“AN INDOOR SOLAR BASED COOKING STOVE WITH STORAGE”

A

Project Report

Submitted in the partial fulfillment of the requirements

For the Degree of

Bachelor of Engineering

In

Electrical (Electronics & Power)

By

Mr. Saurabh Satao **Mr. Harshal Shelke** **Mr. Harish Thokane**

Mr. Parth Gawande **Mr. Pratik Maghade** **Mr. Yashwant Dahibhat**

Under the guidance of

Prof. R. S. KANKALE

Dr. A. K. Damral

DEPARTMENT OF ELECTRICAL ENGINEERING

SHRI SANT GAJANAN MAHARAJ COLLEGE OF ENGINEERING

SHEGAON 444 203 M.S (INDIA)

Session: 2022 - 2023

DEPARTMENT OF ELECTRICAL ENGINEERING
SHRI SANT GAJANAN MAHARAJ COLLEGE OF ENGINEERING
SHEGAON 444 203 M.S (INDIA)

2022-23

CERTIFICATE

Certified that the project report entitled, "AN INDOOR SOLAR BASED COOKING STOVE WITH STORAGE" is a bonafied work done under my guidance by

Mr. Saurabh Satao	Mr. Harshal Shelke	Mr. Harish Thokane
Mr. Parth Gawande	Mr. Pratik Maghade	Mr. Yashwant Dahibhat

In partial fulfillment of the requirements for the award of degree of Bachelor of Engineering in Electrical (Electronics & Power).

Date: 27/05/2023

Prof. R. S. Kankale
Guide

Dr. A. K. Damral
Guide

Approved

(Dr. S. R. Paraskar)
Head
Department of Electrical Engg.

(Dr. S. B. Somani)
Principal

E-mail: principal@ssgmce.ac.in
hod_elpo@ssgmce.ac.in

Phone No. 07265-252116, 252216
Fax No. 07265-252346, 253602

ACKNOWLEDGEMENT

We first pray to our divine source of inspiration “**Shri Sant Gajanan Maharaj**” whose blessings are always with us.

We express our deep gratitude to our Respected Director **Mr. Shrikantdada Patil** for his kind blessings, encouragement and providing us such a good opportunity.

No words could be good enough to express our deep gratitude to our respected **Principal Dr. S. B. Somani** for his kind blessings, inspiration and providing us the necessary support.

We feel great pleasure in expressing our deepest sense of gratitude and sincere thanks for valuable guidance, extreme assistance and cooperation extended to us by our **Guide Prof. R. S. Kankale** in preceding the completion of the project.

We are equally indebted to **Dr. S. R. Paraskar (Head, ElectricalEngineering Department)** for extending necessary help, providing facilities and time-to-time valuable guidance. We are especially thankful to Dr. S. S. Jadhao & Dr. A. K. Damral for their valuable suggestions and inspiration time to time.

This acknowledgement would be incomplete without expressing our special thanks to Prof. G. N. Bonde and Prof. P. R. Bharambe for their support during the work.

Last but not least, we would like to thanks all the teaching, non-teaching staff members of the Electrical Engineering Department, our family members and colleagues those who helped us directly or indirectly for completing this task successfully.

1) Saurabh Satao
2) Harshal Shelke
3) Harish Thokane
4) Parth Gawande
5) Pratik Maghade
6) Yashwant Dahibhat

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 PV Module) 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 the food very quickly.

CONTENTS

CHAPTER: 1
INTRODUCTION

CHAPTER 1

1.1. BACKGROUND:

Indoor solar-based cooking stoves with storage are an innovative technology that is gaining popularity in many parts of the world. These stoves use solar energy to generate heat for cooking, which makes them an eco-friendly and cost-effective alternative to traditional cooking stoves that run on fossil fuels.
Indoor solar-based cooking stoves work by harnessing the energy from the sun to heat up the stove, which can then be used for cooking. These stoves are designed to be compact and lightweight, making them ideal for indoor use.

One of the key advantages of indoor solar-based cooking stoves is that they can store solar energy for later use. This means that even on days when the sun is not shining, the stove can still be used for cooking. The storage capacity of these stoves can vary, with some models able to store enough energy for several hours of cooking.

Another advantage of indoor solar-based cooking stoves is that they are very easy to use. Once the battery has been charged with solar energy, it can be used just like any other cooking stove. There is no need for any special training or expertise, making these stoves ideal for use in rural areas where traditional cooking methods are still prevalent.

Indoor solar-based cooking stoves also have several environmental benefits. Because they run on solar energy, they do not produce any harmful emissions or pollutants, making them a clean and eco-friendly alternative to traditional cooking stoves that burn fossil fuels. This can have a significant impact on the environment, particularly in areas where there is a high level of indoor air pollution.

In addition to their environmental benefits, indoor solar-based cooking stoves can also have a significant impact on people's lives. In many developing countries, the use of traditional cooking stoves is a major contributor to respiratory diseases, particularly among women and children who spend a lot of time in the kitchen. By providing a clean and sustainable cooking solution, indoor solar-based cooking stoves can help to improve people's health and quality of life.

Overall, indoor solar-based cooking stoves with storage have the potential to be a game-changer in the fight against indoor air pollution and climate change. By providing a clean, sustainable, and cost-effective cooking solution, these stoves can help to improve people's health, reduce greenhouse gas emissions, and promote sustainable development. While there are still some challenges to overcome, the future looks bright for this innovative technology.

1.2. PROBLEM STATEMENT:

Indoor cooking is an essential part of daily life in many households worldwide. In rural areas, the primary source of energy for cooking is still traditional biomass such as wood, crop residues, and animal dung. The use of these fuels is detrimental to the environment and human health, as it leads to deforestation, air pollution, and respiratory diseases. In urban areas, the situation is not much better, as many households use fossil fuels such as LPG or electricity for cooking, leading to high energy bills and greenhouse gas emissions. The use of solar energy for cooking has the potential to mitigate these issues, but the technology has not yet gained widespread acceptance due to various challenges. Solar-based cooking stoves provide an alternative that is clean, efficient, and sustainable. The addition of storage to the solar-based cooking stove can ensure that cooking can continue even after the sunset.

1.3. LITERATURE SURVEY:

1] **"Environmental sustainability of cooking fuels in remote communities: Life cycle and local impacts" by Aberilla, J.M., Gallego-Schmid, A., Stamford, L., and Azapagic**

Aberilla discusses the environmental sustainability of cooking fuels used in remote communities and the associated life cycle and local impacts. The authors analyze the environmental impacts of different cooking fuels, including liquefied petroleum gas (LPG), kerosene, biomass, and electricity, in terms of their greenhouse gas emissions, human health impacts, and resource depletion.

Gallego-Schmid's study finds that LPG and electricity are the most environmentally sustainable cooking fuels for remote communities, while kerosene and biomass have significant negative impacts on the environment and human health. The authors also highlight the importance of considering local impacts, such as deforestation, land use change, and indoor air pollution, when assessing the environmental sustainability of cooking fuels in remote communities.

2] Hager, T.J.; Morawicki, R. Energy consumption during cooking in the residential sector of developed nations: A review. Food Policy 2013, 40, 54–63

Hager provides a comprehensive review of the energy consumption associated with cooking in residential settings in developed nations. The authors examine the different types of cooking technologies and fuels used in households, including gas, electric, and wood-fired stoves and ovens. They also analyze the factors that influence energy consumption during cooking, such as cooking habits, cooking times, and the size and efficiency of appliances.

Morawicki's review finds that cooking is a significant source of energy consumption in households, accounting for 4-15% of total household energy use in developed nations. The study also highlights the importance of considering the entire life cycle of cooking appliances, from production and transportation to disposal, when assessing their environmental impacts.

In addition, the article highlights the potential benefits of using renewable energy sources for cooking, such as solar and wind power. The authors suggest that integrating renewable energy technologies with cooking appliances can reduce the reliance on fossil fuels and mitigate the environmental impacts associated with cooking.

The review also discusses the social and cultural factors that influence cooking habits and energy consumption in households. For example, the authors note that traditional cooking practices, such as using wood-fired stoves, may have cultural and social significance and may be resistant to change. They suggest that interventions promoting energy-efficient cooking should take into account these social and cultural factors to be effective.

