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Sustained Hydro Power Generation Using Wheel and Gravity Effect

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ABSTRACT: Because of "wheel effect" a heavy mass can be displaced with very minimal energy compared to the same mass not subjected any wheel arrangement. Also, all the objects are subjected to the downward "gravitational force". These two factors are effectively combined to trap the sustained hydropower using upper and lower reservoir systems. The water will be transmitted from lower reservoir to upper reservoir thru winch based rail systems. This conceptual model is demonstrat with help of conventional vehicle dynamics model development and it is believed to produce two to three times more energy than artificially supplied in the winch system without violating any existing energy law. Expressions for the power gain and efficiency of the proposed Sustained HYdro POower System (SHYPOS) system have been derived using vehicle dynamics model. It is indicated that the power gain of the proposed system can be increased to any desired extent simply by increasing the mass of the winch system and decreasing its speed. Sensitivity analysis of the model parameters results also presented. The numerical results presented in the paper shows that power gain of as high as 3.5 and an efficiency of the conversion close to 78% can be easily achieved with a reasonable design of the energy systems.

INTRODUCTION

There are two kinds of energy conversion; direct and indirect energy conversion. Direct energy conversion occurs when the initial form of energy is directly converted to the final one without any intermediate form of energy. Examples include a solar cell (photon energy to electrical energy) or an electrical motor (electrical energy to mechanical energy). Direct energy conversion has in principle relatively high efficiency and it is therefore considered an important aspect of the design of a direct conversion of energy system. The other form of conversion is indirect energy conversion, in which more than one energy conversions stage is required between initial and final energy forms. As example of indirect energy conversion occurs with a typical coal fired power station. The chemical energy of the fossil fuel is changed to heat; the heat energy produces water vapor which rotates a turbine to produce electricity.

When a heavy mass is placed on the wheel system, energy required to move the mass is very small when compared to the same mass not subjected any wheel arrangement. For example, energy required to travel through bicycle is saved three to five times of calorific energy when comparing a person covering the same distance by walk. This could be possible because of "wheel effect". Also, all the objects are subjected to the downward "gravitational force". These two factors are effectively combined to trap the gravitational energy under the wheel systems.

By rotating a heavy mass in wheel, which is moving in a closed system, will practically be kept in motion by its own momentum and it will only require a small amount of real power to overcome the frictional losses. While heavy mass is in the rotary motion, the gravitational energy is trapped under the wheel. It is believed that the total power produced by the mechanism by converting gravitational energy will far exceed power demand on the motor, which drives the heavy mass. In simple terms, both "wheel effect" and "gravitational effect" is being combined in a systematic manner to trap the sustained electricity. This artificial power generating scheme could be termed as Generating Electricity by Rotating heavy Mass in Gravitational Energy field under wheel Rotary Motion or GERM–GERM or $(GERM)^2$. This $(GERM)^2$ concept is demonstrated with simple mathematical model development in this paper.

ENERGY ESTIMATION OF MASS UNDER WHEEL MOVEMENT SYSTEMS

If roads were flat and frictionless and air resistance didn't exist, there would be no need for an automobile to have an engine as per Newton's first law. In the real world, however, a moving vehicle without an engine slows down because of forces that resist its motion.

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The engine's function is to continuously provide power to overcome this resistance. The power required at the wheels of a vehicle can be modeled as the sum of the power required to overcome rolling resistance, the power to overcome air drag, the power associated with climbing or descending a slope, and the power associated with accelerating or decelerating the vehicle. Neglecting relatively minor losses due to road camber and curvature, the power required at the drive wheel ($P_{vehicle}$) may be expressed as,

$$P_{\text{vehicle}} = P_{\text{rolling}} + P_{\text{air\_drag}} + P_{\text{slope}} + P_{\text{acceleration}} \quad \dots (1)$$

where,

P_{vehicle} = Total mechanical demanded at the wheel of the motion vehicle (W).

P_{rolling} = Power demand to overcome rolling resistance (W).

$P_{\text{air\_drag}}$ = Power demand to overcome Aerodynamic resistance (W).

P_{slope} = Power demand on an incline road (W).

$P_{\text{acceleration}}$ = Power demand for acceleration of vehicle (W).

