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Development OFA Smart Sustainable Free Flywheel Base Energy System

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Abstract **Review Article**

Development of a closed fly wheel based energy system is a concept for generating energy free that is emission free like the renewable energy sources. It comprises a fly wheel 315kg, 2.5Hp 220volts DC motor,10Hp 250volt Alternator, locally developed hub powered with pump for cooling and hydrodynamic lubrication of the flywheel shaft, charge controller, and smart system. The concept of the design and development of a fossil fuel free generator is driven from the high energy stored in fly wheels. An ecofriendly power generation is needed to reduce emissions that have led to the well-discussed global warming and depletion of ecosystem. The momentary motion of any fly wheel is a function of its mass and its velocity as it affect the duration of its rotation before coming to rest. The interconnectivity among the flywheel, generator, a battery and a DC motor can lead production of a reasonable amount of Electrical Energy. Inertia laws and momentum were used in the design of the flywheel. The use of charging controllers and battery management system (BMS) as well as rectifier are used to maintain steady supply and battery life Generation principles, identification of areas of loses, power stability, energy bank, electronic energy booster (fondly known as electronic gear) and smart system for energy management and sustainability.

Keywords: Free Energy, Sustainability, Management, Smart System, Mini Home Fuel less Generator.

INTRODUCTION

Renewable energy has been the world's alternative focus on energy utilization since the problem of global warming. A vast amount of CO_2 gas is being released every second in the world because fossil fuels are the sources of energy on which industrialization, the economy, and civilization run. However, the dire need for energy to sustain the increasing economy as a result of the world population increase has led to the reason why carbonization has not been abated. The hazardous effects attracted by global warming create awareness and inform the world of the imminent danger that will ravage the entire ecosystem and humanity. As a result, drastic actions on alternative energy uses that can aid in decarburization have been researched and developed. shown the varieties of these renewable natural sources of renewable energy are affected by periodic natural phenomena such as the rotation of the earth that causes day and night, the rise and fall of tides, seasons, and time. All these affect the amount of energy generated from renewable energy sources like the sun, wind, rivers, the ocean and seas, etc. These fluctuations in the amount of energy supplied by renewable energy sources necessitate research and development of energy storage systems like flywheels, battery banks, and supercharged capacitors. Researchers are still going to stretch the charging and discharging abilities of the deep-circle batteries as they affect the storage capacity of the deep-circle batteries in the area of electric vehicles and grid utilization. Most inverters do not only rectify voltage but also boost the voltage output.

The world has identified alternative sources of renewable energy. The problems associated with each of them are being proffered, but the problems surrounding the energy trilema are yet to be tackled because of our human nature of want, culture, inequality, and location. Whether a mono or a hybrid system of energy supply, energy management and litigation will help to attain sustainably the availability and dependability of energy generation and supply from renewable energy systems. There are campaigns for renewable energy for all come 2050. Many countries have keyed into it despite some ills that follow it, like solar energy. Installations that can serve a population like a city may occupy twice the land mass of the city. Some of these countries have their installations in the sea, forgetting any harmful effect they may have on the aquatic life, both fauna and flora kingdoms. Solar energy is still untapped because of its viability and abundance. The work is keying into it.

Energy management is very important as it eradicates wastages and enhances availability in future time. Our tradition of showing laise fair attitude towards the used of electric energy dependent facilities in our homes and public places demands attention if energy supplies from renewable energy sources must be sustainable. Solving this problems demand the development of smart systems incorporated in these facilities that will sense day and night, presence of intruder, temperature limit, time etc. For example, majority of people waste energy by leaving their bulbs on in the day whether they are around or not, low energy bulbs should be developed with smart system that can sense day and night. In bed rooms, smart system that will sense movement in the bulb so that if one is asleep nit will automatically trip off. The use of smart systems will help use avoid wastages and conserved our energy for better uses.

As the world is drifting away from fossil fuels and towards clean energy to decarbonize the earth, we should also be researching and working towards equitable technology adaptation for all our faculties, domestic and industrial, to be able to be green energy dependent. This implies lighter machines and facilities with good adaptation to renewable energy sources and low energy efficiency with high performance. This could help in growing our industries, and the fear of the collapse of industries due to litigation on the use of power generation from fossil fuel will be eliminated.

Free Energy tapping power without the use of fuel June Tharaphe Lwin (2019). Many methods are used by different researchers and developers in many countries and amount of power obtained can be very high with few kW needed to power a housing are obtainable. The methods which can be used as the free energy devices are as follows:

a) Battery-Charging Pulsed Systems
b) Moving Pulsed Systems
c) Energy-Tapping Pulsed Systems
d) Aerial Systems and Electrostatic Generators
e) Motionless Pulsed Systems
f) Fuel-less Motors
g) Magnet Power
h) Passive Systems
i) Gravity-Powered Systems

Many suggestions and researches have be done to go into renewable energies – hydro, biomass, geo thermal, wind and solar. Many of these have gain recognition and thriving to take position of the fossil fuels dependent power generation. The need to research for achieving practical zero emission in the source and consumption in addition to the challenge of linking the scientific-technological knowledge to the global interests of a sustainable planet, by means of the promotion of the use of alternative energies, makes evident the aim to design an experimental prototype of this project. In this sense, energy stored in a rotating flywheel plays an essential role in the implementation of clean energies as main electricity source. Energy stored in a rotating flywheel is enormous and can be utilized to generate electric power. Flywheels are employed in the functional ability and efficiency of power generation of an internal combustion engine. It presence does not only aid the momentary motion but generate energy to help in the compression stroke of the engine. Most mills use fly wheel as a means of sustainable energy hence, the conception of flywheel in electric power generation for the design and development of a fuel-less generator. Eco friendly energy production will save the world from pollution, and global warming, the schematic diagram in figure 2 shows an idealized demonstration of the design. Flywheels produce enormous fast response time and optimal grid behavior with simple and robust system, reliable operation and performance .Its efficiency is determined as:

$$\eta = \frac{restored\ energy}{consumed\ energy} \text{(i)}$$

A lead acid battery stores energy with specific energy of 30-40 watt-hour/kg enough to power a 100watt bulb for 20minutes but a flywheel based battery possessed specific energy 3-4 times higher than the acid battery at about 100-130 watt-hour/kg. Flywheel has a potential of storing or discharging stored kinetic energy without being damage within minutes to deliver conveniently more power than conventional battery.

