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Fabrication of Swing Motion Power Generation

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Abstract: *Energy need of the world is growing day by day because of consumption of energy at a larger extent with the population growth. This paper is about generating power by using a swing in such a way that when it swings the mechanical energy is generated and it is converted into electrical energy by a commutator and is stored in a battery. The construction is such a way that, the swinging action makes the horizontal beam rotating through an angle. This shaft is connected to a sprocket to transfer the motion to the free wheel which rotates proportionally with respect to the angle of motion of the swing. The angular movement is converted into a complete rotation with the help of a chain drive connecting both sprocket and free wheel. The free wheel is connected to a shaft which in turn rotates the spur gear and dynamo arrangement to generate electricity..*
Keywords: *Chain drive, Energy, Freewheel, Sprocket, Swing.*

1. Introduction

Energy is the ability to do work. It is a driving force of modern societies and generation and utilization of energy are essential for the socio economic development. Per capita consumption of energy levels are often considered a good measure of economic development. In recent years, energy scarcity has become a serious problem due to depletion of non-renewable energy sources, increasing population, globalization of energy intensive economic development, environmental pollution, and global warming. In this paper, it is proposed to harness the human muscle power of children playing in public spaces such as school playgrounds, on equipment such as teeter totters, swings, and merry-go-rounds. Such an energy conversion is playful and hence does not require deliberate effort. For human power conversion systems to be useful in the context of developing countries, several constraints need to be considered like low cost, low-resource and limited-skills requirements, low-maintenance, safety and comfort to humans, and environment-friendliness. Human power conversion is easily achieved from children's play under conditions where the children are static relative to the moving playground mechanism, such as seesaw, swing, and merry-go-round. Where the children are in a dynamic state relative to a static mechanism (e.g., swing) it will be difficult to employ cost-effective human power conversion techniques due to considerations of safety and simplicity. A variety of mechanisms are used for conversion of human power to usable electrical or mechanical energy like springs, hydraulic components, electric generators, piezoelectric, compressed air systems, flywheels, and so on. The factors affecting the choice of the most suitable conversion mechanism are similar to those for the general energy conversion problem. Human power was perhaps the earliest source of energy known to mankind. Its first uses were in tool-making, rowing boat, and so on. Mechanized uses of human power were achieved in the form of hand cranking by the Romans. However, pedaling which is a simpler and less tiresome means of human power conversion did not come about until the 19th century with the invention of the bicycle. Human power was widely used in the developed countries in the late 19th and early 20th centuries for purposes such as irrigation, operating machinery, and as a source of electricity for watching/listening to television and radio. In many developing countries, human power is still widely used in agriculture, industry, and services. It is clear that the systems proposed in literature are unsuited to power basic domestic appliances such as fluorescent lights, desk fans, television sets, or communications equipment (e.g., fax machines). These are among the basic needs of a majority of the population in developing countries. The low-cost requirement also imposes a trade-off between cost and efficiency of the energy conversion system. Improving the efficiency of the conversion system is often essential in the case of individual human power conversion – generally would result in increased cost of the overall system. In the case of several children playing on playground equipment, power is produced as a by-product. Therefore, a low-cost system can be designed and implemented without seriously affecting efficiency, since a large number of children are involved in the play.

2. Literature Survey

The study by Rajat et al [1] gives a platform of developing a sustainable, low maintenance system to generate electrical energy. There is a lot of availability of mechanical energy in the environment. This mechanical energy can be converted into other form of energy like electrical energy. Low rpm generator produce power at low revolution per minute. Low rpm generators once employed provides years of usage. These generators not only provide higher efficiency but also have low cost. Low rpm generator are used because it gives a highly reliable power output as they work at less speed which leads to less wear and tear of the various part of generators.

Where power can be generated using man power in a playful manner said by Manjunath and Suresh [2], in Swing Electricity Generation System. In this mechanical energy is converted into electrical energy using sprocket and flywheel arrangement. The output voltage of the swing depends on its angle of swing. Here voltage can be amplified using different electronic circuit. In this power is not generated in bi-directional motion of swing.

The study of swing motion by Shastri and Bharath [3], is being exploited to drive mechanical and electrical load there are 2 different types of designs.

i. Harnessing bi-directional motion of swing
ii. Harnessing any one direction of swing.

The study Gokul and Cyril John Tellis [4], as every single details about the design of the swing is listed in this journal with all its 2-D, 3-D model and calculations. Calculations are important but for only fabrication it's not much important to go deep in the design of the swing.

