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The Design of Air Exchanger Device (AED) to Generate Electricity From Waste Air Conditioning Exhaust (WACE)

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Abstract: The purpose of this study is to determine a medium for converting wind energy from air conditioning exhaust to kinetic energy and subsequently into electrical energy. This study concerned about the design of an air exchanger device (AED) to generate electricity from waste air conditioning exhaust for the appropriate application and to evaluate the performance of AED. The idea is to use waste energy to generate electricity and to reduce the use of electricity. This significant research and design have been making to define additional clean energy sources in decreasing the primary electrical sources which are majorly using fossil fuel as sources of energy. The carbon dioxide produces from the combustion process had led to the greenhouse effect which is increasing the global temperature. The method has been being used in this study by using wind energy to generate electricity by following the concept of the wind turbine. The design of this project by compared with five other similar methods which use different renewable sources. The types of materials used in design this project are voltage regulator, dynamo, voltage boost converter, mini fan, diode, capacitor, rechargeable battery and shaft. Upon selection of the right materials and component, the design process needs to be conducted. The AED has been designed in a way that allows the waste from the air conditioning air exhaust to rotate the mini fan that was connected to the dynamo. The electricity generated by dynamo will pass through the voltage boost converter to increase the voltage and have been stored to the rechargeable battery before used inappropriate applications. As a result of the study, AED produces a high voltage which can not only be stored in the rechargeable battery but also light up the LED. It is also capable of saving the electricity of a single house which can then result in saving the global consumption.

Keywords: Electricity, Design, Air conditioner, Waste energy

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1. Introduction

The high rise of population and economic development contribute to higher demands of energy that only deteriorates the situation [1]. Therefore, one of the most significant concerns worldwide is the need for energy security. Energy generation from renewable resources such as wind, solar and biomass is one of the choices to lessen the dependency on fossil resources [2]. The windmills or wind turbines are famous as they can create electricity from the wind. The aspects that had led to the importance of use and profitable development of wind-driven generators that depends on natural air movements are increasing the efficiency of such generators and increased cost of traditional fossil fuel energy sources [3]. The windmills could rotate to face changing wind directions [4].

In other practices, wind-driven electric producing systems have utilised air intake to drive the windmills. Recent inventions have tried to collect moving air generated by travelling motor vehicles to produce electricity. Well-known wind-powered electric generating systems, yet, have not used exhaust air from generally low volume non-ventilation sources normally found in air conditioning exhaust. The present invention uses such low volume airflows to produce electricity [5]. Thus, the idea of this project was design by the concept of wind turbines that utilises waste air exhaust from the air conditioning system to generate electricity. This device was named as Air Exchanger Device (AED). This device has been designed by using recycled materials. The impact of the study was to define additional clean energy sources in decreasing the primary electrical sources which are majorly using fossil fuel as sources of energy that can reduce the usage of electricity.

This study was conducted to design the air exchanger device (AED) that can generate electricity from waste air conditioning exhaust (WACE) and evaluate the performance of the air exchanger device (AED). The scope of this project is, first the material that will be used for designing this AED is recycled materials like steel and plastic. Second, in this design of AED, an electric dynamo used as the generator to generate electricity and the generated electricity can be used for a small application in domestic uses such as charging the phone, to light up the LED light and to store voltage in the rechargeable battery. Next, the dynamo used for AED designs and built own, that can be more efficient and lighter to rotate the fan. Lastly, the dimension of this AED according to height, length and weight are 0.5 m, 0.5 m and 3 kg respectively. Nowadays, the use of waste energy is largely applied all around the world. In this world, there are different sorts of waste energy that can help to minimize the utilisation of non-renewable energy [6]. One of the waste energy that is easy to discover is the air that escapes the air conditioning exhaust. The discovered air from air conditioning exhaust can produce electricity by using a device that can convert wind energy from air conditioning exhaust to kinetic energy and subsequently into electrical energy. By using this device, it can minimise the cost of daily life, reduce the uses of electricity, environmentally friendly and it can replace the solar system [7].

The usage of air conditioning is not eco-friendly as they harm the environment such as the greenhouse effect that will trap heat [8]. Therefore, this device that uses the waste energy released from the exhaust of the air conditioner will be able to minimise the negative impact of the air conditioner to the environment. Thus, the device that is designed can be considered as environmentally friendly as no harm is caused to the environment. Besides that, the device is also portable and can be used at anywhere that has air conditioning system [9].

