FLYWHEEL POWER GENERATION AND MULTIPLICATION

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Abstract:- *This Case study of multi-hour electrical generation using the continuously available rotating force from a specific weight, diameter, and rpm is considered in flywheel power generation technology because the wheel is continuous in motion. we are designing energy generation and storage projects for generating clean electricity using Gear-flywheel and Pinion gear. Pinion gear harboring the generator is the innovation.*

This technology major advantage is the design, where distribution of mass in a given area of the flywheel is the key to success. Flywheels with Different geometrical figures are used for multidimensional requirements. For 1 Kw power generation at least 150 Kg weight is required.

Key Words: Gear Flywheel, Flywheel, Power Multiplication, Generator, Motor, Storage

1. INTRODUCTION

In this technology we always consider weight, diameter and stored rotating force of the flywheel (rpm). This flywheel is designed as a gear flywheel either from the world of steel, rubber, plastic, concrete and hybrid glass or with the combination of the above described material where ever required in the design and as per the design.

For the safety purpose, this innovation adopts bunkers design to fix flywheels horizontally or vertically and rotate below 2000 rpm.

In this design we are using single 12 m diameter gear-flywheel with teeth on the periphery of the wheel and rotate the 67 ton weight with 350 kW motor at 800 rpm and on the periphery we fix small pinion gear to rotate at 1800 rpm there by 19 pinion gears are connected all around the 12 diameter and each pinion gear will be attached with 40 KW PMG generator with 1800 rpm. Here the input motor rpm is only 10 rotations because it is connected directly to the speed increasing gearbox there by the motor connected to the VFD will have minimum stress and consume fewer amps.

In this design we expresses our idea to show, by using less energy motor and connecting a higher kW generator, we are using a big diameter ring gear wheel to balance the back torque generated when the load is applied on the 750 KW PMG generator. Please consider the different torques generated by using the flywheel, motor, and PMG generator to understand how electricity is generated.

67 ton and 12 m diameter, rpm 800 Flywheel torque: - 28070.71 Nm

350 kW Motor torque: - 5570.13 Nm at 600 rpm

750 kW PMG generator torque: - 3978.67 Nm at 1800 rpm

Flywheel + Motor torque = cumulative 33640.84 torque Nm – PMG generator torque 3978.67 Nm = 29662.17 Nm balance torque still in the rotating gear flywheel.

1.1 Related Work

Practical Observation on a case study in our workshop.

By manufacturing 5 Gear-flywheels with equal engineering specifications example:- Each flywheel weight is 13400 kg (total 5 flywheels weight is 67 tons), 3 meter in diameter and rotated at 800 rpm by a 2 speed motor connected to speed increasing, multiple gearboxes by using a common shaft design i.e. using a cardan shaft to connect in-between independent flywheels and fix 5 pinion gearwheels to the 5 gear flywheels so that all the 5 gear flywheels help increase the rpm of the 5 pinion gearwheels connected to the shaft which is connecting the PMG generator, is the working prototype design.

In the flywheel power multiplication design we use mix of renewable energy to charge the Battery bank and the battery bank is connected to VFD and VFD is connected to a motor and motor is connected to more than 1 speed increasing gearbox and the gear boxes to the series of flywheels are connected and rotated below 2000 rpm within 10 to 60 seconds time so that the cumulative torque generated by the 5 flywheels will be absorbed by the PMG generator and generate clean electricity.

Each flywheel with this specification of 13400 kg weight and 3 m in diameter at 800 rpm will store 30 KW of energy in the torus ring design where weight is maximum on the periphery of the flywheel.

There by 5 flywheels are storing 150 KW of energy at 800 rpm.

Please note:- 5 gear flywheels with common shaft are connected to 5 pinion gearwheels with common shaft both are separate but connected with gear teeth with each other

750kW PMG generator is rotated at 1800 rpm by rotating the Pinion gears. 5 gear flywheels rotate at 800 rpm and 5 pinions connected to 5gear flywheels rotate at 1800 rpm. Please understand the design.

The cumulative torque generated by 5 gear flywheels: - In one gear flywheel 359 Nm X 5 gear flywheels = total torque 1795 Nm is the rotating force transferred into the 5 pinion gearwheels connected to 750 kW PMG generator by a common shaft rotated at 1800 rpm to generate clean electricity.

The motor rotating the slow speed shaft of the speed increasing gearbox at 10 rpm. first gearbox (1) input 10 rpm and output 200 rpm second gearbox (2) input 200 rpm and output 800 rpm so that the fully charged flywheel with maximum surface velocity of 126 meters per second is connected to the 750 KW permanent magnet generator with load and is rotated continuously without any stop. The flywheels are fixed on the Plummer block bearings and rotated freely is the innovation. When the flywheels are rotated they rotate freely for a long period of time.

In our workshop we observed, if the diameter is more, the energy is more due to increasing surface velocity, because it has to revolve in bigger circle. Example for 1m, 2m, 3m, 4m, 5m,12m. But the 350 kW Motor used will be the same because mass or weight is same rpm is the same but diameter differs because of bigger circle formation there by more storage of energy.

