Design Calculation of Torque, Powerand RPM of Gearbox for Fuel-less Generating System

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Abstract:

In line with the intention of decarbonization and eliminating the consumption of fossil fuels. A 5000W fuel-less generating set to serve as a source of sustainable and clean power. A customize gearbox is design to meet the intended application. In its features, it consists of a 48V lithium battery, planetary gear motor, rectifier, generator, coupling, gearbox, and a base plate. A 48V, battery (power source) is connected to a 48V 600W planetary gear drive motor which rotates the gearbox to give the mechanical power through the shaft connected to the generator. The gearbox rotates and by its gear ratio it turns the generator to the required speed and torque and gives out electrical energy. Some of the power from the generator will be used to charge the battery as a recycling power method which will go to the rectifier and convert A.C to D.C in charging the battery.

Keywords **—Gearbox,Fuel-less generator, Torque, Power, Gear ratio.**

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I.   INTRODUCTION

A power crisis is very catastrophic in every country it affects the economy and mobility of the people. The range of power failures has to do with the increase in demand which lead to high price because the instability of the global economy leads to very high inflation. Fossil fuels are still dominating our energy mix releasing a huge amount of carbon dioxide and methane into the air, worsening global warming and the health effects associated with it. Our country's electricity tariff is one of the highest in the Southeast Asian region approaching the level of developed nations, though gross domestic product (GDP) per capita is not at that level. The geographical condition consisting of around 7640 islands is also a major constraint in power transmission and distribution. This limitation deprives the communities in remote islands of access to electricity. Ordinary people are suffering from this scenario which calls for innovation in power generation.In this case, a Fuel less generator is considered to be a solution for producing electricity without using fossil fuel, sustainable, clean, and portable energy. However, there is a major concern about its efficiency. Based on its current design in which the generator is driven by a D.C motor its efficiency decreases with an increase in the input load of the generating set. The input power of the device is usually higher than the output power. This condition shows that there is a problem between torque and power because when the rpm decreases the torque will increase but the power will go down this is very evident that the generator cannot operate at its rated power capacity. A fuel-less generating system with customize gearbox will change our perspective on producing electricity.A gearbox is a mechanical device that varies the torque and power depending on the design application and environment condition. By its gear ratio between the meshing gears, it can go at slow speed with a high amount of torque which is

good for lifting and it can also go at high speed with tremendous amount of power for power generation. However, power and torque do not align in same way, as the speed increase it lower the torque but increases the power and vice versa. The torque and power can be manipulated by increasing the number of stages and varying the size of gears. Obtaining adequate torque and power of a gearbox plays a vital in stabilizing the required torque and power of the generator to produce an efficient output. The law of gearing as well Newton's third law of motion shows how the actual machine would rotate according to its intended application.

FIG. I
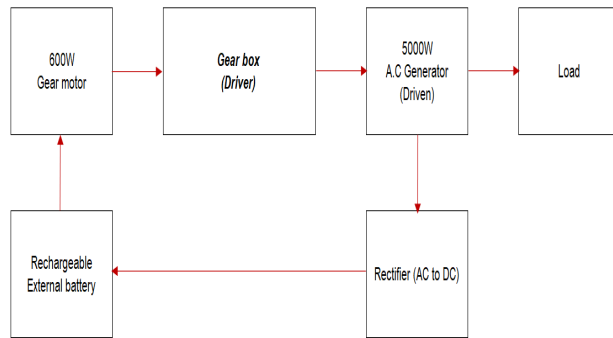
Block diagram of Fuel less generator

II. RESEARCH OBJECTIVE

1. To balance the torque and power by designing a gearbox with its combination of engaging teeth.
2. To calculate the torque and power in each shaft.
3. To obtain the required torque and power of the driven machine(Generator)
4. To check if the combination of teeth meets the required output rpm(1800rpm)
5. To calculate the Mechanical power of the gearbox.
6. To check if there is no over torque between the gearbox and the generator.
7. To calculate the machine's efficiency.
8. To calculate the pure time differential equation for torque and power.

III. METHODOLOGY

The specification for both the input motor and the generator are already given by the manufacturer this is not a problem anymore. The gearbox side will require calculation for torque, power, and rpm to meet the specifications of the generator otherwise it leads to poor power output.
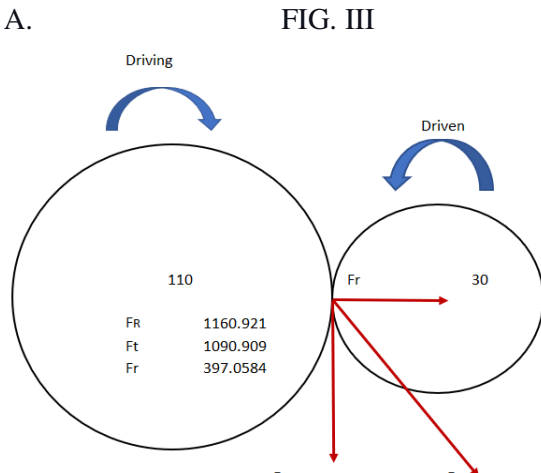
CALCULATION PARAMETERS FOR TORQUE, POWER AND RPM

