Tesla Turbine Powered Solar Refrigerator

Thiyagarajan V[1], GokulKumar V[2], Karthickeyan B[2],
Naveen Kumar E [2], and Nikilaesh A[2]
[1]Assistant Professor, Department of EEE, SSN College of Engineering, Kalavakkam, India.
[2] Student, Department of EEE, SSN College of Engineering, Kalavakkam, India.

ABSTRACT

This project is to design and fabricate Tesla-turbine powered solar refrigerator, with steam as the working fluid. Looking into the potential of the Tesla turbine as a more efficient turbine which will be used in the energy conversion process, and thus provide refrigeration to inaccessible areas of the country. By using solar power, we are able to overcome the fossil fuel crisis and by a Tesla turbine will give us an improvement in performance. The efficiency of the Tesla turbine which is very high, and the maximum recorded efficiency has been 60%. Thus, by incorporating a Tesla turbine and taping solar energy, it enables us to provide refrigeration at very low costs and more efficiently. The use of this turbine to run the compressor, which is basically a pump will increase the efficiency of the overall system. And thus by combining this two technologies, we strive to improve the overall efficiency of the system and a smarter way of refrigeration can be accomplished. The use of step-down DC chopper and the induction coil will be responsible for providing the torque needed to run the Tesla turbine. Finally, the usage of a battery or backup power will enable us to use the refrigerator during night as well as cloudy day.

KEYWORDS: *Solar energy, Solar refrigerator, Tesla turbine, Renewable energy*

I. INTRODUCTION

Conventional sources of energy are fast depleting these days due to their excessive use and poor conservation practices. At this rate, conventional energy sources will fail to fulfil the world's growing energy needs and become scarce. Additionally, the cost of energy sources is rising and their extensive use causes harmful environmental pollution. Hence, there is a need to switch to alternative energy sources such as sun, wind and hydro. Photovoltaic system is a very promising alternative as it uses energy from naturally available sunlight distributed throughout the earth, is pollution free, abundant and recyclable. The only hindrance is its high installation cost and low conversion efficiency. Therefore, we aim to increase the efficiency and power output of the system. It is also required to supply a constant output voltage to the load irrespective of the variation in the temperature and solar irradiation.

In refrigeration, instead of using conventional motor we are using Tesla turbine. Tesla turbine has recorded theoretically 90 % efficiency and practically it has been tested and found to have more than 60 %. Tesla turbine can be run in either air or water vapour or flow of water. Thereby using a Tesla turbine we are planning to design a prototype of a solar refrigerator that has good efficiency and clean energy.

The solar refrigerator is the refrigeration system that runs on the solar energy. The solar refrigerator comprises of all the traditional components like the compressor, condenser, expansion valve and the evaporator or the freezer[1]. The power is supplied not by the domestic electrical supply system, but from the solar panel. The solar system of the solar refrigerator comprises of the solar panel that collects the solar energy[2]. The solar panels converts the solar energy into electrical energy and store it in the battery. During the normal running, the power is supplied directly by the solar panel. However, when the output power of the solar panels is less, the additional power is supplied by the battery. The battery is recharged when excess amount of power is produced by the solar panels. A typical solar system produces 300W or 600W of power depending upon the size of the desired refrigerator. The Tesla turbine was one of the many inventions of Nikola Tesla, the father of the alternating current. It is also known

as boundary layer turbine or flat disk turbine or bladeless turbine.
Nikola Tesla patented this model of bladeless turbine in 1913[3]. It works on the principle of boundary layer effect. It is most unique in the sense that it is the only model of a turbine that does not have any blades. It has a series of closely packed parallel disks attached to a shaft and arranged within a sealed chamber. Tesla claimed that the turbine was the most efficient and the most simply designed rotary engine ever designed. In an ideal scenario the turbine efficiency is estimated to go till 92%. Practically an average gas Tesla turbine's efficiency is found to be 60%[3]. So in our project we are going to use the Tesla turbine to run the compressor instead of the conventional ac motor. There are different types of DC-DC boost converters that can be used for photovoltaic generation. A simple boost converter or a step-up converter is a DC-DC power converter where the output voltage is greater than the input voltage. It belongs to a class of Switched Mode Power Supply (SMPS) comprising of semiconductor elements; diode and transistor and an energy storage element such as inductor or capacitor or a combination of the two. Filters consisting of capacitors or sometimes inductors are added at the output of the converter in order to lessen the output voltage ripple. Boost converter derives its power from batteries, solar panel, DC sources and DC generators to step up DC source voltage from one level to another using DC-DC conversion mechanism. Since the power has to be a constant P=V*I, the load current is lower than the source current. In battery power systems, series of cells are stacked in series for high voltage applications resulting in increased cost of the battery. Instead of using more battery cells, boost converters are widely used to boost the source voltage.

