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FAN-Cycle: A Semi-Self-Charging Fan Powered by Flywheel and Dynamo Circulation

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ABSTRACT

The researchers aimed to make a semi-self-charging fan from a dynamo and flywheel circulation by converting mechanical energy into electrical energy to prolong the fan's operation without relying on external energy resources, since large-scale energy consumption results in the depletion of non-renewable energy sources. To achieve this, the shafting, bearing, flywheel, and eight metal pillars were fabricated to suit the size and weight of the fan blades. A 16x16 plywood board was installed to attach the prototype to the dynamo. The battery was connected to the charging circuit, which contained capacitors, diodes, and resistors through wiring, creating a self-charging fan. The researchers employed an experimental approach, with no sampling method since the researchers picked the sample size. The data, which includes voltage output and revolutions per minute (rpm), were analyzed using descriptive and inferential statistics, presenting the mean, minimum, maximum, and standard deviation to understand the underlying variability between the sample sizes and the difference between the two groups. The study results showed that the mean voltage output was 12.66 V, while the mean revolutions per minute were 1988.88 rpm. The results indicate that, although there was no statistically significant difference between the controlled set-up, where the fan operated without the integrated flywheel and dynamo mechanism, and the experimental set-up, the latter consistently demonstrated longer operational duration. Lastly, this study further demonstrates the potential of flywheels for efficient mechanical-to-electrical energy conversion by offering insights to optimize energy transfer and advance renewable energy applications.

Keywords: dynamo, energy, flywheel, pulley, shafting

Rapid economic growth has increased energy consumption intensity, resulting in a significant depletion of non-renewable energy resources (Chien *et a.l.*, 2023). New energy sources are increasingly integrated with appliances in response to the growing demand for energy-efficient and sustainable solutions. A new hybrid cooling fan and generator system utilizes a mechanical-to-electrical energy conversion mechanism, offering an alternative energy source to reduce the heavy reliance on residential electricity. In contrast to traditional electric fans and power banks, which rely on grid power and contribute to high energy consumption and carbon emissions.

The FAN-Cycle model utilizes mechanical energy derived from a flywheel into electrical energy to maintain the operation of the semi-self-charging hybrid fan. This approach strays from the traditional energy consumption methods, as it operates through the mechanical energy generated during operation, providing continuous functionality without an external power supply.

According to Bamisile *et al.* (2023), in the maintained state, as the flywheel reaches its charging capacity and a certain speed, it stores mechanical energy as electrical energy. The flywheel and dynamo spin quickly to maintain a low voltage, aided by power electronics. This mechanism reduces reliance on external power resources, making the fan suitable for areas with inconsistent electricity access. Adopting flywheels for dynamo systems enhances energy efficiency by capturing and utilizing mechanical energy to operate an otherwise electricity-dependent fan, contributing to energy conservation.

In conclusion, the FAN-Cycle's self-charging capacity enhances convenience and addresses the urgent need for sustainable energy solutions in various settings. Continuous research and development in this field are essential to further improve the efficiency and accessibility of semi-self-charging fans. These efforts are pivotal for pushing forward the boundaries of renewable energy resources, as these technologies could bring about significant changes through cumulative innovation.

REVIEW OF RELATED LITERATURE AND STUDIES

Dynamo. The law of conservation of energy states that "energy can neither be created nor destroyed - only converted from one form of energy to another" (OpenStax, 2016). Therefore, the researchers intend to utilize a dynamo in developing their proposed system. A dynamo is a generator that can convert mechanical energy into electrical energy by applying Faraday's law of electromagnetic induction. This law states that a conductor experiences an induced voltage when exposed to a changing magnetic field, which forms the basis of how a dynamo functions. This voltage, also called electromotive force or EMF, is directly proportional to the conductor's length and the rate at which the magnetic field changes (How Does a Dynamo Work?, 2023).

Lead-Acid Battery. The battery implemented in the self-charging fan was a lead-acid battery. According to Honsberg and Bowden (2019), lead-acid batteries are among the most widely utilized. Lead-acid batteries are more expensive and have a shorter lifespan than other batteries. However, despite these limitations, they also have a lower energy density, moderate energy efficiency, and higher maintenance requirements. One of the unique advantages of lead-acid batteries is that they are the most widely utilized type of battery for most rechargeable battery applications (such as starting automobile engines) and have a well-established, mature technology foundation, as stated by Katkade *et al.* (2022).