ITEM	RATED POWER (W)	TORQUE (N.m)	RPM
INPUT MOTOR	600	120	50
GEAR BOX	5000	26.5	1800
GENERATOR	5000	26.5	1800

FIG. II
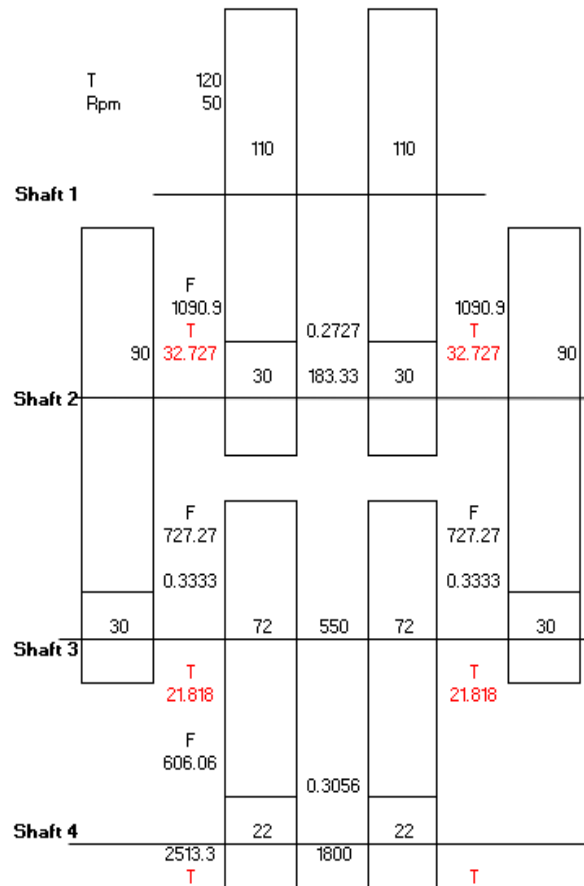
Newton's third law of motion:If Gear A exerts a force on Gear B, then Gear B must exert a force of equal magnitude and opposite direction back on Gear A.

FIG. III

Law's of gearing states that the rotation ratio between the gears must remain constant throughout the mesh. To maintain the constant angular rotation ratio the all contact points with in mesh, should always pass through a fixed point called pitch point.

Gear specification: Module =2 pressure angle = 20°
T is torque F is tangential force
z is number of teeth
PCD = m*z (pitch circle diameter)
Shaft 1: T = 120N.m F = 120N.m/0.110m = 1090.9N
Shaft 2: T= 2(1090.9N*.030m) =65.45N.m
Shaft 3: F= 2(65.45N.m/.090m) = 1454.54N
        T= 1454.54N*.030m = 43.63N.m
Shaft 4: F= 2(43.63N.m/.072m) = 1212N
        T= 1212N*.022m = 26.66N.m

Calculation of rpm in each shaft:

Shaft1: 50rpm input motor rpm
Shaft2: 50rpm/(30/110) = 183.33rpm
Shaft3: 183.33rpm/(30/90) = 550rpm
Shaft4: 550rpm/(22/72) = 1799.97rpm

Overall gear ratio= 0.2727*0.3333*0.3056= 0.0278

Output rpm = 50rpm/0.0278 = 1800rpm
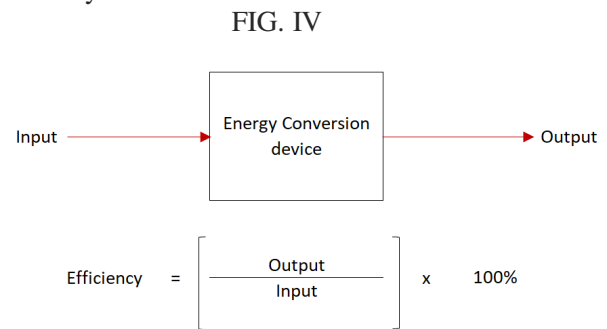
Calculation of power in each shaft:
Power1 = 2*PI()*120N.m*(50/60) = 628.32W
Power2 = 2*PI()*65.45N.m*(183.33/60) = 1256.5W
Power3 =2*PI()*43.63N.m*(550/60) = 2512.9W
Power4 =2*PI()*26.66N.m*(1800/60) = 5025.3W

Mechanical power @ 2% per stage
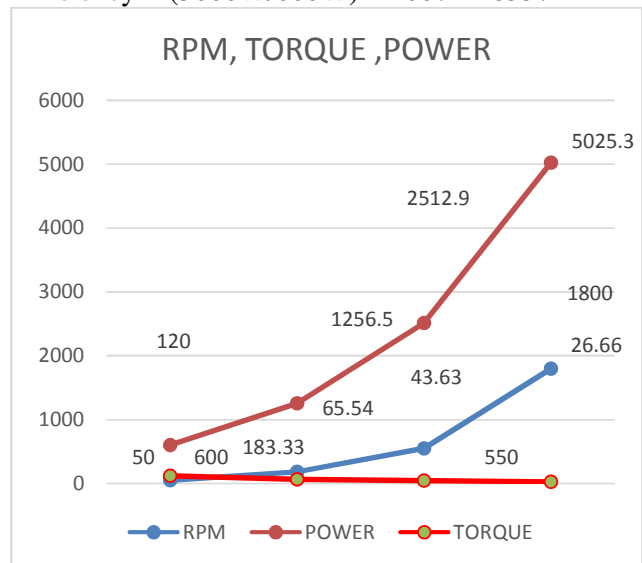= 2*PI()*26.66N.m*(1800/60)*0.98^3 = 4729.76W

