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# Analysis of 20-liter refrigerator system DC compressor-based SPV power

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**Abstract:**

Refrigerators working on Direct current (DC) compressors are suitable to work with solar photovoltaic (SPV) module than the conventional refrigerators working on AC compressors this paper present result of a study undertaken to design and test a DC compressors based test of different capacity refractors integrated with an SPV power supply unit .specification of SPV system,suitable for the purpose,have been formulated during the study

**Keywords**: solar refrigerator, DC compressor, solarphotovoltaic power,testing

## I. Introduction:

Conventional domestic refrigerators available in the market are unsuitable for operation in many rural areas due to the non-availability or unreliability of grid electricity.Rural health centers, veterinary clinics, pharmacists and villagers face difficulty in preserving essential commodities due to lack of refrigeration facility .one of the solution in this preserving essential commodities due to lack of refrigerators with SPV system to draw the required electrical power from solar energy.The SPV module was found to result in problems like high energy consumption higher starting current, and need an inverter to convert DC output of SPV modules into AC .this paper present result of study to design and test 20 liters DC compressor-based refrigerator integrated with SPV modules for its power requirement

## II.PROCEDURE

*Refrigerant Mass Flow Rate*:

from figure 2 we can see that the refrigerant mass flow rate has the same variation tendency with the condensation temperature and evaporation temperature at different compressor frequencies .at the different condensation temperature and evaporation temperature s in map condition (at same suction temperature,sub cooling temperature, and ambient temperature ),the refrigerant mass flow rate and operation frequencies are shown in the table it can be seen that the ratio of mass flow rate at a constant frequency to that in basic frequency remains constant at different condensation and evaporation temperature s .in other words,the mass flow rate ratio is determined only by the compressor frequency and is independent of the condensation and evaporation temperatures.the relation between mass flow rate ratio and the compressor frequency can be expressed as a second-order function of compressor frequencies.

The standard vapor compression refrigeration system consists of a refrigerant in a closed circuit comprising a compressor,a condenser,an expansion device,an evaporator, and interconnecting piping .in the condenser, a compressed refrigerant vapor at high pressure is condensed at temperature by heat transfer to the surroundings.the high-pressure refrigerant liquid is reduced to low pressure at the expansion valve. At low pressure,the refrigerant will evaporate at low temperatures enabling it to extract heat from the substance to be cooled.to complete the cycle,the low-pressure refrigerant vapor exiting the evaporator is compressed is to high pressure by compressor .the total heat rejected in the condenser is the sum of heat extracted plus the

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compressor energy use.

losses in the System:

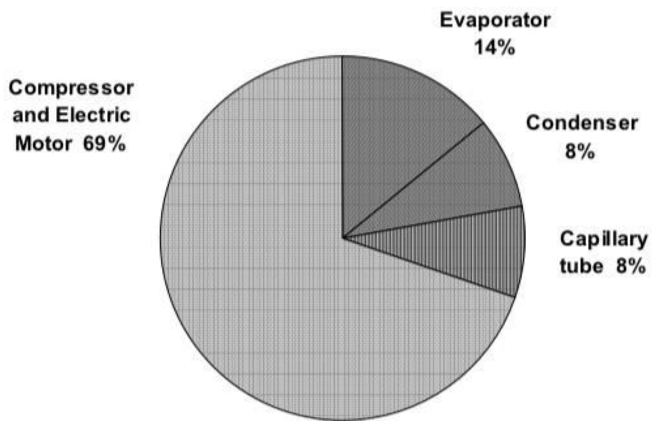


Figure 2.2 Losses in the refrigeration cycle

there is a difference between the real energy consumption and the thermodynamics minimum energy consumption this difference can be called "losses of the refrigeration cycle in figure 2.2 shows the majority of the losses come from the compressor with its motor,followed by the evaporator,condenser, and the capillary tube.

## III.MODEL DISTRIBUTION

*Refrigerant:*

Very few substances have properties appropriate for a refrigerant and, of these,few have stood the test of time and continue to be used as refrigerants some of the substance that has been used as a refrigerant and how use has varied over time there is no ideal refrigerant .selection of a refrigerant is a compromise between many factors including ease of manufacture, cost, toxically,flammability ,environmental impact,corrosiveness, and thermodynamic properties as well as energy efficiency.A key characteristic is the pressure /temperature relationship .in general,energy efficiency is desirable for the refrigerant critical point (temperature above which the refrigerant cannot condense ) to be high compared with the heat extraction and rejection temperatures. Good transport and heat transfer properties are also important for energy-efficient as they reduced running cost and allow smaller temperature differences to be employed in evaporators and condensers and hence smaller overall temperature lifts.in general refrigerant of low molecular weight and low viscosity will have the best properties.