Overall, the article emphasizes the need for more energy-efficient cooking technologies and practices in households to reduce energy consumption and promote environmental sustainability. The authors suggest that policies and programs promoting energy-efficient cooking, such as labeling schemes and subsidies for energy-efficient appliances, can help promote more sustainable cooking practices in the residential sector of developed nations.

3] Cerri, Graziano, et al. "Rigorous electromagnetic analysis of domestic induction heating appliances." PIERS Online 5.5 (2009): 491-495.

According to Cerri and Graziano, analytical electromagnetic of domestic induction heating system is presented about engineering principle of magnetic coupling between the system and the effect of it in the system operation together with looking at the mathematical calculations of the circulating currents and the contribution of it in the system load together with its amplitude to give rise to heating efficiency. The method and the approach used in the paper is similar lies within what is presented in all the literatures about induction cooking system. The paper touches important aspects, pot (load), coil and how the coupling affects the efficiency of the output power. The analysis is looking at the voltage and impedance matrixes and how these can give values of current and impedance in order to analyze induction system operation. The number of tests is performed in an experiment. The contribution comes with fact of getting to know how electric and magnetic currents describe the equation of potential balance of the system and how electric field and magnetic field can used to get self and mutual coefficients. The paper leaves a big gap in how the switching frequency is controlled, what method of switching is use either zero current switching or zero voltage switching, how the study can contribute to the community, only relies on one power source, no simulation study presented, et c. The study need to improve by addressing all above in order to promote research that will show how the study can be taken into practise to help our communities in the problems they facing. Taking note of the existing gap in the paper, induction cooking is now in the market and it efficiency, cleanness and safety is putting it as a number one stove compared to the ones existed long ago. Now the focus is to how the induction cooker in the market can be utilised in a more sustainable way by addressing the issues facing the country in taking renewable energy into practice as a DoE sustainability development. The study will design and build a portable solar powered induction cooking system that uses auto-switching method to make it flexible in terms of power sources by allowing it to be used either by solar or mains and it also present a battery storage that can be charged by both the power supplies, of which makes it a complete standalone which can be run without both power sources being available.

4] Bhavana Ffion, Faseen.K., and Hema Mohan, “Solar Based Induction Cook Top”, 3rd Int. Conf. on Electronics, Biomedical Engineering and its Applications (ICEBEA'2013) April 29-30, 2013, Singapore

Bhavana Ffion discusses about the solar powered induction cooking system. Each stage from solar panel, control circuit, battery, inverter and cook top is presented in details. The microcontroller and the LCD (liquid crystal display) for cooking level indications and control. The aim together with its conclusion was to implement a solar-based system with the idea of looking at the feasibility and advantage of using solar rather than electric or gas supply. The study proved that the installation can be costly but after 5 years, the user will be saving a large amount of Rs 12000. Hema Mohan’s study is in line with the goal of the sustainable development but lacking some advancement. The study did not consider the fact that the most of the country is currently running of Eskom electricity with the lack of renewable based capacity of which means it was going to be perfect if it considered the auto switching between the mains and the solar and introduce more power levels as to meet the user needs for different cooking stages. The idea of the paper was to compare the price savings that comes with the induction cooker compared to the gas and electric stoves. The study can be more improved if it can look at the real problem that is facing the country in terms electricity point of view.

5] Chun-Liang, H., 2007, July. “Circuits analysis of inductive heating-device with half-bridge resonated inverter.” In 11th WSEAS Int. Conf. Circuits (pp. 26-30).

Chun-Liang presents the circuit analysis and simulations of the inverter shows the eight function models of the circuit structure. The phenomenon of the skin effect plays a role in the analysis of the circuit. The study also look at the two factors that resulted in the temperature of the coil i.e. loss during current flow in the coil and the heat produced by the pot during operation. The paper focuses on the circuit analysis by looking into detail how the current flows in the circuit and how the same output current can be achieved using different material of heating coils of which is more of experimenting the theory learn in class rather using the theory into real life application by addressing major issues in the country into real problem solving. The study does not look into how the study can be utilised to solve the current cooking technology to it best. The paper is having great information that assisted the current study that I am doing. The information for circuit analysis and how many factors affect the operation of the inverter topology. The study can be improved by taking the theory and simulations that were performed into practice by looking at the existing gaps in research environment to address real life issues faced by the country.

6] Sweeney, Micah, et al. "Induction Cooking Technology Design and Assessment." Small 5 (2014): 800.

Sweeney presented the induction cooking assessment paper discusses about the comparison between the induction cookers, electric heating element stove and finally the gas burners. The cooking efficiency ranges from 80 to about more than 90 % for the induction hob and about 50 to 74 % in electric stoves and lastly about 40 % in gas burners. The DoE after all the tests saw that induction cooking technology reduces the energy saving about 45 % compared to conventional electric stove. This paper gives this thesis a go ahead and encouragement that the proposed solution of which addresses the efficiency improvement as discussed compared to the other cooking technologies, secondly addresses the issue of renewable based appliances as the country is aiming for the 42 % renewable based capacity by 2030.

7] Anis, Priya, et al. “Customer’s Attitude and Satisfaction of Induction (cook-tops) stove in Tirunveli City.” IRACST 5.1 (2016): 2319-2828

Anis and Priya studied that s the number of different induction cooking stoves since every company is marketing their cooktops with more performance and features. The preference and attitude is being investigated towards induction stove. The paper presents the advantages and disadvantages of advantages overcome the bad view of it. The level of satisfaction is about 80 % compared to the ones being dissatisfied. The relevance of the study with the current study comes with the fact that people are willing to invest in the induction cooking environment of which promotes the study in terms understanding the customer’s attitude and satisfaction amongst the induction cooking technology that is presented in this research. The research takes this advantage and adds more features that will be in line with the country’s goal for the sustainable development in the renewable energy sector. The journal does not focus in the power sources or in how the cooker is being powered but only look at the features like efficiency, safety, savings and etc.

8] Title: "Eddy Currents: Fundamentals and Applications" Authors: David Jiles Journal: Materials Science and Engineering: B Year: 2001

The paper by David Jiles titled "Eddy Currents: Fundamentals and Applications" provides a comprehensive overview of eddy currents, covering their fundamental principles, mathematical modeling, and applications in various fields. The paper begins by introducing the concept of eddy currents and their generation in conductors due to a time-varying magnetic field. It then discusses the effects of various factors that influence the behavior of eddy currents, including the conductivity and permeability of the conductor, the excitation frequency and waveform, and the geometry and boundary conditions.

The paper then goes on to explore the applications of eddy currents in various fields, including non-destructive testing, electromagnetic braking, and energy conversion. In non-destructive testing, eddy current testing is used to detect surface and subsurface defects in conductive materials. In electromagnetic braking, eddy currents are generated in a metal disk or rotor, producing a magnetic field that interacts with a stator to slow down or stop the rotation of the disk. In energy conversion, eddy currents can be harnessed to generate electric power from mechanical motion or heat.

The paper also reviews various experimental techniques for measuring and visualizing eddy currents, such as eddy current testing, magnetic imaging, and electromagnetic simulation. These techniques allow researchers and engineers to better understand the behavior of eddy currents and optimize their applications.

Overall, the paper provides a comprehensive overview of eddy currents, their fundamental principles, and their applications in various fields. The information presented in the paper can be useful for researchers and engineers working in the fields of materials science, electrical engineering, and physics.

9] **"Integration of Solar Energy and Battery Energy Storage System for Residential Applications" by T. Khatib et al., in IEEE Transactions on Sustainable Energy, 2018.**

In this paper, the T. Khatib present a design and analysis of a solar energy and battery energy storage system for residential applications. The paper begins with an overview of the various solar PV system components, including solar panels, inverters, and batteries, and their roles in the system.

The authors then describe the design of the proposed system, which consists of a solar PV array, a battery energy storage system, and a power electronics interface. They discuss the sizing and selection of the different components, as well as the control strategy used to optimize the performance of the system.

The paper also includes a detailed analysis of the system performance under different scenarios, such as varying solar irradiance and load demand. The authors use simulation results to demonstrate the effectiveness of the proposed system in terms of energy savings, peak demand reduction, and grid independence.

Overall, this paper provides a valuable contribution to the design and optimization of solar energy and battery energy storage systems for residential applications. It demonstrates the potential of such systems to improve energy efficiency, reduce peak demand, and enhance the reliability and resiliency of the power supply.