Here is an Example for distributing mass in a given area for designing a flywheel cum energy storage system

Vertical design - 67 Ton weight, Diameter 3 meters, Rpm 1800, Surface Speed (m/sec) 282.78, Ring (joules) 2678811701.39, useful energy 744.11 Kwh ,Motor 350 kW. Flywheel in any Geometrical shape or cylindrical, round etc..

Horizontal design - 67 Ton, Diameter 12 meters, Rpm 1800, Surface Speed (m/sec) 1131.12, Ring (joules) 42860987222.39, useful energy 11905.82 Kwh. Motor 350 kW. Flywheel in disc shape round and flat.

1.2 Body

Concept is derived, using Hydro power formula, General Formula

Head X Flow X Gravity X Efficiency = Kwh and 1800 rpm of the generator

Head 3 m X flow 67m3/sec X gravity 9.81 X efficiency 92% = 1500 KW power generated per hour from hydro sector.

Now in Flywheel Power multiplication technology: Our formula is

Head X Flow X Gravity X Efficiency = Kwh is adopted and made like this.

Head converted to the total Diameter i.e. 3 meters round in shape torus ring wheel X Flow is the water weight in liters changed to kg weight of the Flywheel i.e. 67 cubic meter per sec. is converted to 67000 Kilograms or 67 tons carbon steel torus ring wheel X Gravity is 9.81 X Efficiency of 92% in combination of {Torus flywheel + Generator + Transformer} 92% = 1500 Kwh.

Compare with hydro power and judge the efficiency

Please take the Torque value of the Torus ring wheel with 67000 Kilograms weight and 1800 rpm in between 10 seconds to 60 seconds and 3 meters in Diameter, round flywheel where the maximum weight is on the periphery of the wheel or on the top side of the Rim of the wheel with small 'r' as the maximum width and thickness of the wheel. Convert the Torque of the rotating wheel in 10 seconds time and you get Nm again convert into joules and then into Kwh. Here the Speed (RPM), diameter, weight, time are the deciding key factors for generating the torque from the torus wheel to counter the reverse torque developed when the load is applied on the 750 kW PMG generator rotated at 1800 rpm, in our workshop practical experience we have noted 100 kg back pressure per cubic centimeter of the generator rotor total area as reverse torque opposing the rotating force coming from the flywheel and motor while rotating the common shaft of the cumulative flywheels.

The reverse torque always decreases volts, Hz and Rpm of the motor and generator. To counter all this, 67 ton Flywheel should have maximum torque then, we can generate grid connectivity power with 50 or 60 HZ and required voltage.

We are using one motor for one flywheel in vertical design in horizontal design we use only one big motor this is the difference in vertical and horizontal designs.

For vertical design

Power (kW) = Torque (Nm) x Speed (RPM) / 9.5488

Total 350 kW motor is considered to rotate 67 Ton Weight.

350 kW motor is divided into 5 equal parts of 70 kW each.

Each 70 KW two speed motor (300/600 Rpm)

Torque

At 10 rpm 66841.60 Nm

At 300 rpm 2228.05 Nm

At 600 rpm 1114.03 Nm

There by the torque of the 5 motors will be At 10 rpm 334208 Nm

At 300 rpm 11140.25 Nm

At 600 rpm 5570.15 Nm

5 flywheel cumulative torques is 3978.67 Nm

One 750 rpm PMG generator torque at 1800 rpm is 3978.67 Nm

Motor } Torque

Flywheel 9548.82

750 kW PMG Generator Torque 3978.67 Nm

Motor side torque is more than the torque of PMG generator because the 350 kW is rotated at 10 Rpm i.e. controlled rotations using a VFD.

When the motor shaft is connected to the speed increasing gear box shaft the input Rpm is only 10 there by the speed increasing output shaft will rotate at 1800 Rpm. The PMG generator connected at end of the common shaft will also rotate at1800 Rpm and generate electricity.

2. PERFORMANCE EXPERIMENTS

We have started our carrier in 1994 and we have more than 2 decades of field experience, in this long journey we have clearly understood what are the parameters for successfully generating electricity using flywheels, because big diameter is always the success for power generation and with sufficient weight on the periphery of the wheel then storage of energy is more there by the wheel will be rotating for more time because more surface velocity is available in the rotating force.

As an experiment we have assembled eleven tons of flywheel with two meters in diameter and 2000 RPM we have observed when the motor gets disconnected then the flywheels rotate for more than 30 minutes here we did not use gear box.

In our observation, if we can convert the flywheel or fabricate the flywheel outer section as a ring gear then the rotating gear flywheel in low RPM, in between 500 to 600 RPM will also generate electricity when load applied on the generator.

By attaching a pinion gear to the big diameter gear flywheel, where the periphery is designed as the double helical gear teeth. The pinion RPM will be increased from 600 to 1800 RPM below one minute. Here we use 10 RPM as the input RPM with the

speed increase gearbox and excite to 600 RPM the 67 ton weight below 1 minute there after the pinion gear will reach 1800 RPM after reaching this speed of 1800 rotations in 1 minute then load is connected to the PMG generator.