Parallelism of Hybrid Electric Cars to FAN-Cycle. The FAN-Cycle's mechanism will be related to the concept of hybrid-electric cars capable of self-charging. Direct Current (DC) motors will also be used since batteries are DC. Rose (2019) states that

DC fans have been the preferred option in a designer's thermal management arsenal for many years because they offer effective cooling. Furthermore, hybrid-electric cars also use DC power. They also run on an internal combustion engine (ICE) powered by gasoline and an electric motor powered by batteries. The three ways that PHEV (Plug-in Hybrid Electric Vehicles) batteries can be charged are Regenerative braking, the ICE, wall outlets, and charging equipment. Typically, the automobile operates on electricity until the battery is almost entirely exhausted, automatically converting to ICE power (U.S. Department of Energy, 2019). In the fan's case, the researchers will use a flywheel as a backup energy source, as the fan keeps running at a particular time. Just like hybrid-electric cars, the fan may also be charged via outlets despite being an alternating current (AC) with a lead-acid battery charger.

Theoretical Framework

The researchers formulated the theoretical framework based on the various independent, dependent, and controlled variables presented in Figure 1. The diagram depicts the researchers exploring a 12-volt battery with a motor. In this set-up, the independent variables are the 12-volt electrical battery, flywheel, and dynamo system, both of which influence the fan's performance. The revolutions per minute and the voltage output are dependent variables that will be monitored. The battery capacity will be compared with the FAN-Cycle's non-self-charging and self-charging systems. The lead-acid battery and the fan model serve as the controlled variables.

The review of related studies (RRS) mentions the law of energy conservation, which states that "energy cannot be created nor destroyed and can only be transferred from one form into another" (OpenStax, 2016). The study uses a dynamo that applies Faraday's Law of Electromagnetic Induction, converting mechanical energy from the fan into electrical energy. The remaining electrical energy will be used to keep the fan working for an extended period. The second law of thermodynamics then states that energy losses are inevitable when doing energy conversion. In theory, since there is still a conversion of energy, the FAN-Cycle should function longer than the controlled set-up.

Moreover, implementing a capacitor to regulate the voltage aids in storing and providing excess energy. Regulating the voltage means that the voltage, current, and resistance outputs are constant for the FAN-Cycle to maintain its operations. The Ohm's Law equation supports their relationship:

$$V = IR$$

where V stands for voltage, I stands for the current and R is the resistance (Ling *et al.*, 2016).

As the FAN-Cycle performs its rotation, there are energy losses that pertain to the second law of thermodynamics. However, running the FAN-Cycle with a motor that can handle up to 24 V shares the dynamo's load in carrying the belts for the FAN-Cycle to run efficiently without overheating. Water is also applied as an insulator for the regulators to avoid the effects of energy loss due to overheating. Finally, the flywheel also reduces mechanical resistance depending on its weight to prevent further energy loss.

The battery capacity was then tested to measure how long the FAN-Cycle was powered at a specific current. The following equation was applied:

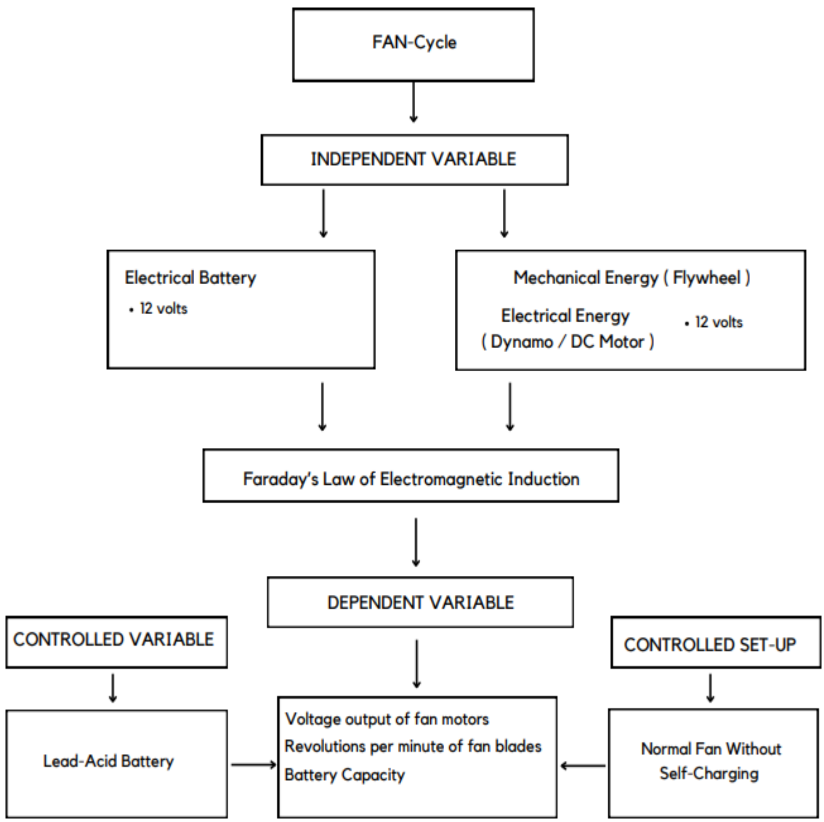
$$Ah = It$$

where Ah is the battery capacity or ampere-hour, I is the current, and t is the time. This was derived from the principles of an electric current, which explains the amount of charge transferred when a current flows per hour (Kuphaldt, 2015). In obtaining the current, the following equation was used:

$$I = (rpm / 1000)\,(V)\,(PF)$$

where rpm stands for the revolutions per minute, V is the voltage, and PF is the power factor. Since the lead-acid battery is a direct current (DC), this means that the value of the power factor is equal to 1.

Figure 1
Theoretical framework



Objectives of the Study

This study aimed to demonstrate the feasibility of the concept of a semi-self-charging fan using a flywheel and dynamo. The goal of this research was to test the efficiency of the different independent, dependent, and controlled variables in proving the possibility of a semi-self-charging fan using the laws of physics. The following questions were asked in this study.

1. What will the voltage output of the fan be when the dynamo is connected to a 12-volt battery?
2. How many revolutions per minute will the fan produce when connected to a 12-volt battery?
3. Is there a significant difference between the battery capacity without self-charging and the battery capacity while self-charging the 12-volt FAN-Cycle?

Significance of the Study

The Philippines faces a critical energy crisis, with 30% of Luzon's energy supply predicted to be depleted by 2024, alongside a constantly expanding population (International Trade Administration, 2020). This study explores the development of electric fans that can harness and store the mechanical energy they generate during operation, using systems like flywheels and dynamos. By converting motion into electrical energy, these fans have the potential to partially recharge themselves, reducing their reliance on external power sources and contributing to more sustainable energy usage, and potentially contributing to solving the Philippines' energy crisis. While self-charging devices and energy-harvesting fans exist, the approach of using a flywheel and dynamo system to directly generate electricity from the fan's movement introduces a novel twist, offering electric fan manufacturers practical insights to improve efficiency, reduce energy consumption, and capitalize on emerging energy-saving technologies (Jaiswal, 2022). The study will help communities become aware of the product's energy-saving benefits. Finally, this research will support engineering academic institutions to continue developing energy technologies in the Philippines.

Scope and Limitations of the Study

This study only examines the possibility of a self-charging fan through the energy exchange between a flywheel and a dynamo generator. This research was conducted at the University of the East, Caloocan, during the second semester of the school year 2023-2024. The data collection involved an in-depth implementation of observation of the system's performance metrics, which comprised the fan's revolutions per minute (rpm), Voltage output (V), and battery capacity (s). Desouza (2015) states that metrics should track performance and guide operational and strategic decisions. Moreover, the data is also collected through in-person consultations with specialized professionals such as mechanical engineers, physics teachers, and electricians, from whom informed consent was obtained first before being consulted. Additionally, the data collection adhered to health and safety protocols, including the use of personal protective equipment (PPE), proper handling of electrical components and batteries, and supervised testing in a controlled environment.