Figure 1 shown Mini Hydro Turbie used to generate electricity using waste pressure. The turbine system been installed at the water tap or by connecting between pipe. The idea was to use the waste pressure from the flowing water to run the turbine. The turbine will be rotating the generator and then will produce power which will be stored in the battery before being used for simple application [10]. Table 1 shows the comparison of existing methods.

Figure 1: Mini Hydro Turbine

Table 1: Comparison of existing methods

Method	Parameter	Remarks	Reference
Pico-hydro method	To calculate energy potential	To determine the water resource by measuring the heat flow of the stream that effectively harnesses the energy potential.	[10]
Photovoltaic systems (PV systems)	To create energy in the form of electricity and heat.	PV systems use panels of photovoltaic cells to convert sunlight into direct current (DC).	[11]
Medium waste to energy power system	To accumulate the data of total waste generation	Converting the waste materials into energy is economically advantageous. To find an environment friendly alternative way to generate electricity.	[12]
Wind Turbine Method	The wind energy system is to extract the maximum power available in the wind stream.	The wind's kinetic energy will converted to electrical energy	[13]
Organic Rankine cycle	To increase the power generation. To determine the potential of the geothermal power plant.	If the reservoir energy is extracted, the higher power energy could be generated compared with the surface potential.	[14]

2. Materials and Methods

It is very important to achieve an accurate and systematic result of the project that has been arranged and designed. The detailed methodology facilitates the completion of the data collection process systematically. The implementation of this study will be explained in details in order to achieve the objectives and goals of the project. It also discusses the methods of how to design the air exchanger device (AED) and explain how to generate electricity from the waste exhaust. This chapter ensures the project is conducted effectively and smoothly.

2.1 Air Exchanger Device (AED)

In this project of designing an air exchanger device (AED) to generate electricity by the concept of wind turbines that utilizes waste air exhaust from the air conditioning system to generate electricity. The idea is simple as, where AED uses the waste from the air conditioning air exhaust to rotate the mini fan that is connected to the shaft. The dynamo that is connected to the shaft will generate electricity. The electricity generated by dynamo will pass through the voltage boost converter to increase the voltage and will be stored to the rechargeable battery before used in small applications. The estimated amount of voltage produced is 5 V to 12 V, which can be used for small application such as charging a mobile phone and light-up LED light. Even though the idea of AED is simple, to create a more efficient project, it requires creative and productive thinking.

The detail process of the Air Ex-Changer Device (AED):

i. Were using waste air from air conditioner exhaust as the main source of energy.
ii. The energy from the waste air turns the blades around the rotor of the mini fan.
iii. The rotor of the mini fan is connected to the main shaft.
iv. The shaft is connected to the dynamo, which produces electricity.
v. The generated electricity is passing through the voltage boost converter to step up the voltage and it will be stored in the rechargeable battery.
vi. The electricity produced and stored can be regulated using the voltage regulator and can be used for small applications.

2.2 Design the Concept of AED

Concept design is an early stage of the design process that includes the design of interactions, experiences, processes and strategies. The concept design might be used as the final design or some modification might be considered for next improvement. Figure 2.1 shows the concept design of AED.

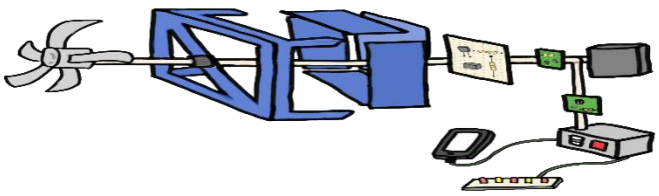

Figure 2: Concept Design of AED

2.3 Flowchart of Methodology

The flowchart is very useful in accordance to run the project smoothly. Figure 3 shows the flow of this project to be considered before starting, during the project go through until the end of the project.