In our work shop we always use a higher capacity of inverter cum VFD to connect to the two speed motor and rotate the motor with a pre-designed programmed in the VFD from 10 Rpm to 1800 Rpm.

We have observed that if we connect the motor with VFD then the motor RPM can be controlled there by consumption of less Amps by the motor because the input gearbox shaft has to rotate at 10 Rpm and we can rotate the motor on critical continuous duty for long hours without any interruption even when load is applied.

In our observation, by using eleven ton weight with 2 meter diameter flywheel rotated at 600 RPM (Pinion gear 1800 RPM) by a 70 Kw motor and connect a 40 Kw PMG generator with 1800 RPM there by the motor connected to VFD will rotate the eleven ton flywheel by consuming 20 Amps. Here one should observe that the eleven Ton flywheel rotating at 600 Rpm and pinion gear rotating at 1800 Rpm what is the maximum contact area of the pinion gear when connected to the two meter diameter having eleven Tons should be discussed.

When load is applied to the 40 kW PMG generator connected to the pinion gear the teeth of the big gear wheel and the pinion gear wheel have small amount of friction. The lubrication in between the big gear and small pinion gear will help to reduce the friction there by the eleven Ton flywheel Rpm is maintained constantly at 600 Rpm.

This is what we have experienced in our workshop.

40 Kw PMG rotor weight is 40 Kilograms

Total flywheel weight is 11 tons and 2 meter diameter

Motor used is 70 Kw at 10 RPM (connected to the VFD)

3 Phases, 50 Hz, 415 Volt

Torque at various Rpm's

10 Rpm 66841.60 Nm

300 Rpm 2228.05 Nm

600 Rpm 1114.03 Nm

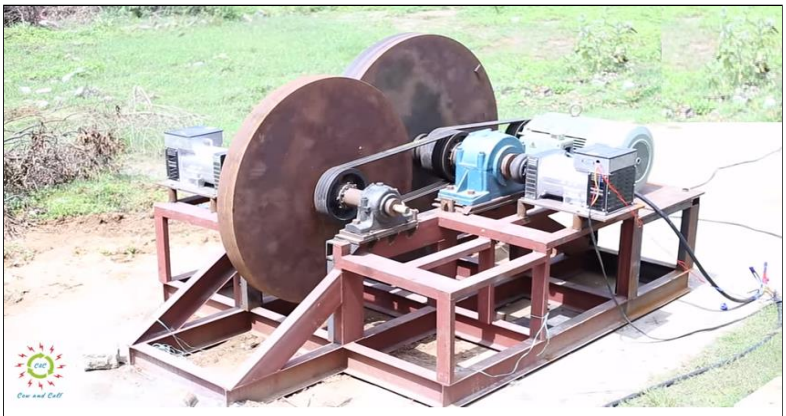
11 Ton flywheel torque 95 Nm at 600 rpm

PMG generator 40 Kw and 1800 RPM 212.20 Nm

40 Kw PMG will be generating 61.83 Amps, useful energy at 80% load is 50 Amps.

3 phase, 50Hz, 415 Volt

These are the Disc type wheel 2 Meter in diameter. In our work shop we have rotated 11 ton at 2000 RPM. Using SKF Bearings. Motor of 110 kW consumed 71 amps and without gearbox.



Flywheel Power Multiplication By Chaganti

2.1 EQUATIONS

The amount of energy 'E' stored in a flywheel varies linearly with moment of inertia 'I' and with the square of the angular velocity 'ω'.

$$E = \frac{1}{2}.I.\omega^2$$

Physical quantity of inertia, is the integral of the square of the distance 'x' from the axis of rotation to the differential mass 'dmx'

$$I = \int x^2 dm_x$$

Cylindrical flywheel of mass 'm' and radius 'r'

$I = m.r^2$

Energy stored is proportional to the square of angular velocity

$E=\frac{1}{2}.m.r^2.\ \omega^2$

Energy stored can be expressed in terms of peripheral velocity 'v',

Perpendicular distance from the axis of rotation and angular speed as

$E=\frac{1}{2}.m.v^2$ since $v= r.\omega$

For a mass density 'ρ', the tensile strength

$\sigma=\rho.v2$

Energy density, E_m is loosely defined for a flywheel as the ratio of energy stored to its mass

$$E_{vmax}=\frac{1}{2}.\sigma_{max}$$

Stored energy equation, as the product of volume and the mass density

$$E_{mmax} = \frac{1}{2}.\frac{\sigma_{max}}{\rho}$$

General expression of maximum energy stored per mass, K is flywheel shape factor

$$E_{mmax} = K.\frac{\sigma_{max}}{\rho}$$

Energy stored per mass, where's' is the ratio of minimum to maximum operating speed, usually set at 0.2

$$E_m = (1 - s^2).K.\frac{\sigma}{\rho}$$

The paper concludes with recommendations for future research.

2.2 DISCUSSIONS

In our workshop we always discuss with our colleagues about the designs, constructions etc. We discuss with cross functional teams like mechanical, electrical, electronics, instrumentations etc.. departments core manufacturing teams to get a successful innovation in flywheel power multiplication design.