So, the total mechanical power P_{vehicle}, demanded at the wheel by the motion of the vehicle may be written as,

$$P_{\text{vehicle}} \approx (C_r mgv\cos\phi) + \left(\frac{1}{2}\rho C_d A v^3\right) + (mgv\sin\phi) + (mav) \quad \dots (2)$$

where,

C_r = dimensionless coefficient of rolling resistance.

C_d = dimensionless coefficient of aerodynamic drag resistance.

ρ = air mass density (kg/m^3) = 1.205 kg/m^3

A = frontal cross-sectional area (m^2) of vehicle

m = mass of the vehicle (kg)

v = instantaneous velocity of vehicle (m s^{-1}).

a = instantaneous acceleration of vehicle (m s^{-2}).

g = acceleration due to gravitational force (m s^{-2}).

φ = angle of inclination of road.

The inertia resistance force is only present when the vehicle is accelerated and the slope resistance force in only present when the vehicle travels on an inclined road surface. So, on flat surfaces at constant velocity, rolling resistance and air drag are the two principal components of power. For flat surface with constant velocity, the Eqn. (2) is reduced to,

$$P_{\text{vehicle}} \approx (C_r mgv) + \left(\frac{1}{2}\rho C_d A v^3\right) \quad \dots (3)$$

When a vehicle is moving at the constant speed of 1 m/sec, the power demand is estimated for various kind of an Indian Vehicle models are presented as shown in the Table 1. The speed range from 1.0 m/sec to 1.5 m/sec (3.6 km/h to 5.4 km/h) is generally defined as an average walking speed. One can easily come to a conclusion that rolling resistance dominates the power requirement at low speeds and air drag dominates at high speeds.

Table 1: Power Demand Estimation of Car and Bus

Sl. No	*Technical Specifications*	*Maruti 800*	*REVA Classe*	*TATA LP 1510*
1.	Overall Length (mm)	3335	2638	5860
2.	Overall Width (mm)	1440	1324	2434
3.	Overall Height (mm)	1405	1510	2550
4.	Gross vehicle weight (kg)	1000	977	13,200
5.	engine power (kW)	27	13	81
6.	Maximum Torque (Nm)	59	70	363
7.	Fuel	Petrol	Electric	Diesel
8.	No of Passengers	4	2adult+2child	55
9.	Coefficient of rolling resistance C_r (dimensionless)	0.015	0.015	0.007
10.	Coefficient of air drag C_d (dimensionless)	0.30	0.30	0.71
11.	Approximate Frontal Area (m^2)	2.00	2.00	6.20
12.	air mass density ρ (kg/m^3)	1.205	1.205	1.205
13.	angle of inclination of road θ (degree)	0	0	0
14.	Constant Speed/Velocity of vehicle (m/s)	1	1	1
15.	Rolling Resistance (kW)	0.1472	0.1438	0.9064
16.	Aerodynamic resistance (kW)	0.0004	0.0004	0.0027
17.	Total mechanical power demanded at the wheel P_{vehicle} (kW)	0.1475	0.1441	0.9091

When a vehicle is moving at the walking speed of 1 m/sec, air resistance will be very meager quantity as stated in the Table 1. For flat surface with constant velocity and at the walking speed, the Eqn. (3) is further reduced to,

$$P_{\text{vehicle}} \approx C_r mgv \qquad \ldots (4)$$

For sloped surface with constant velocity and at the walking speed case, power demand equation may be written as,

$$P_{\text{vehicle}} \approx P_{\text{rolling}} + P_{\text{slope}} \qquad \ldots (5)$$

Then, the required power of the vehicle on the stepping board mechanisms can be written as follows,

$$P_{\text{vehicle}} \approx (C_r mgv \cos\phi) + (mgv \sin\phi) \qquad \ldots (6)$$

The Eqn. (6) accounts only the power required to move the truck and it does not account any transmission losses. We can expect the two kinds of transmission losses in this Coulomb damping models namely, transmissibility efficiency due to horizontal resistive damping T_{hr} and conventional transmission losses between the wheel of the vehicle and motor T_{motor} could be assumed as 0.70 and 0.70 respectively. So, the instantaneous total power required from the electric power-system P_{motor} will be given by,

$$P_{\text{motor}} = \frac{(C_r mgv \cos\phi) + (mgv \sin\phi)}{T_{hr} \times T_{\text{motor}}} \qquad \ldots (7)$$

