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Indoor Solar Based Cooking Stove with Storage

Saurabh Satao, Harshal Shelke, Yashwant Dahibhat, HarishThokane, Parth Gawande, Pratik Maghade

UG Student, Dept. of Electrical (Electronics & Power)

Shri Sant Gajanan Maharaj College of Engineering, Shegaon, India

Abstract: *An induction cooker fed from a renewable source of energy like solar. Many people in the flourishing areas of the world struggle to cook with stoves that emit hazardous fumes and contribute to green- house gas emission; Induction cooking is derived from the principle of electromagnetic induction by inducing eddy currents in the coil that get excited in the ferromagnetic material to cause heating.Solar Powered Induction Cooker uses solar (polycrystalline pvmodule)as a source of energy. The overall setup is done in two stages, one is Dc to Dc converter stage and the other one is conversion of boosted Dc to high frequency Ac. Dc to Dc converter is required for boosting action because output from solar panel is very less. Dc to high frequency Ac conversion stage is used in order to meet the need of high frequency requirement(50KHz) in induction cooking. The output from the converter is given to an induction coil that produces the electrical energy which is converted to heat due to the resistance of the coil that cooks tahe food very quickly..*

Keywords: Solar Panel, Charge Controller, Battery, Inverter, Induction

I. INTRODUCTION

In India, for cooking purposes, Firewood, LPG, and Dung-based fuel are mainly used. Subsequently, they generate a lot of indoor pollution causing staggering damage to human health. More than 50 million people in India nevertheless use the cooking module whose effects are so detrimental. In a bid to replace this conventional methodology, and Indoor Solar Based Cooking Stove with Storage using polycrystalline pv module is proposed.An Indoor Solar Based Cooking System with Storage is an induction-based cooking system which used renewable energy i.e. solar energy for cooking. The Solar Energy is collected with the help of PV modules and further converted to electrical energy which is used for the cooking purpose. Trump Card of the system is that we can cook the food in night times and even on bad sunny days also by using Energy Storage Bank which stores the Electrical energy. Cooking using electricity is one of the cleanest and efficient method of cooking as compared to biomass and other method of cooking.

II. RELATED WORK

The vast majority of solar cells are made today of Silicon. Silicon is a semiconductor and as such, its external electrons are in an interval of energies called the valence band and they entirely fill the energy levels of this band. Above this valence band there is a forbidden band or bandgap of energies within which no electron can exist, and further above, we find the conduction band. This conduction band is almost empty of electrons but it is where valence band electrons will find accommodation, after being excited by the absorption of photons. These electrons have more energy than the ordinary electrons of the semiconductor. The electrical conductivity of the Si, as described so far, called intrinsic silicon, is exceedingly small. Slight impurification with phosphorus atoms will provide additional electrons located in the conduction band, rendering the Si n-type with a conductivity that can be engineered by modifying the density of phosphorus atoms. Alternatively, the impurification with boron or aluminium atoms renders the Si p-type , with a conductivity that can also be engineered. These impurity atoms retrieve electrons from the valence band leaving the so-called "holes" in it, that behave like virtual positive charges. Si solar cells are usually doped with boron, so behaving as a p-type semiconductor and have a narrow (~0.5 microns) superficial n-type region. Between both, the so-called p-n junction is formed in which an electric field is formed which splits electrons and holes, the electrons towards the surface and the holes towards the inside. Thus, a photocurrent is generated, which is extracted by metal contacts located on both faces. The light falling away from the p-n junction is not split and the electron-hole pairs photogenerated end

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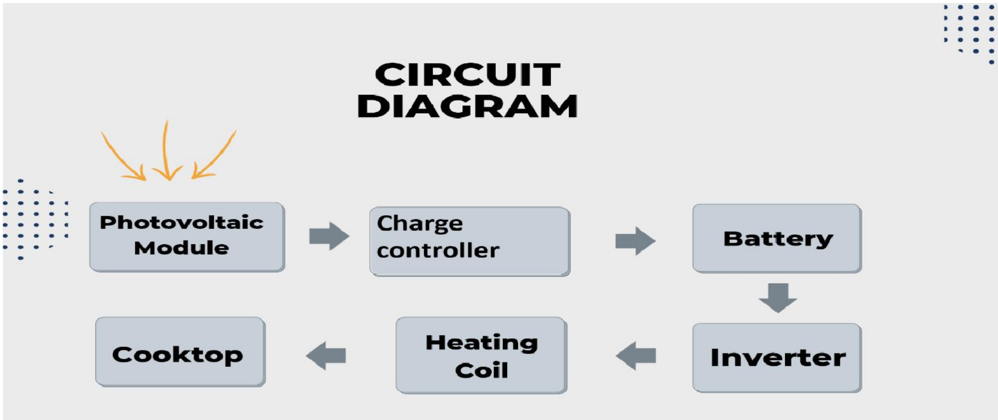
up recombining, and producing no photocurrent. The roles of the p and n regions in the cell, is here explained, can be interchanged.

