Design Of Alternative Power Plant With Apply Flywheel Energy Storage System

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Abstract. Any design or concept of energy generating devices must be in accordance with the laws applicable in the fields of physics, one of which is the law of conservation of energy. This study aimed to determine whether this power plant can work with good efficiency. In the design of the power plant is used a 36 volt DC electric motor to rotate a flywheel *(flywheel)* and a 3000 watt generator with a series-v belt transmission. Initial power to drive the electric motor comes from the battery. Then the power output of the generator used to charge the battery back and the rest is used for other purposes (load). The result is anpower*outputof* the generator is smaller thanpower*the input* by the electric motor, so that the plant can not be used in a long time.The small plant efficiency is due to several factors diantarannya generator and electric motor efficiency is low and the battery charging load is too large so there is a balance between charging and konsunsi power by the electric motor. Keywords: electric motors, generators, *flywheel*

1. Introduction

Nowadays the use of fossil fuelsinto the mainstream choice for generating electricity. But the availability of such fuels are being reduced feared to be extinct. So to cope with the expected extinction of fossil fuel use as fuel is reduced and switched on renewable energy sources. When this has been pretty much done the publication of several concept and design of alternative electrical energy generating devices are based on the principle of free energy *(freeenergy)* both in scientific articles, videosdocumentation, or writings on the internet. Any design or concept of energy generating devices must be in accordance with the law - the law applicable in the fields of physics, one of which is the law of conservation of energy.In the *International Journal for Scientific& Development (IJSRD) vol. 4, issue 02,*2016,entitled*"ConventionalFree EnergyUsing Flywheel* "isexplained that aelectric motor with half the capacity of the HP can produce 21% more power with the help of gravity wheel or *flywheel.* This shows that a *flywheel* (flywheel) can be used as a store of mechanical energy which can then be converted into other energies.In the design of the power plant is used a DC electric motor to rotate a flywheel *(flywheel)* and generator with a series-v belt transmission. Initial power to drive the electric motor comes from the battery. Then the power output of the generator used to charge the battery back and the rest is used for other purposes (load).This study aims to determine whether these plants can work with good efficiency, determine the maximum power that can be produced by plants,and find out if this plant can work in a long time.

2. Review of Literature

2.1 Wheel Crazy (Flywheel)

flywheel*(flywheel)*is a rotating mass is used as an energy storage in a machine. The kinetic energy of a rotating body expressed in a half$I.\omega^{2}$,where*Ithe*ismoment of inertia of the mass of a body against the spin axis and ω is the angular velocity of rotation. If the speed is reduced, energy is released by the flywheel, and conversely, if the speed increases the energy will be stored in the flywheel.

2.2 Generator

generator is an electrical machine which is used to convert mechanical energy into electricity. mechanical energy is used to rotate the coils of wire conductor in a magnetic field orvice versa rotating magnet wires between the coils. Mechanical energy can be derived from steam power, the potential energy of water, gasoline motor, and others. Electric power generated by the generator can be either an alternating current (AC) and direct current (DC), this depends on the construction of the current generator and retrieval systems. Therefore, both types actually have the same principle except the rectification process-flow stream.

2.3 *Electric Motors*

electric motor is an electromagnetic device that converts electrical energy into mechanical energy. This mechanical energy is used for, for example, rotate the *impeller*, pump *fan* or *blower*,drive the compressor, lifting materials, etc. Electric motors are used at home, (such as *mixers*, electric drills, fans) and in industry. The electric motor is sometimes referred to as "work horses" of the industry because it is estimated that motors use about 70% of the total electrical load of the industry. electric motors are divided into two, namely DC motors and AC motors.

2.4 Electric Motors DC

DCmotors that do not use direct current*(direct-unidirectional).*DC motors are used in special use where high torque is required ignition or acceleration that is fixed for a wide speed range. The main advantage is the DC motor speed control that does not affect the quality of power supply.

It can be controlled by adjusting:

1. armature voltage, increasing the armature voltage will increase the speed.
2. Field current, reducing the field current will increase the speed.