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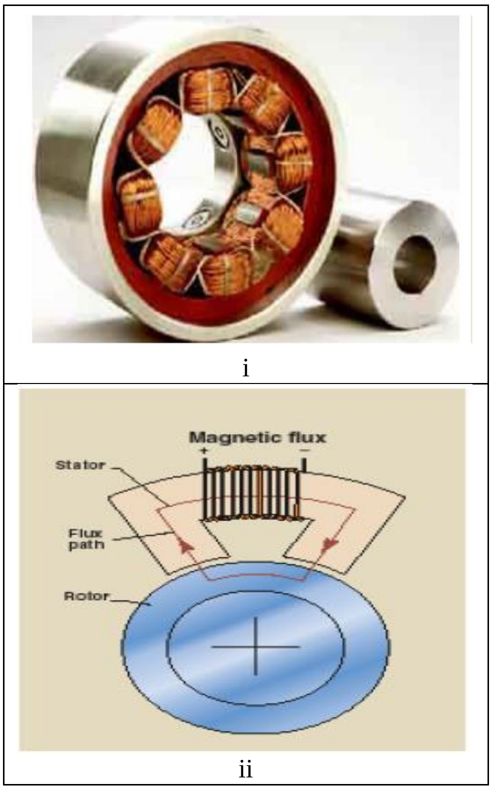


Fig 1: i. Pictorial view and ii a representation of magnetic bearing and rotor
Source: M. Ragheb (2013)

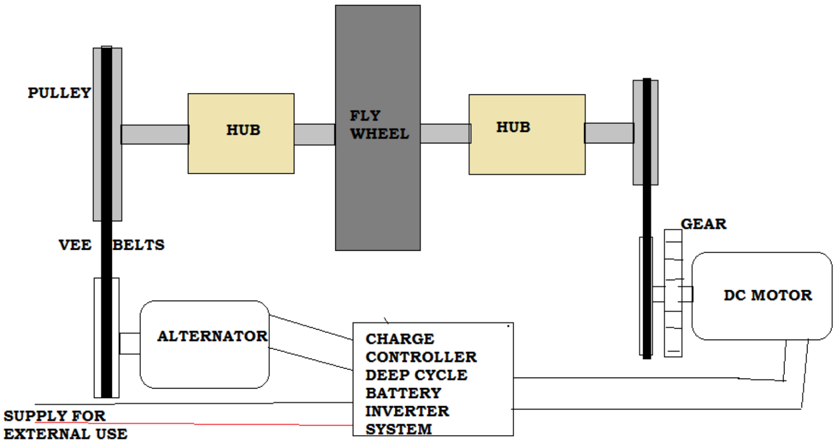


Fig 2: Schematic diagram of the proposed concept

A Flywheel energy system is simple in concept with an electric motor to spin up a wheel or rotor that stores energy, then energy is discharged by an electric generator, thus spinning down the flywheel.

Statement of Problem

Emissions from the utilization of fossil fuels in power generation in mobile automobiles, domestic and industrial power needs has led to global warming that has caused increase in the world temperature. Besides, the noisome environment created by these generators is alarming. This has made every stakeholder to show concern on ways to source and design means of an alternative source of energy other than fossil fuels base. This leads to advent of solar, geo thermal, wind and biomass sources of energy generation. To add to this retinue of all alternative sources of energy, the design and development of a fuel -less, zero carbon emission, generator for constant power energy is investigated and designed

Motivation

The noise propagation and carbon emission in the cities especially at night is alarming. The development of a smart sustainable free flywheel base energy system will help to eradicate these two worrying problem besides the cost of petroleum product for fueling the generator and the dirtiness that follows the utility.

Scope

The generation of the concept, design calculation and material and parts selection, hub design, smart system design and electronic gear, design flow chart, and the simulation of the system with lab center, as well as the CAE work with solid works in the design of the model are within the limit of this work.

Aim and objectives

The development of a smart sustainable free flywheel base energy system for a given amount of power utilization.

To achieve this aim the following objectives must be met

i. Power demand should be know and constant through appliances sizing
ii. Develop flywheel concept and determine the optimum speed
iii. Detail design calculations
iv. CAE work with solid works to develop the model
v. Electronic works, calculation and simulation with lab center

Significance

The essence of this work is to provide a means among other methods of renewable energy generation that can reduce dependence on fossil fuels and eliminates emission of greenhouse gasses that will increase global warming.

History of Flywheel

The use flywheel technology for mechanical energy storage began many hundred years ago and developed throughout the Industrial Revolution. One of the first modern dissertations on the theoretical stress limitations of rotational disks is the work by Dr. A. Stodola, whose first translation to English was made in 1917. Development of advanced flywheel begins in the 1970s. But today Flywheel energy storage systems are widely used in space, hybrid vehicles, military field and power quality. Space station, satellites, aircraft are the main application field in space. In these fields, flywheel systems function as energy storage and attitude control. For the applications in hybrid vehicles and military field, flywheel systems are mostly used to provide pulse power. But for power quality application, flywheel systems are widely used in USP, to offer functions of uninterruptible power and voltage control.