III. PROPOSED METHODOLOGY



Solar cells, also called photovoltaic cells, convert the energy of light into electrical energy using the photovoltaic effect. Most of these are silicon cells, which have different conversion efficiencies.

- This power can be used directly to power devices that run on direct current (DC).
- MPPT regulates the energy from solar to the batteries.
- MPPT devices match the solar panel voltage with battery voltages to maximise charge efficiency by P= VI
- The DC output is then stored in the Energy Storage Bank (ESB).
- The electrical energy is the converted from DC to AC for further use by using Master inverter .
- The induction coil acts as the primary winding and the vessel act as the secondary winding
- As the induction coil has many turns and vessel acts as a single turn the voltage gets induced in the vessel by electromagnetic induction.
- The voltage steps down and the current increases resulting heating the vessels and the food is cooked.

3.1 Solar Modules

A solar cell (also known as a photovoltaic cell or PV cell) is defined as an electrical device that converts light energy into electrical energy through the photovoltaic effect. Individual solar cells can be combined to form modules commonly known as solar panels. Solar panels use sunlight as a source of energy to generate direct current electricity.

A photovoltaic system typically includes photovoltaic modules, an inverter, a battery pack for energy storage, charge controller, interconnection wiring, disconnect switches, voltage meters, and optionally a solar tracking mechanism.

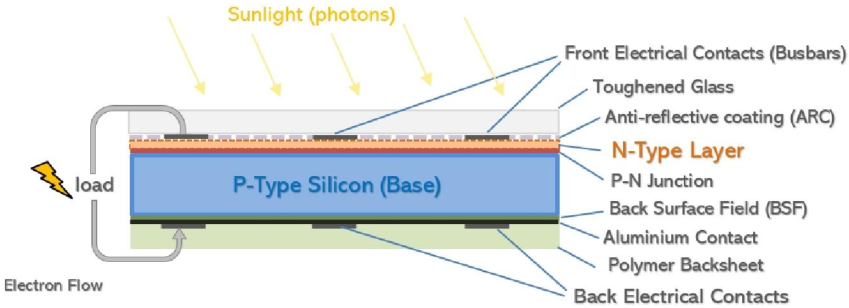
Basic Principle :

Solar cells, also called photovoltaic cells, convert the energy of light into electrical energy using the photovoltaic effect. Most of these are silicon cells, which have different conversion efficiencies and costs ranging from amorphous silicon cells (non-crystalline) to polycrystalline and mono-crystalline (single crystal) silicon types.

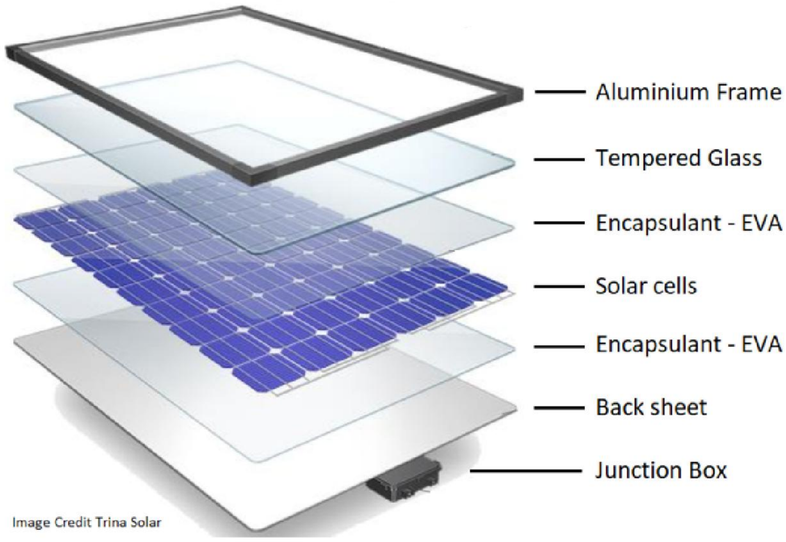
Smaller groups of cells are called solar cell panels or, more commonly, solar panels. The different types of solar panels have a variety of uses, from being placed on rooftops to replace or supplement a domestic electricity supply or to provide electric power to locations where conventional sources are unavailable or expensive to install.

3.2 Construction

A solar cell is basically a junction diode, although its construction it is little bit different from conventional p-n junction diodes. A very thin layer of n-type semiconductor is grown on a relatively thicker p-type semiconductor. We then apply a few finer electrodes on the top of the p-type semiconductor layer.



- The purpose of bus-bars in solar cells is to conduct the electric DC power generated by the cell when photons hit the cells.
- Light weight, high strength, proper corrosion properties, high surface reflectivity, excellent electrical and thermal conductivities, are such as interesting properties of aluminum that make it inseparable part of solar power systems.
- We also provide a current collecting electrode at the bottom of the p-type layer. We encapsulate the entire assembly by thin glass to protect the solar cell from any mechanical shock.
- The surface is coated with anti-reflection coating to avoid the loss of incident light energy due to reflection.
- Ethylene vinyl acetate is a thermoplastic polymer that possesses good radiation transmission and low degradability to sunlight. EVA sheet prevents air and moisture from reaching solar cells and degrading it.
- Solar EVA films protect solar panels for long time with little loss in performance.



