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EXPERIMENTAL INVESTIGATION ON: EFFECTS OF SOLAR FLUX, TEMPERATURE, CURRENT, VOLTAGE, SPEED OF WIND AND TIME VARIATION AND THE EFFICIENCY OF THE SOLAR PV ON A DC COMPRESSOR.

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ABSTRACT

The development of solar refrigerators for use during the daytime has been found to be feasible, however, fluctuations in solar radiations during the daytime is a challenge for direct coupling of the solar refrigerator to the solar panels. The fluctuations in the solar radiations result in variations of the current and voltage from the solar panels. Huge battery banks are therefore always needed to stabilize energy supply to solar refrigerators (which use DC compressors) even when operated during the daytime. In this study two multimeters were used to measure both voltage and current. The Flux DAQ was also used to measure both the temperature of the refrigeration space (T_{rs}) and ambient temperature (T_{ab}) to observe the effects of solar flux, temperature, current, voltage, speed of wind and time variation on an open circuit test on a solar PV panel. The electrical efficiency of the solar PV model using the data from the open circuit test was also investigated. The experimental results indicated that the variation in temperature during the day was not directly proportional to the time. The effect of voltage of solar PV and solar energy results shows that, at a time of 13:00 GMT the temperature was 36.1°C and then increased from 36.6°C to 40 ℃ at 14:00 GMT and finally gradually decreased to 26.5 ℃ at 18:00 GMT. This shows that, fluctuations occurred during the day. In addition, the influence of current and solar flux was observed and the results indicated that, at exactly 7:30 GMT in the morning both the solar flux and current increased with time. The impact of current on the compressor also shown that at 7:30 to 18:00 GMT, the current was less than the start-up current of 2.08 A of the compressor. This also shows that the compressor could only operate at a start-up current of 2.08 amps and beyond. Furthermore, the effect of temperature and solar flux showed that, the solar flux increases as the temperature decreases during the day. The influence of power with voltage showed that, initially the curve followed the normal P-V characteristics but later observed a rough pattern as a results of irregular irradiations and temperature effect during the data collection. The electrical efficiency of the solar PV model result indicated that, the surface area of the solar PV is 1.6368 m^2 and therefore the electrical efficiency of the solar panel was 14.08 %. This implies that, the system can convert 14.08 % of the sun's energy to run the load.

Keywords*: solar photovoltaic, solar radiation, solar refrigerators, ambient temperature, DC compressor, solar flux*.

1. INTRODUCTION

The power sector of every country plays a very important role in its economy. Ghana generates electric power from hydropower, thermal and renewable energy source and their cost increase rapidly. According to the Energy Commission of Ghana's report on domestic applications, refrigerators account for more than 54.4 percent of residential electricity consumption[1]. Refrigeration systems consume about half a building's electricity and 40-45% of offices of institutions in Ghana use table top refrigerators. About 85 % of these offices operate within 8:00 am to 5:00 pm [2, 3]. Currently, power crisis has affected the use of alternate current (AC) source refrigeration systems and other appliances. There is therefore the need to go into solar energy which is clean to the environment. Solar refrigeration systems have low power consumption and low power surge[4, 5]. Research has shown that, it is possible to convert AC refrigerator to DC and it is possible to operate the refrigerator with a solar panel (PV).

