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Design and Development of Swing Mechanism for Electricity Generation

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Abstract: *It is critical to look into alternative methods of power generation due to the rising energy demand caused by population increase and development. In order to generate electricity, the project's main goal is to employ a swing, which is frequently used by kids to play. A horizontal beam is rotated by the motion of the swing, and this rotation is then transmitted to a free wheel by a sprocket that is attached to the beam. A chain drive is used to turn the swing completely from its angular movement. A shaft connected to the free wheel turns an electrical generator by turning a motor setup. A commutator then transfers the generated electrical energy to a battery for storage. A sustainable and easily available source of electricity is possible with this novel approach, which offers the potential for power generation through routine activity. It will lower the amount of energy needed to illuminate the landscape at night.*

Keywords: power generation

I. INTRODUCTION

The depletion of non-renewable energy sources, population increase, environmental pollution, and global warming have all contributed to the urgency of the energy scarcity issue in recent years. It is essential to create sustainable and effective energy generation systems as civilizations work towards socioeconomic growth. Researchers have looked into harnessing the power of human activity in the search for alternative energy sources, notably in fun spaces like playgrounds. Utilising swings to produce electrical energy is an intriguing area of investigation Swings, which are frequently found in public spaces and schoolyards, have the ability to gather and transform the mechanical energy created while kids play into useful electricity. By utilising this energy, it is now possible to turn it into a usable form that can be stored and used to power common products like lighting, fans, and communication devices. Researchers from all over the world have become quite interested in the idea of producing electrical energy using swings. The viability and efficiency of systems based on swing-based power generation have been examined in a number of studies. For instance, Go-kart al. suggested a method for generating electrical energy using swings, highlighting its resource and cost-effectiveness. It is essential to create sustainable and effective energy generation systems as civilizations work towards socio-economic growth. Researchers have looked into harnessing the power of human activity in the search for alternative energy sources, notably in fun spaces like playgrounds. Utilizing swings to produce electrical energy is an intriguing area of investigation. Swings, which are frequently found in public spaces and schoolyards, have the ability to gather and transform the mechanical energy created while kids play into useful electricity. By utilizing this energy, it is now possible to turn it into a usable form that can be stored and used to power common products like lighting, fans, and communication devices. Researchers from all over the world have become 19 quite interested in the idea of producing electrical energy using swings.

1.1 Problem Statement:

In urban environments, playgrounds are often underutilized as potential sources of renewable energy. The kinetic energy generated by children playing on swings is typically wasted, despite the fact that it could be harnessed to generate electricity. This project aims to design and implement a system that captures the rotational energy from a playground swing to generate and store electrical energy, providing a sustainable and engaging way to power small devices or contribute to the park's energy needs.

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1.2 Objectives:

- To design and construct a system that captures the rotational energy from a children's swing and converts it into electrical energy.
- To use the harvested energy to charge a battery and potentially power low-energy devices such as LED lights or any small electronic device.
- To ensure that the system is safe for use in a playground environment and assess its feasibility for long-term integration into public parks.
- To raise awareness of renewable energy through the project's demonstration, particularly focusing on educating children and the community about sustainable practices.
- To measure the electrical output (voltage, current, and power) generated by the system under various operational conditions.

II. METHODOLOGY

Ideation Phase

This phase began with identifying a real-world need for low-power energy harvesting systems. The concept of utilizing the mechanical motion of a children's swing as an energy source was proposed due to its regular oscillatory movement and wide availability in public spaces. The objective was defined: to design a compact, low-cost system capable of converting swing motion into electrical energy using mechanical transmission and a DC motor generator.

Literature Survey

In this phase, a thorough literature review was conducted to understand existing technologies and previous research related to mechanical energy harvesting, pendulum dynamics, gear-based power transmission, and DC motor generation principles. Various research papers, textbooks, and technical articles were studied to understand gear design standards, shaft calculations, material selection (like PETG), and generator performance characteristics. This phase also included benchmarking similar existing systems to identify gaps and design improvements.

Design and Assembly Phase

Based on insights from the literature survey, several conceptual models were developed. Mechanical elements such as gear ratios, swing arm length, angular displacement, shaft diameter, and gear tooth geometry (module 2, 20 teeth pinion) were calculated. Simulations were performed to predict torque transmission, angular velocity, and effective load on gear teeth. Torque-to-RPM conversion and motor output predictions were estimated using theoretical formulas. The most promising concept was selected based on feasibility and expected performance.

