International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

IR and Peltier Effect Based Solar Food Dryer System

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Abstract - The IR solar dryer utilizes concentrated solar power to dry agricultural products efficiently without the need for electricity, preserving food quality by avoiding exposure to sunlight that can degrade vitamins. On the other hand, Peltier effect-based systems can achieve faster drying rates with solar concentrators, enhancing the overall drying process. Additionally, thermal energy storage systems applied to solar dryers can significantly reduce drying costs, improve product quality, and eliminate greenhouse gas emissions. These systems allow stored energy to be used during periods of low solar incidence, enhancing the reliability of solar energy for drying purposes. IR and Peltier Effect Based Solar Food Dryer System would highlight the use of concentrated solar power, Peltier effect technology for faster drying rates, and the integration of thermal energy storage systems to enhance energy efficiency and product quality in solar drying processes.

***Key Words*:** Solar Dryer, Peltier Effect, TEC Module, Raisin Dryer, Solar Panel.

1.INTRODUCTION

Drying is one of the traditional methods for food preservation. Drying of the grapes produce raisins. Sun drying and shade drying methods need more space and there is possibility of contamination due to external environment conditions. Present daysMicrowave (MW) dehydration, Automatic Solar fruit dryers and Infrared radiation dryers have been utilized for the grape drying process. In this project modified technique of present grape drying method using IR radiation is suggested. It is distinctly different from conventional or natural drying.

The infrared radiations accelerate drying process with a better control to achieve uniform drying and reduced drying time. The proposed system makes the use of vacuum chamber which is weather independent and improves the quality by maintaining texture and colour of raisins. The operation of the system makes use of nonconventional source of energy so it is cost effective. The Infrared Radiation drying method has better speed of analysis, so this technique is suited for qualitative in- process use. Efficient utilization of this system by the farmers will lead to profit optimization.

The integration of IR technology and the Peltier effect enhances the performance and efficiency of solar food dryers. IR radiation helps penetrate the food surface, promoting uniform drying and reducing drying time. The Peltier effect, which utilizes the temperature difference between two junctions of dissimilar materials, enables precise temperature control within the drying chamber.

The IR and Peltier-based solar food dryer system represents a significant advancement in the field of food preservation, offering an innovative and sustainable solution to the challenges posed by traditional sun drying methods. This cutting-edge technology harnesses the power of renewable energy, utilizing infrared (IR) radiation and Peltier modules to efficiently dry a wide variety of food products, including fruits, vegetables, and grains.

2. LITERATURE REVIEW

Kitti Korbuakaew, Prasit Phoosomma [1], have investigated that to build a prototype of a combination heated drying cabinet. To address the issue of drying during periods of little or no sunlight. Adding solar-powered hot water tanks to the baking cabinet to help boost the temperature. The drying system is divided into two stages, 1) design of heat energy dryer combined with solar infrared radiation, and 2) build a solar-powered hot water tank design.

Mohd KhairulanwarRizalman, Ervin Gubin Moung, Jamal Ahmad Dargham, Zuhair Jamain, Nurul'azah Mohd Yaakub4, Ali Farzamnia [2] have investigated that Various solar dryer types, designs, and performance, as well as the influence of solar drying on the quality of fruits and the potential of solar dryers in agriculture production .Various solar dryer types, designs, and performance, as well as the influence of solar drying on the quality of fruits and the potential of solar dryers in agriculture production.

Johannes P. Angula ,Freddie Inambao [3] Computational Fluid Dynamics (CFD) is an exceptional modelling method which is used for accurately predicting and solving complex fluid flow regimes. It is used in many engineering applications including food processing. In food processing CFD can be used in designing, analysing and improving the performances of solar dryers in order to enhance product quality. An understanding of the drying phenomena is crucial in the dehydration and preservation of food products.

Rohit Anil Koli ,Rushikesh Deepak Patil, Omkar Rajkumar Wale, Prof. P.P.Kulkarni [4] have investigated that the solar drying system utilizes solar energy to heat up air and to dry any food substance loaded, which is not only beneficial in that it reduces wastage of agricultural produce and helps in preservation of agricultural produce, but it also makes transportation of such dried produce easy and promotes the health and welfare of the people.

Ankit Kumar, Kamred Udham Singh, Mukesh Kumar Singh, Alok Kumar Singh Kushwaha, Abhishek Kumar, Shambhu Mahato [5] have investigated that Food preservation has been practised in many parts of the world for thousands of years, and it applies to a wide range of foods, including fruits, vegetables, cereals, and meat. Food preservation techniques are canning, freezing, pickling, curing (smoking or salting), and drying. Food spoilage caused by moisture is caused by the growth of mould, yeast, bacteria, and enzymes in the food.

Mr.G.D.Lohar, Mr.A.G.Nandekar, Mrs.W.S.Kandlikar [6], have presented modified natural grape drying method using Infrared Radiations. The Infrared Radiation unit mentioned has different sensors to monitor various parameters regarding drying process. They have concluded that Infrared Radiation unit shows significant drop in drying process duration compared to natural drying process.