Over the decades most researchers have conducted various studies on the solar photovoltaic systems. Mito et al [6]presented a review on solar PV and wind energy to drive reverse osmosis to identify challenges and solutions to large-scale implementation. Their results showed that considering the operational strategy, plant configuration, control system and processes used for the improvement of the adaptability of plant to the RES. In addition, the technical challenges included reducing of energy performance recovery devices and shortened life membrane. lick et al. [7]conducted a study on solar - PV arrays by considering heat transfer and momentum of flux. Through their study on the measurement of velocity indicated that the complexity flow construction within the solar array, directed by wakes focussed upwards because of the orientation of the solar panel.Tian et al. [8]Conducted a study on a novel multifunctional PV thermal day lighting panel incorporation of emerge solar collector. Their results indicated that the designed PV/ thermal/daylighting structure could mainly remove the generated heat on the PV cells therefore more efficiency of PV operation could be attained. In addition, the design of the puncturing plate under the transparent dielectric CPC panel can greatly reduce the heat flux to the atrium so that atrial cooling load may be largely reduced. Rajvikram et al. [9]conducted an experimental study on the lowering of temperature operation in the solar-PV panel utilizing aluminium and PCM. Their experimental study verified that, the solar panel-PCM and the aluminium plate behind the panel improved the conversion efficiency of the panel with an average value of 24.4%. the electrical efficiency of the solar panel was increased to 2% for an average decreased in temperature of 10.35 °C.Poompavai et al. [10]performed a review on energy management and control strategies application for wind energy and solar-PV fed water pumping system. Their results indicated that, these systems benefited ensure good design, ensures the necessary speed control for the motor, regulates water flow, ensuring precise operation for any conversion and finally, it maintains the precise balance between the renewable energy produced and the power required by the load (pump).Ceylan et al. [11] determined the PV panels heat transfer coefficient and the impact of different temperatures of the outside air on the heat transfer from the rear-panel was negligible. In addition, the rear panel temperature changes were at 10 to 40 ° C and air speeds of 0.5 m/s. The mathematical calculations show that in winter conditions, the temperature of the panels did not increase a level that would require cooling. Therefore, in operating solar refrigerators during the day time help to reduce peak load on the national grid and support the use of solar energy. Depending on the atmospheric temperature as well as the I-V characteristics of the panel, it is difficult to operate DC compressors directly without the use of converters which is necessary to regulate the output power of the panel to run the refrigerator [12, 13].Generally, Offices of most institutions use 75-82 % refrigeration system and about 85 % of these facilities operate within the hours of 8:00 to 17:00 GMT and rely on the national grid and therefore leading to high cost of energy consumption. There is therefore the need to adopt power systems. However, the major challenges involved are related to the voltage output of the solar panels which vary from sunrise to sunset depending on the solar intensity (insolation) and hour of the day. Seasonal changes also affect insolation (solar irradiation) and therefore make solar system design problematic.

Therefore, the purpose of this research is to study the effects of solar flux, temperature, current, voltage, speed of wind and time variation on an open circuit test on a solar PV panel and also the electrical efficiency of the solar PV model using the data from the open circuit test.

2. MATERIALS AND METHODS

2.1 Characteristics of the compressor

The experiments are carried out on a refrigerator employing a BD35F VSDC type of compressor with Refrigerant (R134a). The BD35F VSDC compressor specifications are given in Table 1.

Table 1: Specification of the BD 35F DC compressor

Item	Manufacturer	Parameters
Dc compressor	Danfoss Made in Germany Model:VY33R45A	Reciprocating type Motor type - Variable speed Type of refrigerant- R134a (CF_3-CH_2F) Type of supply- 12v/24v hermetic Oil charge (ml)-150 Cooling capcity-50 watts Rated current -0.39 (A)

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Source: (Danfoss, May 2004)

This type of compressor comes with an electronic unit (110N0210) which play very important role in the refrigeration system. The electronic unit uses a sensor which directly affects the cooling load of the refrigeration space. At an evaporator temperature of 24 ℃, there is a cut-out mechanism that stops the compressor. The battery protection cut-out mechanism protects the battery. For BD35F compressor and at a speed of 1,850 rpm, there will be a cut-out power and therefore the system will not start. Table 3-2 shows the various speed and the corresponding current at 24 volts for different temperature reading of DB35F compressor.

2.1.1 Compressor Speed

It is identified that, the installed BD35F compressor operates at four speeds, thus; 2000, 2500, 3000, and 3500 revolutions per minute (rpm). The speed of the compressor can be controlled by using resistors of different capacities to the electronic control unit. Connecting specified sizes of resistance to the compressor yields different running speeds. The current is regulated by the resistors of the electronic unit and in turn regulates the rotational speed of the compressor motor. Figure 3-3 describes the electronic configuration of the compressors.

