Design and Fabrication of Human Powered Swing for Electricity Generation

Gokul S P[1], Cyril John Tellis[2], Joash Anchan[3], Nikilesh Reddy Kalluri[4]

[1]Student, Department of Mechanical Engineering, PES Institute of Technology-Bangalore South Campus, Electronic City, Hosur Road, Bangalore-560100, India

[2]Student, Department of Mechanical Engineering, PES Institute of Technology-Bangalore South Campus, Electronic City, Hosur Road, Bangalore-560100, India

[3]Student, Department of Mechanical Engineering, PES Institute of Technology-Bangalore South Campus, Electronic City, Hosur Road, Bangalore-560100, India

[4]Student, Department of Mechanical Engineering, PES Institute of Technology-Bangalore South Campus, Electronic City, Hosur Road, Bangalore-560100, India

Abstract: ***Electricity need of today's modern world is growing day by day because of continues increase in consumption due to growing population. Many concepts are being carried out to generate electricity on local basis and utilize the same for said to locality. This paper is about a swing, which is used by children for playing that produces electricity while being used. In it simple construction, the swinging action of swing makes the horizontal beam member turn through some angle. This horizontal shaft is connected to a wheel which turns along with it. Now this motion is transferred onto another ring of small diameter which rotates proportional to the angle of swing of the big wheel, in this was angular movement is converted to complete rotations. This is done by using a flexible leather belt connecting both the wheels externally. The smaller ring is connected to a step up transforming which in this case is used as a motor to generate electricity. This is done by rotation of the ring cutting flux lines inside the motor. This electricity generation takes place in both to and fro motion of the swing which makes the electricity generated in AC form. This is converted to DC current and amplified by using a special circuit of a bridge rectifier. The electricity thus produced is free of cost and is ecologically friendlier and can be used for local use by storing it in a battery during the time of operation. This way of generation of electricity if implemented at various parks, play houses, schools etc. can certainly lower down the load on main grid thus helping saving electricity.***

Keywords: human powered swing, electricity generation, mechanical energy, eco-friendly

1. Introduction

Energy is the driving force of modern societies, and generation and utilization of energy are essential for socioeconomic development. Per-capita energy consumption 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 recent years, there have been many interesting developments in the field of human power conversion. In the present project, a method of harnessing the power of children's play in playgrounds and public places, on device such as swing is proposed.

When large number of children plays in a school playground, part of the power of their play can usefully be harnessed resulting in significant energy storage. This stored energy can then be converted to electricity for powering basic, low power appliances in the school such as lights, fans, communications equipment, and so on. The method provides a low-cost, low-resource means of generation of auxiliary electric power, especially for use in developing countries.

In the proposed method, a simple belt and wheel mechanism is used along with a motor to generation and storage of electricity. Use of this method is very economical and simple in construction. The lower efficiency of the resulting system is compensated by the simplicity, safety, low-cost of operation and low maintenance cost.

The swing can be used in any atmospheric conditions, no heavy equipment are used and no harmful effects for the child using it. The electricity can be stored in batteries, and used to power dc-operated lights and appliances.

In this paper we have proposed a methodology in which we generate electricity during both forward and backward motion of the swing, without adding any resistance to the person swinging. This is done by using a wheel and belt mechanism and converting the AC output generated to DC using a suitable mechanism makes the construction simple.

2. Objective

The objective of the paper is to provide a method to convert obtained mechanical energy during the movement of seating of swing set into electrical energy along with no added effort and also storing the electricity thus generated into a battery, which can be utilized whenever needed.

3. Methodology

3.1 Working Principle

During the forward and backward stroke of swing some torque is induced in shaft. This torque produces motion in the wheel attached to the shaft which produces motion in the smaller wheel connected, which is in turn connected to the motor by which electricity is generated.

The shaft is mounted between two bearings. At one end of the shaft a large wheel is attached rigidly, this wheel pivots over shaft axis when the shaft is displaced. The larger wheel is attached to a smaller wheel using belt. The smaller wheel is mounted on a motor shaft, on which generator is mounted with help of screws.