1. Flywheels As Energy Storage Medium

Flywheels have for centuries been used to stabilize the rotational frequency and smooth the power in mechanical systems, it is only through relatively recent (1990s) advances in both carbon-composite rotor materials, and the control system that levitates the flywheel, that flywheels have been able to compete as a larger capacity energy storage technology [1]. These include automobiles, compressors, pumping station etc. The world is so dependent on electrical energy in everyday life that there is proliferation of electrical storage systems, rechargeable and inverter systems being developed and improved upon .Flywheels are basically rechargeable batteries as it is used to absorb electric energy from a source, store it as kinetic energy of rotation, and then deliver it at the needed time, in the form that meets the load needs. The energy stored in a flywheel is proportional to the radius of the wheel, and the mass of the rotor, but depends on the square of the rotational speed and therefore in general, high-speed flywheels provide a higher energy density system .see equations in design section of this work

Flywheel energy storage system (FESS) on a grid scale is a recent development, and at this scale it is currently regarded as a solution to the regulation market more than the capacity market [2]. Grid scale FESS have very fast response times and reach rated power in seconds, while possessing relatively low energy capacities capable of supplying rated power typically for the order of minutes.

A FESS consists of a motor/generator unit attached to a rotor of large mass, which is levitated by magnetic bearings inside a strong vacuum chamber in order to minimize frictional losses due to air friction on the flywheel [3]. When grid energy must be absorbed, electrical energy is rapidly diverted to the motor units which accelerate the flywheel. Thus excess electrical energy is stored as rotating (kinetic) mechanical energy. The energy is recovered by switching the operating mode of the electric machine into that of a generator driven by the flywheel, supplying electrical energy back to the grid as the flywheel decelerates. Short discharge time flywheel systems are suitable for voltage and frequency stabilization, while longer discharge durations may be suitable for load fluctuation damping [4]. Flywheels are therefore a fast responding complement to any slower response storage technology. FESSs are able to handle high power levels, with peak powers of the order of gigawatts available in pulsed applications, limited only by the power electronics available. They have a high energy density and do not suffer capacity degradation over their lifetime – whether operated on shallow or on deep discharges. ‘State of charge’ or energy available at any given time can be accurately calculated from the rotational speed of the rotor [5, 6]. For example, the storage plant in Stephentown can reach its rated power of 20 MW in less than 4 seconds, while it is also designed for a lifetime serviceability of 125 000 equivalent full depth-of-discharge (DOD) cycles [7]. A major benefit of flywheel technology is the absence of toxic waste at the end of the life-cycle, with most parts of the FESS being covered by existing electronic equipment recycling infrastructure

Design

Design Concept

The Concept of this design is based on the great deal of energy possessed by a flywheel. The flywheel system mainly consists of flywheel rotor, alternator, inverter system, DC motor, Self manufactured oil cool bearings and housing and power transformation electronic system. In the development of the flywheel energy production system, current researches have focused on increasing the performance while meeting the safety considerations, by incorporating brake system i.e., material, housing and bearing failures. Investigation of energy storage and sustainability considerations are looked into in this work.

Design Consideration

For an efficient design and development of a 'fueless' generators, the following design considerations were not undermined.

(i) The flywheel mass and material selection and design
(ii) Bearing selection: the bearing selection will be based on thrust and speed of rotation as well as maintenance.
(iii) Shaft design
(iv) Sizing the alternator
(v) V-pulley & V- belt
(vi) Storage media determination (Battery)
(vii) DC motor size determination

Flywheel

Flywheel material selection and design depend on individuals because of material availability, size and design presses and manufacturing. But the basic consideration here is the energy to be generated which is a function of its mass and speed of revolution. Hence, the mass helps to determine the size and materials that can be adapted for the design. The energy stored from the conservation of energy is given

$$K_E = {}^1/_2 MV^2 \qquad (1)$$

$$P_E = Mgh = K_E = {}^1/_2 MV^2 \qquad (2)$$

As when its in a stationary position, the potential energy possessed by the flywheel is equal to its Kenetic Energy. Considering centripetal force of a rotating flywheel

$$C_f = Ma \qquad (3)$$

$$C_f = M\frac{V}{t} \qquad (4)$$

$$V = \omega r \qquad (5)$$

$$v = \frac{\pi DN}{60} \qquad (5a)$$

$$a = \frac{V^2}{r} \qquad (6)$$

$$C_f = \frac{M(wr)^2}{r} = M\omega^2 r \qquad (7)$$

If work done ,W_E

$$W_E = Fd \qquad (8)$$

$$W_E = MV^2 r * r \qquad (9)$$

$$W_E = MV^2 r^2 \qquad (10)$$

Hence the parameters to be considered for the energy stored will be its mass (M) and Radius (r) from the axis of rotation. But in the design of a higher radius contain factors many prevent it. For example, the size of material to fabricate it, weight, and its machinability. No Centre lathe can occupy biggerdiameters thus a source for an alternative design with earthy materials like cast, Mortar, sand, cement gravel. But another problem with this process is having a common running centre with external and internal diameters See Fig 2.