Experimental Testing

With the system assembled, experimental tests were conducted. The swing was manually oscillated to simulate regular use, and the DC motor acted as a generator. Output parameters such as voltage, current, and power were measured using a multimeter. Different swing angles and loading conditions were tested to observe variations in electricity generation.

Conclusion

Based on analysis, conclusions were drawn regarding the effectiveness of the swing-based energy harvesting system. Potential improvements such as better material selection, advanced power electronics for efficient charging, and automation of motion capture were identified for future development.

II. LITERATURE REVIEW

- This study examines how a pendulum's swing can be used to generate electrical energy. The study shows how a pendulum-based energy generation system can effectively transform mechanical energy into electrical

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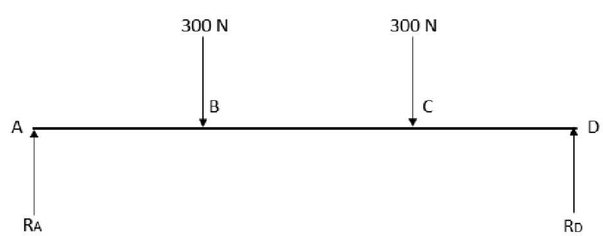
energy. It also describes how the system was designed and put into use. The originality of this study comes in the way it makes use of pendulum motion, a promising strategy for efficient and sustainable electricity production.[11]

- In the study paper, the creation of a spring-driven generator that can deliver regulated electric current to a load is examined. The generator's ability to output a stable, controlled current is examined, along with the generator's design and performance, in this study. The research is special since it concentrates on spring power as a potential alternative energy source for various electrical systems.[12]
- This document describes a human-powered generator based on swings that was created for the DC House Project. The study illustrates the viability and efficiency of using swings to harness human power and produce electricity for small-scale home uses. The paper's originality comes in its application-oriented methodology, which addresses the particular energy requirements of the DC House Project while demonstrating swing-powered generation's capacity to supply essential electrical needs.[13]
- In his study, Shunmugham R. Pandian suggests a method for converting human energy into electricity by harnessing children's play. A system that harnesses the kinetic energy generated during play and transforms it into electrical energy is designed and put into practise in the research. The distinctiveness of the paper is found in its focus on getting kids moving and thinking about the environment while encouraging energy generation in them.[14]
- The study by Rameshwar Kadu, focuses on how swing motion can be used to generate energy while also breaking bottles. In order to create electricity and manage garbage, the study introduces a swing-based system that simultaneously crushes plastic bottles while harnessing the energy produced by swinging. The article offers a novel approach to both energy production and recycling. Its distinctiveness resides in the combination of swing motion with a bottle crushing mechanism.

IV. CALCULATIONS

Assuming weight of person w = 60Kg ≈ 600N.
Load acting at B & C = 600÷2 = 300N
By equilibrium of vertical forces,
$\Sigma F = 0$
$R_A + R_D = (F_B + F_C)$.
$= 600$ N
By taking moment equilibrium at point A
$\Sigma M_A = 0$
$R_D (0.3 + 0.5 + 0.3) - 300(0.8) - 300(0.3) = 0$
$R_D (1.1) = 240 + 90$
$R_D = 330/1.1$
$R_D = 300$ N & $R_A = 300$ N



Maximum Bending Moment in beam,
$BM_A = 0$ Nm
$BM_B = 180$ Nm
$BM_C = 180$ Nm
$BM_D = 0$ Nm

Shaft Design –
We know,
$\sigma_b/Y = M/I = E/R$

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here,
σ = stress induced in MPa (allowable stress for C45 from PSGDDB is 247MPa)
E = young's modulus = 200MPaR = radius in mm
M = Bending moment in N-mm
I = Moment of inertia in mm
Y = Perpendicular to the neutral axis in mm (D/2)

For hollow shaft diameter,
$D_O = M/(\pi * \sigma \text{ allow} * (1- K^2))$

here,
$\sigma_{allowable} = (\sigma_{allow})/FOS$
taking factor of safety =1.3
$\sigma_{allowable}$ = 190 MPa.