When the seating of the swing set moves in both forward and backward directions, some torque is induced in the shaft by the holding bars of swing set. This torque displaces the larger wheel which is pivoted over axis of shaft causing the angular displacement. This angular movement is converted to rotational motion of smaller wheel by belt attachment. The wheel runs the generator, thus producing the electricity. This electricity is converted by a bridge rectifier and voltage amplifier. The electricity thus produced is stored in a battery by using electric circuits.

3.2 Design of the Model

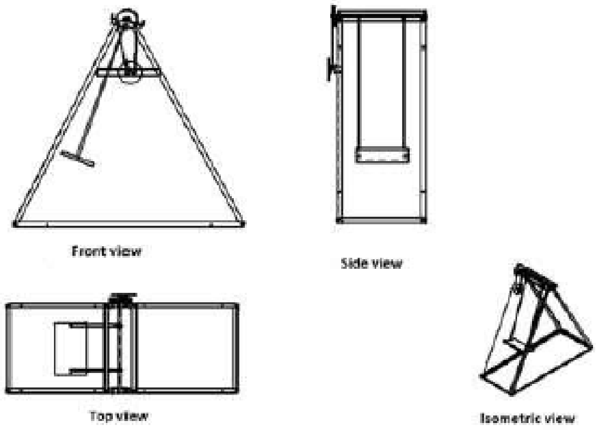

Figure 1: Model Design

3.3 Design Specifications

3.3.1 L-angles

Steel Angle or L - Angle, is a hot rolled, mild steel angle shape with inside radius corners that is ideal for all structural applications, general fabrication and repairs.

