SPECIFICATION

BRIEF DESCREPTION

This innovation relates to a flywheel power plant having its generators power by kinetic energy derived from a large-scale vertical-axis and segmental rotor and flywheel system, equipped with stationary initiator drives and unitary structured with a building that prevailing constraints on conventional power plants practically to none.

POTENTIAL BENEFITS

Having practically with no constraints; this utility-scale power plant truly tolerates any number of units to be built virtually in any place - in towns, cities, etc., and toward to a sustainable world.

Like a hydroelectric power plant; this similarly two stage conversion system is reliable, cost effective, and it can handle both baseload and peak demand quite easily, but unlike the hydroelectric power plant; there are no problems on ecology, drought, etc., and rather makes vast areas of natural resources and rivers free.

Like a fossil-fired and nuclear power plant; it has the capacity to power large towns, cities or a country but unlike those - there are no problems on fuel supplies, gas emissions, nuclear wastes, and the lingering threat to people nearby and down earth.

In addition it is relatively less expensive to build, easy to maintain and above all kinetic energy is practically free, clean and inexhaustible.

BACKGROUND AS POWER PLANT

Renewable energy as it stands today, such as wind and solar, respectively has fundamental problems that are hard to overcome and energy derived from it is intermittent and expensive relative to those from conventional means.

Those technologies while it provides jobs, too much emphases has the potential to put businesses non-competitive in the global trade to countries that may one day turn to clean and low-cost energy, and low-cost electricity comes; clean water, clean transportation, etc.

Conventional power plants, as we all know, have an ongoing issue on gas emissions or something else and are disadvantageously very powerful, a single unit can cause a large and costly disruption on livelihood once critically compromised. The most alarming are; nuclear power plants and nuclear wastes both vulnerable to, God forbid, terrorism and natural calamity.

At present there are 104 nuclear reactors and (hard to know) about 600 coal-fired power generators in the United States with a combined capacity of at least 400GW out of about 1,025GW in total capacity.

To mention a few, power in China and India combined only about 1,170GW, relatively too small for two counties having a combined population of more than 7 times bigger than the United States. With the ongoing rate of development in both countries, demand for electricity at present and in the future are respectively enormous.

Enormous indeed but an incredible challenged too, consider the world still rely mostly on unfavorable conventional means that further escalates the present environmental problems and more toward global implications. The question is - what are our choices???

BACKGROUND AS FLYWHEEL SYSTEM

Flywheel is a rotating mechanical device that is used to store rotational kinetic energy and for millennia had benefited the civilizations to this day. Our car for example, has a flywheel an integral part of the engine enhancing its performance.

Flywheels are also used to stabilize the supply of power on electric grid, as it stores the excess energy when demand is low and vice-versa it supplies at peak hours. Those flywheels are physically small in diameter, its input to output ratio exhibit no energy gain but less, and it cannot supply effectively just by itself.

Flywheel is all about efficiency, the ability to store and deliver energy effectively, and it is fundamental that flywheels are configured having a high mass density at the perimeter or with a rim and it is essential that drag coefficient is low. The cross sectional area, if at all, while in direct contact with air or wind is keep to as small as possible and differently from a windmill.

Flywheels are generally monolithic, a rigid solid mass, yet a spinning rigid mass indeed has the potential to break apart into unpredictable size flying debris and large size fragment can cause a catastrophic failure… should that happened. Also large-scale monolithic flywheel is difficult and costly to handle, moving from production floor to far away site and install is quite expensive.

Further, there is this common knowledge, as briefly quote, “output in a machine is less than input”. This common knowledge when it comes to flywheel is part true and part false.