And, take K = 0.5

$D_O = 21.75 \approx 25$mm

Bending stress in shaft,

$\sigma = (M_b \text{ x } Y)/I$ = 117.5 N/mm2.
σ =117.5 MPa < 190 MPa (σallowable)

Hence, design is safe

Bearing Selection:
Type: Plummer Block
Material: Cast iron
Inside Diameter (d): 25mm
Overall length (L): 127mm
Overall height (H):158.8mm
Housing Width (A):82.6mm.
Bolt hole centers (J): 190/223.8 mm

Calculation of life of bearing:
PSGDDB Pg4.5, assuming we use 8 Hrs./day not always used.
∴ bearing life working hours (12000 to 20000 hrs.)
Let Lh = 12000hrs and n=10 rev/min.
know Bearing life (L) = (10 x 60 x 1000)/1060

∴ L = 7.2 million revolutions

Transmission Calculations:
We are using a 3-stage gearbox with total gear ratio i = 27.

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Torque induced in the input gear,
For θ = 60˚ one 1 side.
T = (m*g) * sinθ * Length of swing

T = 600 * sin(60) * 0.7
= 363.73 N-m

Polar Modulus of hollow shaft = (π(d_o^4 - d_i^4))/32
∴ J = 10876.19 N-mm4.

For revolutions of swing,
The oscillation of swing is determined
Time period of oscillation is given by,
T = 2 π √(L/g) = 2 π * √(0.7/9.81)

∴ T = 1.67 Seconds.

Frequency of swing (swings per second) is:
f = 1/T = 1/1.67

f = 0.595 Hz.

Swing RPM
Swing RPM = f * 60

RPM (N) = 35.6 rpm

The total rpm at the motor will be
Swing rpm * Total (i) = 35.6 * 27 = 961.2 rpm

V. RESULTS AND TESTING

Tests were carried down with respect to the angle of swing. The following table shows the output voltage variation at different ranges of swing angle:

Range of Swing Angle (deg)	Output Voltage (V)
20-30	1
30-60	2.5
60-90	4.5
90-120	6

Table 3: Output voltage variation at different ranges of swing angle

Range of Swing Angle (deg)	Output Current Generation (Amps)
20-30	0.05
30-60	0.070
60-90	0.115
90-120	0.160

Table 4: Output Current generation variation as per range of swing

VI. PROPOSED WORK & DESIGN SETUP

The concept behind the swing through power generating is to use the torque created by the swing's forward and backward motion. A swing set connected shaft experiences torque as the swing moves. Two substantial sprockets rigidly attached to each end of this shaft are installed, and when the swing is moved, they pivot across the shaft axis. The smaller sprocket (freewheel), which is positioned on another shaft, is connected to the bigger sprocket by a chain. Since the freewheel only permits rotation in one direction, the system is guaranteed to run smoothly when moving backward. A coupling mechanism transfers the torque to a DC motor, which uses it to produce electricity. By converting rotational motion into electrical energy, the DC motor works. Numerous gadgets can be powered by this electricity, which can also be utilised to power batteries that will be used later. This project displays a useful and sustainable method of electricity generation by utilising the swinging action of the swing set. By incorporating a freewheel, the system's efficiency is maximised and it becomes a useful tool for capturing renewable energy. Power is generated in both directions of the swing.

VII. ADVANTAGES

The merits or advantages of developing 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 childrenis 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 require any fuel.
- It can be installed in any place quickly as compare to solar, wind and other plant.
- It is simple in construction like other conventional part.
- It required small area for installation.

VIII. CONCLUSION

- As the world's need for energy grows exponentially, various strategies for obtaining energy from the environment are being focused on, and efforts are being made to find alternative sources. For the purpose of the future, which has a lot of potential, the method of generating power from mechanical energy that can be squandered is still being used. So, it is thought that a swing power generator is a possible replacement for depleted energy sources.
- In this study, a brand-new technique for converting human strength into mechanical energy has been put forth, based on how kids play on playground equipment. With careful planning, it may generate enough power if used in every garden. to encourage children to conserve electrical energy. It will be a practical tool that may be applied in rural areas or agricultural fields where electricity is not readily available. Every day, in the days to come, there will be a greater need for energy resources. Developing the planet by enlarging is. the goal of this research, via increased use of its resources. It is now appropriate to put these types of creative ideas to use, and they should be implemented. The system is entirely independent. In rural areas, it underlines the requirement for affordable technology.

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