Performance of a Photovoltaic Solar Cold Storage

H Ambarita¹, C Sitanggang¹ and R Sipayung¹

¹Mechanical Engineering Department, Faculty of Engineering, Universitas Sumatera Utara, Medan, Indonesia

Email: himsar@usu.ac.id

Abstract. Energy is an element of a very important need and can not be separated from human life, especially electrical energy, electrical energy is energy that is widely used and can not be separated from everyday life. In this technological era, the need for electrical energy continues to grow with the development of technology. The energy source for power generation in Indonesia is largely supplied from fossil energy (combustion energy), but these energy sources will be exhausted within about 20 years. Various studies have now led to the development of alternative energy sources such as nuclear energy, solar energy (solar energy), water energy, wind energy, biomass energy, geothermal energy and wave energy. The use of engine coolant in this era has widened where refrigeration is not only applied to household needs, but can also be applied to the needs of industry such as the pharmaceutical industry and the fishing industry as fishermen at sea takes time from weeks to months. The cold storage’s performance analysis aims to determine the best condition of the cooling engine with a variation of 5 photovoltaic units with 250 WP per unit. From the test results obtained daily average performance at 3:32 with testing carried out for 9 hours.

1. Introduction
The problems posed by the conservation of perishable food items in the rural areas of this country justify the interests shown on the application of solar energy for refrigeration. Solar energy has the limitation of intermittency and weather dependence. Consequently, a solar powered system requires a back-up or auxiliary solar thermal energy storage device for its continuous application during the period when it is not available [1]. The development of the current era of globalization has an impact on the increasing need for electricity consumption. There is a need for renewable alternative energy sources to meet current electricity needs, one of which uses solar energy. solar cell that functions to convert solar energy into electrical energy. Solar cell technology is an expanse of semiconductor that can absorb photons from sunlight and convert it into electricity. The solar cells are widely used for various applications, one of them on the lighting [2].

Kattakayam and Srinivasan [3,4] investigated the performance of the domestic refrigerator couples by inverters to the battery bank and photovoltaic panel. Emphasis was put on the power supply system and thermal performance characteristics of the refrigerator. Laidi et al.[5] studied the performance of solar container cold storage of perishable goods and foot supplied by photovoltaic systems. This system has been tested in Algeria. This paper showed that during the daily period, the highest energy amount produced by photovoltaic panels is record between 11:00 and 14:00. Bharj and Kumar [6] experiment the hybrid cold storage system. The photovoltaic on grid used to operating the cold storage, operation the cold storage system continuously for 7 or 8 hours. Aktacir [7] studied a multi-purpose refrigerator system powered by photovoltaic panel. The performance of photovoltaic refrigerator system is
independent of local electricity grid and the capacity and performance were determined experimentally. Rajoria et al [8] investigated the solar photovoltaic (PV) panel driven refrigeration system employs solar PV panel and play a vital role when combines with storage batteries. In this paper, different series and parallel combinations have been applied on four solar PV panels of 35 W each to get 24 V. The objective of this paper was analysis of the applicability of the photovoltaic powered cold storage, performance, work of compressor, and power inlet of photovoltaic were discussed.

2. Method

2.1. Modeling of cold storage

The design is done to make the holder on the Compressor, Battery and Box by using angle and flat iron copper pipe installation using pipes 1/4 and 5/16 and welded, after that a leak test is carried out on the pipe using water foam to see whether there is any leakage in each pipe connection, by seeing if there are bubbles, if not then the pipe will not leak.

The refrigerant filling is carried out by 2 methods: charging based on the amount of weight of refrigerant allowed into the compressor and charging based on maximum pressure. This process is in the form of an analysis of solar radiation loss. This process is by recording P1, P2, P3, and P4 at 30 minute intervals, and looking at 30 minutes at an agile at 5 minute intervals.