The paper which is proposed by Pandian [5], is all about generation of power in small scale using man power in a playful manner and utilizes that power in our daily life. It describes about the requirement and consumption of power in our daily routine and power is generated using paly ground equipment's like swing, see-saw, and merry go-round etc.

Starner [6], study analyses voluntary damping of the oscillating pendulum-lever system, by reverse action of the user system on the lever. User system overtakes a part of the total internal mechanical oscillation energy of the lever-pendulum system. The lever bears orbital damping. Orbital damping of the lever causes radial damping of the pendulum. The work of the outer force periodically compensates the loss of the part of the total internal mechanical oscillating energy of the lever-pendulum system due to the work of the outer force, which affects the pendulum directly. Radial damping of the lever is excluded, since the bearing of the lever axis is fixed. Pendulum overtakes the energy from the environment EO under stable operation conditions of the machine. User system overtakes the resulting energy of the machine ER by means of the lever which oscillates forcedly Work of the outer force on activating the machine, to achieve stable operating regime, can be neglected after a certain period of time since this initial energy is input only once. Only the outer supplied energy EO, which is needed in order to maintain already achieved operating regime of the machine, is relevant for the further analysis. The machine thus continuously gives over the resulting energy ER to the user system. All the energy values in the further analysis are related to the time of one oscillation of the pendulum. Further analysis operates with absolute values of the work of the forces and momentum of the forces. Free energy of the machine is the difference between the resulting energy ER and input energy EO Input of the energy EO from the environment results in transfer of the energy ER to the user system which is a part of the machine having the role of energy consumer. In this study, the free energy is defined as the difference between the resulting, used energy of the machine and the energy input from the outside, the effect of free energy is not in accordance with the energy conservation law but it has been proved experimentally. The objective of this study is to support this effect theoretically and to explain it. Total internal mechanical oscillation energy of the pendulum-lever oscillator system is reduced to the oscillation energy of the pendulum User system overtakes a part of the total internal mechanical oscillation energy of the two stage oscillator by damping the oscillation of the lever. The lever oscillates forcedly, not freely but in a condition of damping its movement. One can assume that the total mass of the lever is in the point where the user system reacts. This equivalent material point of the lever has a variable kinetic energy in reference to the ground. But the lever is periodically changing the direction of the rotation around its axis. This periodical change of the direction is fully depending on the oscillations of the pendulum, so the lever does not have its own oscillation energy. If the equilibrium position of the lever were vertical, a relevant variable component of the gravitational force would affect the equivalent material point as in the case of the pendulum, which is not the case, since the equilibrium position of the lever is horizontal.

3. Design

A traditional swing consists of main frame which is connected with a rotating shaft at both the ends by using ball bearings. Since its swing motion is in single direction, power generated is less. So, new model is designed to generate electrical power based on bi-directional swing motion with sprocket, spur gear arrangement and dynamo. One side of the main shaft as driver sprocket which is fixed and below it a driven sprocket (freewheel) is connected by chain and it is coupled with the spur gear arrangement which drives the dynamo. The swing is designed using solid bars instead of chain in order to allow maximum torque to the bearings which will result in effective power generation.

