A Deep Review of Fly Wheel Energy Storage System Made from Aluminium Material

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Abstract. Nowadays, the most critical crisis for man at hand is to advance itself towards the most effective and efficient means. Hence forth, the flywheel experiment has been performed, to understand and discover more uses for this apparatus. The flywheel itself is a wheel that is used mainly as a prime mover for most every day machines such as steam locomotives, mechanical water wells, etcetera. A more advanced use for this wheel is a flywheel energy storage system which is used to generate clean and environment-friendly energy. This study focusses on optimizing aluminium flywheel and come up with an RPM imposes minimum stress on flywheel and in addition could yield maximum efficiency. At the end it was concluded that low RPM ranging from 1100-1200 could yield a maximum efficiency of 80% approx...

1. Introduction
In the field of engineering and technology, the work of machines has nowadays reduced human effort in almost all aspects of life whether it is from harvesting crops or transportation, but in many cases this aid is extremely costly and at times they may reduce human effort but give very less efficient results. Previously, flywheels have been used in different aspects of studies like the research work of [1] was based on the idea that a fly wheel possess to and fro motion of elastic balls, the research work of [2] was totally based on micro vibrations produced by flywheel during rotation, like how to measure them and how to restrict them during imaging and designing of micro vibration isolator should be according to the micro vibrations produced, the research work of [3] was to minimize the energy losses during the rotation of fly wheel caused by high centrifugal forces in order to increase the rotational speed. His idea was to get the kinetic energy of the flywheel conserved atmost into the desired energy. The aim of this research work which is named as “ A Deep Review Of Fly Wheel Energy Storage System Made
From Aluminium Material”, is to get a result of highest possible efficiency while applying minimal force on the fly wheel with some specific dimensions which are shown in Figure 3. The fly wheel analysis was being performed on various RPM so that optimized speed could be calculated. The flywheel itself is heavy rotating wheel, of specific dimensions, connected in a machine which is then used to increase the moment of inertia of the machine hence providing a very stable rotatory motion. The reason for performing this research is that the scope of this project is very vast and will have a huge impact upon the society. The main application of the flywheel itself is that it is used as a rotor component for many generators so that after beginning rotation the generator can induce current. Other applications of the flywheel are that it is at times used as a simple pulley mechanism as seen in elevator components. One of the major applications of this research is that it can be applied in obtaining renewable energy for example: in both air and water turbines, to work with high efficiency they must be able to provide more mechanical movement for lesser air and water flow so that the generator can supply high amounts of electrical energy. One of the reason, that why Aluminium was being selected was because of its lighter density like for the case of vehicle’s rim, the vehicle should be fuel efficient and in that case the material must be of lesser density so that the vehicle can move larger distances for lesser engine effort. Fuel efficiency is also essential for vehicles such as crop dusters and garbage trucks because these vehicles perform other functions which consume high amounts of fuel.

Above all the main objective of this research was to find the best size of the pulley as three different sized pulleys were being used, in order to get higher RPM. So, to analyse this research a jig was designed in which single-Phase AC motor was embedded and connecting it to the three different size of pulley one by one to the shaft with the belt to rotate it [4].