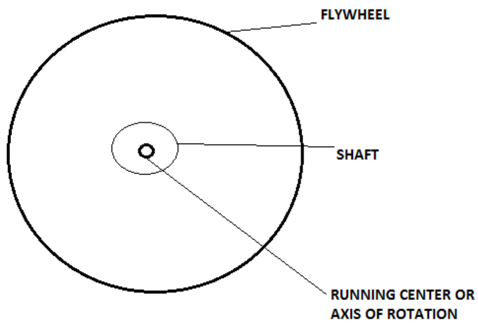


Fig 3: Flywheel – shaft eccentricity

Energy is stored in the rotor as kinetic energy, or more specifically, rotational energy:

$$I = \int x^2 dm_x \, [Kgm^2] \qquad (11)$$

Where, x is the distance from rotational axis to the differential mass dmx. Where I is the mass moment of inertia and ω is the angular velocity. Mass moment of inertia is obtained by the mass and geometry of the flywheel. From equation 11, x becomes the radius of the flywheel. The parameter that could affect the weight, w,(kg) of the flywheel are the grain size of the particle of the material, material composition, flywheel thickness (t), radius (r) of the flywheel, and technology involved in the manufacturing.

$$E_K = {}^1/_2 \times I \times \omega^2 \qquad (12)$$

I is the moment of inertia of the mass about the center of rotation. ω .The moment of inertia for a solid-cylinder is

$I_z = 1/2\, m^2$ (13)

Where m is the mass and r the radius of the flywheel. Specific energy Ek,m isobtained by dividing Ek by the mass to give:

$E_{K,m} = {}^1\!/_4\, r^2\omega^2 [J/JKg]$ (14)

From the above equation it can be concluded that the kinetic energy of the flywheel increases quadratically with angular velocity, and hence high rotational speeds are desirable, also revealed that the rotor diameter has an even greater influence on kinetic energy. The constraint that mechanical strength of the flywheel material imposes on its diameter and angular velocity.

The product of maximum flywheel radius and angular velocity is dependent on the square root of the specific strength of the flywheel material, i.e.

$r_{O,Max}\omega = \sqrt{S_{\theta\theta}/\rho}$ 15

Where SΘΘ is the strength of the material in circumferential or hoop direction. Hence, rotors are preferably made from low density, high strength fiber-reinforced polymer composite (FRPC) materials that are filament-wound in circumferential direction. The maximum stress of a thin rotating ring is given by:

$\sigma_{max} = \rho r^2\omega^2$ 16

Where σ is the maximum stress and ρ is the density of the flywheel material. More complex equations are available for different rotor geometries, but the maximum stress is always proportional to ρ, and the square of peripheral speed, equal to rω. The effect of rotor geometries can be accommodated by introducing a shape factor K. The maximum specific energy and energy density

$\frac{E}{m} = K\frac{\sigma_{max}}{\rho}(J/Kg)$ 17a

$\frac{E}{V} = K\sigma_{max}(J/m^3)$ 17b

Equations (17a) and (17b) indicate that the specific energy (energy per mass unit) and energy density(energy per volume unit) of the flywheel are dependent on its shape, expressed as shape factor K.

The shape of a flywheel is an important factor for determining the flywheel speed limit, and hence, the maximum energy that can be stored. The shape factor K is a measurement of flywheel material utilization, Pena-Alzola, R.; Sebastián, R.; Quesada, J.; Colmenar (2011). Figure 4 shows the values of K for the most common types of flywheel geometries

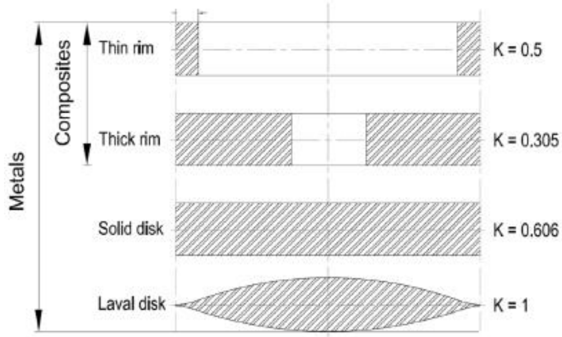


Fig 4: Different flywheel cross section
Source: Pena-Alzola, R.; Sebastián, R.; Quesada, J.; Colmenar (2011)

In this context, the design challenge is to maximize either Ek,m or Ek,v, while satisfying the stress constraints. Tangential and radial stresses are given for cylindrical flywheel geometry where the outside radius (ro) is assumed to be large compared to the flywheel thickness $(t)r_0 \geq 10t$

$$\sigma_t = \rho\omega^2\left(\frac{3+D}{8}\right)\left(r_1^2 + r_0^2 + \frac{r_1^2 r_0^2}{r^2} - \frac{1+3D}{3+D}r^2\right) \quad (18a)$$

$$\sigma_r = \rho\omega^2\left(\frac{3+D}{8}\right)\left(r_1^2 + r_0^2 + \frac{r_1^2 r_0^2}{r^2} - r^2\right) \quad (18b)$$

The running centre or axis of rotation is relevant and must be held with proper attention to avoid problem of dynamic imbalance during rotation. The dynamic imbalance can lead to adverse vibrations that will be inimical to the bearings and their life span. Noise generation is not out of place. Hence given in the design of sizeable flywheels on the lathe machine, the running Centre must be handled with care the hoop stress on the rotor is a major consideration in the design of a flywheel energy storage system, as in equation 16

$$\sigma_t = \rho r^2\omega^2$$

$\sigma_t$is the tensile stress on the rim of the cylinder
$\rho$is the density of the cylinder
$r$is the radius of the cylinder, and
$\omega$is the angular velocity of the cylinder

Rotational speed; directly controls the energy stored, the higher speed ,the more the energy stored, but high speeds assert excessive loads on both flywheel and bearings during the shaft design. Exploration of high strength materials allows designers to reach high operating speeds, yielding more kinetic energy. Using magnetic bearings make it possible to reach high operating speeds providing cleaner, faster and more efficient bearing equipment at extreme temperatures. Recently designed flywheels could offer orders of magnitude increases in both performance and service life and in addition, large control torques and momentum storage capability for spacecraft, launch vehicles, aircraft power systems and power supplies.

Shaft Design

The shaft has significant influence on the power propagation in this design, a straight shaft running concentric with the bearings would yield a great deal of energy as vibration will be minimizes to the minimum.

Design consideration
(i) Size of shaft (diameter)
(ii) Length of shaft

Shaft failures are resulted from material selection, hidden crack and pores from manufacturers, whirling for too long shaft, twist (wrinkle) for low size carry bigger load on torsion. The shaft design is done from the equations under stated.