Lastly, exploring aspects such as production and economic feasibility for regions with limited electricity access is not within the scope of this study. The research emphasizes the fundamental design of the FAN-Cycle and aims to demonstrate the feasibility of its mechanism. However, future studies could build on this foundation to assess potential costs, scalability, and practical implementation in real-world settings. Also, the study does not cover the possible effects of wear and tear on mechanical parts and the results of the FAN-Cycle’s full running time before recharging. Furthermore, solar-powered devices, specifically fans, are not within the research scope, which explains the controlled setup that does not use a charging circuit as the researchers’ choice—there may still be relevant connections between the two technologies as they aim to enhance fan efficiency.

MATERIALS AND METHODS

Research Design

This study focused on the possibility of constructing a semi-self-charging fan through the energy exchange between a flywheel and a dynamo. Since the research involves mathematical calculations and statistical tools, a quantitative method was used for data collection and analysis. Lastly, this study used an experimental research design, which is an information-gathering experiment where the researchers control the independent variables (Zubair, 2023).

Sample and Population

This study consisted of ten trials for the revolutions per minute and the voltage output. Due to time constraints, the battery capacity only had five trials for the controlled and experimental set-ups.

Materials

Figure 3 below shows the flowchart of the procedure followed by the researchers in constructing the FAN-Cycle. It starts with assembling all the materials and concludes with analyzing and interpreting the data.

The schematic diagram explains the entire operation process of the FAN-Cycle. To avoid confusion, the dots in wiring intersections symbolize that these wires are disconnected. Components such as capacitors, diodes, resistors, and voltage regulators were utilized to ensure a smooth flow of electrical energy. When the switch turns on the device, the 12 V battery goes through the regulator and decreases the voltage output to 5 V so the motor can run the FAN-Cycle smoothly. The mechanical energy from the fan blades gets converted into electrical energy using a dynamo which produces an output of 12.66 V. The 12.66 V output heads ,into the charging circuit and heads to the battery to semi charge some of the lost energy. The light emitting diodes (LED), serve as a signal to check if the FAN-Cycle is charging.