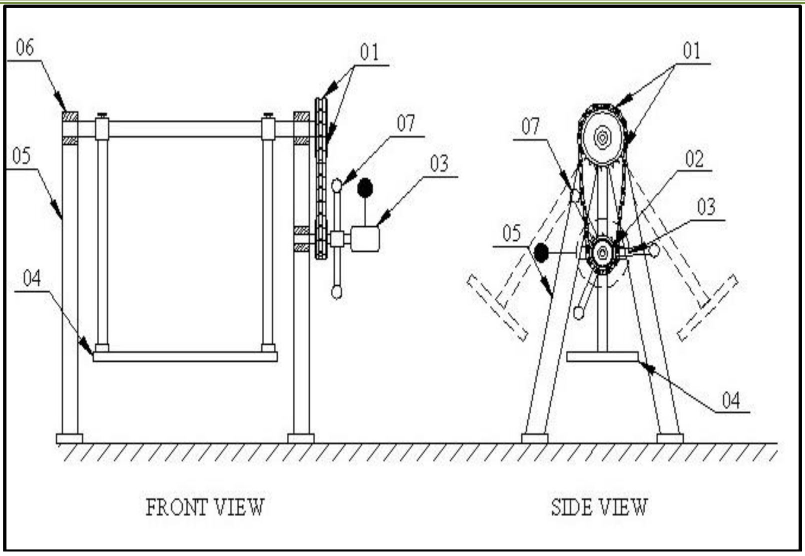

Fig. 1 design of swing

1. Chain and sprocket
2. Free wheel
3. Dynamo
4. Swing frame
5. Main frame
6. Bearing
7. Hand lever

When swing motion occurs (forward and backward), driver sprocket with the chain drive arrangement rotates the driven sprocket which tends to drive the spur gear and the spur gear arrangement in turn runs the dynamo. And the power generation is indicated with help of LED's, the generated power can be stored in the battery. Here, semiconductor diode is used to restrict the reverse flow of charges from battery to dynamo during the backward swing. Fig. 1 shows Design of proposed model.

For the preliminary design, sketch up software was used to build the swing and the gear mechanism, which would allow it to convert the oscillating motion into electrical power. Even though, the manufacturing of the swing is varying from the original design, the main structure was retained from this early concept. The main structure consists of a frame, the bars that hold the swing seat and the position of the gears. The main variation from this design is that the generator is attached to the frame and a separate mounting structure for the motor to attach to the actual frame in order to reduce the price and make it less bulky. A more detailed consideration of this project can be accomplished by analyzing a traditional swing structure and how this would affect the generation of power.

4. Working principle and components used

During the forward stroke & backward stroke of swing some torque is induced in shaft. The shaft is mounted between two bearings. At one end of the shaft a large sprocket is attached rigidly, this sprocket pivots over shaft axis when the shaft is displaced. The larger sprocket is attached to a smaller sprocket using chain. The shaft in which smaller sprocket is mounted is connected with the spur gear arrangement. With this arrangement power is generated in the dynamo and stored in the battery. The construction of the swing model is shown in the Fig. 2.

When the seating of the swing set moves forward & backward some torque is induced in the shaft by the holding bars of swing set. This torque displaces the larger sprocket which is pivoted over axis of shaft causing the angular displacement. This angular movement is converted to rotational motion of smaller sprocket by chain attachment. The sprocket rotates the spur gear arrangement which runs the dynamo, thus producing the electricity. The electricity thus produced is stored in a battery by using electric circuits as shown.

Fig. 2 working mechanism

The main components used to fabricate the model are:

- Chain drive
- Sprocket
- Dynamo
- Bearing
- Spur gear
- Free wheel

4.1 Chain drive

Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. The power is conveyed by a roller chain, known as the drive chain or transmission chain, passing over a sprocket gear, with the teeth of the gear meshing with the holes in the links of the chain. By varying the diameter of the input and output gears with respect to each other, the gear ratio can be altered. There is even very low friction, as long as the chain is sufficiently lubricated. Continuous, clean, lubrication of roller chains is of primary importance for efficient operation as well as correct tensioning. Here chain drive is used for transmitting the motion from sprocket to free wheel. Here the motion from shaft axis of swing frame is transmitted to the low rpm generator coupled to the spur gear via free wheel arrangement.

4.2 Sprocket

Sprocket is a profiled wheel with teeth that meshes with a chain. It is an intended material. The drive sprocket may be positioned at the front or back of the vehicle. Sprockets never mesh together directly, and from a pulley by not usually having a flange at each side. It transmits rotary motion between two shafts where gears are unsuitable or to impart linear motion to a track. Here sprocket is coupled to the shaft where the shaft produces a torque during the oscillation of the swing. Hence, sprocket is used for transmitting the motion through chain drive to the generator to produce power.

4.3 Dynamo

Dynamo is an electricity generator. This dynamo produces direct current with the help of a commutator. It was the first generator, capable of power in industries. The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current. A dynamo machine consists of a stationary structure, called the stator, which provides a constant magnetic field, and a set of rotating windings called the armature which turn within that field. The commutator was needed to produce direct current. When a loop of wire rotates in a magnetic field, the potential induced in it reverses with each half turn, generating an alternating current. Unlike the Faraday disc, many turns of wire connected in series can be used in the moving windings of a dynamo. This allows the terminal voltage of the machine to be higher than a disc can produce, so that electrical energy can be delivered at a convenient voltage.

4.4 Bearings

A bearing is a device to permit constrained relative motion between two parts, typically rotation or linear movement. Bearings may be classified broadly according to the motions they allow and according to their principle of operation. Low friction bearings are often important for efficiency, to reduce wear and to facilitate high speeds. Essentially, a bearing can reduce friction by virtue of its shape, by its material, or by introducing and containing a fluid between surfaces. By shape, gains advantage usually by using spheres or rollers. Here we have selected ball bearing to reduce friction and for free movement of the swing.