We are presenting few picture of discussion held in our workshop for discussing the pros and cons of flywheel power multiplication.

We always considered the flywheel as a round object, square object, rectangle object, elliptical object i.e. in any geometrical figure.

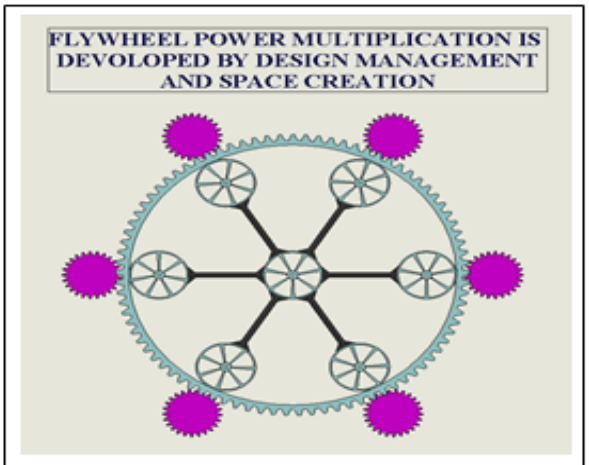
Because ultimately we have to rotate the rotor of PMG generator by using the rotating force of the flywheel.

We always consider various materials for designing of the flywheel, which are viable for various Rpm's.

Here the most important design is fixing of gear teeth either inside or outside of the flywheel there by the flywheel efficiency increase, when we use a pinion gear connected to PMG generator.

2.3 PICTURE FOR DISCUSSIONS

Comparison between our innovation design and world biggest flywheel design as shown below.

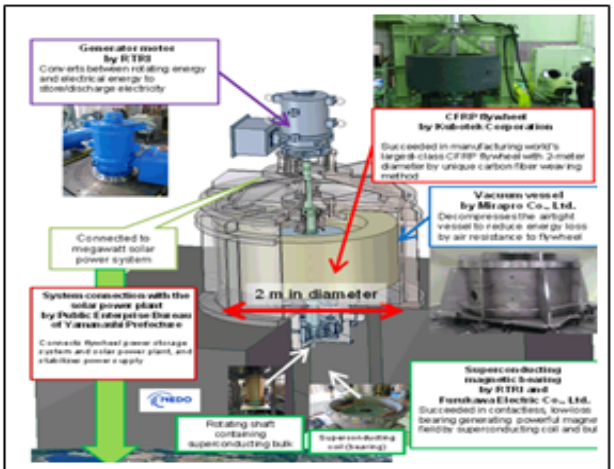


Flywheel power multiplication has design advantage over the existing market technologies where in our design uses low Rpm and which does not need vacuum. It is easy to manufacture, and with very minimum maintenance. Manufactured in steel and Cost is affordable to common man. We can manufacture in mass and cost is below $ 16000 / USD. Mass employment generated.

Specifications:

Which has 300-kW output capability and 100-kWh storage capacity by rotating the flywheel which is 5 meters in diameter and weighs 4 tons and 1800 Rpm.

We can design in as many designs as possible in any axis.



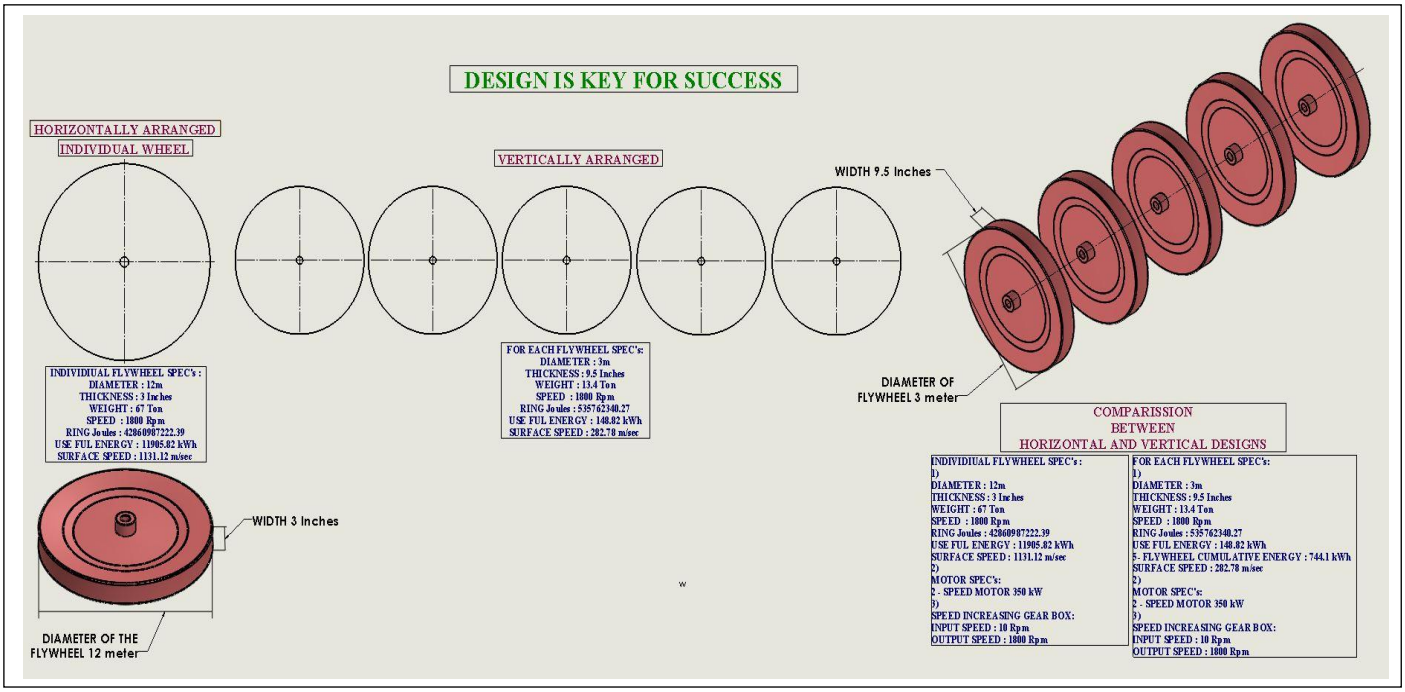
This system is difficult to manufacture very costly and needs high skilled technical involvement. Here vacuum chamber is require, high speed magnetic bearings, very high grade carbon fiber required (carbon fiber-reinforced plastic). Here high maintenance is required.