2.1.2 Operation of BD 35F VSDC Compressor

The compressor has an electronic unit that ensures adequate power supply for compressor operation and that protect the battery too. The compressor is cut-out and restarted again based on the decided voltage limits taken on the positive (+) and negative (-) terminals of the electronic unit as shown in Figure 1.

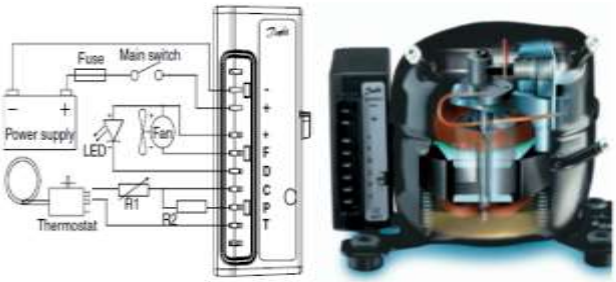

Fig. 1 Cross section of BD 35F VSDC compressor

2.2 Experimental setup and data measurement

The experimental activities were performed in two main ways. The first performance is on the performance characteristics of the 250 watts solar PV on a short circuit test. Characteristics of Solar PV Panel. The type of solar PV for the experiments is the polycrystalline panel with a capacity of 250 watts mounted on a stand at an angle of 10^0 facing south by considering the location (topography) of Kumasi- KNUST (Ghana) as shown in Figure 2.

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Fig. 2 Solar PV setup

The various parameters of the solar PV are selected based on the Technical data at Standard Test Condition of the manufacturer (Sunshine) as presented in table 2.

Table 2: Technical specifications of solar PV

PARAMETERS(MODLE)	Measure values(Sunrise solar AP-PM-250)
Max power (P_{mp})	250 W
Voltage At P_{max}(Vmp)	29.5 V
Current at P_{max}(I_{mp})	8.1 A
Opened-Circuit Voltage (V_{op})	33.0 V
Normal Operating Cell Temperature	48 C
Short circuit current	9.07A
Maximum voltage (system)	1000.0 V
Maximum series fuse rating	10.0 A
Weight	16.1 kg
Dimension	1650X992X35 (mm)

The experiment was carried out on the solar photovoltaic panel on a short circuit test. Current, voltage and solar flux were determined.

2.2.1 Sizing the Solar PV Panel

The size of the solar panel helps in determining the amount of power and energy required to run a load during the day. The required energy also relies on the compressor running time for the day, efficiency of the battery and the peak sun hours of the location as indicated in Equation 1

$$\mathbf{W_{size}} = \frac{\textbf{energy required}}{\eta_{batt} * \eta_{dc} * \mathbf{PSH}} \qquad \text{Equation 1}$$

Where;

η_{batt} is the efficiency of the battery and it is usually between $80\% - 95\%$ and η_{dc} is the efficiency of the DC-to-DC voltage controller and its usually between $80\% - 95\%$. The *peak sunshine hour* (PSH) is 5.1 [5] for KNUST at an angle 6-10° north as the approved tilted angle.

2.2.2 Actual Power Output of Solar PV Panel

In solar system, the real power output is usually affected by some factors such as the formation of clouds and dirt on the solar panel. The actual power output of every panel can be related to equation 2 below and that does not give out a real performance.

$$\boldsymbol{P_{mod} = P_{stc} \times f_{manf} \times f_{temp} \times f_{dirt}} \qquad \text{Equation 2}$$

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Where;
$P_{stc}$is the maximum power specified by the manufacturer at standard test condition, f_{manf} is the tolerance at STC and its specified as 0.9 for the specified solar panel, f_{temp} is temperature and f_{dirt} is the formation of dirt on the solar panel.

$\boldsymbol{f_{manf} = [1 - \times 25]}$ Equation **Error! No text of specified style in document.**

Where γ is the temperature coefficient of 0.45 %/℃ $for\ polycrystalline$ and this is usually related to normal room temperature (25℃). For KNUST, derating factor happens to 0.97 (no unit) and this is of a reason that, it is sited in a rainfall area. Putting all these factors gives out the actual module power in watt.