Table 1: Specifications of L-angles

Type	(h*h) mm	A (cm^2)	Wt./m (kg)	T (mm)	I (cm^3)
ISA 3030	30*30	2.26	1.8	4	0.8

Below are shown the required dimensions of the L-angle used,

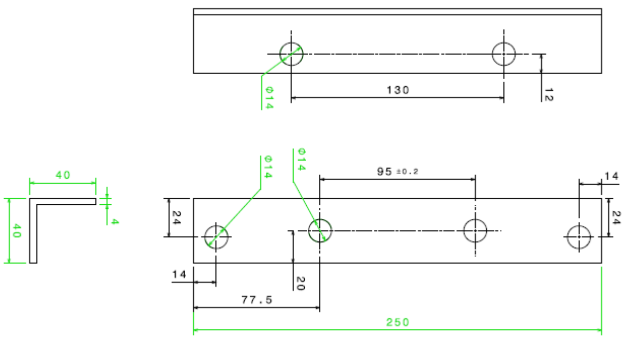

Figure 2: Part drawing of Side Angle

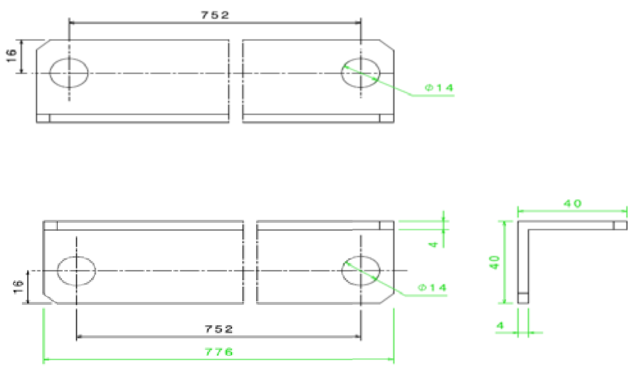

Figure 3: Part drawing of Top Link Angle

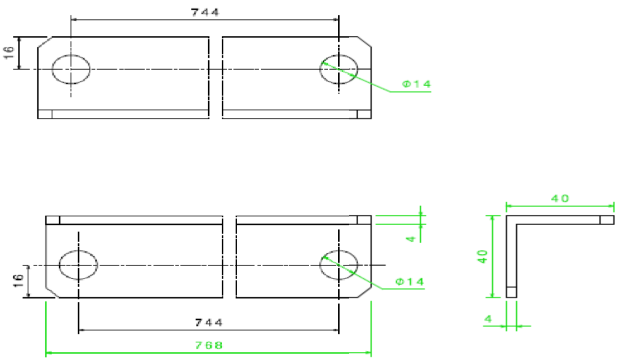

Figure 4: Part drawing of Bottom Link Angle

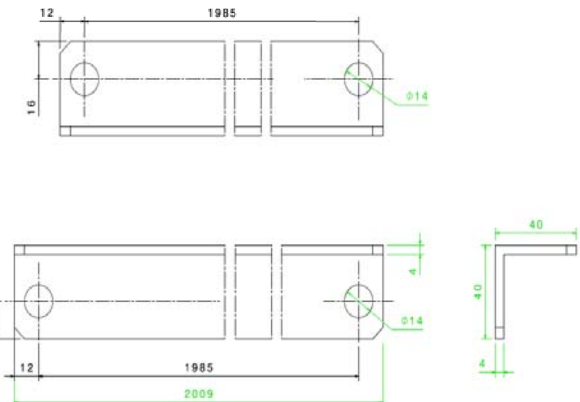

Figure 5: Part drawing of Side angle R.H

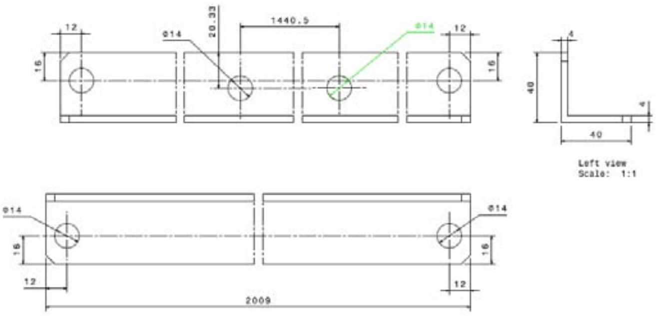

Figure 6: Part drawing of Side angle L.H

3.3.2 Hand Bar and Seat

The hand bar connects the shaft and the seat of the swing through the pad. The main objective of the hand bar is to provide stability to the motion of the swing and also help carry the load on the seat.

The Wooden seat is attached to the MS holding bar rigidly using fasteners. Here we are using Plywood as material for seat. The seat is attached to the shaft by means of hand bar through pad.

Material used: Mild Steel (Hand bar) & Plywood (Wooden Plate)

Figures shows the required dimensions of hand bar and wooden seat used,

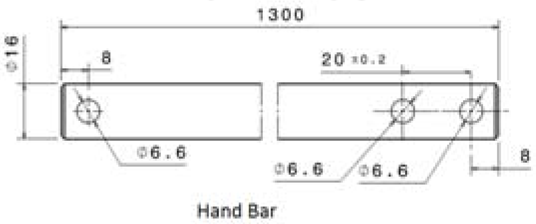

Figure 7: Part drawing of Hand bar

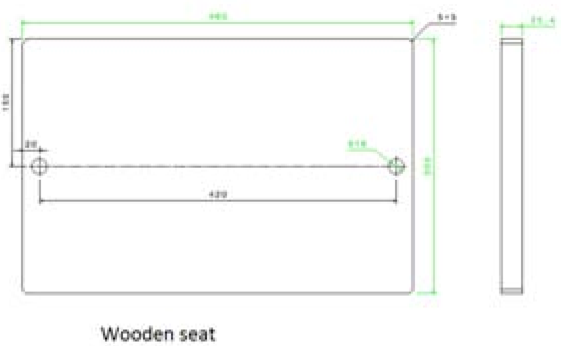

Figure 8: Part drawing of wooden seat

3.3.3 Shaft

A shaft is a rotating element, which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque or tensional moment set up within the shaft permits the power to be transferred to various machines linked up to the shaft, in order to transfer the power from one shaft to another the various members such as pulleys, gears etc, are installed on it. Material used is C45 Steel

This member causes the shaft to bending. In other words we may say that a shaft is used for the transmission of torque and bending. The various members are mounted on the shaft by means of keys.

Shafts are to be designed on the basis of rigidity considering the following two types of rigidity.

