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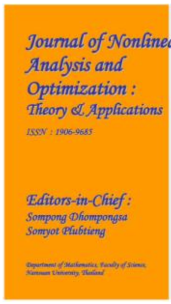

DEVELOPMENT AND DESIGN OF SOLAR DRYER MACHINE

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***Abstract** - This paper discusses a sun drying device that operates automatically. With the use of temperature and humidity sensors, Arduino UNO aids in managing total drying. When the temperature falls below the necessary level, the blower blows hot air while being protected from water by the system. Electricity is supplied for the desired drying process using a solar panel. The agricultural products that are dried using solar energy are uncontaminated, have good flavor and color, do less damage to nutrition, etc. The drying rate and temperature in the dryer were found to be faster than the open-air, natural drying process. This procedure has been enhanced with artificial drying to speed up harvesting in bad weather or reduce field losses. This drier offers faster drying times and a lower risk of spoilage than the conventional open-air sun drying approach.*
Keywords-Solar PV panel, Battery, Sensors, Inverter, dryer.

1. INTRODUCTION

Our article is primarily concerned with the Automatic Solar Dryer Machine. The most enticing and plentiful renewable energy source is solar energy because it is cost-free, ecologically friendly, and accessible for the majority of the year. Solar energy is primarily and fundamentally used to create heat [1]. Agricultural products, especially fruits and vegetables, require hot air that is between 45 and 60 °C for safe drying. Any agricultural crop that is dried under controlled circumstances at a specific temperature and humidity level fast yields the best-quality dry commodities.

The drying process is divided into two stages. While the second stage is influenced by the properties of the drying product with a decreasing drying rate, the first stage happens at the material's surface with a constant drying rate and is akin to the vaporization of water into the surrounding air. Researchers from all over the world are very interested in drying fruits and vegetables due to the high nutritious value of this form of food [2]. Around the world, fruits and vegetables are preserved using a range of techniques, including drying, controlled environment canning, dehydration, and refrigeration.

Solar drying is one of the most alluring methods for preserving fruits and vegetables. It can increase agricultural production, cut waste, and improve the quality and yield of fruits and vegetables. The sun's rays are detected by a solar panel in the proposed solar drying system. The solar panel turns those rays into electricity, which is then utilized to power a heater to generate heat energy for drying. Drying of the goods must be done at night and in inclement weather. This can be accomplished using a variety of techniques, including Chemical drying and freeze drying. Numerous experiments have been carried out over the years.

The only factors controlling the drying rate in this system are mass and heat transmission. In the indirect drying process, heat is provided to the absorber tray first to remove any moisture that may be present, and then it is applied to the absorber plate from the glass to cover it [3]. Natural convection in a solar food drier boosts the effectiveness of solar drying of agricultural products compared to sun drying outside, according to research. Compared to traditional or open-air drying processes, it is quicker and delivers better drying results. It works through two distinct mechanisms. First, it dries the surface and prevents moisture from penetrating into the surface particles' core.

Studies examining the techniques for evaluating the energy efficiency of box-type solar collectors had been published at that time. A test parameter for the solar radiation intensity ratio between the absorber and the surrounding air in the stagnation state has been established based on outdoor experiments done for mechanical drying, hoover drying, and heat drying under no-load or overload situations.

The subject of the current research is thermal drying, which is generally employed to dry agricultural products and entails the application of thermal energy to remove moisture from the material. The complex interplay of heat and mass transfer processes that go into drying a product depends on a variety of factors, including temperature, humidity, and the properties of the agricultural items being dried by the airstream.