Specification of Ball Bearing:

- Bearing Type: Ball Bearing
- Ball Material: Chrome Steel
- Diameter: 0.04 m
- Length: 0.07m

4.5 Spur gear

Spur gears are the simplest and most common type of gear. Their general form is a cylinder or disk. The teeth project radially, and with these straight-cut gears, the leading edges of the teeth are aligned parallel to the axis of rotation. These gears can only mesh correctly if they are fitted to parallel axles. The torque ratio can be determined by considering the force that a tooth of one gear exerts on a tooth of the other gear. Consider two teeth in contact at a point on the line joining the shaft axes of the two gears. The force will have both a radial and a circumferential component. Depending on their construction and arrangement, geared devices can transmit forces at different speeds, torques, or in a different direction, from the power source. Gears are a very useful simple machine. The most common situation is for a gear to mesh with another gear, but a gear can mesh with any device having compatible teeth, such as linear moving racks.

4.6 Free wheel

In mechanical or automotive engineering, a free wheel or over running clutch is a device in a transmission that disengages the driveshaft from the driven shaft when the driven shaft rotates faster than the driveshaft. An overdrive is sometimes mistakenly called a free wheel, but is otherwise unrelated. The condition of a driven shaft spinning faster than its driveshaft exists in most bicycles when the rider holds his or her feet still, no longer pushing the pedals. In a fixed-gear bicycle, without a free wheel, the rear wheel would drive the pedals around.

Fig. 2 shows the 3-D geometry of this model is proposed with all the components in it. This CAD model was designed in such a way that every components which helped in defining their properties and behavior for the different load conditions.

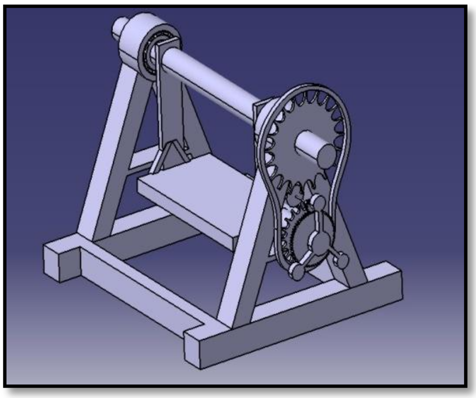

Fig. 3 3-D model of swing motion power generation

5. Parts assembly

The assembly of the various components like sprocket, chain drive, free wheel, spur gear, dynamo and battery is as follows:

5.1 Sprocket assembly

Here the sprocket is placed on the shaft and it can be welded or coupled by a pin joint. But in this case it is welded to the shaft, so as to impart the motion of the swing to the sprocket and then it is transferred to the smaller sprocket (Free wheel) via a chain coupled to it as shown in Fig. 4.

Fig. 4 two views of sprocket assembly

5.2 Free wheel assembly

Here free wheel is mounted on a small shaft which is placed inside the ball bearing as shown in Fig. 5. This free wheel is welded on the outer ring to avoid the free moment of the free wheel and it is converted into a smaller sprocket. The free wheel is used for transmitting the rotary motion to the shaft on which a spur gear is mounted which in turn is connected to a dynamo.

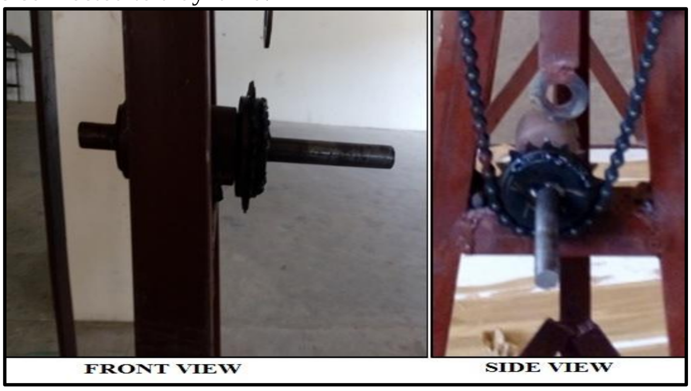

Fig. 5 two views of free wheel assembly

5.3 Chain drive assembly

Here a chain drive is placed between a larger sprocket and a smaller sprocket (free wheel) to transmit the oscillating motion of the swing to the dynamo to produce electricity. It is a way of transmitting the mechanical power from one place to another. Fig. 6 shows the assembly of a chain drive between larger sprocket and a smaller sprocket.