1. Lateral rigidity
2. Torsional rigidity

1. Lateral Rigidity

It is important in case of transmission, shortening and running at high speed where small lateral rigidity is also important for maintaining proper bearing and clearances an for correct gear teeth alignment if the shaft is of uniform cross-section then the lateral deflection of a shaft may be obtained by using the deflection formulae as in strength of materials.

i.e., $M/I=\sigma/y=E/R$

σ = stress induced in MPa (allowable stress for C45 from DDHB-2 is 360MPa)
E = young's modulus = 200MPa
R = radius in mm
M = Bending moment in N-mm
I = Moment of inertia in mm^4
Y = Perpendicular to the neutral axis in mm

Equation of bending moment is given by,

$$\frac{M_b}{I}=\frac{\sigma}{y}=\frac{E}{R}$$

$$I=\frac{\pi}{64}(20^4)$$

$$= 7855\ mm^4$$

y = 10

$$\sigma=\frac{106250\times 10}{7652.9}=138.83\ Mpa$$

This is less than the allowable stress of C-45, hence design is safe.

2. Torsional Rigidity

The torsional rigidity is important in the case of transmission shafts deflection 2.5° to 3°/m. Length may be used as limiting value, the widely used deflection for the shaft is limited to 1 degree in length equal to 20 times the diameter of the shaft.

The torsional deflection may be obtained by using the

$$\frac{T}{J}=\frac{\tau}{R}=\frac{G\theta}{L}$$

ϴ = Torsional deflection or angle of twist in radians (angle*/180)
T = twisting moment or torque on the shaft
J = polar moment of inertia of the cross sectional area about the Axis of rotation.
= $\Pi/32d^4$ for solid shaft.
G = Modulus of rigidity for the shaft material
L = Length of shaft

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

(Allowable shear stress for C45 is 186.36MPa)from DDHB,

$$\tau = \frac{RG\theta}{L}$$

$= 10*79.4*10^3*0.034/850$

$\tau = 31.76 N/mm^2$

Hence design is safe and feasible.

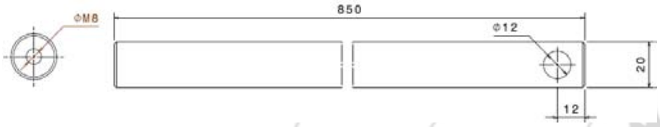

Figure 9: Part drawing of Shaft

3.3.4 Bearing

A standard pedestal bearing housing for 20 mm axle size is used. Such two number of pedestal bearings are used in this project which are clamped on the angles at the top portion.

Specifications:

- Material - Cast iron
- Inside Diameter - 20mm
- Centre Height - 33.3mm
- Overall Height - 65mm
- Length - 127mm
- Depth - 32mm

Figure shows the required dimensions of the bearing used,

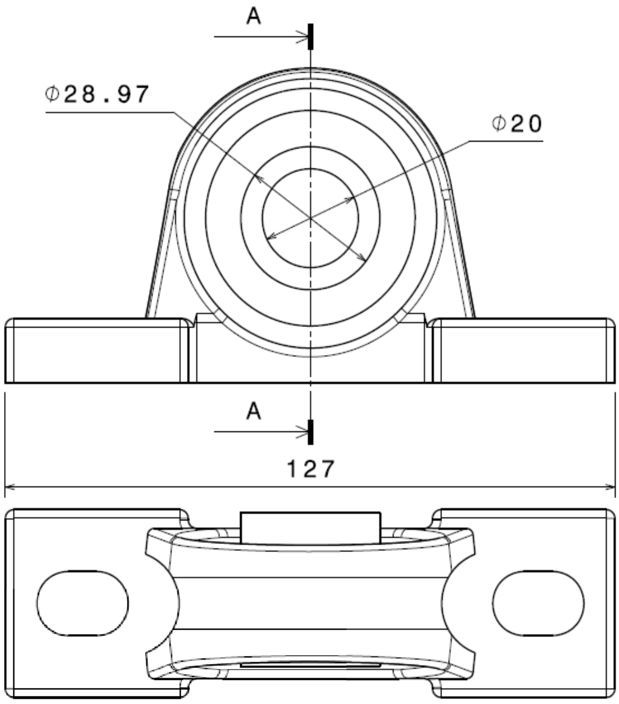

Figure 10: Part drawing of Bearing

3.3.5 Pad

Pad is used for attaching the seat and hand bar to the shaft.
Material used: C45 Steel