The average daily energy (E_{PV}) that comes out of the solar PV is related to equation 4 as shown:

$\boldsymbol{E_{PV} = P_{mod} \times H_{tilt} \times N}$ Equation 4

Where:
H_{tilt} is the tilt angle and is also based on the geographical area of installation of solar panel whilst N is number of solar modules installed (1 panel)

2.2.3 Obtaining Data from Solar PV

The characteristics that were considered are current (amperes), voltage (volts), speed of the wind, humidity, solar flux and temperature (℃) of the panel. Two multimeters were used for both current and voltage in a form of DC power readings. The multimeter measures both AC and DC power. The first multimeter was initially set to the DC voltage range of 200 volts (V) since the standard voltage at peak is 20.0 volts (V) of the panel and secondly, the other multimeter is fixed into the maximum current slot with the current also set at the DC range at 10 ampere (A).

The maximum power of the Solar PV is directly related to ohms' law and it is given in equation 5 as:

$\boldsymbol{Pmax = Voltage\ (Vmp)\ x\ Current\ (Imp)}$ Equation 5

In order to satisfy the first objectives, three consecutive days were chosen to determine the temperature $Tp, current\ Ip,$ voltages Vp, the solar flux with the two multimeters and a Pyrometer (Daystar Meter, polycrystalline PV cell, ± 3% (0 - 1200 W/m^2) respectively as shown in Figure 5 on the fabricated metal stand.

Fig. 5. Measurement of voltage and current

The speed of the wind was also taken. Two temperature sensors were placed directly on the solar panel for the temperature readings. One of the thermometers was used as a check for the other temperature readings. A pyrometer was tilted at the same angle to the solar panel to detect the solar flux on the panel. An anemometer was installed for the measuring of the speed of the wind and a temperature gauge for ambient conditions. The experiment was run for a period of twelve hours each day from 6:00 to 18:00 GMT for the performance parameters of the panel at the premises of KNUST.

2.2.4 Daily Solar Intensity

Based on the results obtained from the solar PV, a model is developed from the relationship of the current, power, the solar flux and temperature. This is stated mathematically in equation 6.

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$\boldsymbol{G(t) = G_{max} sin \frac{P}{T} tdt}$ Equation 6

Where;

E_G: *Band gap energy of semiconductor used in a cell* $= 1.11\ Ev$

G_{max}, G_{sr} − *maximum and daily average values of solar radiation*

T − *length of solar day in hour*

The average solar irradiation is also related to equation 7:

$\boldsymbol{G_{av} = \frac{1}{T}\int_0^T G_{max} \sin\frac{P}{T} tdt}$ Equation 7

Taking T to be 10.5 *hrs* of normal operating period of the day

Therefore, the daily solar intensity is finally given in equation 8:

$\boldsymbol{(E_{Sr}) = G_{av} TWh/m^2}$ Equation 8

2.2.5 Electrical efficiency of the solar PV model

The electrical efficiency of the solar PV model can be done using the relation of the maximum power voltage, (V_{mp}), (the maximum power current (I_{mp}) and the rate of incidence solar energy of the surface of the solar PV obtained from the parameters taken from the day is given as in equation 9.

$\boldsymbol{\eta_{elect} = \frac{P_{max,output}}{S_{inc,pv}}}$ Equation 9

For a maximum power of the solar PV is obtain using Ohms law as indicated in equation 10.

$\boldsymbol{P_{max,input} = I_{mp} \times V_{mp}}$ Equation 10

Also, for the input power ($S_{inc,pv}$) of the solar panel, it involves several parameters and this is given in equation 11.

$\boldsymbol{S_{inc,pv} = G_{mp} N_s N_m A_{pv}}$ Equation 11

Where:

G_{mp} = *maximum solar radiation*

N_s = *number of modules in series per string*

N_m = *numberof strings*

A_{pv} = *area of the solar panel*

And the area is also given in equation 12.

$\boldsymbol{A_{pv} = L \times B}$ Equation 12

Where L is the length of the solar panel used and B is the breath of the solar panel used.