Figure 2
Schematic diagram

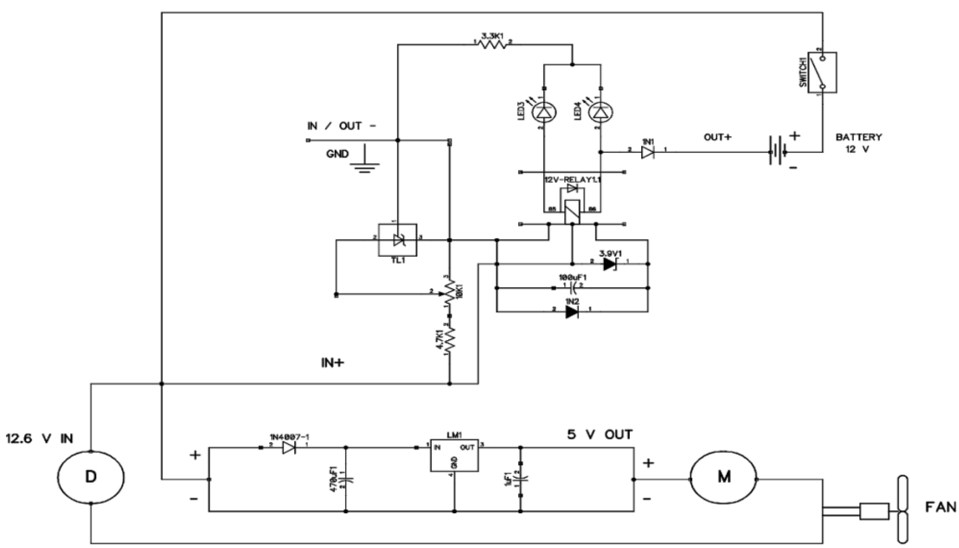
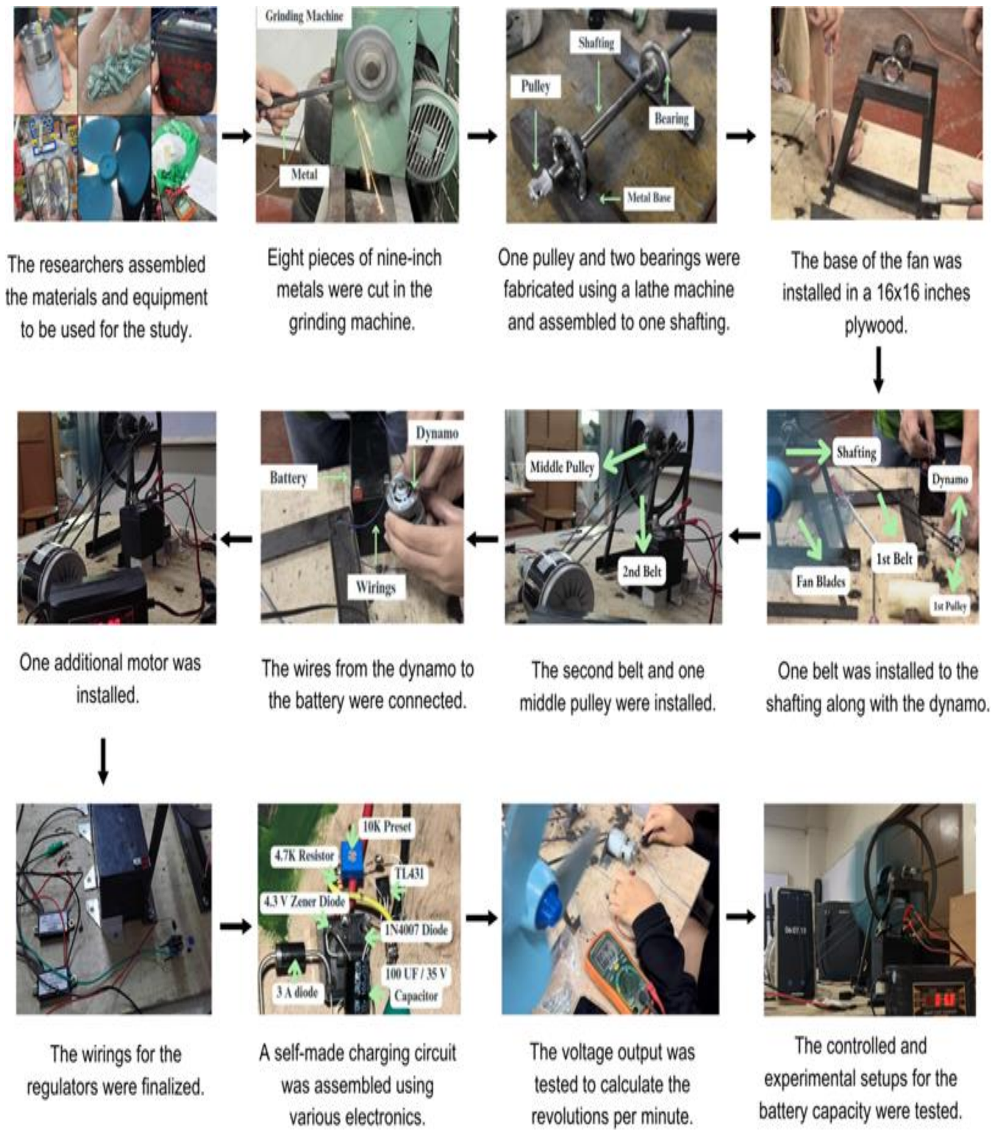


Figure 3
Flowchart of the procedure



Fabricating the Bearing, Flywheel, Pulley, and the Metal Pillars for Shafting. The researchers began the construction of the FAN-Cycle with the implementation of the shafting. A shaft is a rotating circular component that transmits power from a driving device. Shafts carry gears, pulleys, and sprockets to transmit rotary motion to and power via mating gears, belts, and chains (Wikes *et al.,* 2019). A lathe machine was used for the pulley, ensuring it was precisely fitted for the shafting (*Lathe Machine: Learn the Working with Parts and Applications*, 2023). The sequence of processes within a mechanical system provides efficient and reliable power transmission, ensuring its intended functionality. (Belt-Pulley-Unacademy, 2022). Eight pieces of nine-inch metals were ground on a grinding machine to smoothen the edges, and 9 inches were cut from each to form the fan structure. Lastly, the materials were measured using a ruler and constructed.