Manufacturing cost is very high @ 1 Ton High grade carbon fiber cost anywhere between $ 200 a Kg. mass production is not possible.

Specifications:

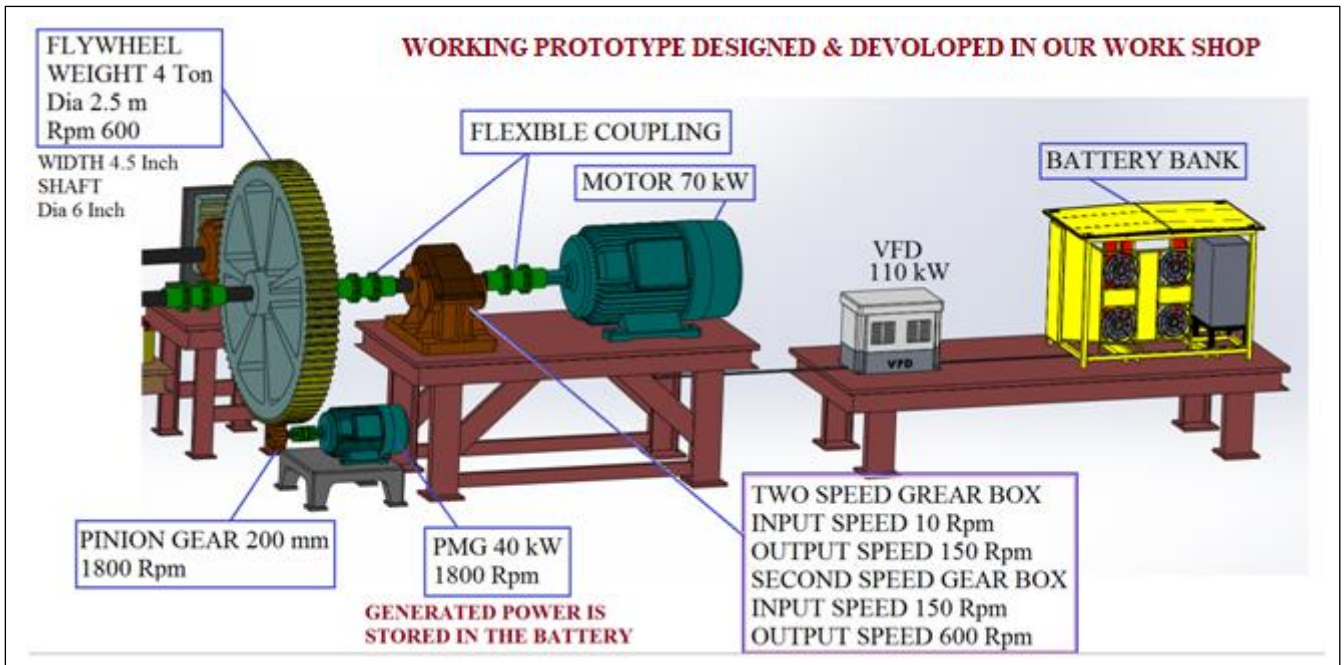
Which has 300-kW output capability and 100-kWh storage capacity by rotating the flywheel which is 2 meters in diameter and weighs 4 tons and 6000 rpm.

Here design limitation are more.



Basic design is management of weight, in this innovation we are removing excess mass and adding this mass to the periphery of the wheel. There by the flywheel diameter is increased. If the surface area is increased the energy stored in the periphery is more there by using the same motor we are rotating a bigger diameter wheel.

Motor capacity 350 kW, Weight 67 Ton, Diameter 12 meter and Rpm 1800



Please Note motor is rotated at 10 Rpm Only with the support of inverter cum VFD. There by very little Amps are consumed.

Zero stress on motor.