Part true, and true only when it comes to small size flywheels, technically these flywheels respectively having its moment of inertia (as the product of mass times the square of the radius) numerically small, in effect its potential output (as determined by the formula, $E = ½I\omega^2$) is small as well and correspondingly less than the input force – input force is determined by the formula, $F = ma$, wherein:

E	energy in Joules or Nm	F	force in Newton,
½	a constant,	m	mass and
I	moment of inertial,	a	acceleration/second squared.
ω	velocity in radiant/second,		

Mathematically, flywheels relative to its potential output can be group into two categories; small-scale or small sizes category and large-scale category. Large-scale flywheels are those having a longer radius and long enough to cause a gain or output larger than the corresponding input, in magnitude directly proportional to its radius, having other factors equal.

This potential gain is not new but unrealized, the fact that large-scale flywheels in reality are not common. Further this phenomenal gain, distinguishes clearly flywheel size that works from what doesn’t relative to this innovation.

What is new indeed is a large-scale vertical-axis and segmental rotor and flywheel system, designed to store and deliver kinetic energy in magnitude larger than the corresponding input force per unit of acceleration, different from the prior art.

OBJECT OF THE INVENTION

1. It is therefore the object of this innovation to provide an abundant supply of less expensive energy, clean and sustainable.
2. Another object of this innovation is to provide a power plant power by kinetic energy from a large-scale vertical-axis and segmental rotor and flywheel system, and that is easy to build, easy to maintain, safe and powerful.
3. Still the object of this innovation is to provide a power plant structured with a building and looks as much as the building pleasing to the neighborhood.

4. And still the object of this innovation is to provide a power plant that is easily upgradable and versatile.

DRAWINGS

Fig. 1, is a cross section view of a typical Power Module,

Fig. 2, is a plan of building outfitted with a large-scale vertical-axis and segmental rotor and flywheel system equipped with roller initiator drives, from 2 of Fig. 1,

Fig. 3, 4 are details, from 3 and 4 of Fig. 2,

Fig. 5, is a detail of a blower initiator drives option,

Fig. 6, is a plan of a typical generator/gearbox assemblies, from 6 of Fig. 1,

Fig. 7, is a Cluster of 5 power modules and

Fig. 8, is a Power Park comprises of clusters, service facilities and space for future expansion.

MECHANICS OF 18Mw POWER MODULE

The following are calculations and the recommended ways and means of operating this particular embodiment of the innovation - 18Mw Power Module.

This power module is designed having 12 stationary initiator roller drives, arranged into 4 groups of 3 drive assemblies active, each drive respectively equipped with a 1.0hp electric motor spaced at 120 degrees apart, with a corresponding idler member supporting the drive wheel (part of the initiator drive assembly), as shown in Fig. 2.

It is recommended that the groups are programmed to operate alternately having only 1 group running at a given time, others in succession stay disengaged with time for heat to dissipate. Prior to the initial start, it is important the rotor system is freed from load with the driven gear in freewheeling mode otherwise the motors by default need not start.

Once activated, the stationary initiator drives turns the rotor to an initial velocity of about 0.2m/s, equivalent to an initial acceleration of $0.004 m/s^2$, as shown in equation (1). Based on Newton's Second Law of Motion (F = ma), this will requires an initial and a sustained input force of 42Nm, as shown in equation (2). This sustained input force plus an incremental energy gain keeps the rotor accelerating until eventually it reaches its final acceleration of $20.9 m/s^2$ in 86 minutes or less, as shown in equation (3).

At final acceleration stage, the speed of the drive wheel matches with the circumferential speed of the roller drives and together they work in a synchronized manner turning the rotor at peripheral velocity of 20.9m/s or 20 rpm as required.