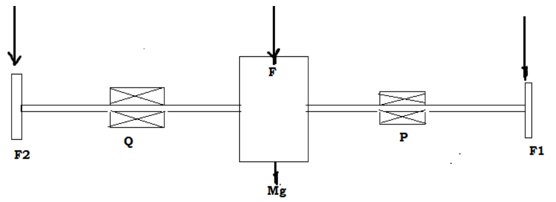


Fig 5: Shaft free body diagram

Torque developed by the rotating flywheel T_q

$T_q = F * r$ (19)

$F = Mg$ (20)

Hence the torsional moment M_t

$M_t = T_q = F * r$ (21)

Determining the bending moment,

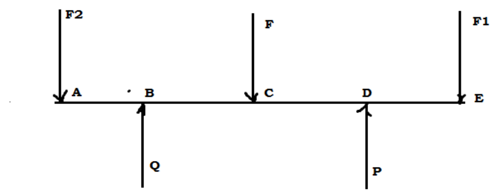


Fig 6: Free body force diagram of the reactions on the shaft

(i) Algebraic sum of vertical forces acting on a body in equilibrium is zero

Hence

$P + Q = F_2 + F + F_1$ (22)

Since,

$M_t = (T_2 - T_1)R$ (23)

It follows that the torsion difference in the pulleys A and E will be govern by the pulley size – Diameter

$R = \frac{D}{2}$ (24)

Therefore, F_1 and F_2 are known by

$F_1 = (T_1 - T_2) = \frac{T_q}{R_E}$ (25)

From

$3.02 \log \frac{T_1}{T_2} = \alpha\mu$ (26)

$\theta_i = \frac{(R_1 - R_2)}{2X_i}$ (27)

$\alpha_i = \frac{(180-\theta)\pi}{180}$ (28)

For aluminum pulley and belt, the design selection for fraction co-efficient μ = 0.3 from equation 22 to 27, the values of T_1 and T_2 for respective pulley at Centre distance X_i are determined for each V pulley – V best drive system. Minimum power lost and no slip condition are conditions for the selection of the drive From the figure 6.

The value for the reaction on the bearing due to load are calculated using the law of equilibrium.

Algebraic sum of moment forces acting at a point on a body is zero. Hence of clockwise turning moment about is equal to the sum of anti-clockwise turning moment about the same point.

Taking moment about B

Algebraic sum of moment forces acting at a point B on the shaft is zero.

$$Clockwise\ turning\ moment\ about\ point\ B = Anti-clockwise\ turning\ moment\ about\ point\ B$$

Clockwise turning moment

$P * |BD| + F_2 * |AB|$ (29)

Anti-clockwise turning moment

$F * |BC| + F_1 * |BE|$ (30)

P is determined.

$P * |BD| + F_2 * |AB| = F * |BC| + F_1 * |BE|$ (31)

Sum of upward forces is equal to sum of downward forces acting on the shaft

$P + Q = F + F_1 + F_2$ (32)

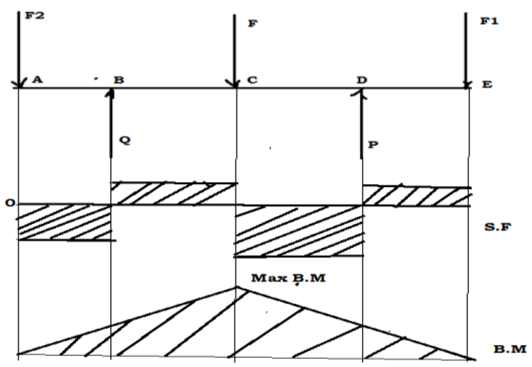


Fig 7: Shear force and Bending moment diagram of the flywheel pulley – shaft system

Hence the size of the shaft is determined (d)

$$d^3 = \frac{\sigma s}{16\pi}\sqrt{(K_t M_t)^2 + (M_B K_B)^2} \qquad (33)$$

$$\theta = \frac{32 M_B}{G L^4} \quad (34)$$

The shaft length however should be as short as possible to avoid twist or formation of wrinkles as well as whirling that will be inimical to the energy production motive.

The power transmitted by the shaft (in watts) is given by [8]

$$P = \frac{2\pi NT}{60} = T\omega \qquad (35)$$

T = Torque transmitted in N-m, and ω = Angular speed in rad/s.

Pulley and Belt Design

Pulley design parameters are selected from the belt cross sectional geometry which govern the formation of a groove HSS tool (form tool) in the workshop. Pulley can be aluminum or cast iron made.

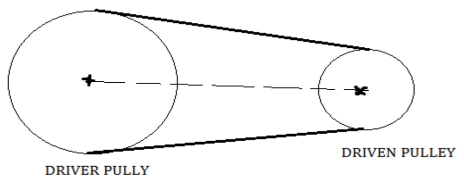


Fig 8: Pulley –belt arrangement

Belt section is determined by the power to be transmitted hence, there are type A,B,C, D kind of belt.

From the torque generated at the electric alternator

$$T_q = (T_1 - T_2)R_a \qquad (36)$$

$$T_{qa} = \frac{P(KW)*9550}{N} \qquad (37)$$

$$P(KW) = \frac{T_{qa}*N}{9550} \qquad (38)$$

The power delivered to the alternator will be used to select the V belt type.