Plywood. The researchers installed a 16x16 plywood piece, which provided structure and balance for the FAN-Cycle. This ensured that the mechanism was elevated from the floor, allowing free movement of rotating machinery. According to Mou (2019), the plywood's stiffness makes it inflexible and difficult to bend, making it a reliable baseboard for the device.

Dynamo, Motor, Belts, and the Battery. A motor was implemented to help the fan keep running at a certain number of revolutions per minute (rpm). The motor was attached to the pulley behind the shafting using a belt to ensure that the fan could run at a constant speed. Following that, the dynamo was connected to the plywood with another belt. The belt and an additional pulley were attached in the middle of the shafting, enabling the conversion of mechanical energy into electrical energy using Faraday's electromagnetic induction law (How Does a Dynamo Work? 2023). Finally, the dynamo was attached to the battery using two wires, enabling the fan to start running.

Attachment of Battery to Charging Circuits, Capacitors, Regulators, Wirings, and Zener Diodes. The battery has a high round-trip efficiency, meaning the device can save and reuse energy without losing too much energy. This allows for efficiently storing and releasing energy over multiple charging and discharging cycles—a factor that the researchers considered in creating the FAN-Cycle, as it needs a dependable and consistent power source. As such, the battery can keep the device running for a certain period. Moreover, two voltage regulators were used to support the system in case of overheating, since the FAN-Cycle carries a considerable load. These regulators have built-in capacitors that ensure the FAN-Cycle does not produce a higher voltage output. The regulators reduced the current, which also decreased the voltage output. Electric devices, circuits, and pulse power systems consistently utilize capacitors due to their remarkable power density, quick charge/discharge rates, and prolonged service lifetimes (Sun *et al*., 2022).

Afterward, a self-made charging circuit was used for the fan to sustain itself. Charging circuits are essential for floating-mode battery charging, DC power supplies, and recharging. System integration is required for FAN-Cycle's self-charging to work. Lee and Ghovanloo (2015) define a charging circuit as a device that recharges a battery and serves as a DC source, power supply, and operates in floating mode. Next, the charging circuit was placed beside the battery and attached to the flywheel's dynamo. It is under a series of connections that provide the mechanism with a stable current.

The zener diode is a crucial component in electronic circuits. It helps regulate fan voltage to prevent overheating, ensuring steady voltage in circuits regardless of load conditions. Thus, zener diodes, LEDs, and other components, as shown in the schematic diagram, were attached to create the self-made charging circuit of the FAN-Cycle.

To ensure the accuracy of the gathered data, the following parameters were measured using the following procedures under the supervision of a mechanical engineer.

Voltage Output. First, the researchers attached the clips of the lead-acid charger to the battery. Wires were then connected from the dynamo to the middle section of the breadboard. A multimeter was used, and the wires' color served as a guide, with the red wire measuring the positive charge while the black wire measured the negative charge. As the fan gains momentum, the voltage stops fluctuating at a particular value, and the highest value was considered the voltage output. Finally, the average or the minimum voltage output from the least amount of voltage, and the maximum voltage output were obtained after ten trials (Galliana & Lanzillotti, 2019).

Revolutions per minute. The dynamo's revolutions per minute (rpm) were set using a drill press up to 1060 rpm and 1740 rpm. The mechanical engineer consultant of the researchers said that since a tachometer was unavailable, a drill press would be used as a substitute to measure the voltage output of the dynamo at a certain rpm. Then, the voltage output of these two values was measured using a multimeter. For 1060 rpm, the dynamo had a voltage output of 3.11 V, while a 1740 rpm value had an output of 10.10 V. Therefore, the two rpm values and the voltage outputs that were measured in the ten trials were utilized to calculate the missing rpm values using the extrapolation method. The equation below depicts a sample formula of the extrapolation method:

$$Y(x) = Y_1 + (X - X_1 / X_2 - X_1) ([Y_2 - Y_1])$$

where $Y(x)$ is the missing value, and X is the voltage output measured from each trial. The coefficient Y_1 has a value of 1060 rpm, while Y_2 is 1740 rpm. Moreover, the value of X_1 is 3.11 volts while X_2 is equal to 10.10 volts (Extrapolation, 2019).