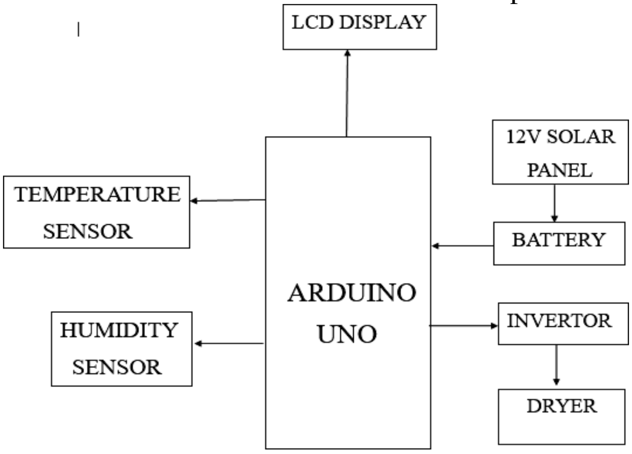
2. EXISTING SYSTEM

This strategy focuses exclusively on sun-drying agricultural products. The classic technique for the notion, open sun drying, is still extensively used today. In this technique, different crops, including fruits, vegetables, cereals, grains, and other foods, are laid out on the ground and rotated occasionally. The system's main shortcomings are that it is hazardous, expensive, and unhygienic. Negative weather, contamination from overheating, pest infestation, vulnerability to re-absorption of moisture while left on the ground in the absence of light, and lack of control over the drying system all blatantly reduce the yield. This technique exclusively employs the sun to dry agricultural items. It is believed that open sun drying is a traditional technique that is still popular everywhere in the world. On the ground, crops including cereals, grains, fruits, and vegetables are dispersed and occasionally rotated. The main flaws of the structure are its high risk, large expense, and poor neatness. Weather conditions, contamination from overheating, vulnerability to re-absorption of moisture if left on the ground without.

Sunshine, difficulty to control the drying process dried products, and assembling misfortunes are the results of a lax drying rate.

3. PROPOSEDSYSTEM

The suggested solar drying method is an advantage over sun drying since products are dried in a closed system with a warmer interior. When crops need to be sheltered from the elements, solar drying keeps a safe moisture level better than conventional drying techniques. The open-air, natural drying approach was shown to be slower in terms of temperature and drying rate. As a result, solar drying is a great choice for drying agricultural and auxiliary products [4]. The latest advancements in sun gathering technology have been credited with the quick development of solar drying. There are thus many opportunities for advancement in the sun-powered drying of agricultural products. Between 50 and 60 degrees Celsius is the normal drying temperature for agricultural and ancillary products, which is within the middle and low temperature range of solar energy [5].



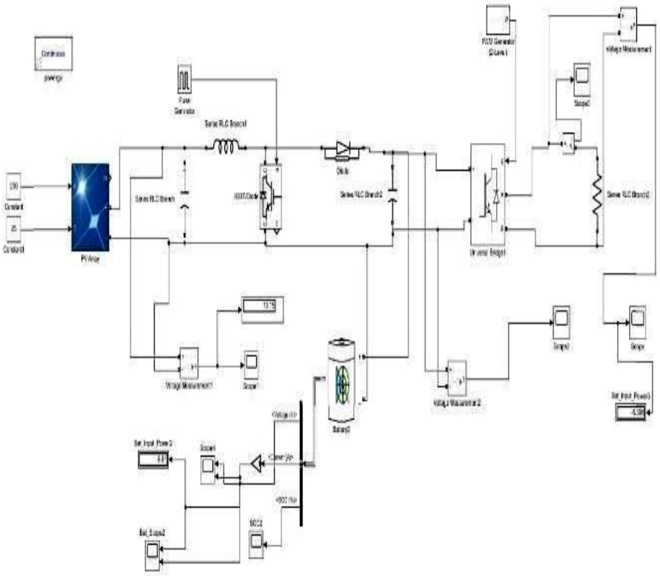
Fig–3: Block diagram of proposed Diagram

4. SIMULATION AND RESULT

4.1 Simulation model for Drying

The simulation of the model will highlight the operation of the solar dryer. The simulation model will examine different product drying processes. The simulation model is built on top of the Dryer. It was discovered that the performance of the dryer process depends on the type of product and its final moisture level.

The way the items are prepared before drying, such as by bubbling or cutting, affects how well they dry because the last moisture in an item typically requires more energy to remove than the underlying dampness. These factors make it challenging to compare the drying efficiency of different systems. The simulated model will focus

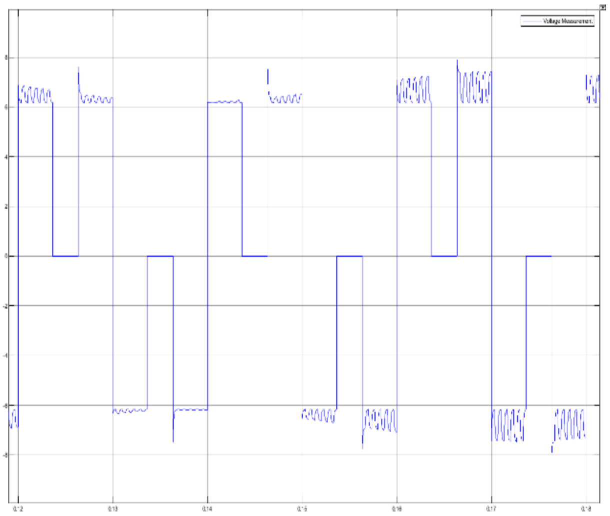


Fig–4.1: Simulation Model for Drying

on the various things' drying cycles. The fundamental thermal, mass, and correlation balances of the digital simulation model control the time-dependent solar radiation, relative humidity, and outdoor air temperature.

