Low-Cost energy contraption design using playground seesaw

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Abstract. The study was conducted at Western Philippines University, San Juan, Aborlan, Palawan. The study used the mechanical motion of playground seesaw as a means to produce electrical energy. The study aimed to design a low-cost prototype energy contraption using playground seesaw using locally available and recycled materials, to measure the voltage, current and power outputs produced at different situations and estimate the cost of the prototype. Using principle of pneumatics, two hand air pumps were employed on the two end sides of the playground seesaw and the mechanical motion of the seesaw up and down produces air that is used to rotate a DC motor to produce electrical energy. This electricity can be utilized for powering basic or low-power appliances. There were two trials of testing, each trial tests the different pressure level of the air tank and tests the opening of on-off valve (Full open and half open) when the compressed air was released. Results showed that all pressure level at full open produced significantly higher voltage, than the half open. However, the mean values of the current and power produced in all pressure level at full and half open have negligible variation. These results signify that the energy contraption using playground seesaw is an alternative viable source of electrical energy in the playgrounds, parks and other places and can be used as an auxiliary or back-up source for electricity.

1. Introduction

Electricity is one of the rudiments of mankind. It deals with the empowerment of machines and equipment that make the human work easier and simpler. Electricity comes from different types of source. It is either from a renewable or non-renewable energy. Nowadays, people are in search of renewable sources of energy. With increasing demand and decreasing resources, many seek new ways of converting different forms of energy to electrical energy. Energy contraption is widely used to produce electricity by transforming different kinds of energy into electrical. One of the sources of energy contraption is from everyday human activities.

A study done by [1] about the human power conversion system based on children’s play provided the basic theory behind the method wherein prototype compressed air-human power conversion system using a teeter totter (seesaw). The playground is used every day by children and produces motion which can be converted to electrical energy. Based on the results of [2] and [3], the up and down movement of the seesaw generates usable power that can be harnessed. This is the one of the alternative generation of electrical energy.

Air pressure engines, as described in [3] and [4], are prime movers that use air pressure to transmit motions to certain machines, specifically in this study, a DC motor from an old CD drive connected by the gear. The air pressure engine will be used to rotate the gear of the DC motor.
Electrical machine is the more general term for electric motor and generator since this device could operate as either a motor or generator depending on its configuration. As described in [3], the advantage offered by DC machines is their versatility. The ability to develop high starting and breaking torques, to make quick reversals of rotations, to maintain constant mechanical power output or to maintain constant torque and to permit continuous speed variation over a range as large as 4:1, make DC motors better suited to many industrial applications.

This study is about conversion of motion to electrical energy by children playing seesaw and measure the output voltage, current and power. Using pneumatic principle (hand pumps were employed in this study) the mechanical energy from the motion of the seesaw is converted to electrical energy. The objective of this study was to design a low-cost, prototype energy contraption using playground seesaw, design the said system using locally available and recycled materials, measure the voltage, current and power outputs produced by the energy contraption design at different situations and estimate the cost of the prototype.

2. Methodology
The study started with the selection of the available materials to be used for localized assembly of a small seesaw to be used as a prototype. The study proceeded with the use of an improvised check valve and acquiring materials from junk shops and old electronics equipment. Then parameters to be considered and the mechanism used to produce the energy were examined. After the system was assembled, it was evaluated. Three trials were done, with two replications each. Different pressure level of the air tank and the opening of on-off valve when the compressed air released was tested. Analysis of the data was done using a descriptive method and Coefficient of Variation.

2.1. Design considerations
The study proposed a low-cost energy contraption design using the seesaw and thus the following were considered: 1) Materials should be locally available; 2) Recycled materials are to be used; 3) No leakage of the air going into the tank; 4) Check valves could allow lower pressure of air entering the tank; 5) Air engine turbine must be suited with the air pressure to ensure rotation. Based on these criteria, the prototype was conceived.

2.2. Machine design
Fig. 1 shows the block diagram of operation of the prototype. The compressed air output from the hand pumps is stored in an air tank. When the compressed air inside the air tank reaches a set pressure level measured by the attached pressure gauge, the on-off valve is opened by the control of evaluator; it is either full-open or half-open. The released compressed air from the air tank is used to drive an air engine or air motor. A DC motor is coupled to the shaft of the air engine, resulting in conversion of the compressed air energy to electrical energy by the mechanical motion of rotation of shaft. The generated electricity was measured using a microcontroller.