Rolling resistance is the energy that is lost when the tire is rolling and the main reason for loss of energy is the constant deformation of the tire. Also rolling resistance force is nearly independent of the vehicle speed. Rolling resistance could be estimated in two ways: empirical equation depends on the type of the material and rolling resistance equation based on the Newton's law. In the case of empirical method, rolling resistance is expressed in terms of Newton resistance per hundred kilograms of gross weight and type of pavement material. The stepping board mechanisms can be assumed as equivalent to the sand material pavement behavior and the average value of $R_{100} = 100$ N rolling resistances per hundred kilograms could be considered. Then, the power required moving 1000 kg mass of the vehicle on the stepping mechanisms could be estimated as follows,

$$P_{\text{rolling}} = \frac{mR_{100}}{100} \times v = \frac{1000 \times 100}{100} \times 1 = 1000 \text{ W} \qquad \ldots (8)$$

We can also express the rolling resistance in terms of mass and acceleration as stated in the Eqn. (4) as follows for rolling resistance on the flat surface,

$$P_{\text{rolling}} \approx C_r mgv \approx 1000 \approx C_r \times 1000 \times 9.81 \times 1 \qquad \ldots (9)$$

$$C_r \approx \frac{1000}{1000 \times 9.81} \approx 0.1019 \approx 0.10 \qquad \ldots (10)$$

So it is very clear that the value of dimensionless coefficient of rolling resistance C_r could be assumed as 0.10 for the sand pavement surface. Whereas, the value of rolling resistance of the flat smooth surfaces like concrete or tar road pavement is being considered as 0.015. That is, the value of coefficient of rolling resistance is approximately seven times more than that of tar or concrete road pavement systems. In the case of rail system, the rolling resistance is much more less than that of concrete road pavement system.

People Pull Large Object using Wheel Effect

On firm, flat, ground, a 70 kg man requires about 100 watts to walk at 5 km/h. That same man on a bicycle, on the same ground, with the same power output, can cover the distance as an average 25 km/h, so energy expenditure in terms of kcal/kg/km is roughly one-fifth as much and this is because of wheel effect. Generally used figures are:

- 1.62 kJ/(km·kg) or 0.28 kcal/(mile·lb) for cycling.
- 3.78 kJ/(km·kg) or 0.653 kcal/(mile·lb) for walking/running.
- 16.96 kJ/(km·kg) or 2.93 kcal/(mile·lb) for swimming.

Often we have seen in the headline that "Man pulls a bus" (Figure 1). It sounds pretty impressive, but let's see how hard it really is to move the bus. Assuming the bus is on level ground, the main force that has to be overcome to move the bus is the rolling resistance of the tires. Since man pulls the vehicle/large objects at the walking speed (3.6 km/h or 1 m/sec), air resistance will be very meager quantity at the walking speed.

Fig. 1: Man pulls the truck with help of wheel effect

This means that the force required to pull the bus is 0.007 multiplied by the weight of the bus, or 0.007 times (say 10,000 kg × 9.81). That is 687 N. There might be some extra force from brake drag or friction in the driveline, so we'll say it takes 150 N of force to move the bus. So the total force required to move the bus is 837 N. That is equivalent to lifting an approximately 85 kg mass. If a man has fit enough to lift about 85 kg of mass, then that man could easily pull the 10,000 kg bus.

Sustained HYdro POower System (SHYPOS)

In the proposed system, water will be transmitted from lower reservoir to upper reservoir thru winch based rail systems as shown in the Figure 2. A number of water containers are positioned side-by-side and mounted for up and down travel between the upper and lower reservoirs. When the containers have attained their lower most position at the lower reservoir, they are engaged by limit switch mechanisms to fill the containers with water from the lower reservoir. Upon being filled the containers travel on the winch based rail system to their upper most position to the upper reservoir. In usual convention methods, hydro power can be generated with help of stored water at the upper reservoir or otherwise power also can be trapped on the rotating disc by allowing the winch system downward gravitational movement system with water body. Water will be collected at the lower reservoir system from the turbine machine point. Again the collected water will be taken back into the upper reservoir to generate hydro power for next cycle.

