

Contactless Energy Generation Using Flywheel for EV

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Abstract–Energy storage systems (ESSs) play a very important role in recent years. Flywheel is one of the oldest energy storage devices and it has several advantages. Magnetic flywheel storage system is upgraded version of FESS. It improves efficiency of power generation. Frictionless power generation is eco-friendly as well as has longer life because of no wear and tear during production. The principle of power generation of the system is based on Faraday's law of induced emf.

Keywords– Frictionless energy, Electric vehicle, Energy storage system, Flywheel

1. INTRODUCTION-

Kinetic energy recovery system KERS is a system for recovering the moving vehicles kinetic energy under braking and also to convert the usual loss in kinetic energy into gain in kinetic energy. Here we use mechanical kinetic energy K.E. energy recovery system by means of flywheel to store the energy which is normally lost during breaking and we use it to help propel the rider when starting. Generally in present condition the energy produced from the bicycle by the use of dynamo. In this arrangement there is some amount of friction, so there is loss of power but we are trying to generate the power without use of dynamo which is frictionless. We will use the coil and neodymium magnet to generate the power.

2. LITERATURE REVIEW

Flywheel is one of the oldest energy storage device. S. M. Mousavi G, Faramarz Faraji, Abbas Majazi and Kamal Al-Haddad researched on A comprehensive review of flywheel energy storage system technology. In this study they have evaluated the importance of flywheel in Energy Storage System (ESS) and also flywheel energy storage structure theory consist of flywheel, motor, rotor bearing and power electronic interface. It also involves the FESS application studies like Fess in electric vehicle, in railway, wind power system, hybrid power generation system, in space, in marine and also in power networks. It also evaluates the advantages and disadvantages of flywheel energy storage system. Overall scientist stated the importance of flywheel in energy storage system.

Chung-Neng Huang and Yui-Sung Chen stated efficiency improvement of magnetic flywheel over simple flywheel in their researched named as Study on design of magnetic flywheel control performance improvement of fuel cells used in vehicle. This research refers that efficiency of magnetic flywheel is increased by 27.3% over simple flywheel in fuel cell output. This improvement is possible only because of the properties of magnetic flywheel such as high energy density, high-speed charging ability and low loss. In this research they have used lithium-ion battery in magnetic flywheel system (MFS).

Michael A. conteh and Emmanuel C. Nsofor did study on journal of applied research and technology Composite flywheel material design for high-speed energy storage. They have analysed properties of flywheel such as low density, low modulus and high strength composite materials for high-speed energy storage. In this research, they did evaluated flywheel stress analysis, energy density of flywheel and composite material properties. They have concluded in order to obtain high energy density a search for higher strength, lower modulus and lower density for constant stress portion is required. Also study demonstrated outperformance compared to the boron/epoxy-graphite/epoxy combination.

Elisa Isotahdon, Elina Huttunen-Saarivirta and Veli-Tapani Kuokkala did research study on journal of alloys and compounds named as characterization of the microstructure and corrosion performance of Ce-alloyed Nd-Fe-B magnet. They studied neodymium magnet is necessary for increase in performance of ESS. In this research we get known about the microstructure and chemical properties of neodymium magnet. They also stated that Ce-alloyed neodymium magnet, Ce is used to increase corrosion resistance property of magnet. In short it increases life span of neodymium magnet. This alloyed Ce can make huge difference in corrosion resistance properties of neodymium magnet. It is possible to replace Ce for Co for alloying. They had also examined microstructure difference between both alloyed neodymium magnets.

The study on journal of energy conversion and management named effect of energy-regenerative braking on electric vehicle battery thermal management and control method based on simulation investigation is done by Jingying Huang, Datong Qin and Zhiyuan Peng. The main problem of re-generative braking is that temperature rise in battery due to braking. This problem is solved by using fuzzy logic simulations. They have stated that higher regenerative braking ratio, higher temperature rise in battery so need to modify RB ratio to control thermal management of battery in electric vehicle. They also reviewed various simulations for thermal management of battery in this research.

In study, there is scope for frictionless power generation with help of magnetic flywheel, regenerative braking and neodymium magnet. Magnetic flywheel instead of simple flywheel, Ce alloyed neodymium magnet and lithium ion battery are assembled to produce contactless electricity power. In design amount of energy produced is stored into battery and used whenever desired in electric car.