The experimental begins by preparing a photovoltaic to be used for testing, by connecting to the solar charge controller, then the solar charge controller is connected to the pure sine wave inverter. Once connected, the inverter is connected to the battery as a power drive to turn on the inverter which will be plugged in with a cooling compressor with an ac current where the current will be converted to dc in the inverter. the media used as cooling objects is water (H20) with a mass of 10kg. Cooling is done by finding the point at the lowest temperature of the cooling process

![Figure 1. Schematic of conceptual power system of the cold storage](image)

2.2. Equation development

Before knowing what the value of the momentary power produced must be known the received power (input power), where the power is the multiplication of the intensity of solar radiation received with the area of the PV module with the equation

\[ P_{in} = G A \]  \hspace{1cm} (1)

The maximum output efficiency (\( \eta \)) is defined as the percentage of the optimum output power of the energy of light is used, which is described as: maximum output efficiency (\( \eta \)) is defined as the percentage of the optimum output power of the energy of light is used, which is described as:

\[ \eta = \frac{P_{out}}{P_{in}} \times 100\% \]  \hspace{1cm} (2)
In addition to efficiency, the characteristics of the other is the fill factor (fill factor, FF). Fillfactor (FF) is the value of the voltage and current ratio at the state of maximum power and open circuit voltage (Voc) and shortcircuit current (Isc). This means that the power possessed by solar cells may not be given to the full load.

The ideal fill factor price is 0.7 to 0.85

\[
FF = \frac{V_{mpp} \times I_{mpp}}{V_{oc} \times I_{sc}} \quad (3)
\]

\[
P_{out} = \eta \times P_{in} \quad (4)
\]

The condenser and the evaporator do not involve any work, and the compressor can be approximated as adiabatic. Then the COPs of refrigerators and heat pumps operating on the vapor compression refrigeration cycle can be expressed as:

\[
COP = \frac{\dot{Q}_l}{\dot{W}_{net,in}} = \frac{h_1 - h_4}{h_2 - h_1} \quad (5)
\]

The design of solar panels based on the intensity of the sun in the 4th Floor Building of Masters in Mechanical Engineering in North Sumatra, obtained how many plates will be used when using 100 wp in the design and 250 wp in the analysis carried out in the 2nd Floor Masters in Mechanical Engineering Building, North Sumatra University.

\[
\frac{\partial M}{\partial t} = D_{eff} \frac{\partial^2 M}{\partial r^2} + \frac{2}{r} \frac{\partial M}{\partial r} \quad (6)
\]

Where \(D_{eff} \text{ [m}^2\text{/s]}\) is an effective diffusivity. This parameter is a coefficient for mass transfer of the water within the object. The phase of water includes liquid and vapor.

3. Result and Discussion

The best experiment is obtained by using 5 photovoltaic plates, which every one of photovoltaic plate has a \(P_{out}\) of 250 WP. The experiment is start out in the morning, starting at 7 a.m. in the morning until the late afternoon, ending around 5 (the intensity of the radiation is not able to run the photovoltaic again

Figure 2. Curve coefficient of performance, power outlet of photovoltaic (\(P_{out}\)),and Time
Figure 2 has been shown a curve of the results of tests on the effects of coefficient of performance, Power outlet of photovoltaic, and Time. The highest COP is obtained at 7 a.m and the lowest COP at 10 p.m, and the most optimal Pout is obtained at 12:30 p.m. The results of the test analysis showed that the highest COP is 3.64 and lowest is 2.56.

![Figure 2](image1.png)

**Figure 2.** Curve of the result of tests on the effects of coefficient of performance, Power outlet of photovoltaic, and Time.

Figure 3 has shown the results of the refrigeration effect and work of compressor test, the ups and downs of QL and W\textsubscript{com} depend on the enthalpy obtained during the test where the rise and fall of pressure (instability) determines the enthalpy’s value as well.

![Figure 3](image2.png)

**Figure 3.** Curve work of compressor (W\textsubscript{com}), refrigeration effect (QL), and Time.

Figure 4 has shown the curve Power inlet of photovoltaic (P\textsubscript{in}), power outlet of photovoltaic (P\textsubscript{out}), and Time.

![Figure 4](image3.png)

**Figure 4.** Curve Power inlet of photovoltaic (P\textsubscript{in}), power outlet of photovoltaic (P\textsubscript{out}), and Time.
Figure 4 has been shown the results of the analysis of the $P_{in}$ and $P_{out}$ during testing with measurements for every half hour, $P_{in}$ and $P_{out}$ are sought to determine the magnitude of the efficiency of the photovoltaic.

4. Conclusion

Power inlet from photovoltaic have high impact for performance of cold storage. The high intensity of the sun in the day needed to operate the cold storage. The average of the performance of cold storage was 3.2 with 134a refrigerant.

5. References

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