3.3 Working Principle

- A solar cell consists of a layer of p-type silicon placed next to a layer of n-type silicon. In the n-type layer, there is an excess of electrons, and in the p-type layer, there is an excess of positively charged holes (which are vacancies due to the lack of valence electrons).
- Near the junction of the two layers, the electrons on one side of the junction (n-type layer) move into the holes on the other side of the junction (p-type layer). This creates an area around the junction, called the depletion zone, in which the electrons fill the holes .
- When all the holes are filled with electrons in the depletion zone, the p-type side of the depletion zone (where holes were initially present) now contains negatively charged ions, and the n-type side of the depletion zone (where electrons were present) now contains positively charged ions.
- The presence of these oppositely charged ions creates an internal electric field that prevents electrons in the n-type layer to fill holes in the p-type layer.

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- When sunlight strikes a solar cell, electrons in the silicon are ejected, which results in the formation of "holes"—the vacancies left behind by the escaping electrons. If this happens in the electric field, the field will move electrons to the n-type layer and holes to the p-type layer.
- If you connect the n-type and p-type layers with a metallic wire, the electrons will travel from the n-type layer to the p-type layer by crossing the depletion zone and then go through the external wire back of the n-type layer, creating a flow of electricity.
- This electric field comprises voltage and current and generates power which is governed by the equation P (power) = V (voltage) x I (current). This power can be used directly to power devices that run on direct current (DC). This power can also be converted to alternating current (AC) using an inverter.

PV MODULE

Parameters	Ideal rating	Observed
Rated power (Pmax)	315W	303.4
open circuit Voltage (Voc)	46.0V	41.0
Short Circuit Current (Isc)	8.90A	7.4
Maximum system Voltage	1000V	1000V
Module Dimension (LxWxD)	1955x990x42mm	1955x990x42mm
Module Weight	22kg	22kg

The table shows the difference between ideal rating of polycrystalline module to the observed data.

IV. RESULT

COMPONENTS

Components	Specifications	Quantity
PV module (polycrystalline)	315	2
Charge Controller	24 – 40V max	1
INVERTER	24V , 1.4KVA	1
BATTERY	12V , 75AH	2
Induction	1600w	1

These are the components that we have used in the prototype ,

Charge controller :

Electronic device, manages the power going to the battery bank from the solar panel.

WhY?

- To ensure that the deep cycle batteries are not overcharged during the day
- The power doesn't run back to the solar panels overnight and drain the batteries.

Available in two different technologies.

- PWM (Pulse Width Modulation)
- MPPT (Maximum Power Point Tracking)

PWM

- Electrical switch between batteries and panels.
- Switch can be quickly switch ON and OFF.
- Therefore, desired Voltage can be obtained to charge the batteries.
- Panel Voltage and battery voltage should be matched in PWM systems.

MPPT

- Regulates the energy from solar to the batteries.
- Solar Panel shows changeable outputs according to the weather conditions.
- MPPT device matches the solar panel voltage with battery voltage to the maximize the charge efficiency by P = VI
- The panel series are allowed to have higher voltage than batteries.
- MPPT are more efficient than PWM.

MPPT > PWM
Cost   cost

4.1 Practical Cooking Results

The solar input is connected to the system using a boost converter which supplies 24V, 14A to the half bridge circuit. Maximum power of the panel is 630W and it is impossible to draw the maximum power from the panel since the direction of the sun is changing each minute of the day,

The induction cooker was capable of heating a pot containing approximately 600ml of water to about 90°C. It observed from the practical implementation that the energy consumed to heat the water from 90°C to 100°C is higher than that used up to 90°C. This is because with an increase in temperature the faster the molecules are moving in the water. However, the speed increase is not proportional to temperature increase as evidenced by the physical manifestation of the molecule movements when water reaches boiling thusly to reach 100°C the input power would have to be drastically increased to adequately boil water. This is due to the latent heat required to convert a liquid to gas. The simulations shows eight different cooking levels in the form of load voltage, load current and pulse width modulation waveform with a dead time of 5 % to allow smooth switching. The variation of frequencies allows the cooker to have plenty of cooking levels. The above analysis indicates eight power levels but only three levels have been presented in this research paper. The output current supplied to the induction coil at various cooking levels are shown in fig. 16 to 18. The highest power is supplied to the coil at 50 KHz selection which is seen as 35 KHz in simulation. It can be observed that these current curves are similar to the simulation results.

V. CONCLUSION

In this paper solar powered induction cooking system is presented. The designed is a standalone product where by the batteries are charged from solar and grid. The grid charging is selected when the solar power is not available. The selection is done using auto switch. This makes the system environmental friendly as it is using clean free energy from sun. The cooker is also powered by the mains power to make it flexible in terms of power supplies in the case of one being not available. The simulation study and practical results are presented for various cooking levels. It can be seen that efficiency drops as the cooking level in increased. To improve the efficiency of the system at lower power levels, two half bridge inverter consisting of a class D and class DE half bridges can be used to operate at high power and low power output ranges.

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