2.2.6Instruments and Measurements

The power signals are determined by the use of three multimeters. One of the multimeters is for voltage and the others for current measurement. Ten minutes' time interval is required until the battery drains to shut down the entire system. The temperature of the refrigeration space ($T_{rs)}$) and ambient temperature T_{ab} is monitored by the use of FluxDAQ Data Reader/Acquisition system. All the data measuring instruments used in the setup were recalibrated at the Ghana standard board and the Department of Electrical Engineering, KNUST. The ammeter and voltmeter accuracy happens to be ± 0.023 amps and 0.020 volts respectively. These multimeters are brought from the AMATROL laboratory of Kumasi Technical University (KsTU) with their specifications summarized as indicated in table 3.

Table 3: Instrument specifications for measurement

FluxDAQ Data Reader/Acquisition system specification	
Input signal type: heat flux sensor and Type-T thermocouple Analog dc voltages	
Number of channels:	8 differentials (16 single-ended)
Type of ADC:	24-bit delta-sigma
Voltage resolution:	$1 < 1\mu V$
Heat flux resolution using PHFS-01/01e:	Approximately 1-2 W/m2
Heat flux resolution using PHFS-09e:	Approximately 0.1-0.2 W/m2
Maximum sampling rate:	

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Standard features:	Integrated Thermistor for Cold Junction Temperature Compensation

Instrument	Specification	Parameters
Multimeters meter	Am probe 30XR-A 10 A MAX FUSED	Voltage and current

2.3 Test Procedure

Before each test begins, the door of the refrigerator was kept open for several hours to allow the temperature inside the refrigerator cabinet to reach thermal equilibrium with the ambient. The refrigerator was kept on a stand for a day (24 hrs) before the experiment is conducted. This was done to make sure the refrigerant of the refrigerator settles well. The door of the refrigerator cabinet was never opened during the entire test. The knob of the thermostat was controlled to the maximum point (number 8). This was to maintain a cut-in and a cut-out temperature of plus 2 ℃and negative 10 ℃ respectively [5].The thermocouples and power measuring instruments (power) were in place and all test conditions were established. Evaporator cabinet and ambient temperatures of the refrigerator were measured using a FluxDAQ and stored automatically onto the hard drive of a computer by the data acquisition system as sensed by the thermocouples. The power consumption of the DC compressor at the initial stage was performed by the use of the multimeter. All the multimeters were connected in series for the various current from the source, within and out of the developed system. These included the current to the load (compressor) and current from the solar PV panel. For voltage readings, the multimeter was set and connected across the circuit (parallel connection). The FluxDAQ is connected directly to the computer to take readings of the relevant temperatures and various heat flux. The time interval to read the data is 10 minutes during the entire experiment until the system shut down. The test process was repeated under different the weather conditions. Figure 6 shows the complete setup of the entire setup of the direct connect solar refrigeration system.

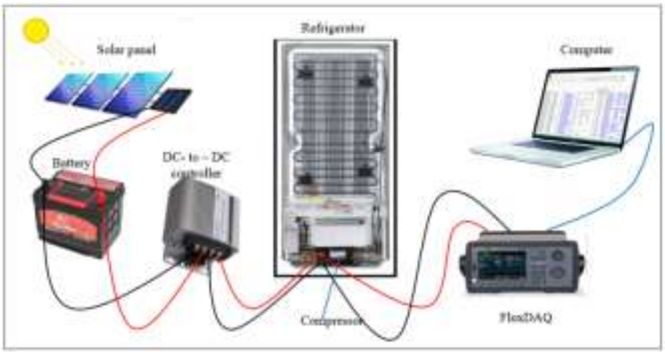

Fig. 6: Photograph of the complete set-up

2.4 Characterization of solar PV

The parameters of the solar PV on an open circuit voltage and short circuit test were performed to determine the power output of a 250 Watt polycrystalline panel during certain periods of the year within the hours of 7:30 to 18:00 GMT. These parameters are solar flux, temperature, current, voltage, speed of wind and time variation of the day. This work has presented various models involved in solar photovoltaic system coupled to DC refrigeration system. This model initially looked at the mathematical and electrical equations involved in analysing the solar panel in three separate days. The angle of solar inclination of the solar panel happens to be 6 to 10 degrees north on top of the solar laboratory of KNUST. Origin Pro 8.5 was use for the construction of graphs to show the behaviour of the various results after the experimentally study.