The vehicle wheel of mass M is acting in the vertical downward direction due to gravity is given (Sen 1991) by,

$$F' = Mg - C_{vr}v \qquad \ldots (11)$$

where, C_{vr} = vertical resistive viscous damping coefficient.(Ns/m)

Force F' is now applied at a point on the rim of the rotating disc wheel. One may find the power developed at the rotating drum (Sen, 1991) as follows,

$$P_{\text{germ}} = T_{\text{joint}} \times T_{\text{mom}} \left(Mg - C_{vr}v\right)v \qquad \ldots (12)$$

where,

P_{germ} = amount of power produced using $(\text{GERM})^2$ concept (W).

T_{joint} = transmission efficiency due to mechanical joints and gear ratio

T_{mom} = momentum gain transmission factor due to wheel and gravity

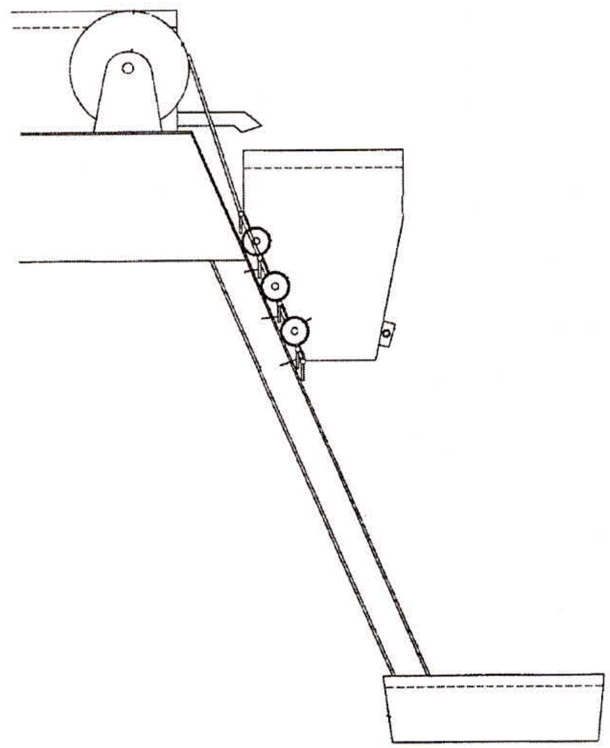

Fig. 2: Power Generating Winch Mechanism using wheel and gravity effect

"Power Gain" in the $(\text{GERM})^2$ Model

Coefficient of Performance (COP) or Coefficient of Energy Economic Performance (CEEP) of a system may be defined as the system's total useful energy output or work output divided by the operator's energy input only (input supplied by artificial means alone). Note that energy is conserved. No energy is "created out of nothing". However, the operator inputs only a fraction of the total input required, and the environment freely inputs the rest. Conversion efficiency loss already considered while calculating the coefficient of performance. In the case of solar system, the thermal conversion efficiency of light energy to electric energy is just 12% to 15% but when we work out economical efficiency or COP or CEEP is infinity (Some output of electrical energy gets against zero input). Same principle can also admit into the wind energy and hydro energy as well. But these solar, wind and hydro can not trap everywhere and all the time and also has some other economical constraints. The term "Power Gain (PG)" introduced by Sen (1991) indicates that some amount of excess energy could be trapped out of the system more than supplied by operator (input supplied by artificial means alone),

$$PG = \frac{\text{Useful Power Output}}{\text{Energy Supplied by artifically}} \qquad \ldots (13)$$

By substituting the values in the Eqn. (13),

$$PG = \frac{T_{\text{hr}} \times T_{\text{motor}} \times T_{\text{joint}} \times T_{\text{mom}} \left(Mg - C_{vr}\nu\right)}{\left(C_r mg \cos\phi\right) + \left(mg \sin\phi\right)} \quad \text{... (14)}$$