Motor 70Kw, 2 Speed 300/600 Rpm, Torque for 10 Rpm 66841.60 Nm, for 300 Rpm 2228.05 Nm, for 600 Rpm 1114.03 Nm

Motor capacity 3 Phase, 50 Hz, 415 Volts, 108Amps.

3. CONCLUSIONS

This technology mainly rotates in and around weight and space management, there by using a specified weight i.e.

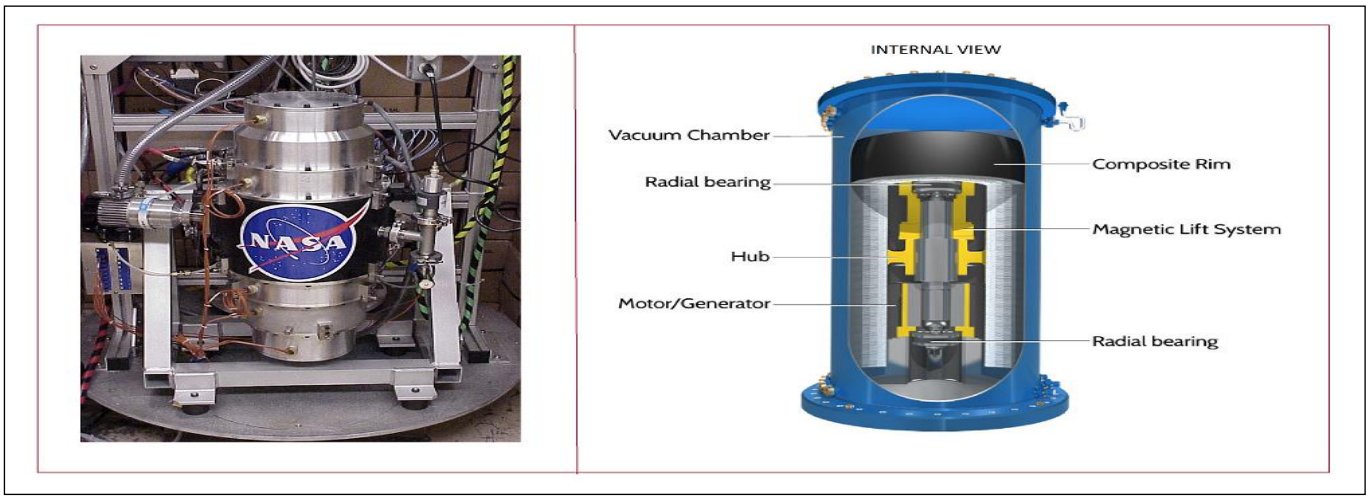
For example

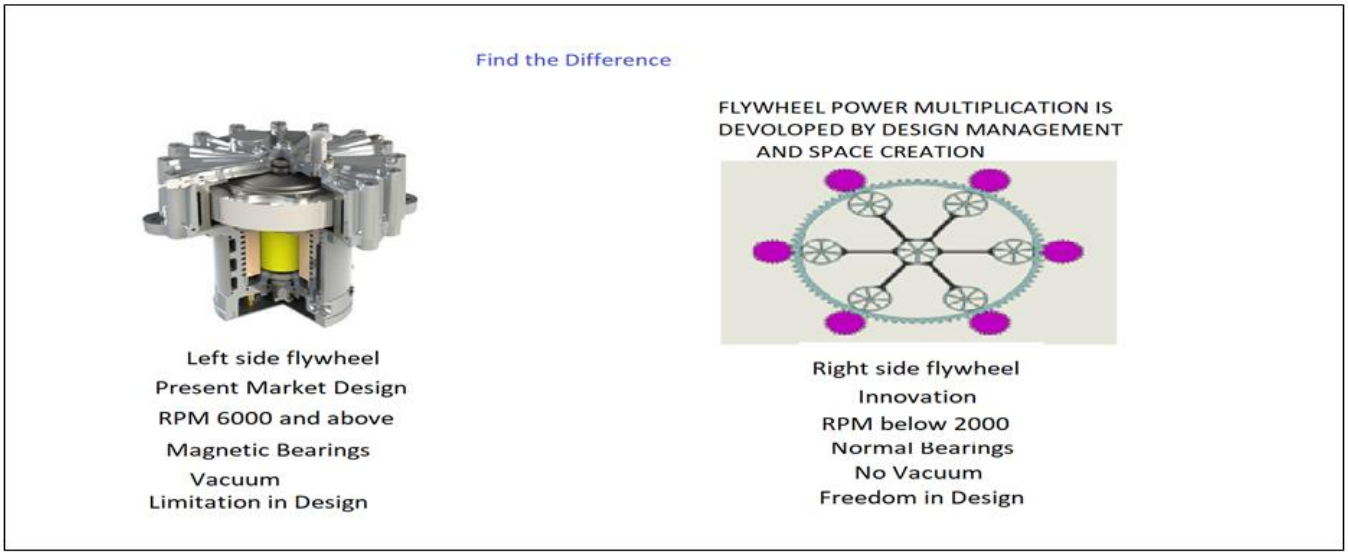
In the present market design, 67 Ton weight is designed as a cylinder by using carbon fiber-reinforced plastic flywheels fixed in a vacuum chamber and rotated in between 6000 to 16000 Rpm using magnetic bearings and after reaching the peak Rpm then deceleration of the flywheel starts.