Battery Capacity. For both set-ups, the researchers ensured that the battery was fully charged using the lead-acid battery charger. Afterward, the charger was disconnected from its socket but was still attached to the FAN-Cycle's battery. The FAN-Cycle's lifespan was monitored once it started to turn on, and then by reconnecting and disconnecting the charger every two minutes until it reached zero percent. The experimental set-up, however, applies the self-made charging circuit once the FAN-Cycle gains enough momentum (Taylor, 2024). After five trials for each set-up, the formula of the battery capacity was applied as stated in the theoretical framework, since the trials gave the unit of time in terms of how long the FAN-Cycle operated until the battery reached zero. Lastly, the mean voltage and revolutions per minute were applied to have a constant current when calculating the battery capacity.

Data Analysis

The researchers used descriptive statistics, such as the mean, minimum, maximum, and standard deviation, for the first two statements of the problems using Microsoft Excel and Jamovi. The mean, minimum, and maximum revolutions per minute, voltage output, and battery capacity were analyzed, and a tabular presentation of the data was made. For the third statement of the problem, inferential statistics was used; an independent t-test was used to compare the means of the two groups (Hayes, 2023). The significance level of the study is an alpha level of 0.05, which represents a 5% probability of error, as it is not harmful to any living thing. A comparison between the p-value and the p-level was made to evaluate the significant difference. Lastly, the researchers used Jamovi to analyze and confirm the data's validity, with the aid of a statistician guiding the researchers on how to use the software.

Ethical Consideration

Electrical waste was disposed of properly by first ensuring that all personal data was removed before disposal, before looking for electrical stores that offer e-waste recycling programs. Additionally, to reduce the environmental impact, the researchers ensured that any material, such as lead-acid batteries, was appropriately stored or recycled until they were no longer functional.

RESULTS AND DISCUSSION

This section includes the testing results along with the descriptive and inferential statistics used to compare the controlled and experimental set-ups.

SOP 1: What will the voltage output of the fan be when the dynamo is connected to a 12-volt battery?

Table 1

Readings of the Voltage Output of Dynamo

Trials	1	2	3	4	5	6	7	8	9	10	AVE
(V)	12.69	12.54	12.25	12.12	12.93	13.19	12.6 5	13.4 1	12. 40	12.4 5	**12.6 6**

Table 2

Summary of Readings of Voltage Output

	N	Mean	SD	Minimum	Maximum
Voltage Output (V)	10	12.66	0.434	12.12	13.41

Table 1 represents the measurements of the voltage output, with a sample size of ten. The mean voltage produced during these observations was 12.66 V. Furthermore, 0.434 V was determined to be the standard deviation. This relatively low standard deviation suggests consistency and dependability in the voltage output since the voltage readings are tightly clustered around the mean. Moreover, the voltage varied throughout the experiments within the range indicated by the minimum and maximum voltage outputs, which were 12.12 V and 13.41 V, respectively. These results collectively imply that the voltage output typically hovers around 12.66 V. The voltage outputs shown are almost identical to the battery voltage since the voltage is 12 V. This is because the voltage output was measured from the dynamo after converting the mechanical energy output from the flywheel into electrical energy. The 0.66 V increase does not cause harm to the battery itself but provides additional charge to the battery, making it semi-self-charging. However, higher voltage use can shorten the battery's lifespan and damage the battery. Every battery is limited to the voltage it can utilize before overheating, regardless of the power provided (Tycorun, 2023). Finally, even without implementing the semi-self-charging feature, the battery will still undergo wear and tear due to the second law of thermodynamics.

SOP 2: How many revolutions per minute will the fan produce when connected to a 12-volt battery?