Eqn. (14) may be referred as "*(GERM)^2 Conceptual Model*". Since, our proposed gravitational energy system is a relatively new area of research it is very difficult situation to arrive definite conclusions on the model parameter values. This could be effectively handled with help of sensitivity analysis of all doubtful parameters. Eqn. (14) contains three kinds of efficiency parameters namely motor control transmission efficiency, transmissibility of horizontal resistivity and other transmission losses due to say gear ratio. Many cases one can witness these three parameters values could be minimum in the order of say 0.70 or 70% efficiency in the today's available advanced mechanical systems. By substituting the above assumed efficiency parameter values in the Eqn. (14),

$$PG = \frac{0.70 \times 0.70 \times 0.70 \times T_{\text{mom}} \left(Mg - C_{vr}\nu\right)}{\left(C_r mg \cos\phi\right) + \left(mg \sin\phi\right)} \quad \text{... (15)}$$

For the typical case, when we substitute the values M = 1000 kg, v = 1 m/sec (3.6 km/hr), φ = 10°, C_{hr} = 1000 Nsec/m, C_{vr} = 500 Nsec/m, and T_{mom} =1 in the Eqn. (16), then the term Power Gain is worked out as 1.20. The total system Power Gain will depends on the number of massive underground wheel on the circular path system, which can be equated to number of solar panels and number wind blade installation will give maximum output in the given systems. Also, the overall efficiency of the (GERM)^2 model system can be calculated as follows,

$$\eta = \frac{P_{\text{germ}}}{\left(P_{\text{motor}} + P_{\text{germ}}\right)} \quad \text{... (16)}$$

The expressions for power gain and overall efficiency of conversion of the proposed (GERM)^2 model system, given by Eqns. (15) and (16) respectively, were determined numerically for different values of the slope angle φ and for four different values of the momentum gain transmission factor T_{mom}. The results are presented in Figures 3 and 4.

As Sen (1991) said, a considerable power can be achieved in the system if the slope angle φ of the stepping board is not allowed to exceed 10°, and the power gain becomes higher for higher values of the momentum gain transmission factor. So, for the limiting value of slope angle φ = 10°, one may note, from Eqn. (15), that the power gain of the (GERM)^2 model system can be increased to any desired extent simply by increasing the mass of the winch systems and by decreasing its speed. From Figure 5, it is clear that the dimensionless Coulomb damping coefficient C_r values might be in the ranges from 0.05 to 0.1. In any case, if the dimensionless Coulomb damping coefficient C_r values in the ranges from 0.1 to 0.2, then momentum gain transmission factor should be more than one. As an average, the momentum gain factor T_{mom} could be expected as two.