Here the pulse of the flywheel recorded is maximum in between 1 to 5 min. Then again the process of acceleration and deceleration has to be repeated. There is no continuous mode.

In our technology 67 Ton weight is distributed on a large surface area there by bigger surface area is available and will generate more surface velocity there by more energy is stored in the rotating flywheel mass.

In our design we make from 67 Ton a 12 meter diameter flat and round circle flywheel and rotate below 2000 Rpm using normal SKF bearings there by please compare the design of the cylinder type flywheel where mass is compressed and made into a cylindrical flywheel and when mass is spread on a large area as shown in our design the flywheel is designed as a merry go round disc.





If the surface velocity is more the flywheel will rotate for more time.

Flywheel power multiplication design is more efficient than the designs available in the commercial market.

In our innovation the design cost is less and more efficient.

3.1 RECOMMENDATIONS

Flywheel power multiplication is recommended for existing power generation technologies in the present market because of the efficient plant load factor compared to other technologies.

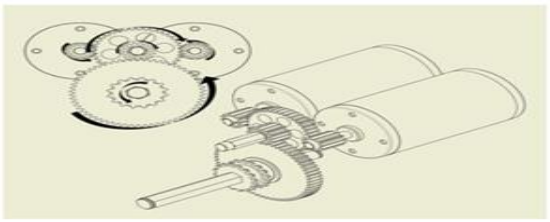
For example solar PLF has in between 10 to 13 % efficiency, wind PLF has in between 15 to 20%, Hydro PLF has in between 70 to 80 %, Thermal PLF has in between 70 to 80 %, and Nuclear PLF has in between 70 to 80 % and Flywheel power multiplication PLF 98%.

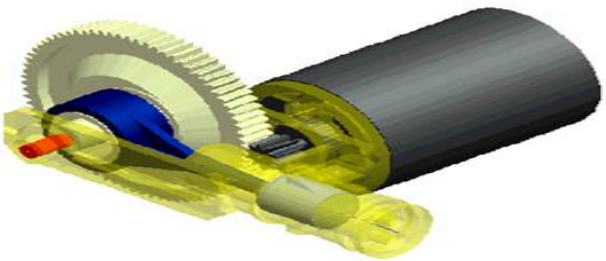
3.2 FUTURE WORKS

We are designing flywheel power multiplication energy storage application by using road ways, air ways, and seaways using technologies for multi megawatt power generation for our future projects.

For example in this sector we will be using the available electrical vehicles to rotate the flywheel fixed in vertical or horizontal designs.

In air ways we will keep a flywheel under side of the air craft and when the plane climbs to the maximum height the flywheel is lowered down and rotated by the wind blowing under side of the plane and generated electricity is stored in the batteries. In marine ways a flywheel is fixed in the water and a boat or a ship used to rotate the flywheel. By going Round of the defined path and generated energy is stored in the batteries.