Compressor:

The compressor will lose efficiency if the temperature lift is higher than necessary and they will also lose efficiency if the droplet of refrigerant liquid is present in the suction vapor or if the suction vapor becomes too hot .compressor maintenance,where possible,and the preservation of lubricant quality are important to retain energy efficiency .for some compressor types (particularly screw and centrifugal),their part -load energy-efficient performance is poor compared with a full load,so the sustainable part-loaded operation should be avoided .variable speed drive technology and improved control system can minimize the energy penalty butincrease’s capital costs.

Condenser:

To keep refrigerant heat rejection temperature as low possible,condenser heat transfer rates should be maximized and the cooling medium temperature minimized .evaporatorative condensers are often the most efficient because they reject heat to the wet-bulb temperature of ambient air .for instance,humid air at 25 censuses and 60 Celsius relative humidity has a wet temperature of 16 however, therequired careful maintenance to avoid legionella contamination. water-cooled condensers combined with cooling water tower also approach ambient wet bulb temperature but there is an additional temperature difference to drive heat from the refrigerant into the water, so the refrigerant heat rejection temperature is generally higher .water use can be excessive if a cooling tower is not used. Air-cooled condensers are usually the least efficient method as they reject heat to the air dry-bulb temperature,which is generally significantly higher than wet-bulb or water temperature .however,for the small system they are commonly used because they are cheap, simple ad require little maintenance. it is important to keep all type of condenser clean and free from fouling .condensers rejecting heat to the atmosphere must be allowed plenty of fresh air and protected against any tendency for the air to re-circulate back to the condenser inlet .systems that operate with refrigerant suction pressures against any tendency for the air to re-circulate back to the condenser inlet .systems that operate with refrigerant suction pressures against any tendency for the air to re-circulate back to the condenser inlet .systems that operate with refrigerant suction pressures less than atmospheric (e.g low-temperature ammonia )

Expansion Valve:

Many expansion valve devices require significant pressure difference to allow proper operation therefore condensing pressure is often maintained at artificially high levels, even at low ambient temperatures.the biggest culprit in this respect is the conventional thermostatic expansion valve which is often selected because of its very low cost .one solution is to use electronically controlled expansion valves.

Evaporators:

As for evaporators, evaporators should be designed to operate at minimum economic temperature difference so that the refrigerant heat extraction temperature can be as high as possible for a given substance temperature.increasing heat extraction temperature also reduces the size,aspect such as refrigerant distribution,circuiting, and velocity,use of the enhanced surface,air speeds (for air coolers) can all significantly affect energy efficiency .air coolers that operate at a temperature below freezing must be defrosted regularly to restore performance.Electric defrost is simple is least efficient and therefore only suitable for small systems. Electric defrost has to be paid for at least twice,to put the electric heat into the cooler,are all potentially more efficient, however,whatever the system,it is important to optimize the frequency and duration of defrosting to avoid unnecessary defrosting

Interconnecting Piping:

Efficiency can be reduced if interconnecting piping is of the wrong size or is arranged in ways that cause unnecessary pressure drop or inhibit oil return (e.g. excessive bends and fitting ).importance of controls.

A refrigeration system with a well-designed component will not operate efficiently unless the component is correctly matched and controlled .energy efficiency has not always been the prime consideration when selecting effective controls. if possible, the following control option should be avoided to maximize energy efficiency.

-slide valve unloading of oversized screw compressor

-hot gas bypass of the compressor,

-throttling valves between evaporator and compressors,

-evaporator control by starving refrigerant supply,

-too frequent defrost,

-condenser head pressure control except when necessary

## IV.PROCESS

The aim and objective of this research and project are to decrees the electricity consumption in a compressor of refrigeration system the frequent start-stop action of compressor affect its life by decreasing bearing durability which is, in turn, result in frequent maintenance activity proper and timely defrosting is another factor which determines heat transfer capacity of the system by new research system provided a temperature sensor based defrosting .the digital controller also indicate compressor mode and temperature the main attraction of digital inverter compressor solution large load cold storage system simultaneously operate and the main stand by compressor our dedicated effective combination of the different rated compressor to make the system energy efficient and operationally efficient. Speed controlled compressor according to temperature demand improper energy-efficient life and improper energy efficient

The microcontroller typically monitor the temperature in the space to be controlled and adjust the speed of the compressor to maintain the desired temperature the drive modulated inverter compressor speed and prevent from operating out of the compressor operating out of the compressor limit the inverter frequency drive need to use algorithm to developed s[pacifically for cooling or refrigeration as the compressor rotational speed changes the amount of refrigerant oil flowing through the compressor increases or decreases the drive ensure that the compressor and bearing are optimally lubricated at all compressor speed and greater efficiency the model is built at the basic frequency and the map condition as the second-order function of condensation temperature d evaporation temperature anthem it is corrected by the the compressor frequency as the second-order function of frequency and by actual operating condition as actual specific volume suction gas .this method is used to setup simulation model of compressor different speed and temperatures for refrigerant mass flow rate ,compressor power input and coefficient of performance respectively .This model of digital invertible compressor for a cool storage system is suitable for the refrigeration system analysis based on the experimental data and simulation model, the frequency at zero mass flow rate and power input at zero frequency are discussed and the relation between the cop and compressor is analyzed