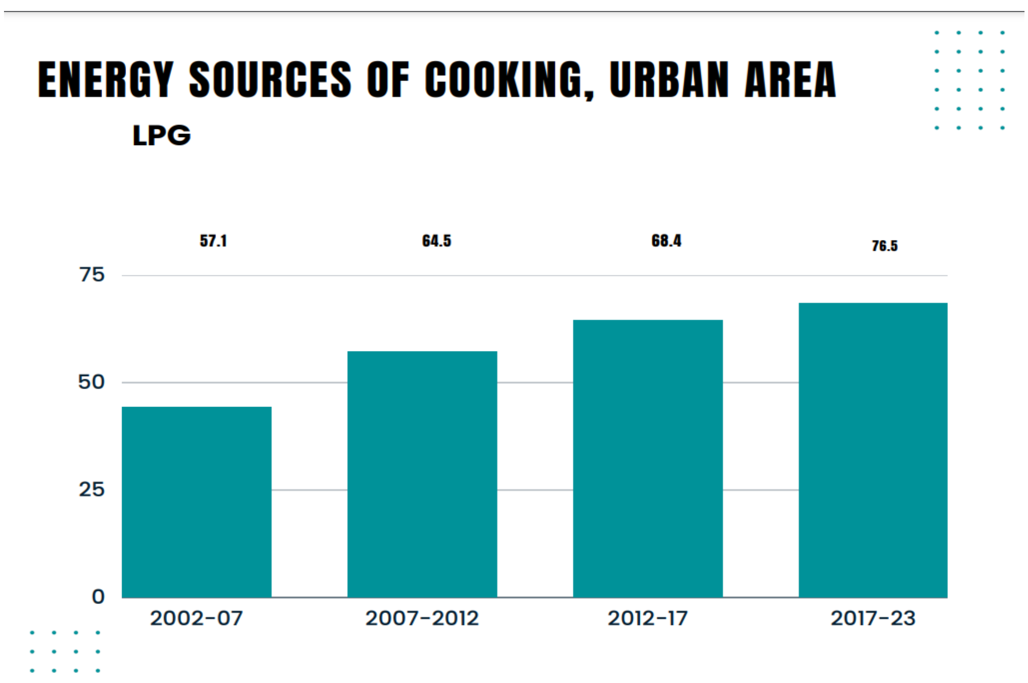

Table 1

- The use of liquefied petroleum gas (LPG) for cooking in Urban areas has increased from 29.6% to 68.4% of households during the period 1995-2000 to 2015-2020, has increased nearly 3 times.

- Poorer states use firewood, richer states LPG
- As of 2011, around 95% of households in urban areas in India use LPG as their primary cooking fuel, according to the Ministry of Petroleum and Natural Gas. The average consumption of LPG per household in urban areas in India is around 6-7 cylinders per year, according to the Ministry of Petroleum and Natural Gas

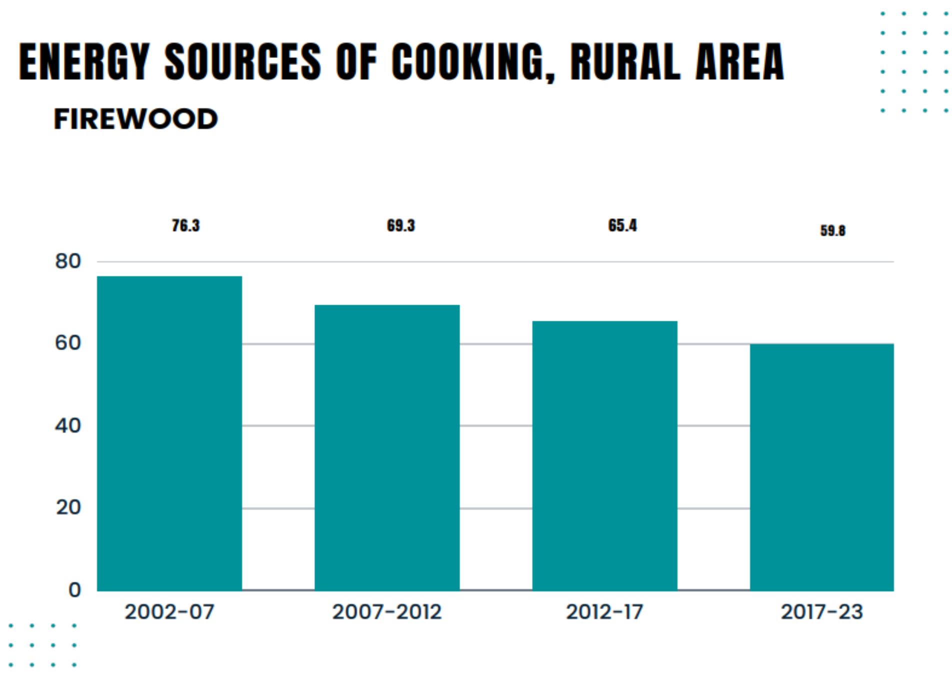

Table 2

According to the Census 2011, around 68% of rural households in India used biomass as their primary source of cooking fuel, while in urban areas, around 22% of households used biomass which includes wood-based fuels like firewood, wood chips, and sawdust.

It's worth noting that while biomass includes wood-based fuels, it also includes other types of organic matter like cow dung, crop residue, and charcoal.

The National Sample Survey (NSS) data from 2017-18 shows that among households using biomass as their primary source of cooking fuel, around 39%

used firewood and wood chips, while the rest used other types of biomass like crop residue, dung cakes, and charcoal.

The use of bad cooking fuels, such as solid fuels like wood, charcoal, and dung, can lead to indoor air pollution, which has been linked to various health problems, including respiratory diseases, heart disease, stroke, and lung cancer. According to the World Health Organization (WHO), exposure to indoor air pollution was responsible for an estimated 4.2 million deaths worldwide in 2016.

In India, the use of solid fuels for cooking is still prevalent, particularly in rural areas, and is estimated to be responsible for a significant burden of disease. A study published in The Lancet Planetary Health in 2018 estimated that household air pollution in India was responsible for around 1.24 million premature deaths and 81 million disability-adjusted life-years (DALYs) lost in 2017. While not all of these deaths can be attributed to the use of bad cooking fuels, it is a significant contributing factor.

Indoor air pollution is a significant health concern, it is often one of many risk factors contributing to disease, making it challenging to attribute deaths to a single cause.

In addition to the use of solid fuels, there are other hazardous cooking methods used in India, which include:

Stove type: Traditional stoves used in India for cooking are often poorly designed and inefficient, leading to incomplete combustion of the fuel, which results in the emission of high levels of pollutants like particulate matter, carbon monoxide, and nitrogen oxides.

Cooking practices: Some cooking practices, such as open cooking with uncontrolled flames, can also result in the emission of high levels of pollutants. For example, frying and roasting of food can produce high levels of particulate matter and other harmful gases.

Lack of ventilation: Poor ventilation in kitchens can exacerbate indoor air pollution, as pollutants from cooking can accumulate in the indoor environment.

Lack of awareness: Lack of awareness among people regarding the health hazards of using solid fuels and other hazardous cooking practices is also a significant problem in India.

1.4. AIM:

Design and development of indoor solar based cooking stove with storage.

1.5. Objective:

The objectives of indoor solar-based cooking stoves with storage are to provide a sustainable and efficient solution to cooking using renewable solar energy, while also improving the health, well-being, and economic status of individuals and communities.

Some specific objectives of these stoves are:

1. To reduce the use of traditional fuels such as wood or charcoal for cooking, which can cause deforestation, indoor air pollution, and health problems.
2. To promote the use of renewable solar energy for cooking, which is a sustainable and clean energy solution.
3. To provide a reliable and sustainable source of energy for cooking, even in areas with limited access to electricity.
4. To improve the health and well-being of individuals and communities by reducing indoor air pollution, which can cause respiratory problems.
5. To reduce household expenses by providing a cost-effective alternative to traditional fuels.
6. To promote the use of energy-efficient technologies, such as to maximize the use of solar energy.
7. To reduce greenhouse gas emissions and mitigate the impacts of climate change by promoting the use of renewable energy.
8. To save the Fossils and conventional energy sources up to a mark.