Figure shows the required dimensions of the Pad used,

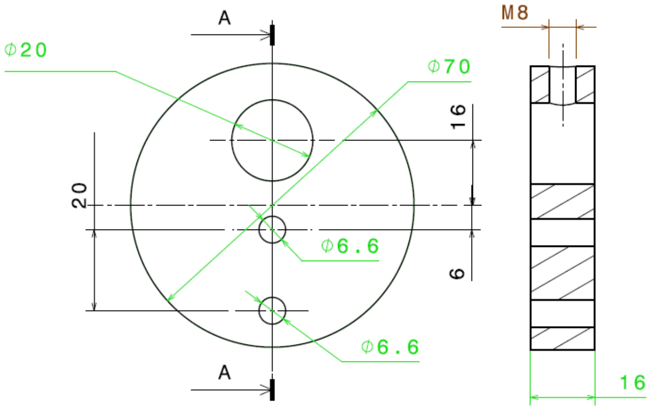

Figure 11: Part drawing of Pad

By using pad the hand bar can be fixed rigidly to the shaft. Above fig. shows the brief design that we are going to use. It is made of MS, machined and drilled to proper dimensions.

3.3.6 Belt and Wheel

A wheel that is used is a normally used cycle wheel which has groove on the outer surface for meshing with the belt used. The wheel rim used is of 13 inch radius.

Material used for the wheel – Aluminium
Material used for the Belt - Leather

The angle of contact between both the pulleys and the belt are as shown below:
Diameter of the larger pulley (D) = 0.325m

Diameter of the smaller pulley (d)= 0.01m
Centre distance (C) = 0.7m
Hence, the angle of contact of the smaller pulley(ϑ_s)

$$\theta_s = \pi - 2\sin^{-1}\frac{D-d}{2C} = \pi - 2\sin^{-1}\frac{0.325-0.01}{2\times 0.7}$$

$\Theta_s = 2.69^c$ or 154°

The angle of contact of the larger pulley (Θ_l)

$$\theta_s = \pi + 2\sin^{-1}\frac{D-d}{2C} = \pi + 2\sin^{-1}\frac{0.325-0.01}{2\times 0.7}$$

$\Theta_l = 3.59^c$ or 205°

The length of the belt used is given as follows:

$$L = 2C + \frac{\pi}{2}(D+d) + \frac{(D+d)^2}{4C}$$

$$L = 2\times 0.7 + 0.52 + 0.035$$

L = 1.95m

3.3.7 Step up motor and battery

A step up motor is connected to a rectifier circuit and an amplifier circuit which is then connected to a lead acid battery to store the energy developed.

3.4 Fabrication

Raw materials are fabricated according to the requirement as explained in the following,

3.4.1 L – Angles

L – Angles of required dimensions are cut as per the requirements. Later holes are drilled at required positions based on design for introducing fasteners during the assembly.

These L – Angles form the frame of the structure.

3.4.2 Shaft

A 20mm*850mm shaft is fabricated by reducing the raw material from Turning and Facing operations.

A 34mm*40mm sprocket shaft is fabricated by reducing the raw material from Turning, Facing and Tapping operation is also performed to get the holes of required dimension

Figure 12: Fabricated Shaft

3.4.3 Pad

This is used to attach the holding bar to the shaft. Facing, Turning and Drilling operations are performed to get the required dimension.

Figure 13: Fabricated pad

3.4.4 Hand bar

A 16mm*1300mm shaft is fabricated by reducing the raw material from Turning and Facing operations.

Holes are drilled and internally threaded in order to be able to fix them to the seat and the upper shaft.

Figure 14: Fabricated Hand bars

3.5 Assembly

Following are the main steps involved in assembly operation,

- Building the frame
- Attaching the Shaft and Holding bars to top of frame.
- Attaching the wheel and belt pulley mechanism and Generator to side of frame to form the working mechanism

The final assembly of the model looks as follows:

Figure 15: Side view of the assembled model

Figure 16: A front view of the assembled model

4. Results and Discussions

Tests were carried down with respect to the angle of swing and duration of usage to measure the voltage generated in both conditions of with load and without load.