DC motors are available in various sizes, but its use is generallylimited to a few low speed, low power usage to moderate such as machine tools and *rolling mills*, because of problemswith mechanical commutation at a larger size. Also they are restricted to use of so diarea clean and not dangerous because the risk of sparking at the brushes. DC motors are also relatively expensive compared to AC motors.

2.5 Transmission Belts

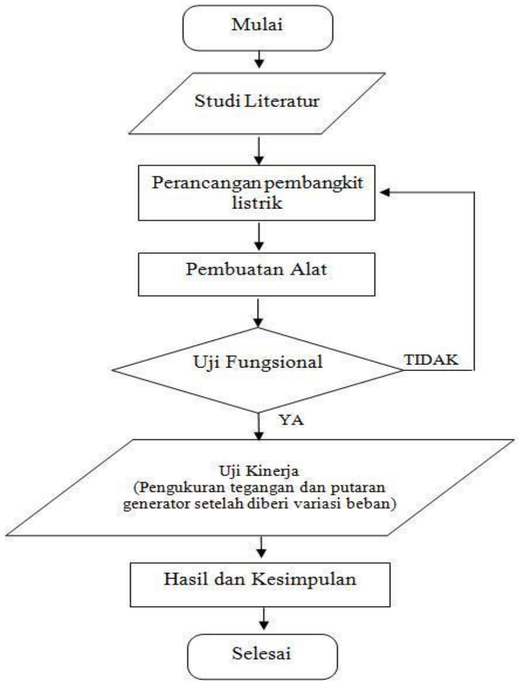
V-V belts are made of rubber and has a trapezoidal cross-section. Woven fabric or the like is used as the core of belts to carry a big attraction. V-belts wrapped around the circumference pulleys V-shaped groove, too. Part of the belt being twisted in this pulleys experiencing arch so that the width of the inside will increase. The friction force will also increase due to the wedge shape, which will result in large power transmission at relatively low voltage. This is one advantage compared with the V-belts flat belts.

2.6 Battery(accumulator)

battery or *accumulator* is an electric cell in which there takes place a reversible electrochemical process (back can) with a high efficiency. What is meant by the electrochemical process of reversible is inside the battery laststhe process of converting the chemical into electrical power, and instead of the electrical energy into chemical energy (charging again by regeneration of electrodes are used, which are passing an electric current in a direction (polarity) opposite in cell).

3. Design Methodology Design Flowchart

The following is a flow diagram of the design of alternative power generation by utilizing a *flywheel energy storagesystem.*



3.1 Tools and Materials

Tools and materials used in this scheme are as follows:

1. *Flywheel*/ Flywheel
2. Motor Electric
3. Generator
4. Batteries/*accumulator*
5. Adapter
6. *Tachometer*
7. *Voltmeter*
8. *Ammeter*, *etc.*

3.2 Schematic Design

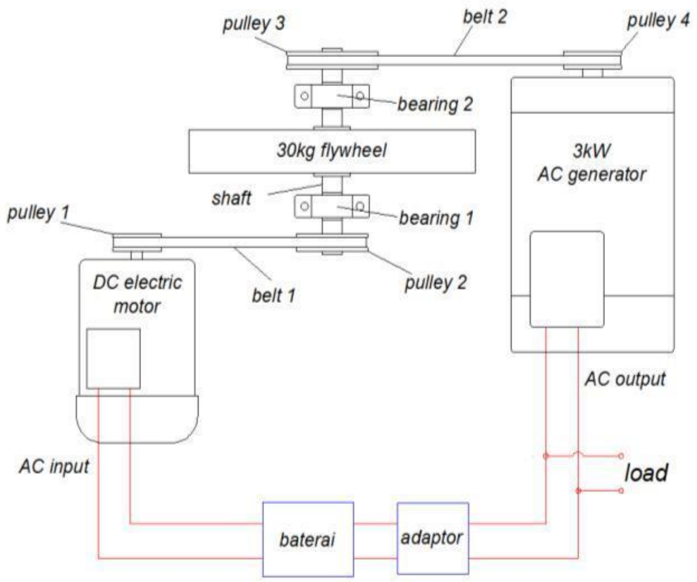


Figure 1. schema design tool

In the design of the system consists of the design berberapa parts such as *Pulley,Flywheel,* belt drive *(belt drive),* Shaft *(Shaft),* bearings *(Bearing),* and others.