9. To make Human Life easier and contribute towards the development.

Overall, the objective of indoor solar-based cooking stoves with storage is to promote sustainable and clean energy solutions for cooking, while also improving the health, well-being, and economic status of individuals and communities.

CHAPTER: 2
INDUCTION COOKING

CHAPTER 2

INDUCTION COOKING

Induction cooking is a modern and efficient method of cooking that utilizes the principles of electromagnetic induction to heat up cookware. Induction cooktops are becoming increasingly popular due to their fast-heating times, precise temperature control, and energy efficiency. In this article, we will delve deeper into the theory behind induction cooking and explore its technical aspects.

Principles of Electromagnetic Induction:
Electromagnetic induction is a phenomenon that occurs when a changing magnetic field induces an electric current in a conductor. This principle was first discovered by Michael Faraday in the 19^{th} century and forms the basis of many electrical devices, including electric motors and generators.

In the case of induction cooking, an alternating current (AC) is passed through a copper coil located beneath a ceramic or glass cooktop. This current generates an oscillating magnetic field that passes through the cooktop and induces an electric current in the ferromagnetic cookware placed on top of it. This electric current generates heat within the cookware, which in turn heats up the food.

The cookware used in induction cooking must be made of a ferromagnetic material, such as cast iron or stainless steel. Non-ferromagnetic materials, such as aluminum or copper, do not generate sufficient eddy currents to produce heat and cannot be used with induction cooktops.

Construction of Induction Cooktops:

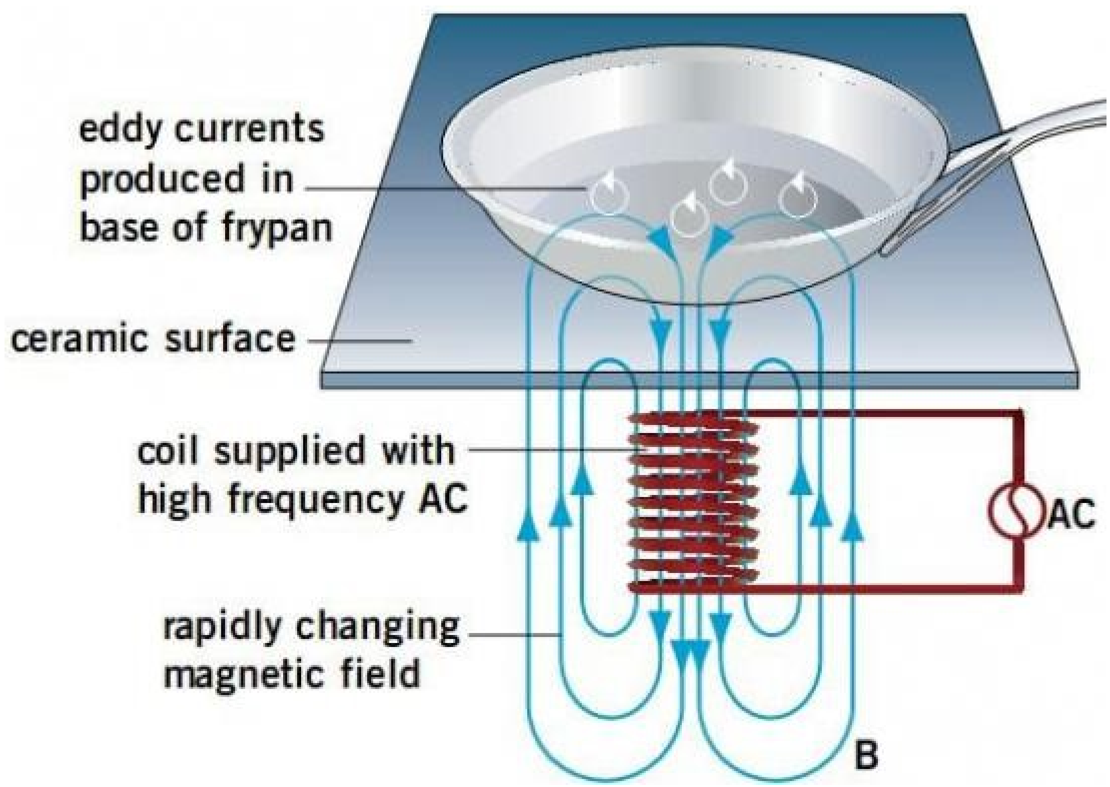

Figure 1. Construction of induction cooktop

Induction cooktops consist of several components, including the power supply, the control circuitry, and the cooking surface. The power supply converts the alternating current (AC) from the electrical outlet into a direct current (DC) that is used to power the control circuitry and the induction coil. The control circuitry regulates the power to the coil, allowing the cooktop to be adjusted to different heat settings. The cooking surface is typically made of glass-ceramic material and contains the induction coil and associated circuitry.

Heating Mechanism:

The heating mechanism of induction cooking is based on the principles of eddy currents and hysteresis losses. When the magnetic field generated by the coil passes through the cookware, it induces eddy currents in the metal. These eddy currents generate heat due to the resistance of the metal. The heat generated by the eddy currents is transferred to the food in the cookware.

Hysteresis losses also contribute to the heating mechanism of induction cooking. Hysteresis losses occur when the magnetic field alternates rapidly, causing the magnetization of the ferromagnetic material in the cookware to constantly reverse direction. This constant reversal of magnetization generates friction within the metal, which generates heat.

Control Mechanism:

Induction cooktops offer precise temperature control due to their ability to rapidly adjust the strength of the magnetic field generated by the coil. This is achieved through a control mechanism that regulates the frequency and intensity of the alternating current passing through the coil.

The frequency of the alternating current determines the depth of the magnetic field and therefore the maximum thickness of the cookware that can be used. Most induction cooktops operate at a frequency of 20-40 kHz, which can penetrate up to 10mm into the cookware.

The intensity of the magnetic field determines the amount of heat generated within the cookware. This is controlled by varying the amplitude of the alternating current passing through the coil.

Characteristics of Induction Cooking:

Induction cooking has several characteristics that distinguish it from traditional cooking methods. Firstly, induction cooking is very fast and efficient, as the heat is generated directly in the cookware rather than being transferred through a heating element or flame. This means that induction cooktops can heat up and cool down very quickly, and the heat can be precisely controlled. Secondly, induction cooking is very safe, as there is no open flame or exposed heating element. The cookware itself becomes the heating element, and the cooking surface remains cool to the touch. Finally, induction cooking is very energy-efficient, as it uses only the energy necessary to heat the cookware and its contents, rather than wasting heat by heating up the surrounding air.

Advantages of Induction Cooking:

Induction cooking offers several advantages over traditional gas or electric cooktops. These include:

1. Energy efficiency: Induction cooktops are up to 90% efficient, compared to gas or electric cooktops which are typically only 50-60% efficient.

2. Precise temperature control: Induction cooktops offer precise temperature control and can rapidly adjust the heat output.

3. Safety: Induction cooktops do not produce an open flame, making them safer to use. They also have built-in safety features that automatically shut off the cooktop if no cookware is detected or if the cookware is removed during cooking.

4. Fast heating times: Induction cooktops heat up cookware much faster than gas or electric cooktops, reducing cooking times.

CHAPTER: 3
SOLAR PV SYSTEM

CHAPTER 3

SOLAR PV SYSTEM

3.1. INTRODUCTION:

- 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

3.2. 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.

3.3. 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.

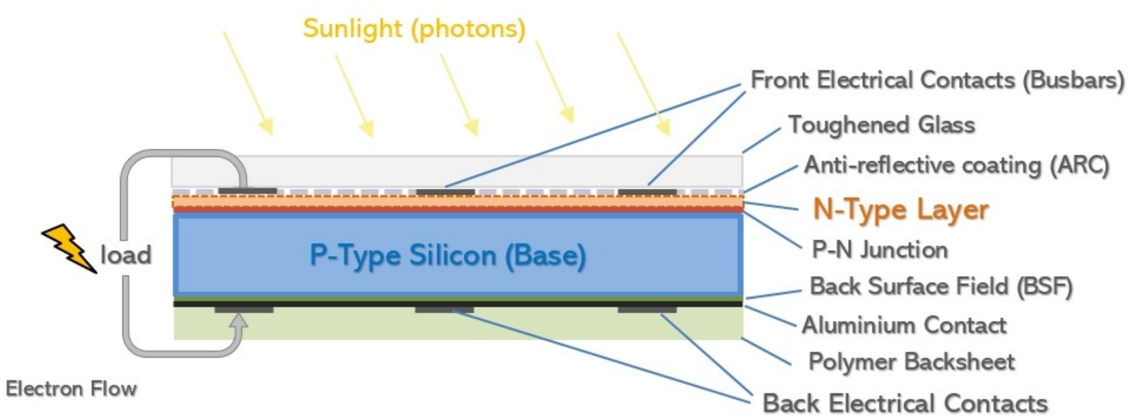

Figure 2. Working of PV Module

- 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.