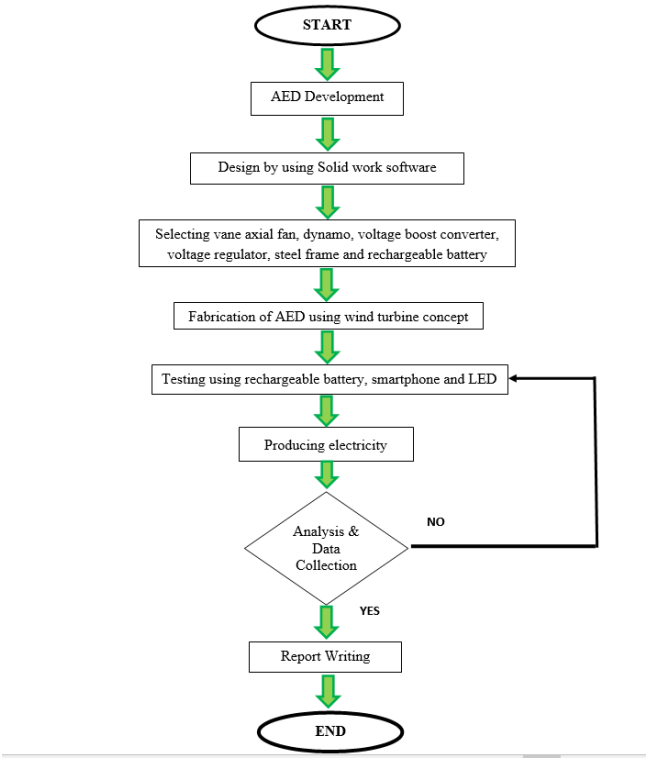

Figure 3: Flowchart

2.4 Build the AED

After determining the right material and component, the design process needs to be conducted. The design concept is very important for the AED to be running in its term. The first step in building AED is to build the frame of the AED. The frame was built using a rectangular steel tube and welded. Then, the frame was added with four short steel stands to make sure there is a gap between the air conditioner exhaust fan and the mini fan. Next, flat steel was welded in the middle of the frame. After that, the dynamo that was fabricated by using coils and magnets were fixed to the centre of flat the steel. The mini fan rotor was then connected to the dynamo using a shaft. The mini fan type will be the axial vane type as it has the blade shape of aerofoil that will rotate in high speed. Thus, when the mini fan rotates, the shaft also rotates causing the dynamo to generate electricity.

Furthermore, two boxes were added to keep the circuits, battery and wires of the AED in place. As for efficiency purpose, in order to ensure the waste air from exhaust does not escape to the surrounding, Perspex is fixed around the frame. Then, a voltage boost converter was used to step up the voltage produced, and a rechargeable battery was used to store the boosted voltage. The voltage can also be regulated using a voltage regulator. Therefore, it can be used for small applications. The final outcome of designed AED is as shown in Figure 4.

Figure 4: Complete AED

2.4.1Design Consideration

In the concept design, the basic system drawing had been shown. However, the concept design is just the general idea of installing AED. In real applications, there are several considerations that need to be done for the AED to work in the best condition.

The first consideration is the installing of a mini fan. The fan is important as it is the main source that will run the AED by rotating using the exhaust waste air from air conditioning. Thus, the weight, size and shape of the mini fan should be considered when choosing the mini fan. The suitable mini fan type will be the axial vane type. The mini fan's weight will be less heavy as the blade of the mini fan is lighter which consumes less energy from the waste air to rotate the fan. The size of the mini fan should be compatible the size of air conditioning exhaust. Moreover, the blade of the mini fan is in aerofoil shape so that it can rotate faster and more efficiently.

The second consideration is the dynamo and voltage boost converter. Voltage boost converter function is to step up the voltage and supply specific voltage required by the small applications. For this project, the dynamo will generate electricity to be used in small applications. As for this small application, the voltage required is between 5 V to 12 V. The dynamo used is light in weight with a small size, remains stable and uses low power consumption. The dynamo is fixed into the rotor of the mini fan.

3. Results and Discussion

3.1 Design of AED

The measurement of AED frame was developed with the dimension of 38 cm of length, 15 cm of width and 38 cm of height. This dimension is chosen because it is compatible with the size of air conditioner's exhaust fan when measured. The frame was added with four short steel stands to make sure there is a gap between the air conditioner exhaust fan and the mini fan. When the AED fan is fixed to the air conditioner, the AED fan is placed with a gap of 15cm from the air conditioner fan to allow the air flow push the blade of AED fan to rotate in constant speed.

In addition, the AED designed is also portable. Thus, the shape of the frame is in square shape so that it is stable, and also to make sure all the waste air from the air conditioner is passed to the mini fan. Therefore, according to the measurement of the frame and the shape of the frame, the mini fan can rotate at an optimum speed. Besides that, the mini fan which is fixed on the flat steel is positioned at the centre of the AED so that the waste air that flows from the air conditioner pushes the blade of the mini fan to rotate optimally. Moreover, the Perspex is added around the frame to ensure the waste air from the exhaust fan doesn't escape to the surrounding to maintain the efficiency of the AED.