3. RESULTS AND DISCUSSION

3.1 Variation of temperature with respect to time

The variation of temperature with respect to time was studied as shown in Figure 7. It was shown that the temperature kept on varying throughout the day. At 12:00 (noon), the temperature was at a maximum of 49.5℃ when the sun radiation was directly hitting the panel. This shows that the variation in temperature during the day was not directly proportional to the time as shown in Figure 7.

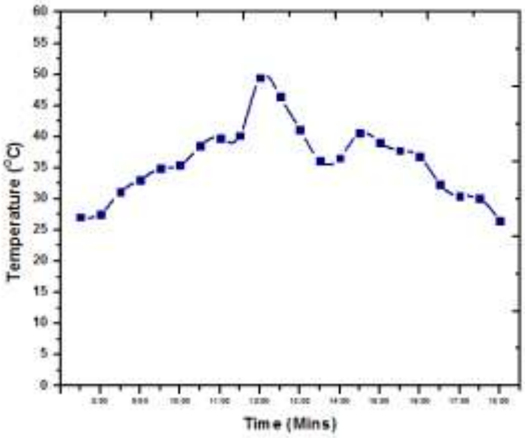

Fig. 7: Temperature variation according to time

3.2 Effect of voltage of solar PV, solar flux and voltage with time

At a time of 13:00 GMT the temperature was 36.1 °C and then increased from 36.6°C to 40 ℃ at 14:00 GMT and finally gradually decreased to 26.5 ℃ at 18:00 GMT.This shows that, there were fluctuations that normally occur during the day. It also shows that; temperature variation has influence on solar intensity. The Figure 8(a)show the behavior of the solar flux, voltage and time interval from 7:30 to 18:00 GMT. It was also observed in Figure 8 that the voltage increased from 7:30 to 9:00 GMT with their corresponding value of 33.5 V to 37V. it then decreased from 9:00 to 10:30 GMT and then increased again, then decreased from 11:00 GMT and finally decreased to 30V at 18:00 GMT. Similarly, the effect of current and solar flux was also considered with respect to the period of the day as presented in Figure 8(b). It was observed that at exactly 7:30 GMT in the morning both the solar flux and current increased with time. The maximum solar flux and current were observed at 12:00 to 13:00 GMT and then decreased till 18:00 GMT. This shows that the was much influence on the solar energy in the afternoon where more energy was absorbed into the solar panel.

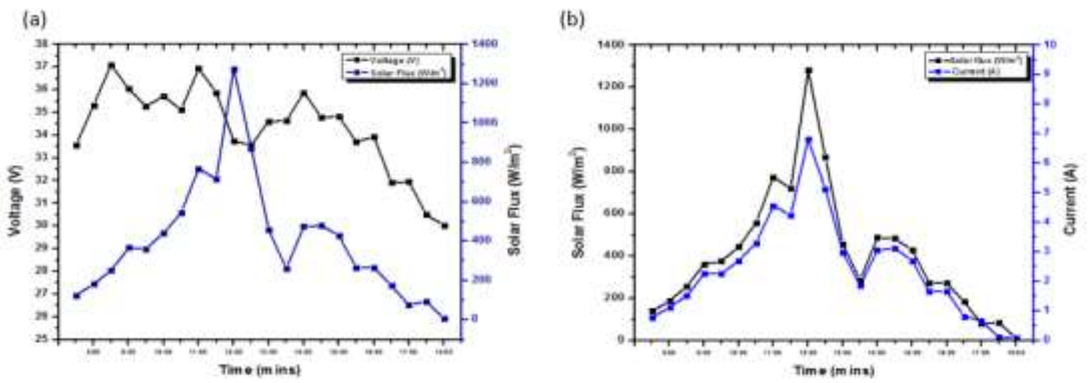

Fig. 8: (a) Solar flux and voltage of the solar PV with time; (b) solar flux and current of the solar PV with time

3.3 Effect of solar flux with time on the compressor

From the graph, it shows that at 7:30 to 8:00 GMT, the current was less than the start-up current of 2.08 A of the compressor. The current rose at 8:00 am to 1.08 amps. This shows that the compressor could only operate at a start-up current of 2.08 amps and beyond. The graph also indicate that current is proportional to voltage. It can be seen that; voltages could be high but with low corresponding currents. Figure 9 shows a graph of solar flux with respect to time.