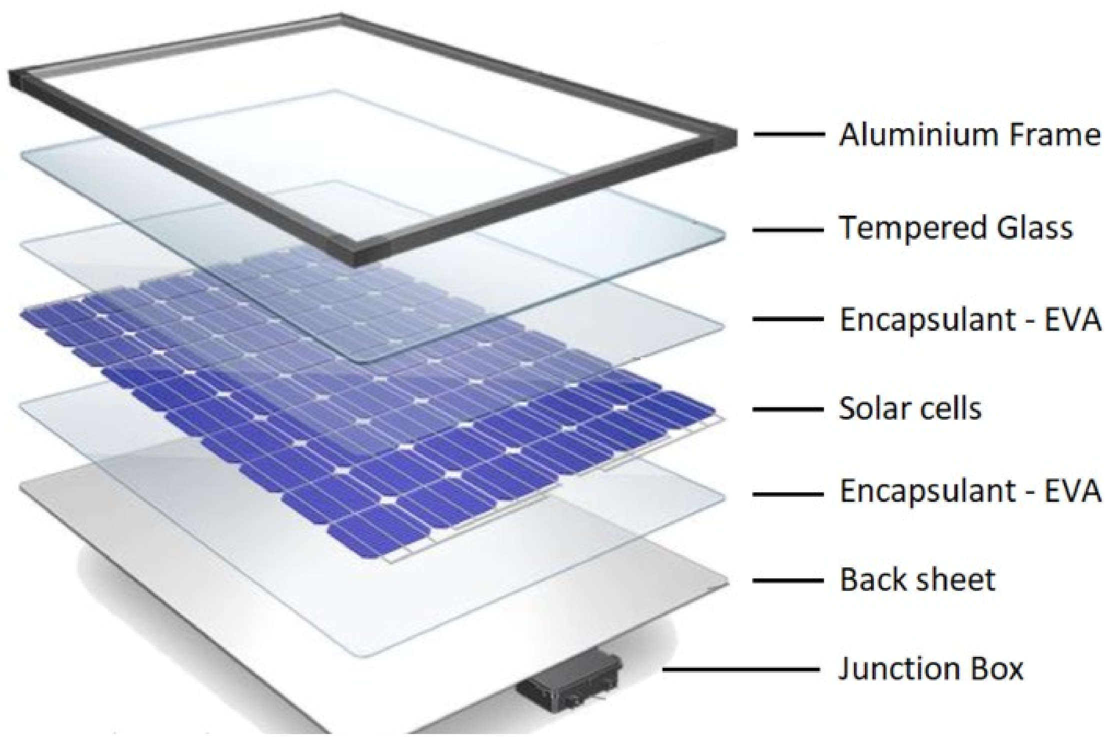

Figure 3. Construction of PV Module

3.4. 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.
- 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.

3.5. TYPES:

Solar cells can be broadly classified into different types depending upon their construction.

Monocrystalline:

A mono-crystalline solar panel is a solar panel comprising monocrystalline solar cells. The panel derives its name from a cylindrical silicon ingot grown from single-crystal silicon of high purity in the same way as a semiconductor. As the cell is constituted of a single crystal, it provides the electrons more space to move for a better electricity flow. Usually, a monocrystalline panel will contain either 60 or 72 solar cells, depending on the size of the panel. Most residential installations use 60-cell monocrystalline_silicon panels.

Monocrystalline solar panels usually have the highest efficiency and power capacity out of all types of solar panels. Monocrystalline panel efficiencies can range from 17% to 20%

Advantages:

They require less space compared to other types due to their high efficiency.

Manufacturers state that this form of solar cell lasts the longest, with most giving them a 25-year warranty.

These panels exhibit greater heat resistance.

They perform better in low levels of sunlight, making them ideal for cloudy areas.

Disadvantages:

The performance levels tend to suffer from an increase in temperature. However, it is a small loss when compared to other forms of solar cell.

There is a lot of waste material when the silicon is cut during manufacture.

Polycrystalline:

Polycrystalline or Multicrystalline solar panels are solar panels that consist of several crystals of silicon in a single PV cell. Several fragments of silicon are melted together to form the wafers of polycrystalline solar panels. These solar panels have a surface that looks like a mosaic. They have a square shape and a shining blue hue as they are made up of several polycrystalline silicon. As there are multiple silicon crystals in each cell, polycrystalline panels allow little movement of electrons inside the cells. These solar panels absorb energy from the sun and convert it into electricity.

Advantages:

Polycrystalline solar panel price is more affordable than monocrystalline panels due to being easier to make and using multiple silicon cells.

The amount of waste is less on the polycrystalline panel because of the way the silicon wafers are applied to the panel.

They can be used with batteries and inverter technology.

The manufacturing process requires very few fossil fuels.

Disadvantages:

- The efficiency of polycrystalline-based solar panels is less than Monocrystalline solar panels because of the lower silicon purity.
- Although the difference is getting smaller all the time, you generally need to cover a slightly larger area to output the same electrical power with polycrystalline solar panels as you would with the best monocrystalline solar panels.
- They may not last as long.
- They damage easily when exposed to high temperatures.

Bifacial:

Bifacial solar modules offer many advantages over traditional solar panels. Power can be produced from both sides of a bifacial module, increasing total energy generation. They're often more durable because both sides are UV resistant, and potential-induced degradation (PID) concerns are reduced when the bifacial module is frameless.

Advantages:

- Increased Efficiency. As bifacial modules can produce powers from both sides of the panel, there is an overall increase in energy generation.
- More Durable.
- Aesthetically Pleasing.
- Works Well in Diffuse Light.
- Reduce PID.
- Longer Warranties.

Disadvantages:

- Bifacial solar panels can cost up to 10% more than monofacial solar panels .
- Installation Costs due to manufacturing process.
- Heavier

Multijunction Soar Cell (MJ):

- It is made up of different semiconductor materials. Each materials's p-n junction will produce electric current in response to different wavelengths of light.
- Use of multiple semiconducting materials allows the absorbance of broader range of wavelengths, improving the cell's sunlight to electrical energy conversion efficiency.
- The efficiency we get is 43%.

Quantum Dot Solar Cell:

- This cell uses quantum dots as the absorbing photovoltaic material and the quantum dots have bandgaps that are tunable across a wide range of energy levels by changing the dots' size.
- The drawback is that the efficiency is very low.

Polymer Solar Cell:

- Another name for polymer solar cell is plastic solar cell
- The principle is the transformation of the energy in the form of electromagnetic radiation into electrical energy that is physical phenomenon called photovoltaic effect.
- Drawbacks - Life is very low
- Efficiency is only 10%

CHAPTER: 4

BLOCK DIAGRAM OF PROPOSED WORK

CHAPTER 4

BLOCK DIAGRAM OF PROPOSED WORK

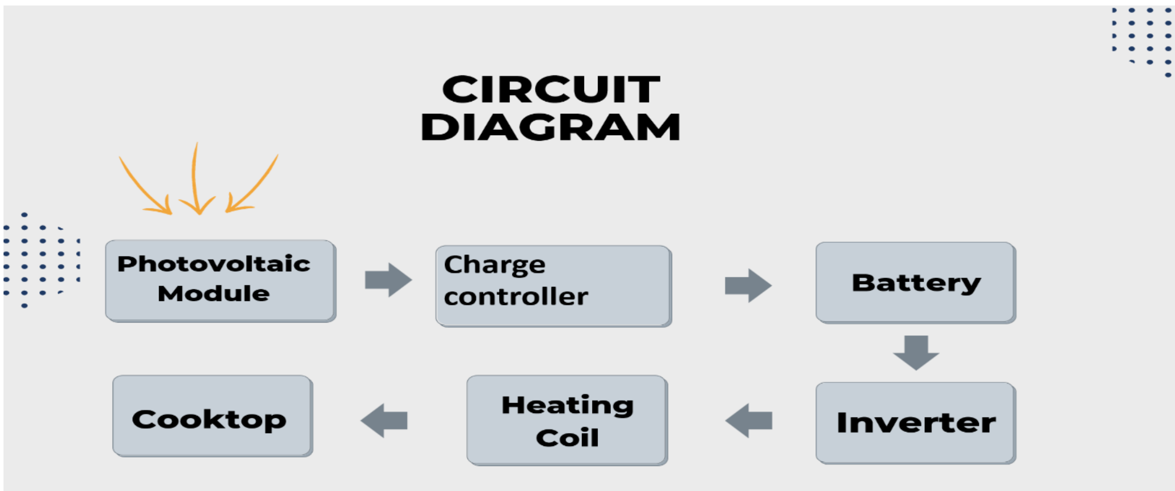

Figure 4. Circuit Diagram

- 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.