At 20 rpm; input force is calculated as shown in equation (4). Accordingly this input force is more of kinetic energy and a fraction of the total peripheral kinetic energy - peripheral kinetic energy is calculated as shown in equation (6).

$$a_{iv} = v_i^2 / r \qquad (1)$$
$$= (0.20\text{m/s})^2 / 10.0\text{m}$$
$$= (0.04\ \text{m}^2/\text{s}^2) / 10.0\text{m}$$
$$= \underline{0.004\text{m/s}^2}\ \text{(Ans.)}$$

$$F_{ia} = (m - (- R_{sb} - R_{dg}))\ a_{iv} \qquad (2)$$
$$= (9{,}000\text{kg} - (-11{,}760\text{Nm} - 1{,}411\text{Nm}))\ 0.004\text{m/s}^2$$
$$= (9{,}000\text{kg} + 1{,}200\text{kg} + 144\text{kg})\ 0.004\text{m/s}^2$$
$$= (10{,}344\text{kg})\ 0.004\text{m/s}^2$$
$$= \underline{42\text{Nm}}\ \text{(Ans.)}$$

$$T_{fa} = (a_{fa} - v_i) / a_{iv} \qquad (3)$$
$$= (20.9\text{m/s}^2 - 0.20\text{m/s}) / 0.004\text{m/s}^2$$
$$= 5{,}175\text{s or } \underline{86\text{minutes}}\ \text{(Ans.)}$$

$$F_{fa} = (m - (- R_d - R_{sb} - R_{dg}))\ a_{fa} \qquad (4)$$
$$= (9{,}000\text{kg} - (- 342{,}000\text{N} - 11{,}760\text{N} - 1{,}411\text{N}))\ 20.9\text{m/s}^2$$
$$= (9{,}000\text{kg} + 34{,}898\text{kg} + 1{,}200\text{kg} + 144\text{kg})\ 20.9\text{m/s}^2$$
$$= (45{,}242\text{kg})\ 20.9\text{m/s}^2$$
$$= \underline{945{,}558\text{Nm}}\ \text{(Ans.)}$$

where: a_{iv} = Initial acceleration,

F_{ia} = Initial input force,

T_{fa} = Time span for the rotor to reach its final acceleration,

F_{fa} = Input force to cancel all the resistance forces at final acceleration,

a_{fa} = Final acceleration (20.9m/s^2),

m = Peripheral mass (9,000kg),

r = Radius to the center of mass (10.0m),

v_i = Initial velocity (0.20m/s),

R_d = equation (10),

R_{sb} = equation (11),

R_{dg} = equation (12),

$$I = m\, r^2 \qquad (5)$$

$$= (9{,}000\text{kg})\ (10.0\text{m})^2$$

$$= \underline{900{,}000}\ \text{(Ans.)}$$

$$E_{rk} = ½\, I\, \omega^2 \qquad (6)$$

$$= (½)\ (900{,}000)\ (2\pi/3)^2$$

$$= (½)\ (900{,}000)\ (4.386)$$

$$= \underline{1{,}973{,}700\text{Nm}}\ \text{or Joule per second (Ans.)},$$

where: I = Moment of inertia (for now it is based on point mass only),

E_{rk} = Peripheral kinetic energy,

½ = A constant,

ω = Peripheral velocity in radiant per second = ($2\pi r/3$),

r = of equation (1),

m = of equation (2),

The torque at the axis of rotation is calculated as shown in equation (7) and indeed the rotor exhibits a significant gain. This significant gain provides this innovation the energy to operate of itself (if so desired) totally free from fuel once it gets started. This significant gain makes this power plant truly different from the prior art.

This phenomenal gain is not new. What is new is a large-scale vertical-axis and segmental rotor and flywheel system, what is new is a means to store and deliver kinetic energy in magnitude larger than the corresponding input force per unit of acceleration, and what is new is a power plant without the need for fuel and yet potentially reliable.

$$T_S = (E_{rk} - F_{fa})\ r \qquad (7)$$

$$= (1{,}973{,}700\text{Nm} - 945{,}558\text{Nm})\ 10.0\text{m}$$

$$= (1{,}028{,}142\ \text{Nm})\ 10.0\text{m}$$

$$= \underline{10{,}281{,}420\text{Nm}^2}\ \text{(Ans.)}$$

where: T_S = Torque at the axis of rotation,

r = of equation (1),
F_{fa} = equation (4),
E_{rk} = equation (6),
R_d = equation (10),
R_{sb} = equation (11),
R_{dg} = equation (12),

The torque of 10,281kNm at the axis of rotation or spindle is anticipated to be more than enough to power the said 18Mw capacity power module, with a sufficient peripheral net force to spare, as shown in equation (8). While the generator loads and other forces had been cancel-out, this net force and the initiator drives together keeps the rotor continue running at speed according to Newton's First Law of Motion.