1). Axle and *Bearing*

In this scheme, the pivot function and the power forward rotation of the electric motor to genenerator where the shaft is mounteda*flywheel* withmass of 30kg. designthe shaft must be calculated to determine the proper shaft diameter and is resistant to torsional loads and bending loads that occur on the shaft. Selection of *bearing* also an important criterionto ensure a smooth and durable system function.

2). V-belts and pulleys

We know that the belt *(belt)* is useful for transmitting power using pulleys. Each pulley has a diameter and at different speeds. Puli selected according to standard specifications. Diameter pulleys needed is determined by rotation. In this scheme digunankan total of four pulleys and two belts.

3). Flywheel

In this scheme used a *flywheel* with a mass of 30kg and 440mm in diameter.

3.3 Working Principle Tool

A 36 volt DC electric motor rotating a *flywheel* which is then connected to an electric generator by using a transmission-v belt and pulleys. Initial power to drive an electric motor that is derived from the 3 pieces of 12-volt batteries that are arranged in series so that the battery voltage to 36 volts. Then the electrical power generated by the generator partially reused to charge the battery with the help of an adapter and the rest is used for electrical purposes other (expense).

3.4 Testing Methodsequipment

After manufacture power plantis completed, then the functional testing of the power plant. This test aims to determine whether the plant can work well. The next test was done by measuring the rotation of the generator voltage and before and after a given load and then determine the maximum load that can be supplied to the plant.

4. Calculation of Design Data Design

1. Electric Motor
   - motor power *(P)* = 800watt
   - Turn the motor *(n +1)* = *300* rpm
   - pulley diameter *(dp1)* = 203 mm
2. *Flywheel*
   - mass *flywheel (m)* = 30 kg
   - Fingers *flywheel (r)* = 220 mm
3. Generator
   - Power generator *(P)* = 3000 Watt
   - Round generator *(n3)* = 1500 rpm
   - pulley diameter *(dp4)* = 90mm-V

4.1 *Calculation of Transmission belts*

Transmission belt-v 1

1. *P* = 0.8 kW, *n1* = 300 rpm

2. Comparison pulley ratio (i):

$$dp_1 = 203mm\ ,\ dp_2 = 110mm$$

$$i = \frac{dp1}{dp2} = \frac{203}{110} = 1.84$$

3. Turn *the flywheel (n2)*

$n2 = n1\ x i$ ....(1)

$= 300 \times 1.84$

$= 552$rpm

4. correction factor *(f* c): *fc* = 1.4 (taken)

5. Power plans *(P* d):

Pd $= f$ c. P ....(2)

= 1.4.0.8 *kW*

= 1:12 *kW*

6. cross-section of the belt - V: Type A
7. belt speed *(v)* =

v 3.14. *dp* 1. *n1(60.1000)* /

= 3.14. 203. 552 / (60.1000)

= 5.86 m / s

8. calculation of the circumference (L):

$$L = 2C + \frac{\pi}{2} \cdot (dp_1 + dp_2) + \frac{1}{4C} \cdot (dp_2 - dp_1)$$ ....(3)

assumed distance pulley shaft axis *(C)* 1 and 2 is 380 mm, then:

= 2. 380 + 1.57. (203 + 110) + $\frac{1}{}$ 4.380.