Bearing Selection

In this design friction less bearing are advisable for motion, high thrust power on energy transmission by the flywheel. Availability and cost may inhibit this suggestion. Bearing selection is based on the bearing with the maximum reaction; hence bearing at c with Reaction P governed the selection.

$$F_A = 2R_P \quad (39)$$

The shaft diameter determines the bore size of the bearing

$$P_e = YW + VF_a \quad (40)$$

$$\frac{W_C}{F_a} \geq W_e \qquad (41)$$

$$L = \left({}^{P_e}/_{C}\right)^3 \qquad (42)$$

1. Key And Keyway

Key size is determined by the nominal diameter, (d) of the shaft, the relations given in equation 43 and equation 45

Width of the key (w)

$$w = d/4 \qquad (43)$$

Thickness of the key (t)

$$t = \frac{2w}{3} \qquad (44)$$

Or

$$t = d/6 \qquad (45)$$

Energy Storage

The energy storage system is a system of inverter that will help to store enough power for driving the entire system and utilization. The efficiency of the charging system is a function of the reliability of this design by awesome energy potential of the flywheel which is a function of its speed. Hence a good charging electronic system is designed.

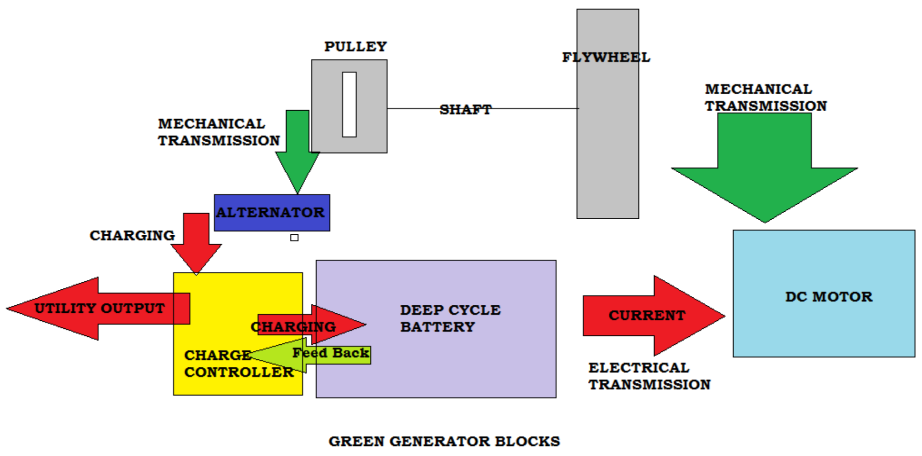


Fig 9: Representation of the green power concept

Charge Controller Design

The battery is protected from being overcharged by a charge controller. If an excess voltage from the sources is allowed to the battery, it will overcharge it. This may reduce battery performance or lifespan and may pose a safety risk, hence, the charge controller.

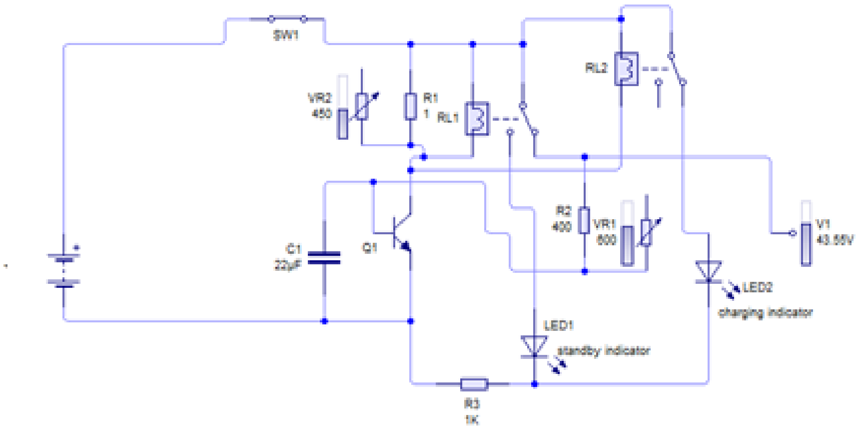


Fig 10: Live wire circuit for the charging of the battery.

Calculation

Nb : 1Hp≅ $746watt$

The input power is calculated

Input parameters for the DC motor

Voltage=220v

Rated parameters

Volt =240v

Measured current =23.65Ampere

The input current I_{input}

$$I_{input} = \frac{220 \times 23.65}{240}$$

$$I_{input} = 21.68 Amps$$

Hence the input power is determined as

$$Input\ power = v_{input} 1_{input} \cos \emptyset$$

$$Input\ power = 220 \times 21.68 \times 0.8660$$

$$Input\ power = 4.13kw$$

For the generator

Output voltage=250v

Rated 305v

Output power 305v gives 10kw

Hence

$$P_{output} = \frac{10 \times 250}{305}$$

$$P_{output} = 8.20kw$$

Efficiency of the system

$$efficiency\ of\ the\ system(\eta) = \frac{total\ output\ power\ of\ generator}{total\ input\ power\ of\ the\ motor} \quad [46]$$

$$efficiency\ of\ the\ system(\eta) = \frac{8.20}{4.13} \times 100\%$$

$$efficiency\ of\ the\ system(\eta) = 198.5\%$$

Therefore, this implies that more than extra (100)% output is obtained from the system.

Energy Sored by flywheel at varying speed

From equations 1 and 5a

$$K_E = {}^1/_2 MV^2 \quad [47]$$

$$v = \frac{\pi DN}{60} \quad [48]$$

Where,

N = angular speed of flywheel (RPM)

v = velocity of flywheel (m/s)

E= kinetic energy stored in flywheel (Joules or kgm2/s2)

M = mass of flywheel (kg)

D = diameter of flywheel (m)

D =650mm=0.65m

$$v = \frac{3.142\ x0.65x1500}{60}$$

$$v = 51.06m/s$$

from equation [47]

$$K_E = {}^1/_2 MV^2$$

$$K_E = \frac{315 \times 51.06^2}{2}$$

K_E = 410,622.Joules or kgm2/s2

From the equation 1 and 5a fly wheel system storage data is determine see Table 1.