The frame of AED made by steel rectangular tube that is normally used for a wide variety of mechanical applications. The size of the steel rectangular tube used in AED is 1" x 2"x 0.120" wall. The reason steel rectangular tube is chosen is, it can be used either statically or dynamically and also it's close tolerances, good finish, lighter and dense structure make it ideal for parts such as AED frame [15]. The design of the mini fan will be the vane axial type as it has the blade shape of aerofoil that will rotate in high speed and can produce more electricity from the dynamo. Besides that, two holders that are designed to attach the AED to the air conditioning. The circuit box is placed at the bottom part of AED to avoid damage such as direct sunlight and rain. Figure 5 shows the design of AED using Solid Work

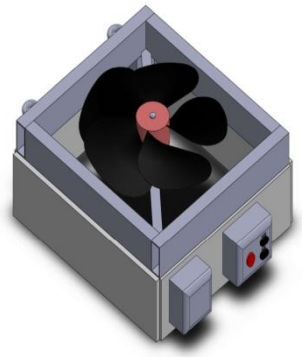

Figure 5: Design of AED using Solid Work

3.2 Experimental Disclosure

In this experiment, five different brands of the air conditioner with the same horsepower tested. The readings were taken using tachometer and multimeter. The results of the readings show it is similar with only a slight difference. Thus, Acson brand air conditioner is chosen to take data readings for this experiment. Therefore, the readings of data for this experiment is fully based on the range of air conditioner's horsepower and not the type of brands. The rotation speed of Acson air conditioner fan and AED mini fan was recorded as shown in Figure 6 and 7 The initial reading of voltage from the dynamo that is connected to the AED mini fan is between the ranges from 3 to 5 voltage.

Several readings were taken to obtain an average reading of voltage for first and second voltage boost converter as well as the voltage value stored in the rechargeable battery as shown in Figure 8, Figure 9 and Figure 10 The reading shows the larger the horsepower, the higher the voltage. This causes the average voltage stored in the battery to increase. The voltage produced and stored is used in small applications such as for charging the phone and lighting up a LED light in order to analyse the AED's performance. The charging time required for the phone to fully charge is slightly longer than the normal time because of the current production by AED lesser. It also chargers according to its battery capacity. The total charging time taken for several phones with different battery capacities is as shown in Figure 11.

Besides that, the LED light is also tested with the AED. It can be seen that the LED lights up for eight hours using the voltage that is increased by the second voltage boost converter which is 12 V and more when the AED is running. When the AED's mini fan stops rotating, the LED lights up for a while until the voltage stored is used and then goes off.

From the standard and the data taken from the experiment, the estimation can be made for how long the time needed to fully charge the phone battery and also to light up the LED light. The LED light-up using the voltage from the second voltage boost converter that can produce more than 12 V.