(203-110) ^{2}

= 1257 mm

(nominal numbers obtained belt - V: No. 49 L = 1245mm)

9. Distance to the actual pivot axis (C):

$$C = \frac{b + \sqrt{b^2 - 8.(dp2 - dp1)^2}}{8}$$

dimana :

b = 2.L – 3,14 ($dp_1 + dp_2$)

= 2 . 1245 – 3,14 (203 + 110

= 1507 mm

maka,

$$C = \frac{1507 + \sqrt{1507^2 - 8.(203-110)^2}}{8}$$

= 352 mm ....(4)

9. contact angle () and the correction factor*(K)* =

$$\theta = 180^o - \frac{57.(dp2 - dp1)}{C}$$

$$= 180^o - \frac{57.(203-110)}{352}$$

$$= 165^o$$

...........(5)

Transmission belt-v 2

1. P = 0.8 kW, $n2$= 552 rpm

2. Comparison pulley ratio (i): *dp3 = 254mm, dp4 = 90mm*

i = ^{3} $_4$ = $^{254}{}_{90}$ = 2.82

3. Round *generator (n4)n4 = n3 xi*

= 552 x 2.82 = 1558rpm

4. correction factor *(f* c): *fc* = 1.4 (taken)
5. Power plans *(P* d): *Pd=Fc , P*
   = 1.4.0.8
   = 1:12kW
6. cross-section belts - V: Type A
7. belt speed *(v)* =
   v 3.14. *dp* 3. *n3(60.1000)/*
   = 3.14. 254. 552 / (60.1000)
   = 7.3 m / s
8. calculation of the circumference (L):
   L = 2*C* +$_2$, *(Dp3* + *Dp4*) +$_4$ ^{1},*(Dp3* - *dp*4)assumed distance pulley shaft axis *(C)* 3 and 4 is 440 mm, then:

   = 2. 440 + 1.57. (254 +90) + $\frac{1}{}$4,440.

   (254-90) ^{2}
   = 1414 mm

(nominal numbers obtained belt - V: No. 55 L = 1397mm

9. distance actual pivot axis (C):

$$C = \frac{b + \sqrt{b^2 - 8.(dp3 - dp4)^2}}{8}$$

dimana :

b = 2.L – 3,14 (*dp*$_3$ + *dp*$_4$)
= 2 . 1397– 3,14 (254 + 90) = 1713mm

maka,

$$C = \frac{1713 + \sqrt{1713^2 - 8.(254-90)^2}}{8}$$

= 433 mm ....(6)

10. contact angle ( ) and the correction factor*(K)* =

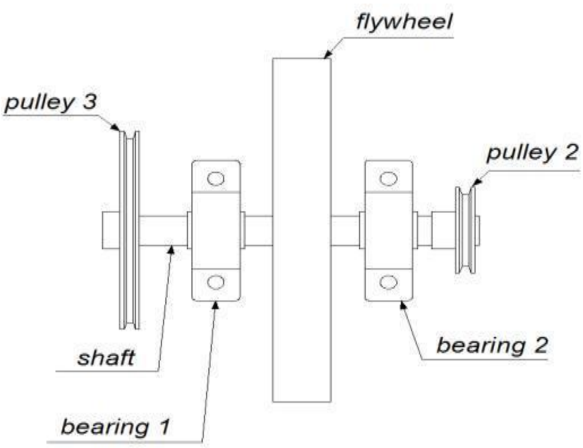
$$\theta = 180^o - \frac{57.(dp3 - dp4)}{C}$$

$$= 180^o - \frac{57.(254-90)}{433}$$

$$= 158^o$$

.......(7)

4.2 Calculation of Poros



1. *P = 0.8 kW,n3*552 rpm=
2. correction factor *(f* c): *fc* = 1.4 (taken)
3. Power plans *(P* d): *Pd=Fc , P*

= 1.4.0.8
= 1:12kW

4. Moment of the plan *(T)*

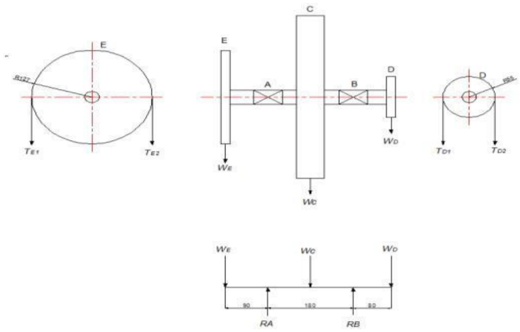
$T = 9.74 \times 10^5 x$ (3)