Table 1: Energy storage data of the flywheel

s/n	Mass (M) Kg	Diameter (D) (m)	Speed (N) RPM	Velocity $v = \frac{\pi DN}{60}$ (m/s)	Energy stored (Joules or kgm2/s2)
1	315	0.65	1500	51.0575	410581.7582
2	250	0.65	750	25.5288	81464.63457
3	100	0.65	1440	49.0152	120124.4916
4	400	0.65	2880	98.0304	1921991.865
5	450	0.65	1800	61.269	844625.3312
6	500	0.65	750	25.5288	162929.2691
7	150	0.65	1200	40.846	125129.6787

But the gear or speed ratio was adopted for maximum out put with the speed of the motor as the basis for determination.

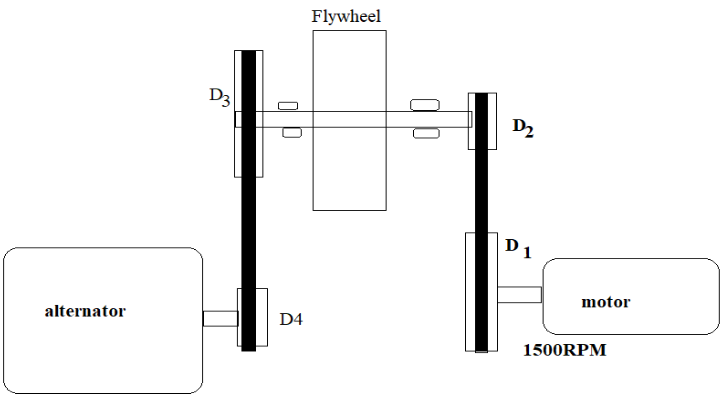


Fig schematic of pulley –speed arrangement in the system

Given that

$$D_1 = 300mm$$
$$D_2 = 75mm$$
$$D_3 = 300mm$$
$$D_4 = 75mm$$

The power delivered to the pulley by the motor, and N_1 is the speed of the rotation of the pulley, which can be determined from the speed ratio of the shaft and the motor as thus:-

$N_1/N_2 = D_2/D_1$ [49]

Where

N_1=motor speed (rpm)

N_2= the alternator speed (rpm)

D_1=the motor pulley diameter =300mm and

D_2 is the alternator pulley diameter connecting D_1 =75mm

$N_2 = \frac{N_1 D_1}{D_2}$ [50]

$N_2 = \frac{1500X300}{75} = 6000RPM$

Since the D_2 and D_3 are in the same shaft it means both possessed same speed hence the speed of the alternator would be

$N_4 = \frac{6000X300}{75} = 24000RPM$

This is a very high speed, but this has shown how we can boost the power output by speed ratios.

Very high speed as this is inimical to shaft and the flywheel owning to the vibration that will be followed hence proper shaft design and selection is needed, the flywheel material should be steel or carbon fibre not cast iron that may shatter because of its brittleness.

HUB design

In a power generating system like this a high speed rotor is designed for but the bearing life is short for high speed design besides the consideration of friction elimination. Electromagnetic bearing serves these purposes that will eliminate friction and reduce wear. Improvising for this, a local bearing hub is designed with other bearing materials and it is constantly serviced with oil for hydrodynamic lubrications like in journal bearing metals in crank shaft, cooling and wear reduction.

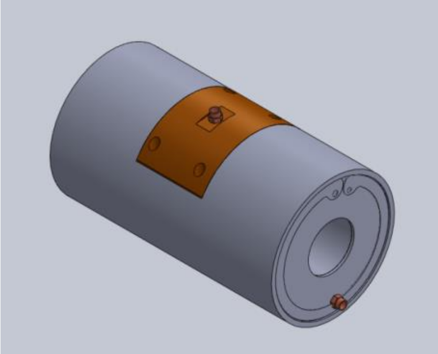


Fig 3-D hub model

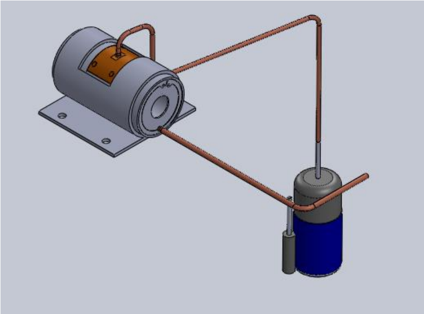


Fig 3-D model of the hub in its housing with oil supply connection from the pump and to the oil tank

Self-starting

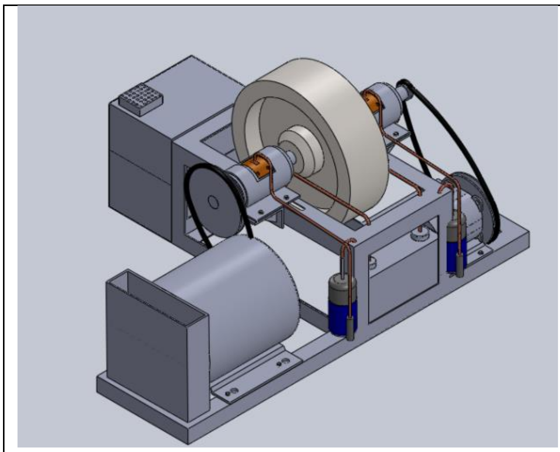
This will require the use of super charge capacitors that will store energy to be use to drive the DC assuming the battery is down .super charge capacitors will also act as back up for the entire system.