3. METHODOLOGY AND DESIGN

Experimental Setup:

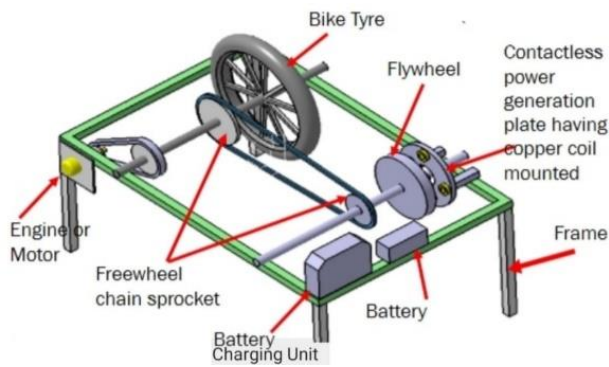


Fig. 1. Experimental setup

In design, the flywheel, copper wire and neodymium magnet are main component of system. Flywheel is used for energy storage system with copper wire used to transfer electric flux to system and neodymium magnet for magnetic flux generation. The wheel which is connected to the pulley mounted on the same shaft and its diameter is less than the wheel diameter due to which its speed of rotation will be increased. On another shaft connected to the pulley is having the assembly of flywheel and copper magnet-coil arrangement. Flywheel will store the kinetic energy while wheel is in running condition and will release the K.E when the brake is applied on the wheel. So the use of flywheel provides such kind of energy which help to run the cycle by less efficient power. Copper magnet will start rotating shaft and coil is steady. So here variable e.m.f is produce from magnet and coil arrangement. By this way power will be generated and stored into battery.

POWER GENERATION

When designing a generator it is important to have a firm grasp of the basic laws that govern its performance. In order to induce a voltage in a wire a nearby changing magnetic field must exist. The voltage induced not only depends on the magnitude of the field density but also on the coil area. The relationship between the area and field density is known as flux (Φ). The way in which this flux varies in time depends on the generator design. The axial flux generator uses the changing magnetic flux to produce a voltage. The voltage produced by each coil can be calculated using Faraday's law of induction:

$$v = -N \frac{d\phi}{dt}$$

Time varying magnetic flux

An important factor is that the greater the change in magnetic field the greater the induced voltage. Translating this to the construction of a wind turbine is that the greater the velocity of the wind the greater the rate of change in the magnetic field and hence more voltage will be produced. Faraday discovered that the induced voltage was not only proportional to the rate of change in the magnetic field but it is also proportional to the area of the magnetic field.

This area directly relates to the size of each coil in a generator or the area of a coil. Increasing the size of each coil will proportionally increase the voltage output. A term known as the magnetic flux is formulated from the dot product of the area and the magnetic field density in a uniform field.

$$\text{Flux} = \Phi = BA \cos \theta$$

In most cases a uniform magnetic field cannot be produced so the flux is calculated by the integral of the magnetic field with respect to the area.

$$\Phi B = \int B \, dA$$

A close approximation of the induced voltage can be taken using the dot product.

Coil design:

The number of windings per coil produces a design challenge. The more windings will increase the voltage produced by each coil but in turn it will also increase the size of each coil. In order to reduce the size of each coil a wire with a greater size gauge can be utilized.

Again another challenge is presented, the smaller the wire becomes the less current will flow before the wire begins to heat up due to the increased resistance of a small wire. Each one of our coils has a measured resistance of 40 Ω ; a smaller gauge wire would further reduce this resistance

In our design we have chosen to sandwich the coils between two attracting magnets. This design will increase the field density greatly improving the voltage output.

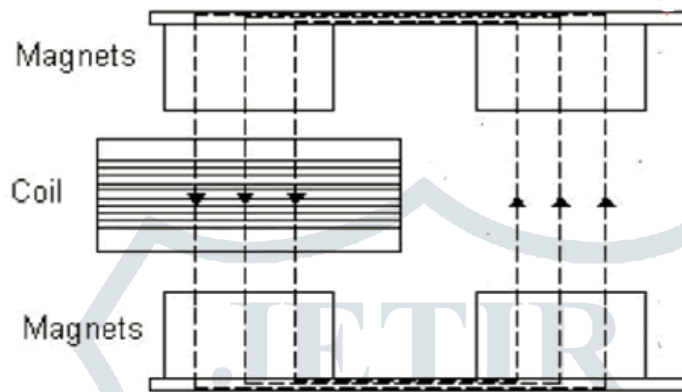


Fig 2: Coil design

N-52 grade NdFeB magnet:

The magnets used in this design is N-52 grade NdFeB magnets. The flux density of such magnet is 2100 Gauss and that is indicated by the green glow of light in the figure below.