= $9.74 \times 10^5 \times$ (1300.12)

= *3636 kg.mm*

= *35 669N.mm*

5. Calculation Imposition On Poros



RA + RB = Wtotal

a) expenses total *(Wtotal)*

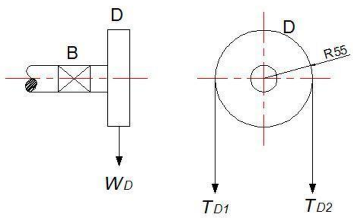
Wtotal = WC + WD + WE ....(7)

o *WC = mass flywheel x acceleration of gravity*

= $30\ kg \times 9.81\ m/s^2$

= *294.3 N*

o *WD = TD1 + TD2*



Where:

T	= *(TD1 - TD2)R*
35 669 N.mm	= *(TD1 - TD2)55 mm*
(TD1 -D2T)	= $\frac{35\ 669.}{55}$
(TD1 -D2T)	= *648 N . ..... (8)*
2.3 log ($\frac{1}{2}$)	= *µ. 0.91π θ = 0.3 x*
	= *0857*

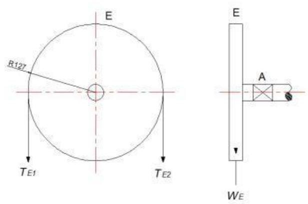
log (= 0857= *0.372*
1
)
2 2.3
1 = 2.3 ....*(9)*

2

rom equation *i* and *ii*, obtained:

TD1 = 1128N, and *TD2 = 480 N* Then:

WD += 1128N 480N = 1608 N
o *WE = TE1 + TE2*



Where:
T = *(TE1 -T)E2R*
35669N.mm = *(TE1 -T)E2127mm*
(TE1 -TE2) = 35 669. / 127

(TE1 -E2T) = *280 N .... (10)*
2.3 log (= *μ. 0.87π θ = 0.3 x*
1
)
2 = *0826*

log

(1)
=
0,8
26
=
0,3
59
2
....(11)

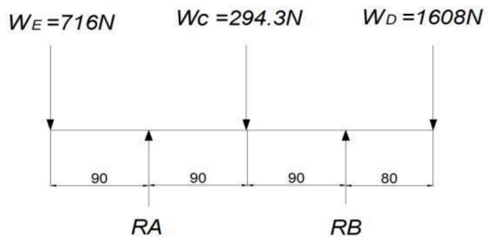
2

From equation *i* and *ii*, obtained:
TE1 = 498 N, and *TE2 = 218 N* Then:

$WE \quad = 498\ N + 218N$
$= 716\ N$

$Wtotal \ = WC + WD + WE$
= + 1608 + 716 2618.3
= 294.3 N

b) bending moment



o $RA =$ (1608 260) + (294.3 90- (716 90) 180

= 380 127. $= 2111.82N$
180
$= 215.27kg$

o $RB =$ (716 270) + (294.3 90- 80)

180
= (160891167. $= 506.48\ 51.62\ kg\ N =$

180
o point A bending moment *(MA)* and B $(MB) MB = MA = 0$
o point C bending moment $(MC) MC = RAx\ 90mm$
$= 215.27kgx\ 90mm = 19374.3kg.mm$
o point Dbending moment $(MD) MD = RBx\ 80mm$
$= 51.62kgx\ 80mm = 4129.6kg.mm$
o point Ebending moment $(ME) ME = RAx\ 90mm$
$= 215.27kgx\ 90mm = 19374.3\ kg.mm$
So the maximum moment *(M)* is $ME = 19374.3\ kg.mm$
6. shaft material S30C,
$\sigma B = 48\ kg / mm^2\ Sf1 = 6.0, Sf2 = 2.0$
7. permissible bending stress
$\tau a \ =$

1. 2
= 48

6.0 2.0
$= 4\ kg / mm^2$

8. bending correction factor *(Km)* and torsion *(Kt)*

$Km = 1.5, Kt = 1.0$

9. Specifies the shaft diameter *(ds)*

$$d \geq \left[\left(\frac{5.1}{\tau a}\right)\sqrt{(Km.M)^2 + (Kt.T)^2}\right]^{1/3}$$

$$\geq \left[\left(\frac{5.1}{4}\right)\sqrt{(1.5\,x\,19374.3\,)^2 + (1.0\,x\,3636)^2}\right]^{1/3}$$

$$\geq 33.42\text{mm} \rightarrow 34\text{ mm (dibulatkan)}$$ ....(12)

In this scheme 1½in been shaft diameter (38.1mm) for adjusting the shaft in the market.