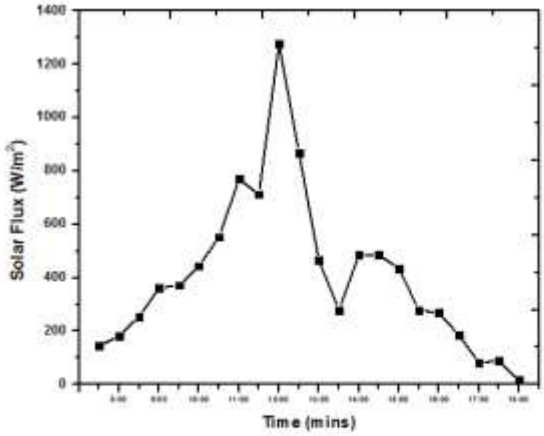

Fig. 9: Solar flux against time in a day

3.4 Effect of temperature, solar flux, power and voltage with time

The solar flux increases as the temperature decreases during the day. The graph also shows that, there were fluctuations in the solar flux and in this turned to affected the current and voltage during the day. Figure 10(a) shows a graph of solar flux against temperature. Similarly, the characteristic of the power and voltage was considered as shown in Figure 10(b). Initially, the curve followed the normal P-V characteristics but later observed a rough pattern as a results of irregular irradiations and temperature effect during the data collection. Figure 10(b) shows a plot of the output power of the solar PV against the output voltage.

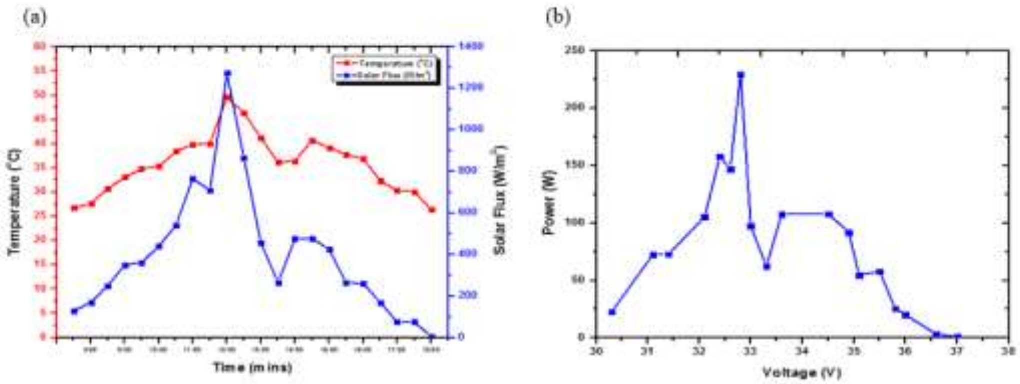

Fig. 10: (a) Temperature, solar flux with time; (b) power and voltage characteristics