![Figure 1. Block diagram of operation](image)

2.3. Evaluation and data collection
The prototype was evaluated at Western Philippines University for data collection. The data were collected on January 20-21, 2016. Three trials were done, with two replications each. Different pressure level of the air tank (30psi, 20psi and 10psi) and the opening of on-off valve (full open and half open) when the compressed air released was tested. Output voltage and current was measured using ATMEGA 328p Microcontroller Unit (MCU), and then logged into a laptop.
Fig. 2 shows the block diagram of the data logging process. The output voltage was directly measured using the analog input of the MCU while the current passes through the ACS712 current sensor before going into the analog input of the MCU. Data were recorded every second as long as the DC motor is rotating. The data measured from the MCU was directly recorded into a laptop through the serial cable. The average values of voltage and current for every rotation was computed and analyzed. Analysis of the data was done using descriptive method and confidence interval.

3. Results

3.1. Assembled prototype design
The prototype playground seesaw was made from ¾ inch diameter Galvanized Iron Pipe and constructed in a welding shop. Additional fittings were added for compatibility of the materials connected. Some of the parts of the system were from recycling shops. The air tank (or gas tank of mini gas stove as alternative) in Fig. 4 was brought from a junkshop. Based on the measurement, the tank has a maximum pressure of 30 psi.

The assembled air engine is shown in Fig. 5. DC generator and plastic gears from condemned CD drive were used. The DC generator produces 13volts. The gears have two different sizes, the high speed gear has ⅜ inch diameter and the low speed gear has 2 inches diameter. Bearings were brought from a shop of glass and aluminum; it was from junked sliding glass windows. The bearings have a size of ¾ inch diameter and ¼ inch diameter at the hole. Other materials were brought from a warehouse of used/old materials and equipment.

The other parts that were modified are the air engine/motor and air tank. The check valves, in Fig. 6, were devised using jackstone rubber ball inserted to ¾ inch diameter PVC straight connector.
3.2. Output values

The relationship between the different pressure level of the air tank (30psi, 20psi and 10psi), the opening of on-off valve (full open and half open) and the output values of voltage, current and power were tested. Gathered data were analyzed using confidence interval analysis and statistical interaction of variables.

Results revealed that the pressure level at 20 psi produced highest voltage of 10.74V, than at 15psi with the voltage value of 8.41V and 10 psi with 7.61V as seen in Fig. 7. Current values also decrease gradually as the pressure decreases, average current values recorded are 9.18mA, 8.55mA, and 6.81mA for the corresponding 20psi, 15psi and 10psi respectively. From Fig. 8, it can also be seen that opening of the on-off valve at full open produced higher voltage (11.65V) and power (0.1W) as compared with the half open with an average voltage of 5.89V and a power of 0.05W, while current values do not vary extensively.

The interaction between the pressure levels and the opening of the valve is presented in Table I. Statistical analysis showed that all pressure level at full open produced significantly higher voltage than the half open. But, the 20 psi at half open also produced significantly higher voltage. However, the mean values of the current and power produced in all pressure level at full and half open have negligible variation. These results imply that higher output values are produced at higher pressure and at full open valve.

| Pressure | On-off Valve | Voltage (Volt) | Current (Ampere) | Power (Watt) |
|----------|--------------|----------------|------------------|--------------|
| 20 psi   | Full Open    | 12.13 ± 1.04   | 0.010061 ± 0.0037| 0.123711 ± 0.0442|
|          | Half Open    | 9.36 ± 2.67    | 0.008308 ± 0.0016| 0.081280 ± 0.0312|
| 15 psi   | Full Open    | 12.03 ± 1.28   | 0.008971 ± 0.0026| 0.118256 ± 0.0320|
|          | Half Open    | 4.78 ± 1.47    | 0.008126 ± 0.0029| 0.047627 ± 0.0281|
| 10 psi   | Full Open    | 10.80 ± 1.66   | 0.005433 ± 0.0024| 0.060657 ± 0.0389|
|          | Half Open    | 3.53 ± 1.89    | 0.008189 ± 0.0022| 0.029319 ± 0.0190|

Note: Means with the same letter in the same column are not significantly different (p > 0.05).
4. Conclusion
A prototype system of playground seesaw for energy contraption was developed in this study. Results showed that higher pressure at full open valve can be associated to higher output values (see Fig. 7). These results signify that the energy contraption using playground seesaw is an alternative viable source of electrical energy in the playgrounds, parks and other places and can be used as an auxiliary or back-up source for electricity, especially in developing countries. The study could be further improved by providing bigger air tank to prolong the release of the compressed air, investigating the different diameters and length of the hose that can be used, use of a double-acting pneumatic cylinders to be more efficient in air production than the hand air pumps, exploring different types of the compressed air engine/motor and turbine design, and utilization of an automatic on-off valve or pressure relief valve to release air if the certain pressure level of the air tank is reached.

5. References
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Acknowledgments
The authors gratefully recognize Prof. Sharon Rose P. Anunciado, statistician, for the analysis. Engr. Mirriam Banlawe, the dean, together with the whole faculty and staff of the College of Engineering and Technology, Western Philippines University, Aborlan, Palawan for their kind suggestion and invaluable support in this study.