4.3 bearing

In this scheme used *pillow blockunits* with the following specifications:

- *Housing* *number:p208*
- *Bearing* *number:UC 208-24*
- *Shaft diameter* *(d):1½ in*

4.4 Flywheel

1. Angle Speed *Flywheel (ϖ)*

$$\varpi = \frac{2.}{60}$$

$$= \frac{2552}{60}$$

$$= 57.8 \text{ rad / s}$$

2. Moment of Inertia *Flywheel (I)*

$$I = mr^2$$

$$= 30 \times (0{:}22)^2$$

$$= 1{,}452 \text{ kg m}^2$$

3. Kinetic Energy *Flywheel*

$$Ek = 1/2\ I\,\varpi^2$$

$$= 1/2\ x\ 1{,}452\ (57.8)^2$$

$$= 2426 \text{ joules}$$

4.5 Data Testing Results

After the functional test, then test the performance of the power plant. Here are the results of testing with loading.

Table 1. Result testing by giving load

Beban (watt)	Tegangan *output* generator (volt)	Putaran generator (rpm)
0	215	1607
20	212	1590
40	206	1568
60	200	1550
90	197	1535
115	192	1529

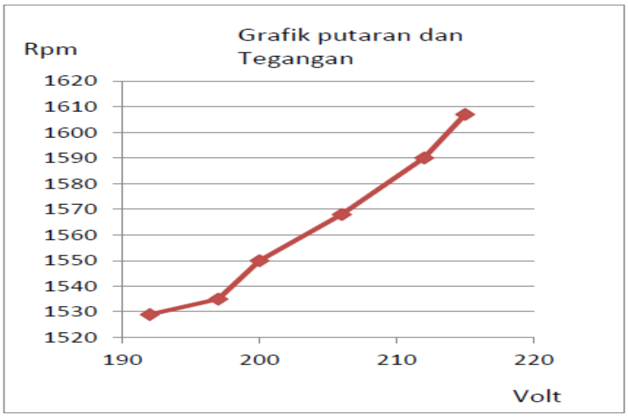


Figure 2. Graph round relations and voltage

When generator given load, round decreased, resulting in a voltage generator that produced also declined. In addition, the battery charging current is also unstable due to the voltage generatedby the generator decreases resulting in the battery voltage also decreases. This can cause the battery runs out of power so that the plant can not be used in a long time.

5. Closing Conclusion

5.1 Conclusion

From the calculation and discussion, it was concluded as follows:

1. Specification or the diameter of the pulleys used are 203mm, 110mm, 254mm and 90mm, are connected by a belt-v type A with No. 49 and the belt-v type A with No. 56. Meanwhile, for the shaft used is S30C material shaft with 38mm diameter.
2. From the test results by providing load on the generator was found that the voltage and generator rotation decreases with increasing the applied load.
3. electric power *Input* by the electric motor is greater in comparison to the electric power *output* generated by the generator, so that the plant can not work in a long time.
4. Kecilnyaefisiensipembangkitini
   caused by several factors diantarannya generator and electric motor efficiency is low and the battery charging load is too large so there is a balance between charging and konsunsi power from the battery to the electric motor.

5.2 Suggestions

Research and development of power generation is especially needed since there are many factors that can improve the performance of this power plant. Thus the authors have suggestions as follows:

1. Use of the generator with good efficiency is strongly recommended in order to improve the efficiency of this power plant.
2. It is advisable to use the electric motor driving with good efficiency and a higher round.
3. It is advisable to use a battery charging termator as a tool that can reduse the load generator.

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