Results are shown below for various cases.

1. Variation of output voltage with respect to angle of swing without load

Table 2: Variation of output voltage with respect to angle of swing without load

Angle of swing(˚)	Average Output voltage(V)
20-30	9
30-60	13
60-90	17
90-120	22

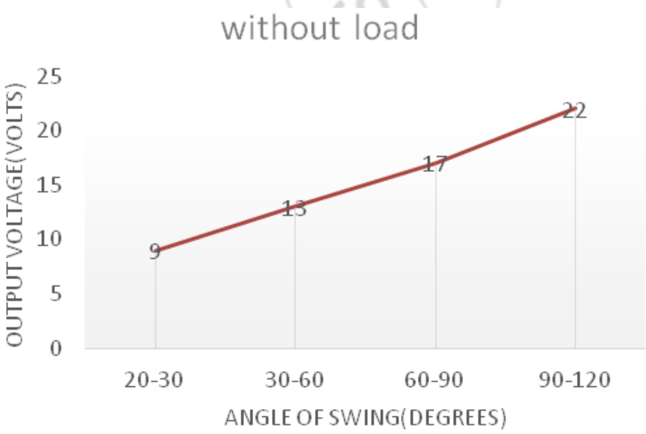

Figure 17: Variation of output voltage with respect to angle of swing without load

2. Variation of output voltage with respect to angle of swing with load

Table 3: Variation of output voltage with respect to angle of swing with load

Angle of swing(˚)	Average Output voltage(V)
20-30	4
30-60	7
60-90	10
90-120	14

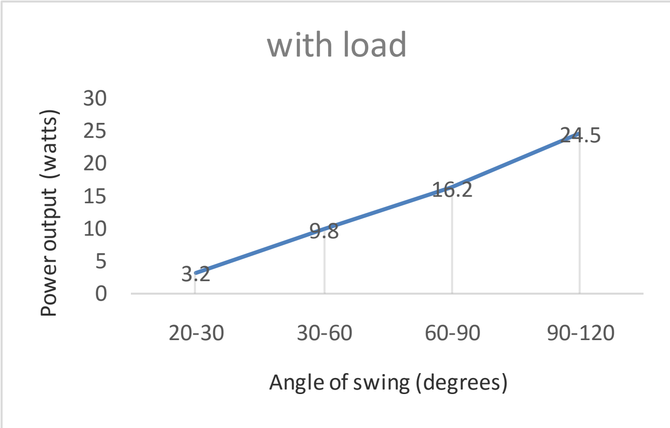

Figure 18: Variation of output voltage with respect to angle of swing with load

Hence, the output depends on the angle of swing and time of movement of seating of swing set. We can also observe that as the duration of usage increases, slipping starts to take place which reduces the voltage output.

5. Conclusion

A new method for human power conversion based on children's play on playground swing has been proposed. The power harnessed can be used as an auxiliary or back-up source for electricity, especially in developing countries. A swing has been designed and developed and experimental results are obtained which illustrate the practical effectiveness of the proposed method of electricity generation.

Acknowledgements

We are grateful to our guide and mentor, **Dr. Subrahmanya S. Katte**, HOD of Dept. of Mechanical Engineering, PESIT-BSC for his constant technical and moral support that has been of immense help in realizing this work. We would like to thank **Dr. S.V. Satish**, Associate Professor, Dept. of Mechanical Engineering, PESIT-BSC along with all the other faculty members for helping us as and when required.

References

[1] A Human Power Conversion System Based on Children's Play by Shanmugham R. Pandian, Tulane University IEEE 2010.

[2] J.B.K Das and P.L Srinivas Murthy "Design of machine element I & II" Sapna publications 6th revised edition 2011

[3] A.J. Jansen and A.L.N. Stevels, 1999, "Human power, A sustainable option for electronics", Proc. IEEE Int. Symp. on Electronics and the Environment, Danvers, MA, 1999, pp.215-218.

[4] Intermediate Technology Development Group (ITDG), 2000, Sustainable Energy for Poverty Reduction: An action plan, Rugby, UK