Table 3

Revolutions per minute of fan blades

Trials	1	2	3	4	5	6	7	8	9	10	AVE
rpm	1991.6	1978	1950.8	1937.2	2012	2039.2	1984.8	2059.6	1964.4	1971.2	**1988.88**

Table 4

Summary of Readings of revolutions per minute

	N	Mean	SD	Minimum	Maximum
Revolutions per Minute (rpm)	10	1988.88	39.6	1937.2	2059.6

Table 2 presents the revolutions per minute (rpm) readings with a sample size of ten. Overall, the mean rpm is 1988.88, along with a standard deviation of 39.6 rpm. The range of the data is represented by the minimum and maximum rpm, which were 1937.2 and 2059.6, respectively. The data also suggests that the rpm of the FAN-Cycle is related to its voltage output, since most of the voltage outputs increased as the rpm increased. This increase indicates that higher momentum and mechanical energy must be applied for a consistently higher output. A high revolutions per minute would mean that the FAN-Cycle provides more air in a certain timeframe, but may also have drawbacks such as noise, which were observed during the trials. However, thanks to the regulators, the noise was removed, producing a lot of air while also limiting noise at the same time.

SOP 3: Is there a significant difference between the battery capacity without self-charging and the battery capacity while self-charging the 12-volt FAN-Cycle?

Table 5
Readings of Battery Capacity of Controlled and Experimental Set-ups

Trial	Battery Capacity Without Charging Circuit (Ah)	Battery Capacity With Charging Circuit (Ah)
1	4.67	5.92
2	2.57	3.36
3	2.13	3.36
4	1.06	4.62
5	2.67	3.68
AVERAGE:	**2.62**	**4.19**

Table 6
Summary of Battery Capacity of Controlled and Experimental Set-ups

Independent Samples T-Test

		df	P-value	Remarks
Battery Capacity (s)	Student's t	8.00	0.074	Not Significant

Note. H_a $\mu_{\text{Controlled Set-up}} \neq \mu_{\text{Experimental Set-up}}$

Table 3 describes the results of an independent sample t-test comparing battery capacity between an experimental and control set-up. The test yielded a p-value of 0.074 with 8 degrees of freedom. This implies that, at the significance level of 0.05, there is no significant difference in battery capacity between the two set-ups. This is supported by their means, with the controlled set-up having a mean of 2.62 ampere-hour (Ah), while the experimental set-up has a mean of 4.19 Ah. A higher Ah indicates longer battery life, in which case the mean of the experimental setup is 1.57 Ah higher than the controlled set-up's mean. The 1.57 ampere-hour (Ah) difference between the controlled and experimental set-ups signifies that using the charging circuit extended its battery capacity. This means it has a higher current output within the range of one to five minutes when compared to the controlled set-ups. Although there was no significant difference, the researchers' objective was to prove that prolonging the battery capacity of the FAN-Cycle through energy transfer is possible. Future studies can build on this integration, allowing them to progressively explore and refine energy transfer to maximize output while minimizing losses. Additionally, this study's utilization of a flywheel highlights its efficiency in maintaining momentum and generating energy, underscoring its potential for broader applications in renewable energy resources. This research encourages further exploration of a flywheel's mechanism and the mechanical-to-electrical energy conversion to assist in modern energy solutions, so it can be used in future settings such as a house appliance, since the results depicted that further improvements for the FAN-Cycle may aid in conserving electrical energy.

CONCLUSION

The study aimed to create a self-charging fan using a dynamo and the circulation of a flywheel. Since creating a perpetually moving machine is impossible based on the second law of thermodynamics, the researchers eventually developed a system in which, although there would be energy losses, some energy was conserved thanks to the flywheel and dynamo circulation along with the charging circuit. Although the results demonstrated that there is no significant difference when comparing the control and experimental set-ups, the experimental set-up consistently outlasted the control set-up, which gives room for further improvements in creating mechanisms that can conserve energy.

RECOMMENDATIONS

Based on the results of the study, the researchers recommend the following: :

- Increase the voltage output of the FAN-Cycle and the charging circuit.
- Use a tachometer instead of a drill press for specific measurements of the revolutions per minute.
- Test the FAN-Cycle's running time until it eventually stops. Afterward, test how long the battery lasts before fully breaking down.
- Test the durability of the FAN-Cycle's mechanical parts to see how wear and tear affect its functionality.
- Try to decrease the load of the FAN-Cycle.
- Create an insulator for the charging circuit regulators to avoid overheating.
- Test a flywheel of a different size since mass and momentum have a direct relationship.
- Test another type of battery since the researchers implemented only a lead-acid battery.
- Do further tests for all variables to ensure the accuracy of the data.
- Implement a device that uses both solar and energy transfer methods for more efficiency.

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