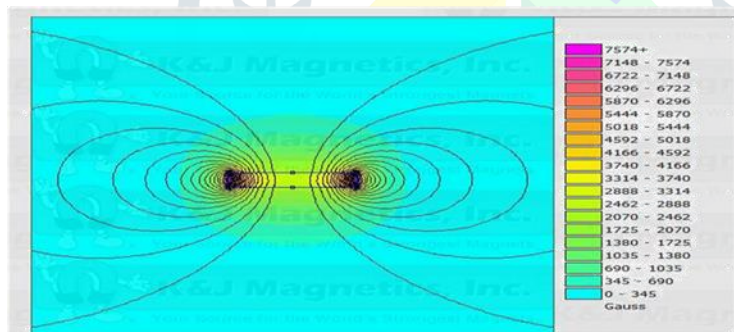


Fig 3: Flux density NdFeB magnet

The website for the permanent magnets(N52) supplied the specs that are required to make this calculation as seen in Table

Max. Energy Product	Residual Flux Density	Coercive Force	Outer Diameter	Inner Diameter	Thickness
B ^H (MAX)	B ^R (MAX)	H ^C	D ^O	D ^I	H
33-52 MGOe	11.7-12.1 KGs	>11.0 Koe	40 mm	20 mm	5 mm

Data Reduction:

1. **Belt drive transmission**

Motor RPM =1440 (standard motor) Motor pulley Diameter (Input) = 75mm
 Large pulley Diameter (output) = 85mm Centre Distance = 250mm
 Output Rpm = To find

Formula

$$\frac{\text{RPM of motor}}{\text{RPM of shaft 1}} = \frac{\text{Diameter of shaft pulley}}{\text{Diameter of Motor pulley}}$$

1440/RPM of shaft 1 = 85/75 RPM of shaft 1 = 1270.58

RPM of shaft 1 = N₂ = 1270.58

2. **Chain drive transmission**

Rpm output of belt drive is input rpm of chain drive therefore,
 Large sprocket RPM = 1270 Large Sprocket diameter = 120mm
 Small Sprocket diameter = 80mm Large sprocket teeth (input) =22
 Small sprocket teeth (output) =14
 Centre Distance = 400mm Chain length= 1000mm

Formula

$$\frac{\text{RPM of Shaft 1}}{\text{RPM of shaft 2}} = \frac{\text{No of teeth on larger pulley}}{\text{No of teeth on smaller pulley}}$$

1270/RPM output = 22/14

RPM output = 808

Hence, the input speed of 1440 RPM is converted to 808 RPM to flywheel through a belt drive and chain drive So according to design magnet will also rotate with same speed as flywheel