II. SOLAR REFRIGERATION

The solar refrigerator is the refrigeration system that runs on the solar energy. The solar refrigerator comprises of all the traditional components like the compressor, condenser, expansion valve and the evaporator or the freezer. The power is supplied not by the domestic electrical supply system, but from the solar panel. Fig. 1 shows the schematic representation of solar powered refrigerator.

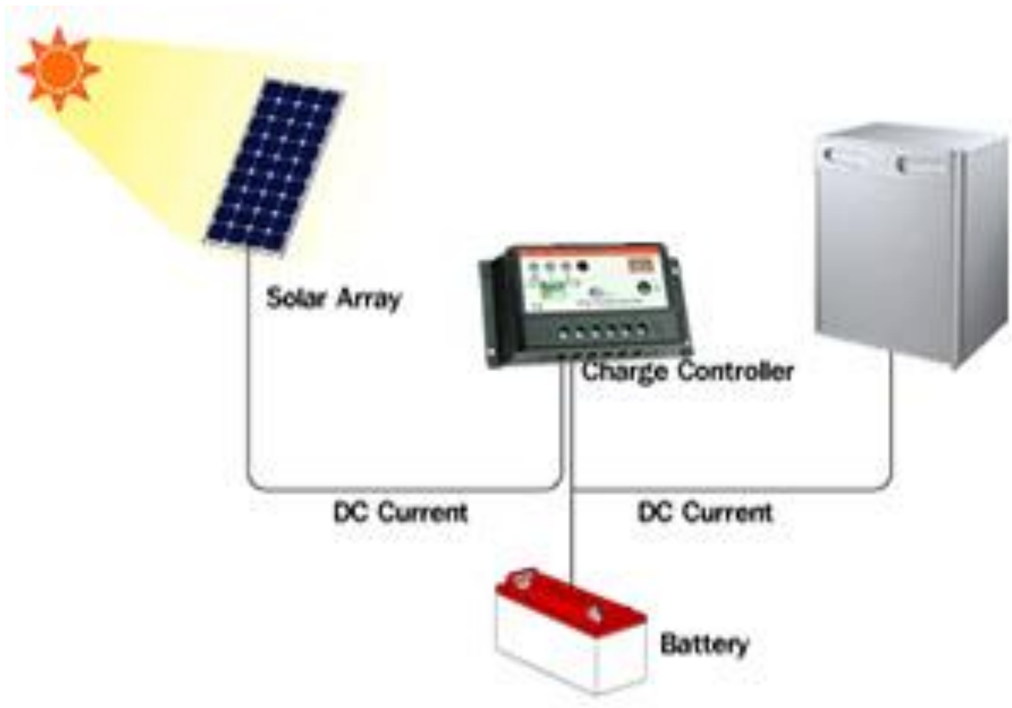


Figure 1: Solar powered refrigerator

The solar refrigerator consists of four major components: solar panel, solar charged controller, refrigerator compressor and battery. The solar refrigerator works like a vapor-compression system for cooling. A refrigerant gas like ammonia is placed under pressure, causing it to get hot. As it cools back down, it condenses into a liquid. When this liquid travels to a lower-pressure area, it expands and vaporizes[4]. This vaporization absorbs heat, rapidly cooling the coils of the refrigerator. The solar refrigerator system simply uses photovoltaic cells instead of coal or nuclear power to generate electricity.

III. CONSTRUCTION OF THE TESLA TURBINE

Tesla turbine consists of a series of closely packed parallel disks attached to a shaft and arranged within a sealed chamber. All the plates and washers are fitted on and keyed to a sleeve threaded at the ends and equipped with nuts and collars for drawing the thick end-plates together. This construction permits free expansion and contraction of each plate individually under the varying influence of heat and centrifugal force and possesses a number of other advantages which are of considerable practical importance. A larger active plate area and consequently more power is obtained for a given width, improving efficiency. Warping is virtually eliminated and smaller side clearances may be used, which results in diminished leakage and friction losses. The rotor is better adapted for dynamic balancing and through rubbing friction resists disturbing influences thereby ensuring quieter running. For this reason and also because the discs are not rigidly joined it is protected against damage which might otherwise be caused by vibration or excessive speed[5]. The construction of Tesla turbine is shown in Fig.2.