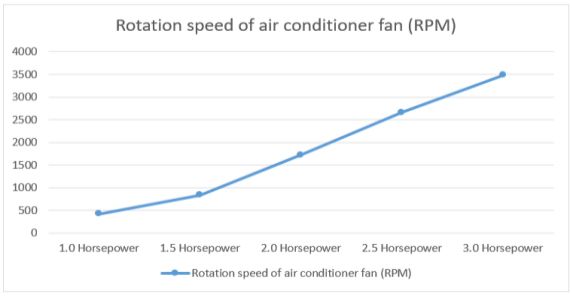

Figure 6 : Rotation speed of air conditioning fan

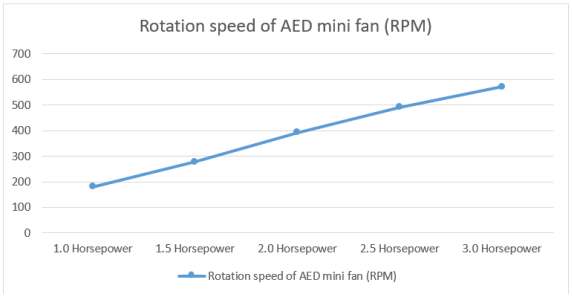

Figure 7: Rotation speed of AED mini fan

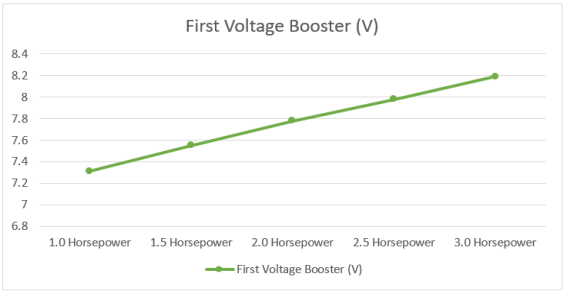

Figure 8 : Reading of first voltage booster

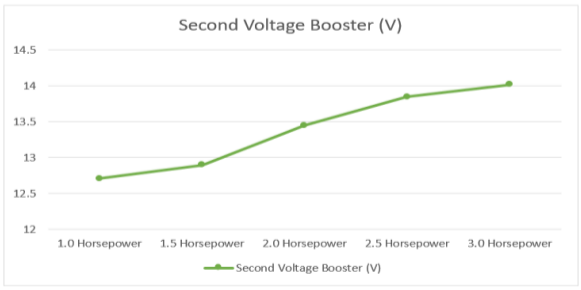

Figure 9 : Reading of first voltage booster

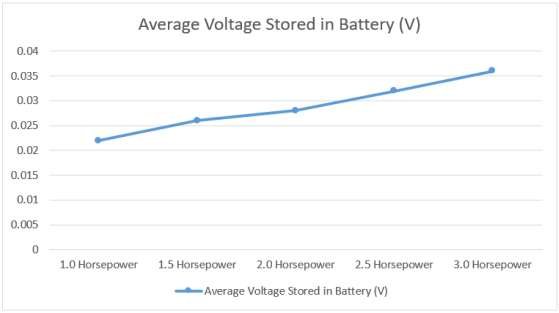

Figure 10 : Average voltage stored in battery

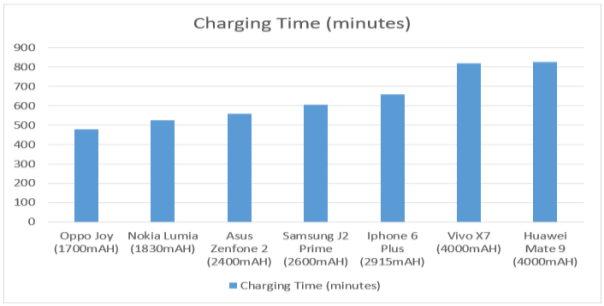

Figure 11 : Charging time of smartphones using AED

3.3 Analysis and Discussion

The method that is used in this study which is using wind energy to generate electricity by following the concept of a wind turbine, there are also several similar methods to generate electricity using different renewable sources that have already been developed as compared earlier in Table 1.1.

The turbine system has been installed at the water tap or by connecting between pipe. The idea was to use waste pressure from the flowing water to run the turbine. The turbine will be rotating the generator and then will produce power which will be stored in the battery before being used for simple application [16]. This study is a similar method used with different renewable sources. The AED is invented in order to generate electricity using waste air conditioning exhaust. The AED is installed on the air conditioner to use the waste air to rotate the fan of AED to generate the electricity. The generated electricity will be step up by the voltage booster and stored in the rechargeable battery while another voltage booster is used to light up the LED. The AED is better as it produces higher voltage which can not only be stored in the rechargeable battery but also light up the LED compared to the Mini Hydro Turbine which can only store the voltage in the battery and use it for simple application. As an addition, the AED is also capable to save the electricity of a single house which can then result to saving the global consumption and it can also prevent global warming.

4. Conclusion

This project was initiated by the concept of wind turbines that utilizes waste air exhaust from the air conditioning system to generate electricity. This device is named as Air Exchanger Device (AED).

Based on overall studies, the result had been obtained from the experiment and calculations done. The main goal of this project is to generate electricity from waste air conditioning exhaust (WACE) by designing an air exchanger device (AED) and to evaluate AED performance. The AED shows that it is possible to recover energy in the air that is being discharged from an exhaust system without negatively affecting its performance. The discharged air from the system has the quality of being able to generate predictable electrical energy. The device designed is considered as environmentally friendly as no harm was caused to the environment.

Based on the result, it can be seen that if the horsepower of the air conditioner is high, the rotation speed of air conditioner fan increases causing the rotation speed of AED mini fan to increase as well. The voltage produced by the dynamo through the rotation speed of the mini fan is stepped up by two voltage boost converter to be used for small applications. Therefore, the voltage that is step up from the first converter is stored in the rechargeable battery while the voltage from the second converter is used to light up the LED light. This design of AED is also portable; thus the installation process, maintenance and storage can be easily done. The design of AED is also focused to reduce the use of electricity and its cost for domestic customers.

While this project works and runs at its best, there can be other improvement done to the project for it to perform excellently. Thus, several recommendations were made. Firstly, the shape of the AED frame can be modified to be narrower. As the shape of the outer body of the project is being narrowed, the velocity of the wind will be higher. Secondly, the type of dynamo used can also be changed to a more efficient one. This will aid in producing higher voltage so that the mini fan can rotate speedily and easily. Thirdly, the number of blades of the mini fan can be added. By this, the airflow of the mini fan can increase causing more electricity to be generated by the dynamo.

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