Fig. 6 two views of chain drive assembly

5.4 Spur gear assembly

Spur gears are the simplest and most common type of gear. Their general form is a cylinder or disk as shown in Fig. 7. The teeth project radially, and with these straight-cut gears, the leading edges of the teeth are aligned parallel to the axis of rotation. These gears can only mesh correctly if they are fitted to parallel axles.

Fig. 7 spur gear assembly

The spur gear is mounted in parallel with the smaller sprocket (Free Wheel) on the common shaft, where it meshes externally with the smaller spur gear which is coupled to the dynamo to generate power.

5.5 Dynamo assembly

Dynamo is an electrical generator. This dynamo produces direct current with the use of a commutator. The dynamo uses rotating coils of wire and magnetic fields to convert mechanical rotation into a pulsing direct electric current. Here the dynamo is mounted on the main swing frame and it is meshed externally to a spur gear by using a smaller spur gear. Dynamo produces direct current due to the motion of the swing and this electricity is stored in the battery. Fig. 8 shows the assembly of a dynamo.

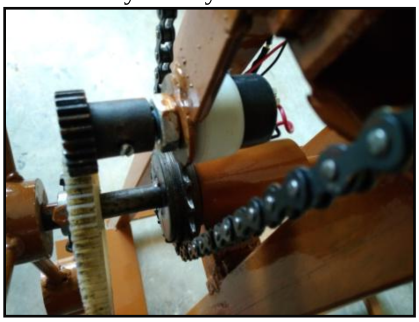

Fig. 8 dynamo assembly

5.6 Battery assembly system

A battery as shown in Fig. 9 is used for storing the electricity generated by the dynamo. This electricity is stored to run the low power appliances. This electricity can also be used to charge the mobile battery, power the light bulbs etc.

Fig. 9 battery assembly system

In this below Fig. 10, all the assembled part which have been mentioned above are combined or assembled, and the following figure shows the fully assembled view.

Fig. 10 final assembly

6. Calculations

The capacity of the battery is 6 V and 4.5 A, the average current output from the swing motion during forward and backward oscillation is 0.45 A, output volts is 4 V calculate the power output and time for the complete charging of the battery.

Solution:-

Battery capacity = 6 V, 4.5 AH

Average output current = 0.45 A

Average output volts = 4 V

Therefore,

Power = V × I

Power = 4 × 0.45 = 1.8 W

Time for charging the battery = Maximum capacity of current/output current

T = 4.5 AH / 0.45 A = 10 hours.

7. Tests and results

The following are the tests performed depending upon the swing angle. The below Table 1 shows the output volts for the different swing angles from 0 to 120 degrees.

Table 1 validation of output volts

Swing Angle (Degrees)	**Output Volts (Volts)**
0 – 30	1.0 – 2.0
30 – 60	3.0 - 4.0
60 – 90	4.0 - 5.0
90 – 120	5.0 - 6.0

The below Table 2 shows the output current for the different swing angles from 0 to 120 degrees.

Table 2 validation of output current

Swing Angle (Degrees)	**Output Current (Amps)**
0 – 30	0.3
30 – 60	0.4
60 – 90	0.5
90 – 120	0.65

The above table shows the amount of output volts and output current for the different swing angles from 0 degree to 120 degree. This output volts and current can vary for different design of swings.

8. Advantages and applications

The merits of developed model are:

- Pollution free electricity generation.
- This power can be stored in battery array so as to use it further.
- Can be installed at places such as schools, playgrounds where mass transit of children is sighted e.g. hotels, fairs etc.
- Easy installation and maintenance.
- It can be used in remote areas where power supply is not available.
- It does not require no running cost because it does not required any fuel.
- It can be installed in any place quickly as compare to solar, wind and other plant.
- It is portable; it can be used as portable power generator.
- It is simple in construction like other conventional part.
- It required small area for installation.

Applications of the developed model are:

- Schools
- Nurseries
- Parks
- Gardens
- Playgrounds

9. Conclusion

With the demand for energy increasing tremendously, different methods of extracting energy from the available environment is focused and world is in search of alternative sources. The way of producing power from the mechanical energy that can be wasted is persevered for the future purpose which is having a great scope. So, swing power generator is considered as a promising alternate for exhausting energy sources.

10. Future scope

The extent of power generation can be increased by improving the design the charging circuit or by controlling the flexibility of the swing it can be designed as weather proofing and also adopt different types of safety measures.

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