3. HARDWARE AND SOFTWARE USED

Hardware :

- Arduino Uno
- Solar Panel
- Peltier Plate
- ATMEGA 328
- Thermistor
- IR LED
- LCD 16*2
- Battery
- LED Driver
- PC 817
- IRF 3205
- IC 7805
- Connecting Wires

Software :

- Arduino IDE

4. METHODOLOGY

4.1 Working :

The IR and Peltier effect-based solar food dryer system involves utilizing a solar collector to absorb sunlight and convert it into heat energy, which is then used to heat the air entering the drying chamber. Infrared (IR) radiation is applied to the food items to accelerate the drying process by causing water molecules to vibrate and heat up, while the Peltier effect is employed for cooling purposes, using an electric current to create a temperature difference that cools the air entering the chamber. This combination of technologies optimizes the drying process, ensuring efficient removal of moisture from the food items while maintaining quality and reducing drying time, ultimately leading to a more sustainable and effective method of food preservation. At the core of the system is the solar collector, which absorbs sunlight and converts it into thermal energy. The interior of the collector is painted black to maximize the absorption of light and its conversion to heat.

This heat is then trapped within the drying chamber, which is isolated from the outside air using a clear solid material like a plastic bag or glass cover. This design allows sunlight to enter the chamber while preventing the escape of the heated air, enabling the dryer to maintain high temperatures even on cold or windy days.

The integration of infrared (IR) radiation and the Peltier effect further enhances the drying process. The IR radiation is directed towards the food items, causing the water molecules within them to vibrate and heat up, leading to faster evaporation and drying. Meanwhile, the Peltier effect is utilized for cooling purposes, where an electric current is applied to a Peltier module, creating a temperature difference that can be used to cool the air entering the drying chamber.

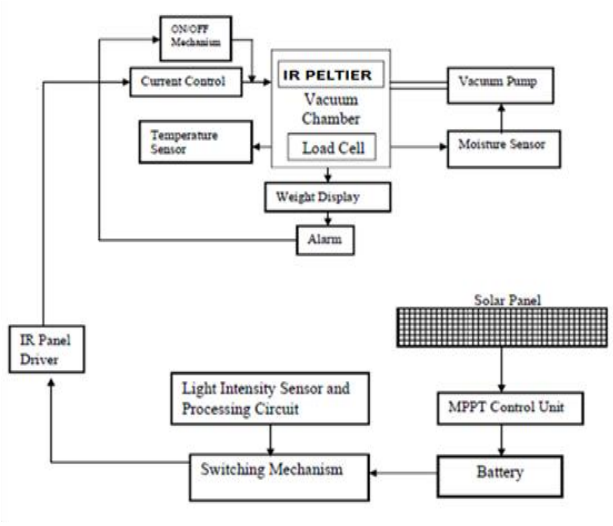

Fig.4.1.1 Block Diagram of IR and Peliter Effect Based Solar Food Dryer System

4.2 Flowchart

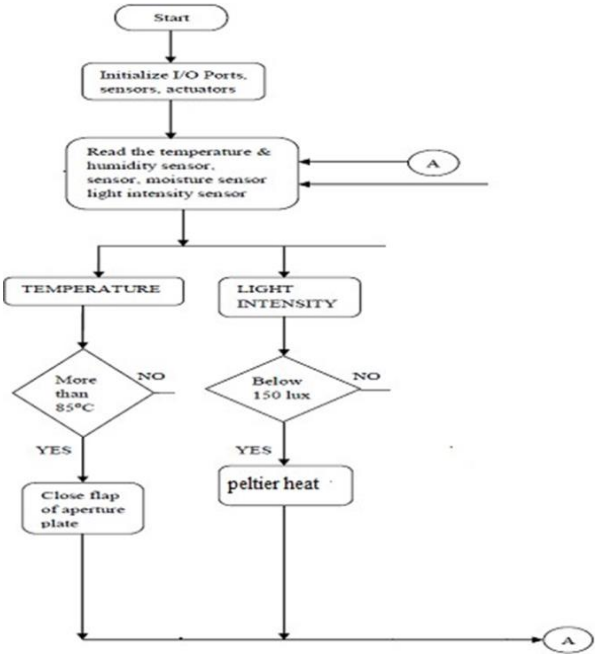

Fig 4.2.1 Flowchart of IR and Peliter Effect Based Solar Food Dryer System

The entire hardware system alone cannot serve the purpose, unless the real-time program instructions are flashed into the hardware.

1.The software part plays an important role to coordinate and control all the peripherals connected with the controller, the system becomes functional by configuring and initializing the peripherals as per the software instructions.

2.In the beginning all the sensors, controllers and entire components are initialized. At first the grapes are placed in tray which is mounted on weighing sensor.

3.The sensor reads the weight and displays the same on LCD. The weight is continuously monitored, when the weight goes 30% of its initial weight alarm is generated and weight is displayed on LCD.