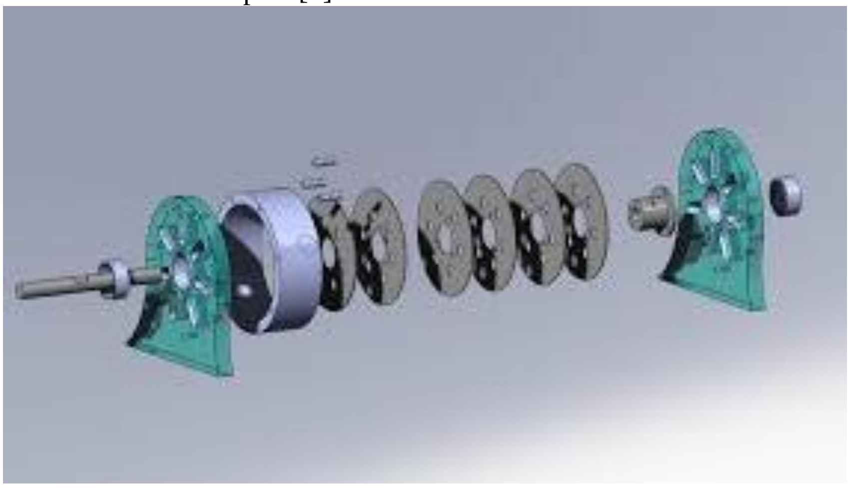
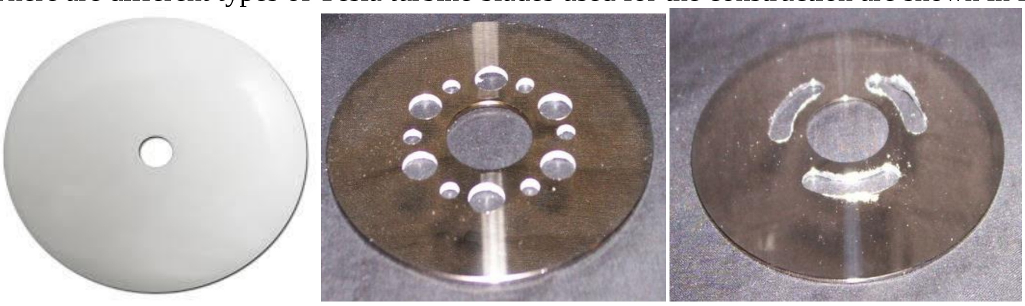


Figure 2: Construction of Tesla Turbine

There are different types of Tesla turbine blades used for the construction are shown in fig.3.



(a) (b) (c)

Figure 3: Blades (a) without holes (b) with small holes and (c) with rainbow arcs

IV. MODELLING OF TESLA TURBINE

The values of various parameters used for the construction of Tesla turbine are:

Ratio, r/b = 50
$\lambda = 815$
$R_e = 1.31 \times 10^4$

where, r = outer radius of the disc
b = spacing between two discs
λ = Laminar flow coefficient value

The design specifications for Tesla turbine powered solar refrigerator is given in Table 1.

Table 1: Design specifications

Parameters	Values
Outer radius, r_o	50 mm
Inner radius, r_i	12.5 mm
Disk spacing, δ	1 mm
No of discs, n	10
No of spacers	9
Total length	48.6 mm

V. IMPLEMENTATION OF SOLAR REFRIGERATOR

The hardware implementation of the solar charge controller was done with the help of a 12V, 12Ah lead-acid battery. The specified voltage of 12V was recorded and a current of magnitude 0.01A was recorded during the same experimentation. The solar irradiation data of Chennai based on Solar India Plan is shown in fig. 4.