To check for over torque: Mechanical power $\leq$ Generator power (4729.76W $\leq$ 5000W)

Efficiency

FIG. IV

Efficiency = (Generator rated power) / (Gear motor power)

Efficiency = (5000W/600W) * 100% = 833%

Calculating the pure time differential equation for torque and power

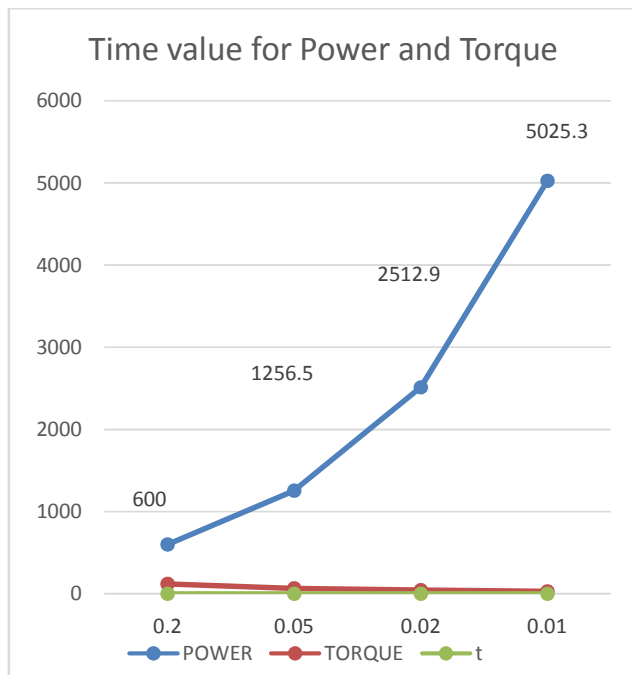P = power   T = torque t = time

$[P = (T/t)] * (1/t)$
$P/t = T/t^2$
$d(P/t) = d(T/t^2)$
$\int dt^2/dt = \int dT/dP$
$t^2/t = T/P$
$t = T/P$

Time anticipation is very vital for rotational bodies like gear, shafts, etc. The graph above shows how this torque and power exist at their respective time constrain. Critical speed is one of the serious events rotating bodies will undergo at the point we need to make sure the timing of every change in rpm concerning time. It will serve as a guide also in our preparation for starting the machine and shutting them down properly.

FIG. V
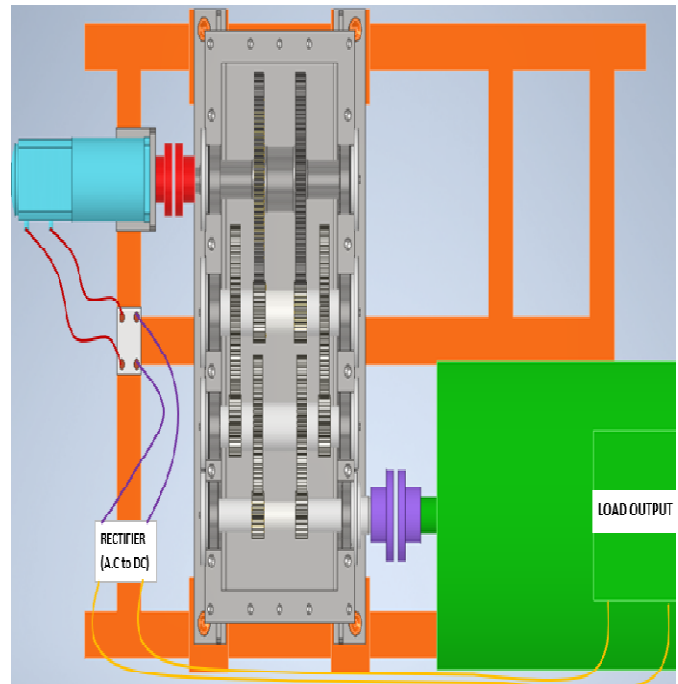
IV.   CONCLUSION

The gearbox torque and power based on the calculation above can be manipulated according to its design intention. The gearbox is a mechanical engineering field of life where we can design and conceptualize a different kind of application by the law of physics. The other implication is that future studies should go for innovation bringing these concepts and principles into a large scale of power generation. The efficiency satisfies the generator specification of torque and power. Now it's very realistic that a fuel-less generating system can be done. A new perspective of power generation that has zero greenhouse gas emissions and 100% decarburization. Economically its reduce cost with zero use of fossil fuel and help also in reducing human illnesses caused by air pollution. A very sustainable source of power by not needing sunlight, water, and wind in producing electricity.

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