CHAPTER: 5

SYSTEM COMPONENTS

CHAPTER 5

SYSTEM COMPONENTS

5.1. SOLAR PV MODULE:

Figure 5. Solar Panel

Polycrystalline solar cells are a popular type of photovoltaic (PV) cell used in solar panels to convert sunlight into electrical energy. They are made up of multiple small silicon crystals, unlike monocrystalline solar cells which are made from a single crystal.

The manufacturing process of polycrystalline cells begins with melting multiple silicon fragments together to form a single ingot. This ingot is then sliced into thin wafers which are used as the basis for solar cells. The process of melting and slicing the silicon creates small imperfections in the crystals, which are visible as a textured, speckled surface. These imperfections can cause light to scatter, reducing the overall efficiency of the cell.

Polycrystalline solar cells are cheaper to produce than their monocrystalline counterparts because the process of melting and slicing the silicon is less expensive than the process of growing a single crystal. This makes them a popular choice for residential and commercial solar installations where cost is a significant factor.

However, the efficiency of polycrystalline solar cells is typically lower than monocrystalline cells. This is because the multiple small crystals within the cell create more defects and impurities in the silicon, which reduces the cell's ability to convert sunlight into electricity. In addition, the textured surface of polycrystalline cells can cause light to scatter and be lost, further reducing efficiency.

Despite these limitations, polycrystalline solar cells are still a popular choice for many solar installations due to their lower cost and good overall performance. They are particularly well-suited for installations where space is not a limiting factor, such as on a rooftop or in a large solar farm.

In recent years, manufacturers have been able to improve the efficiency of polycrystalline solar cells through a variety of methods. For example, they have been able to reduce the size of the crystals in the cell, which reduces the number of defects and impurities. They have also developed new texturing techniques to minimize light scattering and increase efficiency.

In terms of environmental impact, polycrystalline solar cells are a relatively low-impact technology. They do require energy and resources to manufacture, but they generate clean, renewable energy without producing greenhouse gas emissions or other pollutants. They also have a long lifespan and can be recycled at the end of their useful life, further reducing their environmental impact.

Overall, polycrystalline solar cells are a cost-effective and reliable technology for generating renewable energy. While they may not be as efficient as monocrystalline cells, they are still a popular choice for many solar installations due to their lower cost and good overall performance. With continued innovation and development, polycrystalline solar cells are likely to play an important role in our transition to a clean energy future.

5.2. CHARGE CONTROLLER:

PWM is commonly used in solar panel systems to regulate the power delivered to the battery. A solar panel generates direct current (DC) voltage, which can be used to charge a battery. However, the voltage and current output of the solar panel varies depending on the level of sunlight and temperature. To ensure that the battery is charged safely and efficiently, a charge controller is used. A charge controller is an electronic device that regulates the power delivered to the battery. A PWM charge controller uses a PWM signal to regulate the power delivered to the battery. The PWM signal is generated by a microcontroller, which adjusts the duty cycle of the PWM signal based on the battery voltage and current. The PWM signal is used to control the power delivered to the battery by turning a transistor switch on and off. When the PWM signal is high, the transistor switch is turned on, and the solar panel delivers full power to the battery. When the PWM signal is low, the transistor switch is turned off, and the solar panel delivers no power to the battery. By adjusting the duty cycle of the PWM signal, the average power delivered to the battery can be varied, and hence the battery can be charged safely and efficiently. A PWM charge controller can also protect the battery from overcharging, which can damage the battery and reduce its lifespan. In addition to PWM charge controllers, there are other types of charge controllers, such as Maximum Power Point Tracking (MPPT) charge controllers, which use a different method to regulate the power delivered to the battery. MPPT charge controllers can be more expensive than PWM charge controllers, but they offer higher efficiency and can extract more power from the solar panel in low light conditions.

In a solar panel system, the charge controller plays an important role in regulating the power delivered to the battery. The charge controller must maintain the battery voltage at a safe and optimal level, which can vary depending on the type and capacity of the battery. A PWM charge controller is a popular choice for small to medium-sized solar panel systems, due to its simplicity, reliability, and affordability. A PWM charge controller typically includes a microcontroller, a transistor switch, and a voltage regulator. The microcontroller generates a PWM signal with a fixed frequency and variable duty cycle, based on the battery voltage and current. The voltage regulator ensures that the voltage delivered to the battery is constant and within a safe range. The PWM signal is used to control the transistor switch, which turns on and off at the same frequency as the PWM signal. When the transistor switch is on, the solar panel delivers full power to the battery. When the transistor switch is off, the solar panel delivers no power to the battery. By adjusting the duty cycle of the PWM signal, the average power delivered to the battery can be varied, and hence the battery can be charged safely and efficiently. The duty cycle of the PWM signal is determined by the microcontroller, based on the battery voltage and current. When the battery voltage is low, the duty cycle of the PWM signal is increased to deliver more power to the battery. When the battery voltage is high, the duty cycle of the PWM signal is decreased to reduce the power delivered to the battery. The PWM charge controller can also protect the battery from overcharging, which can damage the battery and reduce its lifespan. When the battery is fully charged, the PWM charge controller reduces the duty cycle of the PWM signal to prevent further charging. In addition to regulating the power delivered to the battery, the PWM charge controller can also provide feedback on the status of the solar panel system. Some PWM charge controllers include LED indicators that show the battery charging status, the solar panel output, and any faults or errors in the system.

Overall, PWM charge controllers are a simple and reliable way to regulate the power delivered to a battery in a solar panel system. While they may not be as efficient as other types of charge controllers, such as MPPT charge controllers, they are well-suited for small to medium-sized solar panel systems and can provide reliable and safe charging for batteries.

Construction:

A PWM charge controller typically consists of a microcontroller, a voltage regulator, a transistor switch, and some passive components like resistors and capacitors. The microcontroller generates a PWM signal, which is fed to the transistor switch. The transistor switch turns on and off at the same frequency as the PWM signal, and its output is connected to the battery.

Working:

A PWM (Pulse-Width Modulation) solar charge controller is a device that regulates the charging of a battery from a solar panel by controlling the amount of current and voltage that is delivered to the battery.

The basic working principle of a PWM solar charge controller involves a microcontroller that monitors the voltage of the battery and compares it to the target voltage. If the battery voltage is lower than the target voltage, the controller allows more current to flow from the solar panel to the battery. If the battery voltage is higher than the target voltage, the controller reduces the current flow to prevent overcharging.

To achieve this, the controller uses a technique called pulse-width modulation, which involves rapidly turning the charging circuit on and off to control the amount of current flowing to the battery. The duty cycle, or the amount of time the circuit is turned on relative to the off-time, is varied to achieve the desired charging voltage.

The PWM charge controller also has built-in protection features such as overvoltage protection, overcurrent protection, short-circuit protection, and reverse polarity protection, which ensures the safety of the battery and the solar panel system.

Overall, a PWM solar charge controller is an essential component of a solar power system as it ensures efficient and safe charging of the battery from the solar panel, prolonging the battery's life and optimizing the performance of the system.