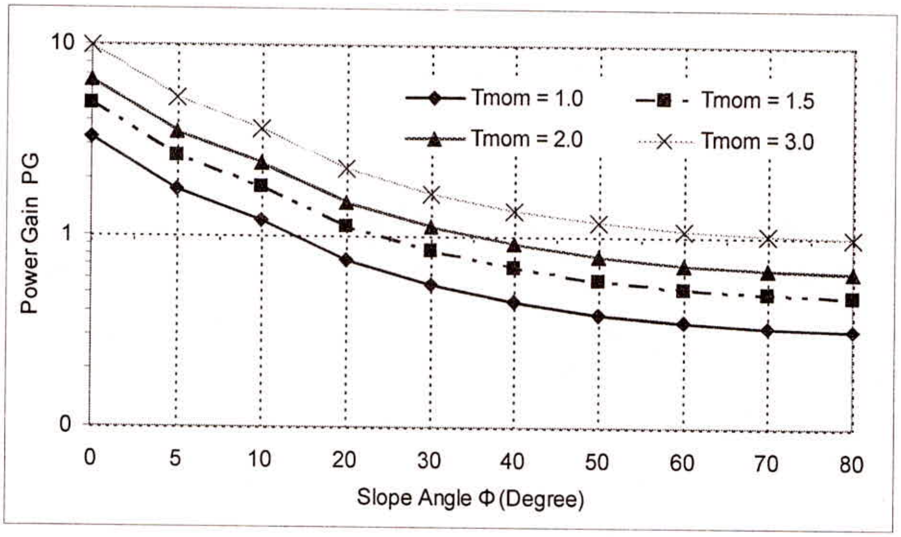

Fig. 3: Power Gain Characteristics of (GERM)^2 model

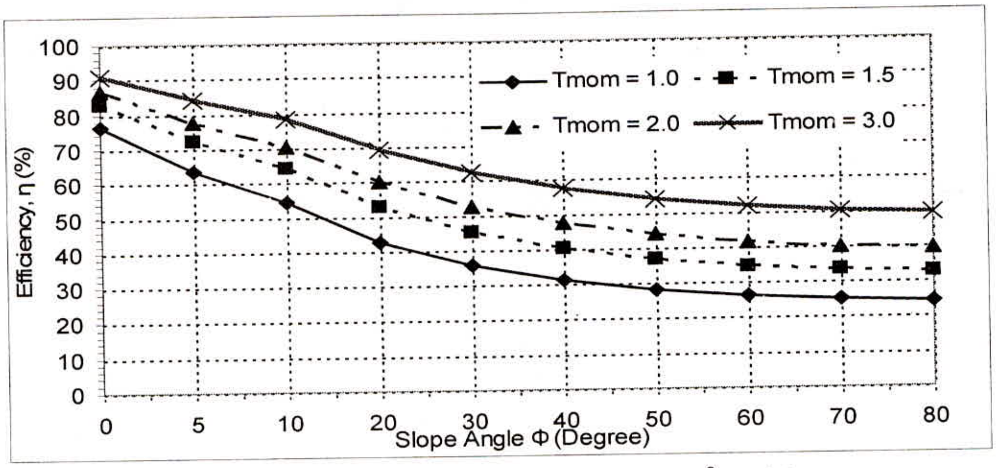

Fig. 4: Efficiency Characteristics of $(GERM)^2$ model

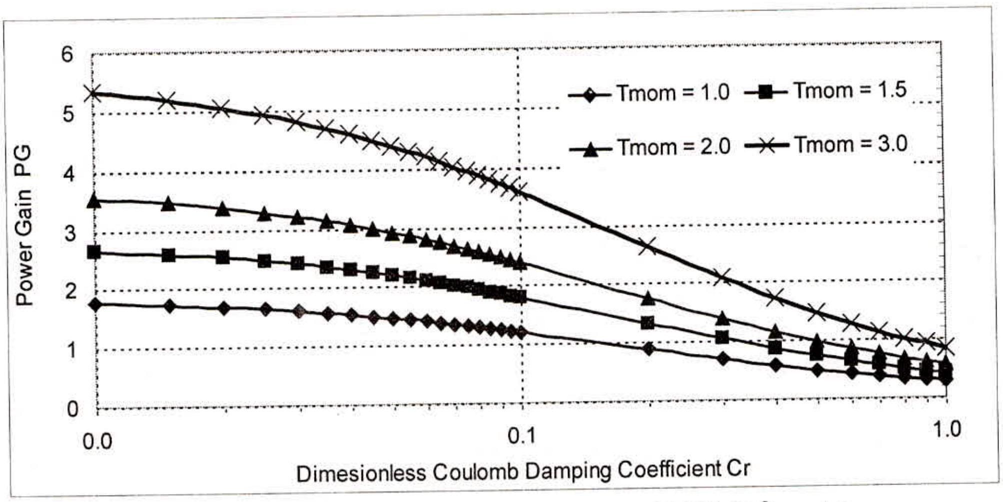

Fig. 5: Coulomb Damping Characteristics of $(GERM)^2$ model

CONCLUSIONS

In this paper, both "wheel effect" and "gravitational effect" are effectively combined in a systematic manner to trap the sustained electricity. Expressions for the power gain and efficiency of the proposed $(GERM)^2$ system have been derived. It is indicated that the power gain of the proposed system can be increased to any desired extent simply by increasing the mass of the winch systems and decreasing its speed. Sensitivity analysis of the model parameters results also presented. Coulomb damping coefficient C_r values might be in the ranges from 0.05 to 0.1. We also witnessed that the momentum gain transmission factor should be more than one when the dimensionless Coulomb damping coefficient C_r values in the ranges from 0.1 to 0.2. The numerical results presented in the paper shows that power gain of as high as 3.5 and an efficiency of the conversion close to 78% can be easily achieved with a reasonable design of the energy system.

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