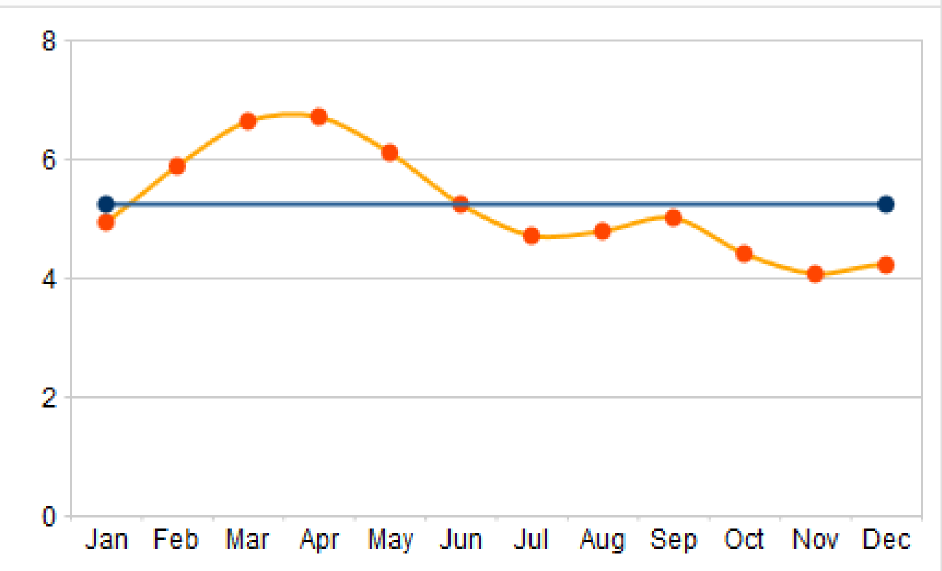


Figure 4: Solar irradiation data

Based on the above data, the solar panel and kit ratings have been deduced. The ratings are as follows

- Rating of solar panel : 200W, 24V
- Rating of Charge Controller: 20A,24V
- Rating of Battery : 60 Ah,24V (provides back up for 12 hours)
- Type of Battery : Lead acid battery

The components such as aluminium discs, spacers, collets and the stator are assembled and hence, the Tesla turbine has been fabricated for the required specifications. The Tesla turbine was tested and a maximum speed of 3156 rpm was achieved. The calculations for an on-load rpm of 800 was done and the energy calculations for the entire system is given below for a time period of one hour. And, finally it is theoretically calculated that the Tesla turbine powered solar refrigerator takes 6.5 hours to convert one kilogram of liquid water at the normal room temperature to ice of the same quantity. The temperature conversion is 298K to 273K in 6.5 hours. Fig. 5 shows the hardware implementation of the Tesla turbine powered Solar Refrigerator.

Figure 5: Prototype of the Tesla turbine powered Solar Refrigerator

Fig. 6 shows the measurement of speed of the Tesla turbine.

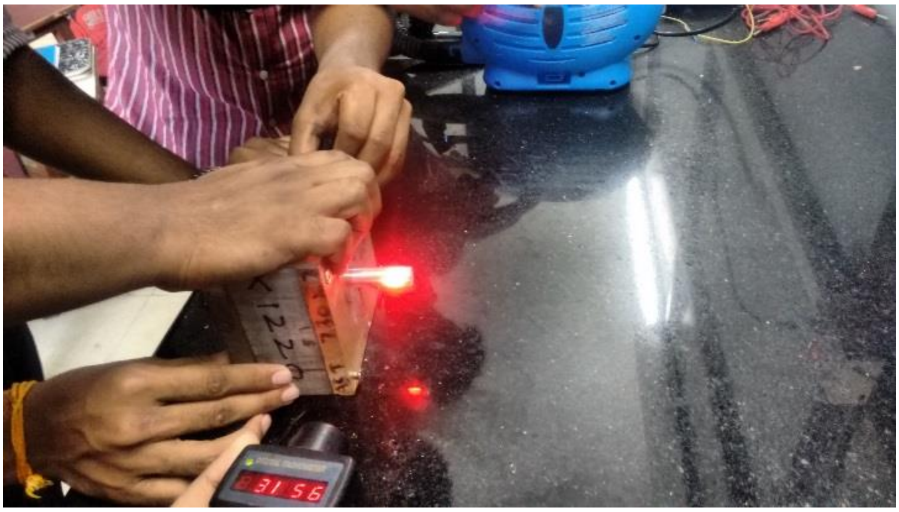


Figure 6: Measurement of speed of the Tesla turbine

VI. CONCLUSION

The refrigeration process is Eco-Friendly as solar power is non-polluting. Solar power usage does not emit any greenhouse gases or harmful waste. It provides a new opportunity for operating a refrigerator in the most economical and using an alternate source of energy. Since the turbine runs on air the noise from the refrigerator is comparatively less. This solar power is used also reduces the electric power consumption from the grid and can be used in remote, hostile and harsh terrains where construction of power lines is very difficult. The solar refrigerators can be very useful in far off remote places where there is no continuous supply of electricity Thus by using this Tesla turbine powered solar power refrigeration we can have an efficient, clean energy which goes hand-in hand with the high performance of the refrigerator.

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