Figure 6. Charge Controller

5.3. INVERTER:

A master inverter, also known as a hybrid inverter or a multi-mode inverter, is an inverter that can operate in both grid-tied and off-grid modes, and can switch seamlessly between different power sources, such as solar panels, batteries, and the grid. Some master inverters can also operate as both DC-to-AC and AC-to-DC inverters. A master inverter that is capable of operating an induction motor from both solar and AC power sources is certainly possible. However, there are several factors that need to be considered when choosing an inverter for this application:

Power rating: The inverter must be capable of delivering enough power to operate the induction motor. The power rating of the inverter should be at least equal to the rated power of the motor.

Efficiency: The inverter should be highly efficient to minimize energy losses during the conversion process. High-efficiency inverters can help maximize the use of solar power and reduce energy costs.

Waveform quality: The waveform produced by the inverter should be of high quality, with low harmonic distortion, to ensure that the induction motor operates smoothly and efficiently.

Protection features: The inverter should have built-in protection features to safeguard the motor and other connected devices against overvoltage, under voltage, overcurrent, and other electrical faults.

Compatibility: The inverter should be compatible with both the solar panels and the AC power supply. Some inverters may require additional components, such as DC-to-DC converters, to convert the DC power from the solar panels to the voltage required by the inverter.

There are other features that are commonly found in master inverters that make them well-suited for a variety of applications. For example:

Dual MPPT: Many master inverters come equipped with dual maximum power point tracking (MPPT) controllers. This allows the inverter to optimize the output of multiple solar arrays, even if they are facing different directions or have different shading conditions.

Battery management: Some master inverters have built-in battery management systems that can control the charging and discharging of connected batteries. This allows the inverter to store excess solar power for use later, or to provide backup power during a grid outage.

Grid-tie capabilities: Some master inverters can be used in grid-tie mode, where they can feed excess solar power back into the grid for a credit or a payment. This can help reduce energy bills and make the system more economically viable.

Remote monitoring: Many master inverters can be remotely monitored and controlled using a smartphone app or a web portal. This allows users to monitor the performance of their solar system, adjust settings, and receive alerts in case of any issues.

Master inverters are commonly used in a variety of applications, including:

Residential solar power systems: Master inverters are often used in residential solar power systems to convert DC power from solar panels into AC power that can be used to power homes and businesses. They can also be used to store excess solar power in batteries for use later.

Commercial solar power systems: Master inverters are also used in larger-scale commercial solar power systems to convert DC power from multiple solar arrays into AC power that can be fed into the grid or used on-site.

Off-grid systems: Master inverters can be used in off-grid systems, where they can convert DC power from solar panels and batteries into AC power that can be used to power homes and businesses in remote areas without access to the grid.

Emergency backup power: Master inverters with battery backup capabilities can be used to provide emergency backup power during a grid outage or other emergency situation.

In conclusion, master inverters are versatile and highly capable electronic devices that can convert DC power from solar panels and batteries into AC power for use in a variety of applications. They offer a range of features and capabilities that make them well-suited for residential, commercial, off-grid, and emergency backup power systems.

One important aspect of master inverters is their ability to switch between different power sources seamlessly, which is called "power source management." A typical master inverter can automatically switch between solar power, battery power, and grid power based on the availability and priority of each power source. For example, if solar power is available and the battery is fully charged, the inverter will prioritize solar power and use it to power the load while also charging the battery. If solar power is not available and the battery is not fully charged, the inverter will switch to grid power to power the load and charge the battery. If the grid power goes out, the inverter will automatically switch to battery power to provide backup power to the load.

Another important feature of master inverters is their ability to communicate with other devices in the solar power system. For example, some master inverters can communicate with solar charge controllers, battery management systems, and smart meters to optimize the performance of the system. This communication can take place over wired or wireless networks, and can provide real-time data on the performance of the system, such as power production, power consumption, and battery state of charge.

Master inverters are also available in a variety of sizes and power ratings, ranging from small inverters that can power a few lights and appliances to large-scale inverters that can power entire communities. The choice of inverter depends on the size and complexity of the solar power system, as well as the load requirements and the desired level of backup power.

In addition to the features I mentioned earlier, some master inverters also offer advanced capabilities, such as:

Reactive power control: This feature allows the inverter to control the flow of reactive power to the grid, which can help stabilize the grid and improve its efficiency.

Frequency regulation: Some master inverters can regulate the frequency of the AC power output to match the frequency of the grid, which can help maintain grid stability and prevent power outages.

Grid support functions: Some master inverters can provide grid support functions, such as voltage control, power factor correction, and low voltage ride-through, which can help improve the reliability and stability of the grid.

Overall, master inverters are a critical component of solar power systems, providing the ability to switch between different power sources, communicate with other devices in the system, and offer a range of advanced capabilities. Their flexibility and versatility make them well-suited for a wide range of applications, from small residential systems to large commercial and utility-scale systems.

5.4. BATTERY:

A lead-acid battery is a type of rechargeable battery that uses a combination of lead plates and an electrolyte solution to store and release energy.The construction of a lead-acid battery is based on the principles of electrochemistry. It consists of a plastic container divided into several compartments, each containing a set of positive and negative lead plates. The plates are made of lead and coated with a paste of lead oxide and sulfuric acid. The positive plates are coated with lead peroxide while the negative plates are coated with pure lead.

The plates are immersed in an electrolyte solution made of dilute sulfuric acid (about 25%) and distilled water. The sulfuric acid dissociates into positive hydrogen ions (H+) and negative sulfate ions (SO_4^{2-}) in the electrolyte. When the battery is discharged, the sulfuric acid reacts with the lead plates, producing lead sulfate and water. During the charging process, the lead sulfate on the plates is converted back into lead oxide and sulfuric acid.

In general, lead-acid batteries are known for their relatively low cost, high reliability, and robustness. They are also able to deliver high bursts of power, making them well-suited for applications such as starting a car engine.

The construction of a 12V 75Ah lead-acid battery typically consists of six individual cells connected in series, each producing 2.1 volts. Each cell consists of a positive and negative plate, separated by a porous insulating material called a separator. The cells are arranged in a plastic container, and the top of each cell is sealed with a vented cap that allows gas to escape but prevents the electrolyte from spilling out

When the battery is discharged, the sulfuric acid reacts with the lead plates, producing lead sulfate and water. During the charging process, the lead sulfate on the plates is converted back into lead oxide and sulfuric acid. The flow of current in the battery is controlled by a series of chemical reactions that take place between the lead plates and the electrolyte.

Overall, the lead-acid battery 12V 75Ah is a robust and reliable power source that has been used for many years in a variety of applications. However, it is important to properly maintain and charge the battery to ensure optimal performance and longevity.

The power output of a 12V 75Ah lead-acid battery can be calculated by multiplying its voltage and current. For example, if the battery is delivering a current of 10 amps, its power output would be 12V x 10A = 120 watts. It's important to note that the actual power output of the battery can vary depending on factors such as its state of charge, temperature, and the load connected to it.

The maximum current that a 12V 75Ah lead-acid battery can deliver depends on its capacity and the load connected to it. As a general rule, the maximum current that a lead-acid battery can deliver is proportional to its capacity. In the case of a 75Ah battery, the maximum current it can deliver can be calculated using the formula: Maximum current = Capacity (in Ah) x C-rate. For example, at a C-rate of 1C (which means a discharge current equal to the battery's capacity in ampere), a 75Ah battery can deliver a maximum current of 75A.

During charging ,the electrical specifications are 24V, 14Amp and during discharging it is 24v, 40Amp.

Efficiency of lead acid battery is 60% to 70%.

Figure 7. Battery

5.5. INDUCTION:

Induction cooking is a method of cooking that uses electromagnetic fields to generate heat directly within the cooking vessel. This is achieved through the use of an induction cooktop, which contains an induction coil made of copper wire, which generates an alternating magnetic field when an electric current is passed through it.

The magnetic field produced by the induction coil creates a current in the metal of the cooking vessel, which in turn generates heat through resistance. This heat is then transferred to the food within the vessel, allowing it to cook.

Because induction cooking heats the cooking vessel directly, rather than relying on heat transfer through the air or through the surface of the cooktop, it is more energy-efficient than traditional gas or electric cooking. It also allows for more precise temperature control and faster heating.