Measuring systems:

the test and measurement have been done in the refrigeration laboratory using an FA14 fridge of 140l volume,in a thermostatic with 25 degrees ambient temperature with this system were recorded data from thermocouples about the temperature of any part of the system and power consumption all measurement have been done to situate the fridge under the test an energetic class (A,A+,B,etc),each test had the minimum time of 24 hours after few cycles of stability of the operation .after test b has been done,the data about the average temperature .the position of thermostat thepops., the average power consumed in a cycle,p/cycle the average time when the compressor runs ton,the average time of a cycle Tricycle,number of cycles/day Ncycles/day,was kept and was collated the daily usage of energy E24.the formula used to calculate E24 was

$$E24=P/CYCLES*Ncycles/day \qquad (1)$$

ata different stage,the test was calculated the daily energy used of the refrigerator and presented in the table

FIRST STAGE

at the first stage the fridge was equipped with a Danfoss PL50F compressor .this compressor has a size of 54W and a constant speed of 2500RPM.it was used refrigerant R134a in a charge of 30g.the temperature was calculated as an average value of 3 temperature at a different level in cabinet .the table 1 shows the result of measurements on this refrigerator with mentioned compressor .the daily usage measured is 761Watts

SECOND STAGE

At this stage,the PL50F compressor of the refrigerator was changed with a Danfoss BD50F compressor .the electrical and mechanical characteristics of this compressor are similar to the first one (the same displacement of 2.5cm*3)the compressor is BLDC motor with the variable speed

the refrigerant and the charge was the same R134a and 30g .the temperature of thermostatic chamber was the same 25 degrees celsius.The measurement was done for 3 positions of thermostat-1.0,2,0 and 2.75, for 3 constant speeds of motor -3500, and 2500RPM.in this stage the compressor was stopped when the temperature of evaporator -17 degree celsius,and started again when the temperature was +3 degree celsius .theses large limites created a variation of temperature in the cabinet of 4-degree Celsius(minimum 3.22 degrees celsius,maximum 7.16 degrees Celsius )when the compressor is stopped .this shown in the figure below

Overall,the result at this stage is presented in table 2.6 the average daily usage of the system was 434Wh.

THIRD STAGE

At this stage,the thermostat was substituted,and the control of the speed of compressor was done by a system with the PIC16F877 microcontroller .the block diagram shown in the figure below

**V.RESULT/CONCLUSION**

comparing the result from table 2 and 3-the compressor driven by the thermostat and by the controller,concluded into these two aspects :(1) the average power consumption in a cycle was in the same domain of values 25-37W,(2) the running time of compressor with the controller was longer (1.47-1.83h),and the number of cycles/day (13.11-16.33)less than without it.

this new condition of operation of compressor (drive-by controller) has led to daily usage of 413kwh/day,and annual usage of 151kwh/year this was done at 25degree Celsius ambient temperature.The evolution of temperature inside of the refrigerator for a long time (more than 20 hours ) is shown in figure 4.the temperature was set at +2degree and the measured temperature is between 0 and +4degree,(Tset+-2degree) as shown a detailed evolution of temperature in one cycle to see the effect of variable speed.it can be observed 7 levels of temperature corresponding to 7 levels of speed of compressor .data acquisition system with the next values:(1) test time:24.71hours,(2)running time:19.08hours,(3) running time %77.23,(4) hour cycles:0.53.

in this situation, the compressor turns on at a temperature of 3.5-4.0degree,from the settled temperature,but this variation doesn't have any effect because the temperature has an average value of +2degree as was settled .inthe diagram of figure 5 can be observed that the longest period is the one when the compressor runs with low speed-700RPM-600RPM,32 minuteswhen the consumption of compressor is minimum.The consumption in one cycle is shown in figure 6.a close examination of the diagram from figure 6 shows the 7 steps of the speed of the compressor .the compressor run with a low speed of a long time in one cycle-steps 5,6 and 7. this time are 64 minutes (66%) in the cycle presented with Ton =96 minutes,and Tcycle=125 minutes

Improving the energy efficiency of the refrigeration system is not difficult and should be encouraged because of the enviromentantal benefits if often involve a trade-off between initial cost and on operating costs.there are many situations where economics motivate the equipment supplier to provide the cheapest solutions,especially if the supplier does not pay for the running cost of the system .standard should be set for energy efficiency for all types of the refrigerating system.

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