In practice however, if this amount of net force proved to be excessive or insufficient with the rotor operating unsatisfactory, the solution is simply reduce or increase strategically the number of plates in a given mass assemblies otherwise the rotor will eventually come to stop due to insufficient mass, or vice-versa may accelerate beyond the speed limit until it triggers the emergency brake system.

On the other hand, this is relatively a simple power plant to operate and various options, if so desire, are available in the market to make it works to anyone satisfaction within the scope of the innovation.

$$K_N = T_S - (-T_g \; r_{sg} \; P_c) / r \qquad (8)$$
$$= [10{,}281{,}420Nm^2 - (-370{,}000Nm)\,(1.4m)\,(18Mw) / 10.0m$$
$$= [10{,}281{,}420Nm^2 - 9{,}324{,}000Nm^2\,) / 10.0m$$
$$= 957{,}420Nm^2 / 10.0m$$
$$= \underline{95{,}742Nm} \text{ or Joule (Ans.)}$$

where: K_N = net force or the remaining peripheral energy after all the resistance and generator loads have been cancel out,
P_c = Power capacity of a Module (18Mw),
r = of equation (1),
T_S = equation (7),
r_{sg} = of equation (12),
T_g = equation (13),

A rotor or a flywheel this big, safety is vital. In particular, the amount of tension a lever member is subjected to while at final velocity is calculated, as shown in equation (9), which members accordingly are designed to avoid the potential catastrophic failure on the building and further prevent debris from flying outside in case one or more of the lever members unfortunately break part.

It is within the spirit of this innovation, lever members can be made physically bigger and/or correspondingly less number of pieces in an assembly. This option is more applicable on power module with a bigger capacity.

$$T_C = (m\, a_{fa}) / L_n \qquad (9)$$
$$= (9{,}000kg)\,(20.9m/s^2) / 384$$
$$= 188{,}100Nm / 384$$
$$= \underline{490Nm \text{ or } 50kg} \text{ (Ans.)}$$

where: T_C = Tension force on individual lever at final acceleration,
L_n = Number of Lever in the rotor assembly (384),
m = of equation (2),
a_{fa} = of equation (4),

The following are pre-requisite equations that respectively have been incorporated in the above calculations:

Equation (10) in particular deals with drag and drag is a difficult force to deal with as the value of respective factors in the equation by nature is more of an art than math. The trade-off fortunately is, mass was not considered as part of the equation and that is advantageous relative to the innovation.

Accordingly it is the feature of this innovation having the mass of the flywheel made upgradable, compensating for whatever drag therewith in a desired to fine-tune the operation of the rotor system. In other word the rotor system itself, in addition to, becomes the means in determining on how much the actual drag there is by experimentation, which drag further varies significantly relative to the prevailing module's capacity which is upgradable as well.

$$R_d = - (½\, C\, p\, A\, v_{fa}^2) \qquad (10)$$
$$= - (½)\,(2.0)\,(1.3kg/m^3)\,(600m^2)\,(20.9m/s)^2$$
$$= - (½)\,(2.0)\,(1.3)\,(600)\,(20.9m/s)^2$$

$= - (\tfrac{1}{2})\ (2.0)\ (1.3)\ (600)\ (438.06)$

$= - \underline{342{,}000\text{Nm}}$

where:

R_d = Drag on the rotor at final acceleration,

½ = A constant,

C = Drag coefficient (say 2.0),

P = Air density (say 1.3 kg/m^3),

A = skin area (say $600m^2$, area near the axis of rotation excluded),

v_{fa} = velocity at final acceleration (20.9m/s),

$$R_{sb} = - (\mu\ m_t\ N) / r \quad (11)$$

$= - (0.06)\ (200{,}000\text{kg})\ (9.8) / 10.0\text{m}$

$= - 117{,}600\text{kg} / 10.0\text{m}$

$= - \underline{11{,}760\text{Nm}}$

$$R_{dg} = - (\mu\ m_{dg}\ N) / r_{dg}\ )\ r_{sg}\ ) / r \quad (12)$$

$= - (((0.06)\ (24{,}000\text{kg})\ (9.8) / 1.4\text{m}\ )\ 1.4\text{m}\ ) / 10.0\text{m}$

$= - ((14{,}112) / 1.4\text{m}\ )\ 1.4\text{m}) / 10.0\text{m}$

$= - (10{,}080)\ (1.4\text{m}) / 10.0\text{m}$

$= - (14{,}113) / 10.0\text{m}$

$= - \underline{1{,}411\text{Nm}}$

where:

R_{sb} = Resistance on the spindle vertical load bearing,

R_{dg} = Resistance on 12 freewheeling driven gear members,

μ = Coefficient of friction (say 0.06),

m_t = Total mass of the rotor assembly (say 200,000kg),

m_{dg} = Mass of the driven gear (say 2,000kg each or 24,000kg),

r_{dg} = Radius of the driven gear (1.4m),

r_{sg} = Radius of the spindle gear (1.4m),

r = radius of the flywheel/rotor (10.0m),

N = Newton,

$$T_g = - \{ [(p_{kw} \times 9550) / s]\ g_r \}\ r_{dg} \quad (13)$$

$= - \{ [(1{,}000\text{kw})\ (9550) / 1800\text{rpm}]\ 90 \} / 1.4\text{m}$

$= - 341{,}071\text{Nm}$ or say $- \underline{370{,}000\text{Nm/Mw}}$ (Ans.)

T_m = [(p_{kw} x 9550) / s] / r_{dr} (14)

= [(0.746kw) (9550) / 1800rpm] / 0.12m

= 33Nm (Ans.)

where: T_g = Torque on 1Mw generator/gearbox measured at the driven gear,

T_m = Torque of a 1.0hp electric motor measured at the drive roller,

p_{kw} = Power in kilowatts per second,

g_r = Gearbox ratio (1 : 90),

r_{dg} = Radius of the driven gear (1.4m),

s = 1800rpm,

r_{dr} = Radius of the drive roller (0.12m),

M_{hp} = F_{ia} / T_m / m_{nq} / η_m (15)

= 42Nm / 33Nm / 3 / 0.70

= 0.6hp or say 1.0hp (Ans.)

where: M_{hp} = horse power of the individual motor,

m_{nq} = number of motor in a group,

η_m = motor efficiency (say 70%).

F_{ia} = equation (2),

T_m = equation (14),

With those equations as references and while the rotor at its final velocity, 12 driven gear members are activated onward from Stage1 to Stage2 and finally to Stage3, gradually one after the other, preferably in opposite sequence relative to the spindle.

Alternately however, once the rotor had stored sufficient energy and before it reaches its final velocity, it is recommended to start the said engagement process and prevent the rotor from running with too much energy without load.

At Stage2, the driven gear is made partially engaged in a manner that progressively accelerates the generator from the state of rest to its final speed prior to Stage3. At stage3, the driven gear is made fully lock-up with the respective gearbox while and finally in operation.

A damper system is provided to dynamically balance the rotor system as necessary while operating otherwise vibration to such extend will activate an emergency brake system gradually bringing the rotor to stop for inspection and the like.

Having the above discussion focused on rotor system equipped with roller initiator drives, other means are also applicable and may proved to be more effective, i.e. compressed air, blowers, etc. - Fig 5.

Finally and having all the generators connected to the respective transformer and to the grid; a reliable, cost effective and sustainable electricity supply is now achievable closer to homes and practically indeed with no constraints.

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