![Figure 1. Mechanism Flow chart](image_url)
2. Literature review

Since harnessing energy is a critical and most researched upon topic, the research on flywheel has also been performed by the number of groups before us. One such research article is of R. Sebastián and R. Peña Alzola of the Department of Electrical, Electronic and Control Engineering, Spanish University for Distant Education, UNED, 28040 Madrid, Spain [5]. Their research was on flywheel energy storage systems (FESSs), which had been conducted before 28th of March 2012. In their research, they emphasized upon the working principles and construction of the FESSs. Their system consists of a bi-directional converter, an electrical synchronous machine operating at high speed and multiple types of flywheels. They are also using a low speed asynchronous motor for the iron flywheel as to be able to save on size without compromising on energy output as iron seemingly has a high density and because asynchronous machines are used to generate power from non-uniform sources such as water and air flow. They have used multiple types of material for the construction of the flywheel such as Aluminium, Steel, Glass and Graphite, and have even constructed different shapes of flywheels. The reason behind this is because the efficiency of FESSs is linked to the constructs of the systems which include the electrical machine, to which the flywheel is connected, the materials of the flywheels and the type of bearings used to allow the spin of the wheel since the kinetic energy is directly proportional the angular velocity of the flywheel and the moment of inertia of the wheel [6]. The moment of inertia in turn, is proportional to the radius of the flywheel exposed to the atmosphere and the mass of the flywheel alone. After constructing the flywheel, they went on towards the simulations for which Isolated Wind Power System (IWS) was used. Its result showed significant power generation of near 250 KW after a slight amount of fluctuation before the wind speed step and during the load step. After the load had been applied, the IWSP produced ample power for further use as 100 kW remained unused [7,8]. As a conclusion they have assimilated that FESS can be useful as a short-term power supply before requiring maintenance and that low-speed FESS are considered more economical and efficient compared to their high-speed counterparts. Another review has been conducted by S.M. Mousavi G and group in 2015 on flywheel energy storage system technology [9]. They give the review of FESS for latest hybrid vehicle, wind power system, railways, hybrid power generation system, power network, marine, space and several application. They used three device in FESS machine, bearing, and power Electronic interface and discussed the advantages and disadvantages of these devices. But in this research the aim was to find out the best size of puley that should one use to make flywheel more energize. Previously in several research they used fly wheel to convert mechanical energy into electrical easily [10].
3. Methodology:
   A single-phase asynchronous motor has been embedded in a jig (whose sole purpose was to hold
   the flywheel and the pulleys while experiment was being conducted) which will act as a rotator for the
   flywheel, the shaft which was being used was threaded at one end to fix the flywheel while performing
   operation and at supports bearings were used to make the rotation of the shaft more smoother. This
   removed the friction element which was present when ball bearings were not being used. The
   construction of the wheels consists of an inner diameter with less thickness which is then connected to
   an outer diameter with larger thickness. The construction of the wheel shows slight resemblance to
   metal rim of a car tire with the acceptance of a hollowing at the center for the screw threading. A
   unique feature of the performance of this project is that the size of the pulley which is connected to the
   motor with help of belt is being changed as three different sizes were being used, until it was not found
   that which size would be perfect as per requirement. The performance of this the experiment is that
   after starting the motor, the change in frequency of the wheel is being measured as it rotates while
   keeping the power supply constant. Since the power is constant the motor’s rotation speed will have to
   be measured without the flywheel so that a reference point can be set. Then, the flywheel was fixed
   and the changes in rotation speeds were noted as the size of the pulley was being changed each time.
   The pulleys which were used, each have a specific radius which in turn produced different results
   when the motor was started to rotate the flywheel. One pulley was used at a time, but these pulleys are
   constructed together and lie on the same rotating rod. The observations that are being taken are the
   number of rotations per minute which are to be taken using a tachometer. The other two observations
   are based on the amount of time that the motor was switched on and the amount of time that the
   flywheel kept rotating after the motor had been switched off. Jig was basically used to energize the
   flywheel with the help of a AC motor connected to the Shaft which was fixed by the 2 bracket bearing
   for supporting the shaft. The shaft was of 1 in. diameter of material, Carbon Steel. Reverse-threads of
   M20 bolt of 2mm pitch on shaft were being made to connect the Flywheel and to avoid losing while
   conducting the experiment. Fly wheel could be of several shapes and distinct material but the material
   which was being used for this research was solely Aluminum because of its unique properties as
   compared to the other materials like carbon steel, stainless steel, etcetera. Dimensions of the Flywheel
   which was being used is shown in Figure 3 below.

4. Analysis
   A constant input to the system was given with the help of a AC motor and when the
   flywheel reaches to its maximum frequency, the input supply was turned off and after turning off the
input supply it was observed that the flywheel was still rotating for a while because of inertia flywheel works as an energy storage system, that particular extra rotation was the main idea behind this research. That particular duration for which it was rotating, was noted and marked it as “Time out” and the duration for which the input was given was declared as “Time in”. Three random sized pulleys, small, medium and large were used. While doing the performance it was analysed that while increasing the size of the pulley, the frequency (RPM) and time out, which is the sole purpose of this research, both were decreasing and vice versa.

![Figure 4. Three steps pulley](image)

The above pulley were connected to the shaft in which the flywheel were attached, As shown in figure below

![Figure 5. Jig](image)

Efficiency \(= \frac{t_{\text{in}} - t_{\text{out}}}{t_{\text{in}}} \times 100\) \hspace{1cm} (1)

| S.No. | RPM | Time taken to supply energy ‘\(t_{\text{in}}\)’ (s) | Time taken to consume energy ‘\(t_{\text{out}}\)’ (s) | Efficiency % |
|-------|-----|---------------------------------|---------------------------------|--------------|
|       |     |                                 |                                 |              |

Table 1. Reading of Pulley A.
Table 2. Reading of Pulley B.

| S.No. | RPM | Time taken to supply energy \( t_{in} \) (s) | Time taken to consume energy \( t_{out} \) (s) | Efficiency % |
|-------|-----|-------------------------------------------|-------------------------------------------|--------------|
| 1     | 1362| 21.82                                     | 4.55                                      | 79.14        |
| 2     | 1382| 21.87                                     | 4.61                                      | 78.92        |
| 3     | 1315| 22.03                                     | 4.88                                      | 77.84        |
| Average | 1353 | 21.90                                     | 4.68                                      | 78.63        |

Figure 6. Graph of pulley A results
While looking this table it can be concluded that larger the diameter of the pulley will result in lesser RPM and time out and vice versa. Because if the diameter of the pulley is increased, it will take more time to complete revolution which will disturb the RPM as well as time out of flywheel.
5. Conclusion

Hence, it was concluded that, the largest pulley which was named as “Pulley C” gave an average rotation of 1159.67 RPM, time out was 3.81 seconds and efficiency calculated was 80.50%, the medium sized pulley which was named as “Pulley B” gave an average rotation of 1353 RPM, time out was 4.68 seconds and efficiency calculated was 78.63%, the smallest pulley which was named as “Pulley A” gave an average rotation of 1920.33 RPM, time out was 6.09 seconds and efficiency calculated was 71.27%. Observations showed that the highest R.P.M was obtainable when the pulley with the smallest radius was used. This was simply because the smallest pulley had considerably less mass and required lesser torque to fully rotate. These extra RPMs due to inertia can be used to conserve energy according to the desired requirements, such as plants where flywheels are rotated by the help of motor in order to get desired results, when power supply is turned off then these extra rotations can be used to generate electricity. In short, these extra rotations which are due to inertia can be utilized in various ways while conserving this kinetic energy into our desired energy most likely electrical energy.

6. References

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