3.5 Effect of solar energy and solar flux with time

A daily solar model was developed (Discrete Model) from the data acquired form the solar PV using equation 12.The data was obtained on clear sunny days in January, where solar flux (G) could go above the standard test condition. An average data collection was carried out for a period of 3 days. The model for the experiment was based on average solar radiation at the maximum power rating of panel (250 W) and maximum solar irradiation $(G_{max})\ of\ 1275\ {}^{W}/_{m^2}$ taking t, to be the time sequence in minute from the experimental time length (T) as 10.5 hours. This implies that, the time interval is $0 secs (7{:}30;\ T_1) \le t secs \le\ 10.5\ secs\ (18{:}00;\ T_2)$. Analysing the system using intensity and the time (t) varying of reading, the solar flux can manually be given in the form: $E_{sr} = G_{av} \times t$.From equation 12, the total daily solar energy (intensity) (Esr) is now determine to be as7,206.3 ${}^{Wh}/_{m^2}$.Figure 11 shows the effect of solar energy with respect to flux for a time of 10 hrs. The result shows that the solar intensity was much higher than that of the solar flux at the same time of 250 to 300 min with their corresponding values of 3500 and 1100 $W/^{m2}$ of solar energy respectively. Initially the solar flux increased more than the solar intensity with respect to time and finally declined till the 600 min of time. This

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shows that during the afternoon time the solar energy with respect to time was very high as compared to both initial time and the 600 min time.

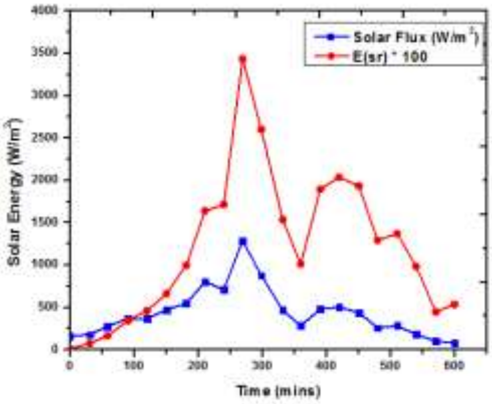

Fig. 11: Solar intensity and flux with time

3.6 The electrical efficiency of the solar PV model

The electrical efficiency of the solar panel talks about the ability of the sun's energy that could be converted by the solar panel. It also highlights on the type and size of the PV needed. To determine the electrical efficiency of the panel, the data collected during the open circuit test on the module was used. At the maximum point, a current(I_{mp}) of 6.78 $amps$ and a corresponding voltage $(V_{mp})$of 34 volts were obtained. This gave out an actual maximum power of 230.52 watt from the solar PV. Using the above equations 9 to 12respectively, the surface area of the solar PV is 1.6368 m^2 and therefore the electrical efficiency of the solar panel is 14.08 %. This implies that, the system can convert 14.08 % of the sun's energy to run the load.

4. CONCLUSION

This study looked at how efficient solar refrigerator can be operated with a minimal or without a battery for office use with a VSDC compressor within the normal working hours (8:00 to 15:00 GMT). This led to the study of the effects of solar flux, temperature, current, voltage, speed of wind and time variation on an open circuit test on a solar PV panel and also the electrical efficiency of the solar PV model using the data from the open circuit test. The experimental results concluded that the variation in temperature during the day was not directly proportional to the time. The effect of voltage of solar PV and solar energy results shows that, at a time of 13:00 GMT the temperature was 36.1 °C and then increased from 36.6°C to 40 ℃ at 14:00 GMT and finally gradually decreased to 26.5 ℃ at 18:00 GMT. This shows that, fluctuations occurred during the day. In addition, the influence of current and solar flux was observed and the results indicated that, at exactly 7:30 GMT in the morning both the solar flux and current increased with time. The impact of current on the compressor also shown that at 7:30 to 18:00 GMT, the current was less than the start-up current of 2.08 A of the compressor. This also shows that the compressor could only operate at a start-up current of 2.08 amps and beyond. Furthermore, the effect of temperature and solar flux showed that, the solar flux increases as the temperature decreases during the day. The influence of power with voltage showed that, initially the curve followed the normal P-V characteristics but later observed a rough pattern as a results of irregular irradiations and temperature effect during the data collection. With the effect of solar energy with respect to flux for a time of 10 hrs, result shows that the solar intensity was much higher than that of the solar flux at the same time of 250 to 300 min with their corresponding values of 3500 and 1100 W/m^2 of solar energy respectively. The electrical efficiency of the solar PV model result indicated that, the surface area of the solar PV is 1.6368 m^2 and therefore the electrical efficiency of the solar panel was 14.08 %. This implies that, the system can convert 14.08 % of the sun's energy to run the load.

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