1. Turning moment diagram.

1.4 Performance Characteristics Curves

Performance characteristics curves are the graphical presentation of engine performance. These curves are constructed from data obtained during actual engine testing and are useful for comparison of two flywheels. Here we are plotting engine performance parameters verses load. [3].

1.4.1 Effect of Load on Engine Speed

As load on engine is increased, the speed of engine goes on decreasing. It means there is inverse relation between load and speed. [3].



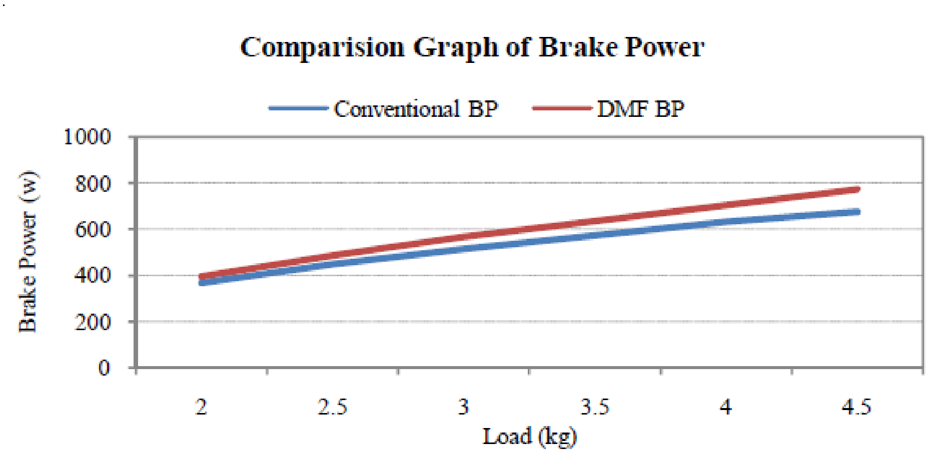
Graph1. Comparison Graph of Speed

3].

Fig. 2. Speed Vs Load

1.4.2 Effect of Load on Brake Power

As load on engine is increased, the brake power of engine goes on increasing. It means there is direct proportion between load and speed.[3]



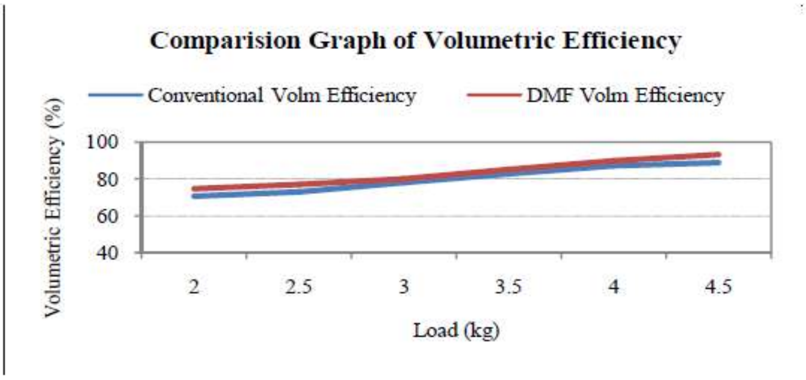
Graph2. Comparison Graph of Brake Power

[3].

Fig. 3. Brake Power Vs Load

1.4.3 Effect of Load on Volumetric Efficiency:

Volumetric efficiency of engine goes on increasing as load on engine is increased due to increase in charge density.[3].



Graph.3 Comparison Graph of Volumetric Efficiency

[3].

Fig. 4. Volumetric Efficiency Vs Load.

V. Conclusion

From this paper we have studied that the material of flywheel should be cast iron or carbon fiber. Also from the above graph it is clear that as the load on the flywheel increases, speed deceases. We studied effect of load on break power and result is that if the load increases break power increases. As well as load increases, volumetric efficiency also increases.

In suction, compression and exhaust stroke power is taken from the engine hence graph is in the negative side. The peak point represent the maximum torque. The shaded region represent excess energy. The area of the TMD above the mean torque line represents the excess energy that may be stored by the flywheel, which helps to design the dimensions & mass of the flywheel.

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