3. **Equivalent torque applied on primary shaft**
Power transmitted by shaft

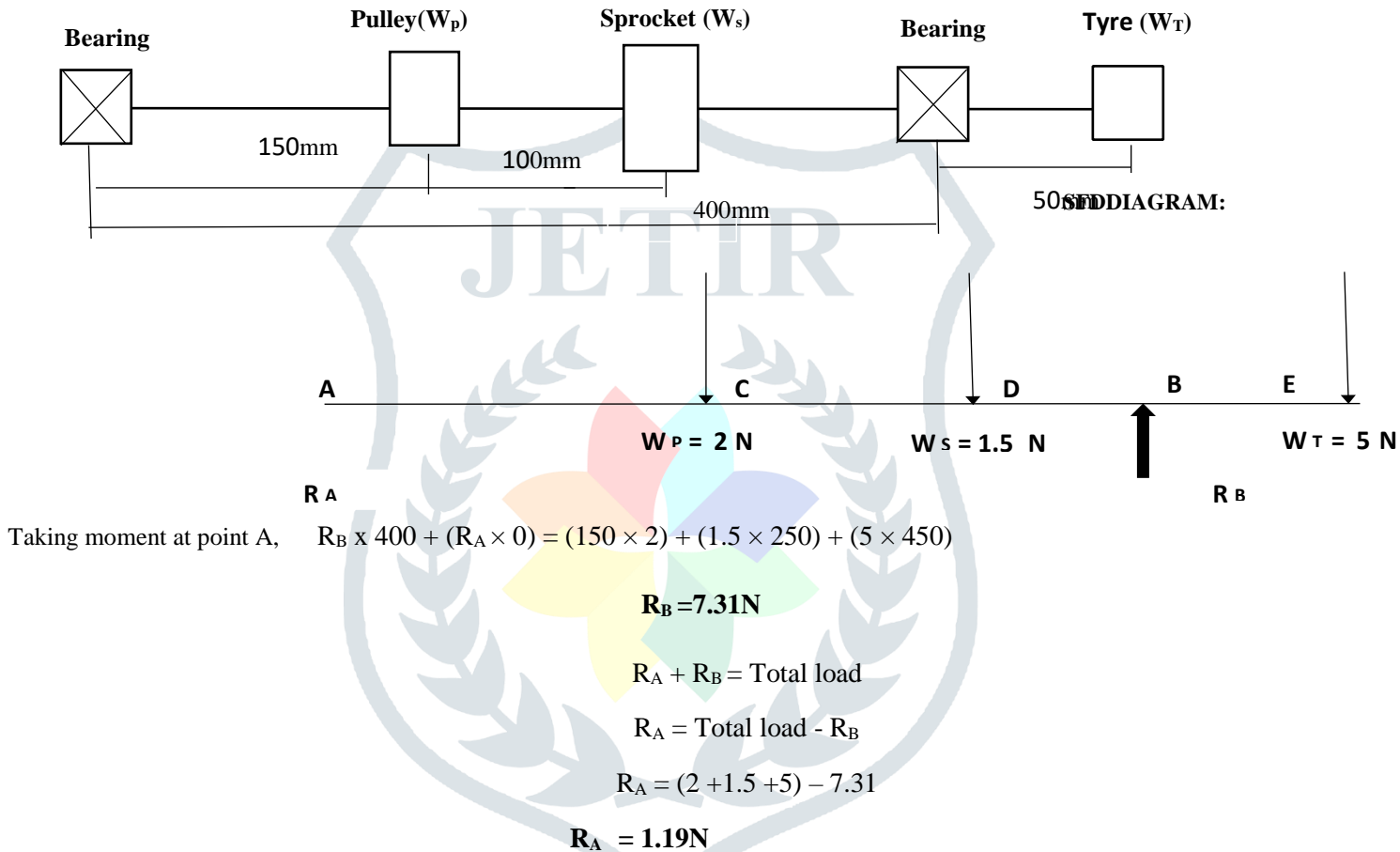
$$P = \frac{2\pi NT}{60}$$

Where, N → Rpm of shaft 1 = 1270 T → Torque transmitted

P → Power Available = 0.5kw = 0.5 × 10³w

$$P = \frac{2\pi \times 1270 \times T}{60 \times 1000}$$

$$T = 3.76 \text{ Nm}$$



Calculation of maximum B.M:-

$$M_A = 0 \text{ Nm}$$

$$M_C = R_A \times 150 = 1.19 \times 150$$

$$M_C = 178.5 \text{ Nmm}$$

$$M_D = 1.19 \times 250 - 2 \times 100$$

$$M_D = 97.5 \text{ Nmm}$$

$$M_B = 1.19 \times 400 - 2 \times 150 - 1.5 \times 50$$

$$M_B = 101 \text{ Nmm}$$

$$M_E = 0$$

∴ Maximum bending moment at point C = 178.5 Nmm = 0.178 Nm

Combine Twisting and Bending

$$T_{eq} = \sqrt{T^2 + M^2}$$

$$= \sqrt{3.76^2 + 0.178^2}$$

$$= \sqrt{14.161} \text{ Nm}$$

$T_{eq} = 3.76 \text{ Nm}$

As we know that,

$T_{eq} = (\pi \times D^3 \times \tau) / 16$

Where,

$D = \text{Diameter of shaft} = 20 \text{ mm} = 0.02\text{m}$

$\tau = \text{Shear Stress}$

$\tau = (16 \times T_{eq}) / (\pi \times 0.02^3)$

$\tau = (16 \times 3760) / (\pi \times 0.02^3)$

$\tau = 2.3949 \text{ N/mm}^2$

For steel,

Allowable shear stress $60 \text{ N/mm}^2 \geq \tau$.