4.The temperature in the chamber is monitored by temperature sensor. When the temperature crosses the set point the aperture plate is closed and the incoming radiations from sun are reduced.

5.The light intensity sensor monitors the lux in the sun light. As the light intensity of sun reduces the IR panel from the vacuum chamber is turned ON.

6.The moisture humidity sensors sense the moisture inside the vacuum chamber. The vacuum pump extracts the moisture and maintains vacuum in chamber

5. RESULT & DISCUSSION

Fig.5.1 Result of IR and Peliter Effect Based Solar Food Dryer System

The system appears to be designed to monitor weight changes and provide alerts when weight loss reaches a certain level. This could be useful for individuals tracking their weight or for healthcare applications where sudden weight loss may indicate health issues.the table presents a structured dataset reflecting weight, voltage, alarm status, and mobile messages, suggesting a system designed to monitor weight changes and alert users when significant weight loss is detected. Further details and analysis would be required to fully interpret the underlying theory and functionality of this system discussion.

6. ADVANTAGES AND APPLICATIONS

6.1 Advantages

- Infrared drying systems are highly energy-efficient, with effectiveness ranging between 80% and 90%. This efficiency is attributed to the narrow wavelength range of emitted radiation and the miniaturized nature of the system, leading to reduced energy consumption and costs.
- One of the significant advantages of using infrared radiation for fruit drying is the short processing time. Compared to traditional drying methods, infrared drying can significantly reduce the drying time, leading to quicker production cycles and improved efficiency
- Infrared radiation provides uniform heating of materials, ensuring consistent drying throughout the product. This uniform heating helps maintain the quality of the fruits by preventing localized over-drying or under-drying, resulting in a more consistent final product.
- The use of infrared radiation in fruit drying systems enhances the quality of the dried fruits. It helps preserve the sensory, nutritional, and safety attributes of the fruits, leading to better appearance and overall quality of the final product. This results in improved consumer acceptance and satisfaction.
- Infrared drying systems have the potential to reduce production costs by lowering energy consumption, shortening drying times, and improving overall efficiency. This costeffectiveness makes them a viable option for commercial fruit drying operations.

6.2 Applications

- The system provides high energy efficiency, short drying times, and uniform heating of materials, leading to improved overall efficiency in the drying process.
- Infrared radiation heating helps maintain the quality of fruits by preserving their sensory, nutritional, and safety attributes during the drying process. This results in better appearance and overall quality of the dried fruits.
- The use of infrared radiation heating can lead to lower energy consumption and costs due to the high heat transfer rate and effectiveness of the technology, making it a costeffective solution for fruit drying operations.
- The system allows for precise control over the drying process, ensuring that fruits are dried uniformly and efficiently, leading to consistent quality in the final dried fruit product
- By efficiently removing moisture from fruits, the Intelligent Fruit Drying System using Infrared Radiation Heating Mechanism can help extend the

shelf life of fruits, reducing waste and ensuring longer storage periods for the dried products

7. CONCLUSION & FUTURE SCOPE

7.1 Conclusion :

The IR and Peltier Effect-based Solar Food Dryer System is a groundbreaking innovation that has the potential to transform the food processing and preservation industry.

By leveraging the benefits of infrared radiation and the Peltier effect, this system offers a highly efficient, sustainable, and environmentally friendly solution for drying and preserving fruits, vegetables, and other agricultural products.

The system's ability to harness solar energy and utilize advanced technologies such as infrared heating and Peltierbased refrigeration makes it an attractive option for off-grid and remote areas where traditional energy sources may be limited or unavailable.

The IR and Peltier Effect-based Solar Food Dryer System also offers significant advantages in terms of energy efficiency, reducing the need for fossil fuels and minimizing the environmental impact of food processing. Additionally, the system's ability to preserve the sensory, nutritional, and safety attributes of the dried products ensures that consumers receive high-quality products that meet their evolving demands.

7.2 Future Scope :

The Future Scope of IR and Peltier Effect Based Solar Food Dryer System are given below:

- The search results indicate that infrared (IR) drying systems can achieve high energy efficiency, ranging from 80% to 90%. Further improvements in the design and integration of IR heating technology can lead to even greater energy savings.
- The use of IR heating and the Peltier effect can help preserve the sensory, nutritional, and safety attributes of the dried fruits and vegetables, resulting in higher-quality final products.
- IR drying has been shown to significantly reduce the drying time compared to traditional methods. Optimizing the IR heating parameters and integrating it with other drying techniques, such as hot air, can lead to further reductions in drying time.
- The use of renewable solar energy and the absence of ozone-depleting refrigerants make the IR and Peltier-based food drying system an environmentally friendly solution, contributing to the reduction of greenhouse gas emissions.
- The solar-powered, Peltier-based refrigeration system discussed in the search results can be integrated with the IR-based food drying system to create a comprehensive, off-grid solution for food preservation and processing in remote areas

8. REFERENCES

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