Smart system

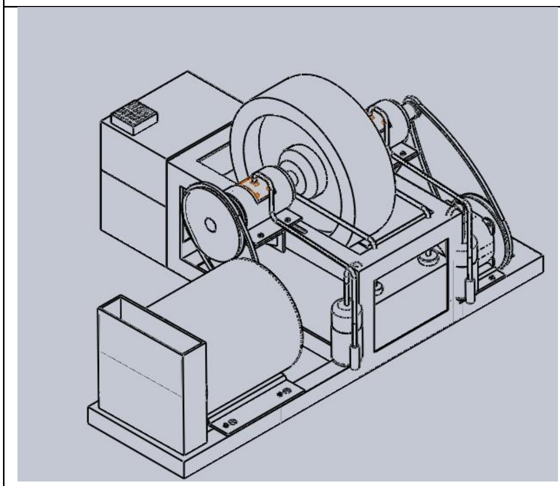
The smart system employed here is a group of monitoring systems with transducers deployed to monitor the flywheel rotor speed, battery charging and discharging rate and the output voltage . This is stem is design for a particular load and over loading may drop the process .hence , the load to be carried is calculated per hour while adding peripheral energy consumptions by pumps, charging load per hour and the expect output generation besides energy loss due to friction that will make up the total load to be designed .

Models

The model design using solid works 2018 is shown in the figures 11 to while the appendix show details of some vital parts.

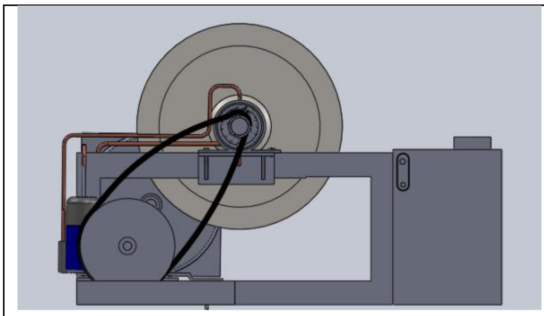


i.



ii.

Fig 11: Isometric view of 3-D solid model and wire frame of a free energy generator



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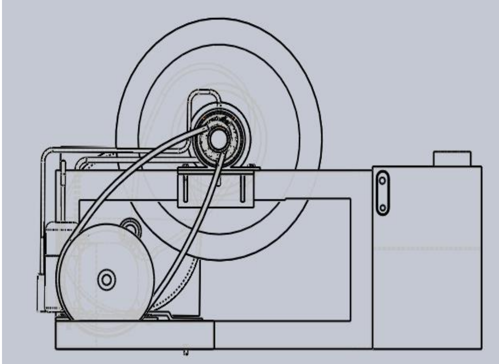
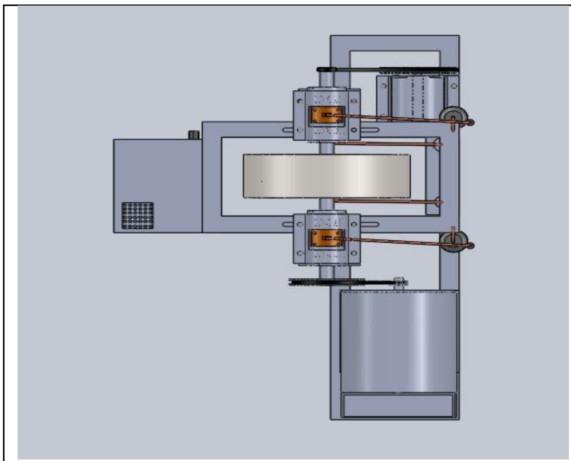


ii.

Fig 12: Right side view of 3-D solid model and wire frame of a free energy generator



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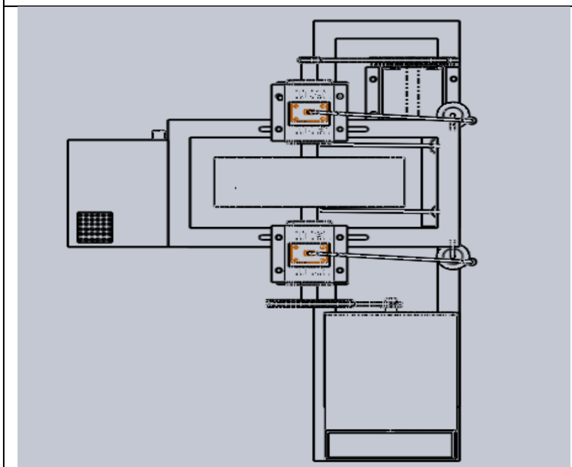

ii.

Fig 12: Top view of 3-D solid model and wire frame of a free energy generator

CONCLUSION

Flywheels systems and energy storage efficiency and performance of flywheel have large research areas. The energy generation concept under consideration will help to generate an enormous amount of energy if improved upon because research had shown that if the right materials and components are used the world will embrace it and over dependency on fossil fuels which are inimical to the ecosystem and human will drastically reduce. This paper work does not specifically work any operating conditions impose limitations, of energy storing or amount of improvements that may contribute in the overall success but to see if the energy could be converted into a useable electricity supply. On the fabrication and testing in the rig certain parametric factors and conditions influencing the operation, efficiency and performance will be verified. Using the available technology at hand, we could very well make fast but crucial improvements in the advanced research areas requiring flywheel utilization on green power generation, where engineers are frequently confronted with the limitations on magnetic bearing load carrying capacity, size limitations and efficiency, work is being conducted on the design of locally sourced oil cooled bearing powered by pumps.

RECOMMENDATION

From the calculation on speed ratios so as to boost power output it has been seen that the speed is too high, on fabrication other speed ratios should be tried in order to save the life of the bearing, shaft and the flywheel. But bear in mind that speed is needed for the performance of the flywheel and the alternator (generator)

Future work

Rig test development and fabrication is ongoing, improvising for materials locally like roller bearings instead of magnetic bearing, and casting of aluminum for fly wheel .But precision machining with CNC is strictly followed to avoid dynamic imbalance, the concept an electronic centrifugal gear system is being looked into that will be engaging and disengaging the DC motor when the speed of the flywheel is reduced to a predefined level**.**

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