Hence our Design is safe.

4. Equivalent torque applied on secondary shaft

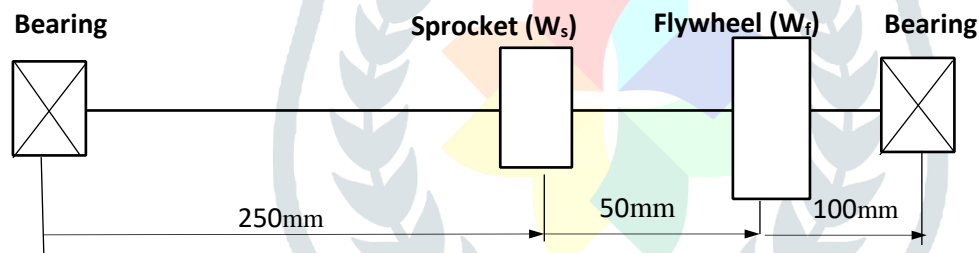
The power available for shaft 2 is same.

Power transmitted by shaft,

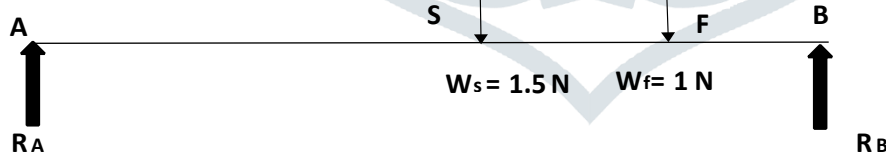
$P = \frac{2\pi NT}{60}$

$P = \frac{2\pi \times 808 \times T}{60 \times 1000}$

$T = 5.912 \text{ Nm}$



SFD DIAGRAM:



Taking moment about point A, $R_B \times 400 + (R_A \times 0) = (1.5 \times 250) + (1 \times 300)$

$400 R_B = 675 \text{ N}$

$R_B = 1.68 \text{ N}$

$R_A + R_B = \text{Total load}$

$R_A = \text{Total load} - R_B$

$R_A = (1.5+1) - 1.68$

$R_A = 0.81 \text{ N}$

Calculation of maximum B.M:-

$$MA = 0Nm$$

$$MF = 0.81 \times 300 - 1.5 \times 50$$

$$MS = R_A \times 250 = 0.81 \times 150$$

$$MF = 168 Nmm$$

$$MS = 200.5 Nmm$$

$$MB = 0 Nmm$$

∴ Maximum bending moment at point S = 200.5 Nmm = 0.2005 Nm

Combine Twisting and Bending

$$T_{eq} = \sqrt{[T^2 + M^2]} = \sqrt{5.912^2 + .2005^2}$$

$$= \sqrt{34.9517 + 0.0402}$$

$$T_{eq} = 5.915 Nm$$

As we know that

$$T_{eq} = (\pi \times D^3 \times \tau) / 16$$

Where,

$$D = \text{Diameter of shaft} = 20 \text{ mm} = 0.02m$$

τ = Shear Stress

$$\tau = (16 \times T_{eq}) / (\pi \times 0.02^3)$$

$$\tau = (16 \times 5915) / (\pi \times 0.02^3)$$

$$\tau = 3.76 N/mm^2$$

For steel, Allowable shear stress = 60 N/mm² ≥ 3.76 N/mm²

Hence design is safe

4. RESULT AND DISCUSSION

The system arrangement generates electricity without any friction with flywheel and it can be utilized in the maximum amount. The voltage output taken from the assembly is totally dependent on the rpm of the wheels so voltage is fluctuating so a battery is used to provide a constant power supply to charging vehicle or appliance. A battery connected to the generator assembly is continuously charged when shaft moves. The result of this experiment is based on trial and error method. So with the help of iteration process, the output voltage from design is equal to 12 V.

5. CONCLUSION

It is eco-friendly clean energy production from the waste. Under the dynamic operating conditions the magnetic flywheel system satisfactorily reaches requirement for the EV system. Also, it will help in reduce stress on non-renewable sources like petrol, diesel and kerosene. It will make our nation a step ahead in eco-friendly energy production

6. REFERENCES

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