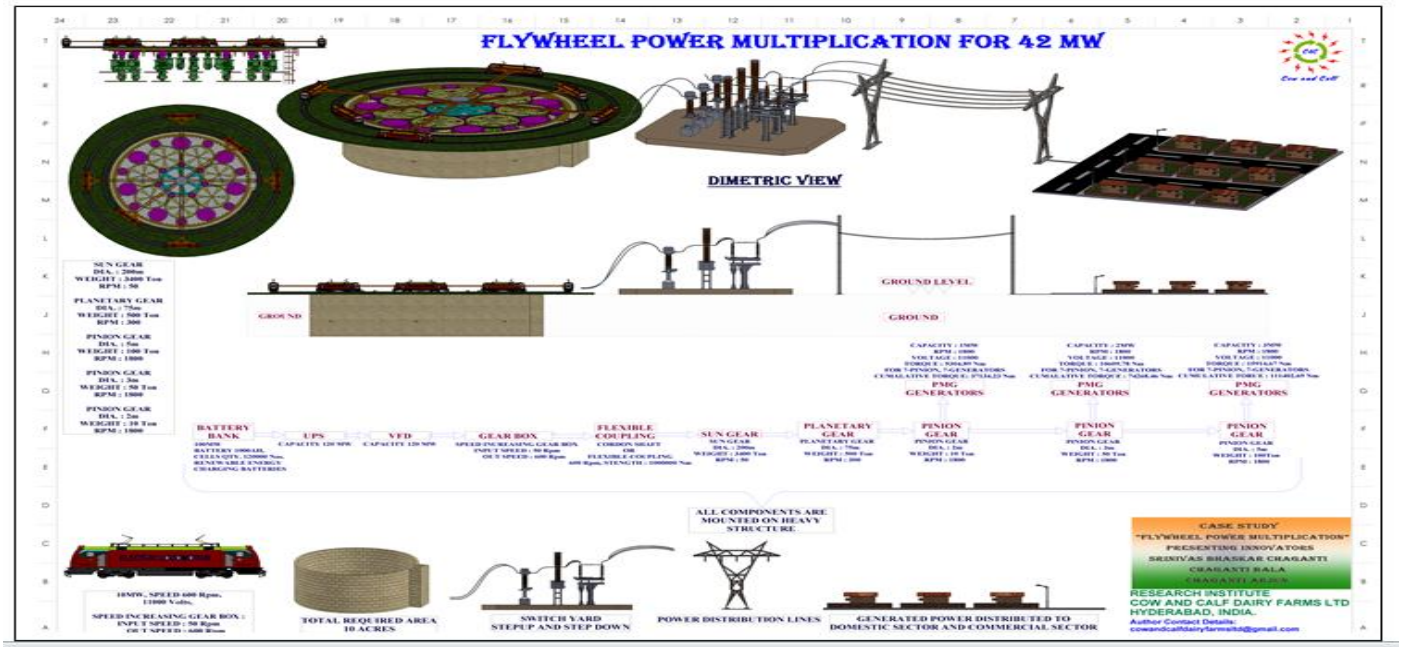


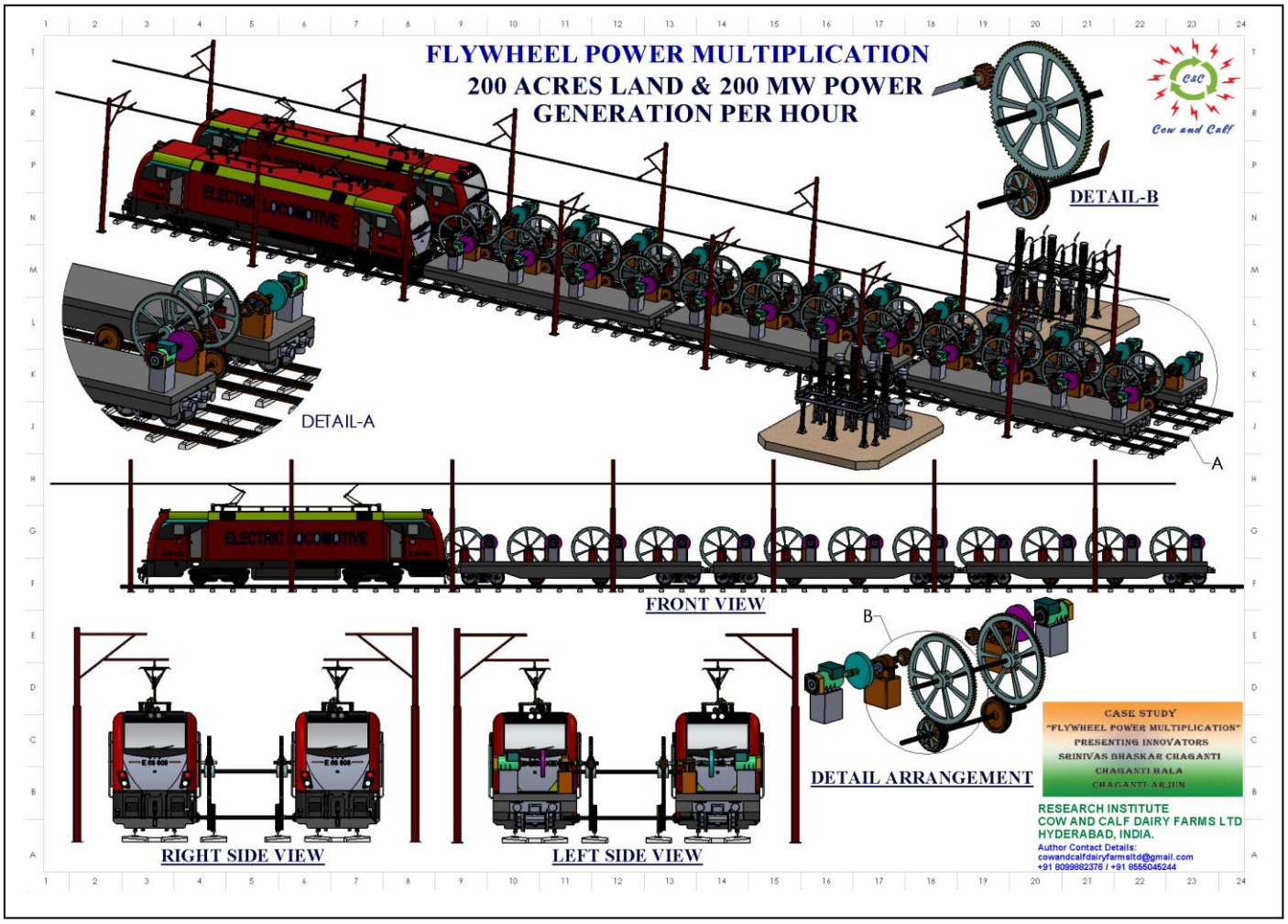
For power requirement of various fields

Generators cum flywheel attached to speed increasing gear box and rotated with power of hydraulics with pull and push mechanism.

We are developing these designs for multiple applications for road ways, air ways, sea ways and for applications of armed forces.

Small grid is smart grid where you generate there you distribute.





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