One of the key advantages of induction cooking is that it is much safer than traditional cooking methods, as there is no open flame or hot surface to accidentally touch. Induction cooktops also cool down quickly after the cooking vessel is removed, reducing the risk of burns or accidents.

Induction cooking is becoming increasingly popular in both home and professional kitchens due to its energy efficiency, safety, and precision. However, it is important to note that not all cookware is suitable for use with induction cooktops, as it must be made from a ferromagnetic material such as cast iron or stainless steel in order to generate the necessary current.
Induction cooking is a method of cooking that uses electromagnetic fields to generate heat directly within the cooking vessel. This is achieved through the use of an induction cooktop, which contains an induction coil made of copper wire, which generates an alternating magnetic field when an electric current is passed through it.

The magnetic field produced by the induction coil creates a current in the metal of the cooking vessel, which in turn generates heat through resistance. This heat is then transferred to the food within the vessel, allowing it to cook.

Because induction cooking heats the cooking vessel directly, rather than relying on heat transfer through the air or through the surface of the cooktop, it is more energy-efficient than traditional gas or electric cooking. It also allows for more precise temperature control and faster heating.

One of the key advantages of induction cooking is that it is much safer than traditional cooking methods, as there is no open flame or hot surface to accidentally touch. Induction cooktops also cool down quickly after the cooking vessel is removed, reducing the risk of burns or accidents.

Induction cooking is becoming increasingly popular in both home and professional kitchens due to its energy efficiency, safety, and precision. However, it is important to note that not all cookware is suitable for use with induction cooktops, as it must be made from a ferromagnetic material such as cast iron or stainless steel in order to generate the necessary current.

Figure 8. Induction

CHAPTER: 6

RESULT AND DISCUSSION

CHAPTER 6

RESULT AND DISCUSSION

The implemented system is a 1600 watts supply. All the power dissipation of the important components was measured using 1600 watts operating power. The losses can be of IGBT, diode, filter and coil. These losses are estimate that the cooker efficient is expected to be around 80%.

The stove successfully heated the pot using the principle of electromagnetic induction by varying switching frequency.

- The components to construct the stove are very few, cheap and affordable.
- The efficiency is very encouraging from power level three upwards and this will prolong the life cycle of the components used and decrease cooling requirements and expenses.
- Battery tank can run the cooker at it maximum for about 6 hours with charging needed. The stove output power levels and its efficiency is comparable and can compete with the commercial stove in the market. This analysis was tested and proven by comparing the commercial stove and this stove I have designed with the advantage of being flexible in terms of power sources.
- The system can also run the whole house lighting, charge cell phones, play radio and television at the same time if proper inverter is connected in the system.

The main result of induction cooking is that it provides faster, more efficient, and precise heating compared to traditional gas or electric stovetops. This is because induction cooking directly heats the cookware, rather than the air around it, which reduces heat loss and allows for more efficient transfer of heat. Induction cooking systems also allow for precise temperature control, as the heat can be adjusted instantly and accurately.

Some other results of induction cooking include:

Safety: Induction cooking systems do not use an open flame or a heating element that can stay hot after being turned off, making them safer than traditional stovetops.

Energy efficiency: Induction cooking systems are more energy-efficient than gas or electric stovetops, as they waste less heat and can transfer heat more quickly and precisely.

Ease of cleaning: Induction cooktops have a smooth, flat surface with no grates or burners, making them easy to clean with a simple wipe-down.

Noise reduction: Induction cooktops operate quietly, without the noise of gas burners or electric heating elements.

Overall, the result of induction cooking is a more efficient, precise, and safe cooking experience. While the initial cost of an induction cooktop may be higher than traditional stovetops, the long-term energy savings and other benefits may make it a worthwhile investment.

Rated Power (Pmax): This is the maximum power output of the module under standard test conditions (STC), which are defined as irradiance of 1,000 W/m^2, a cell temperature of 25°C and an air mass of 1.5. The rated power is measured in watts (W).

Open Circuit Voltage (Voc): This is the voltage across the module's terminals when there is no load connected, and the module is exposed to sunlight. It is measured in volts (V).

Short Circuit Current (Isc): This is the current that flows through the module when the positive and negative terminals are connected with a short circuit. It is measured in amperes (A).

Maximum Power Voltage (Vmp): This is the voltage at which the module generates maximum power output, and it occurs at a specific point on the module's current-voltage curve. It is measured in volts (V).

Maximum Power Current (Imp): This is the current at which the module generates maximum power output, and it also occurs at a specific point on the module's current-voltage curve. It is measured in amperes (A).

Module Efficiency: This is the ratio of the module's output power to the input power from sunlight. It is expressed as a percentage.

Temperature Coefficient: This parameter describes how the module's power output changes with temperature. The temperature coefficient of the module's power output is typically given in %/°C.

Operating Temperature Range: This is the range of temperatures within which the module can operate without experiencing damage or significant efficiency losses.

Dimensions: This includes the physical size of the module, as well as its weight.

PARAMETERS	**OBSERVED**
Rated Power (Pmax)	303.4 watt
Open circuit Voltage (Voc)	41.0 volt
Short Circuit Current (Isc)	7.4 ampere
Maximum System Voltage	1000 V
Module Dimension (L*W*D)	1955*990*42 mm
Module Weight	22 kg

Table 3. Observed parameters

Experimental result:

Serial No.	Different types of cooking	Required Watt for particular cooking	How much time battery will work (Hour)
1.	To boil water	1600 watt	1.12
2.	To make soup	1600 watt	1.12
3.	To fry	240 watt	7.5
4.	To steam	1500 watt	1.2
5.	To all cooking	200 watt	9.0

Table 4. Experimental Results

Sample Calculations:

Since the battery has a capacity of 75Ah at 24V, we can also calculate the total energy it can store: 24V x 75Ah = 1800 Wh

Therefore, the battery can provide 1800 watt-hours of energy at 24 volts.

Now, we can calculate the time the battery can power the device by rearranging the formula above:

*Time in hours = energy in watt-hours / power in watts

For example (to boil water):

Time in hours = energy in watt-hours / power in watts

= 1800 Wh / 1600 watt

= 1.12 hour

CHAPTER: 7
CONCLUSION AND FUTURE SCOPE

CHAPTER 7

CONCLUSIONS AND FUTURE SCOPE

CONCLUSIONS

In this project solar powered induction cooking system is presented. The design 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 environmentally 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 experimental results are presented for various cooking levels. It can be seen that efficiency drops as the cooking level in increased.

FUTURE SCOPE

The project work presented in this report can be further extended to;

- Reduce the size of the project.
- Figure out and use the best solar panels which will be more efficient and pocket friendly.

  Make use of most efficient battery.
- Reduce the weight of the model.
- Minimize the cost of the project.

REFERENCES

1] Aberilla, J. M., Gallego-Schmid, A., Stamford, L., and Azapagic, "Environmental sustainability of cooking fuels in remote communities: Life cycle and local impacts", science direct, 2020.

2] Hager, T. J.; Morawicki, R.” Energy consumption during cooking in the residential sector of developed nations: A review.” Science direct ,2013.

3] Cerri, Graziano, et al. "Rigorous electromagnetic analysis of domestic induction heating appliances." PIERS Online 5.5 (2009): 491-495, piers online, 2009,[491].

4] Bhavana Ffion, Faseen.K., and Hema Mohan, “Solar Based Induction Cook Top”, 3rd Int. Conf. on Electronics, Biomedical Engineering and its Applications (ICEBEA'2013) April 29-30, 2013, Singapore, 2013.

5] Chun-Liang, H., July. “Circuits analysis of inductive heating-device with half-bridge resonated inverter.” In 11th WSEAS Int. Conf. Circuits (pp. 26-30), research gate ,2007.

6] Sweeney, Micah, et al. "Induction Cooking Technology Design and Assessment." Small 5 (2014): 800. American research council for energy efficient economy, 2014

7] Anis, Priya, et al. “Customer’s Attitude and Satisfaction of Induction (cook-tops) stove in Tirunveli City.” IRACST 5.1 (2016): 2319-2828, 2017

8] David Jiles, "Eddy Currents: Fundamentals and Applications", Journal: Materials Science and Engineering: B Year: 2001

9] T. Khatib, "Integration of Solar Energy and Battery Energy Storage System for Residential Applications", IEEE Transactions on Sustainable Energy,

2018