4.2 Current Wave form for Drying

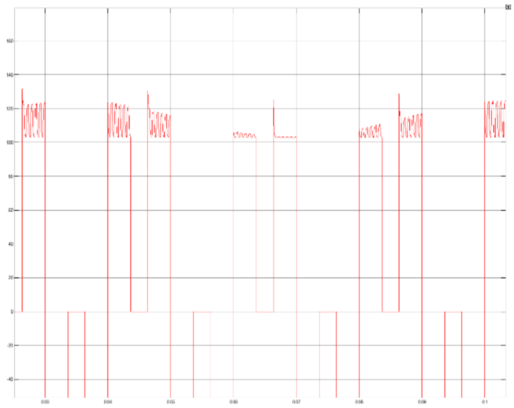
A time-dependent increase in the maximums that match the peaks for the current that are highlighted is another thing we can see. The current waveform's depiction of how long it took to dry.



Fig–4.2: Current Wave form for Drying

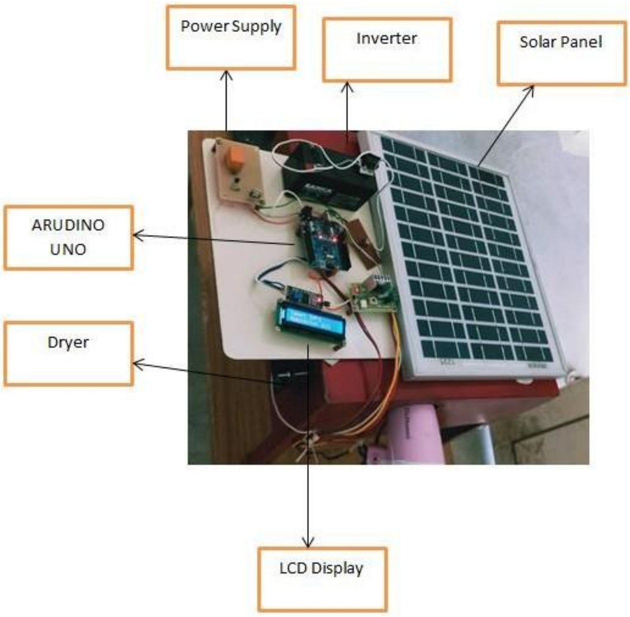
4.3 Voltage Wave form for Drying

The maximum temperature rises, raising the internal air's maximum temperature and the cover's maximum temperature in the process. The voltage waveform will be shown in the figure 4.3.



Fig–4.3: Voltage Wave form for Drying

4.4 Hardware Implementation



Fig–4.4: Schematic view of solar dryer

5. ARDUINO UNO

The Arduino UNO is in charge of heating, regulating the exhaust fan's speed, displaying the time, and maintaining a steady temperature inside the chamber. Solar collectors heat the air and send it to the next enclosure where the meat drying chamber is located in order to dry the meat using solar energy [6].

6. SENSOR

6.1 Temperature sensor

The temperature of the air entering the dryer is monitored by a sensor near the dryer's engine, and the temperature of the exhaust air is monitored by a sensor in the dryer vent. These extra sensors, when used in conjunction with moisture sensors, can modify drying periods to accommodate certain loads or your preferred level of dryness [7]. The maximum amount of humidity for air at a certain temperature is compared to the live humidity reading at that temperature to determine the relative humidity. As a result, in order to calculate relative humidity, RH sensors need to measure temperature. Absolute humidity, on the other hand, is calculated independently of temperature.

Temperature Change of Air (based on First Law of Thermodynamics):

$$\Delta T = \frac{Q}{m \times C_p}$$

Airflow Rate (based on mass flow rate):

$$\dot{m} = \rho \times A \times V$$

Psychrometric Equations (for air properties):

$$\dot{W} = 1.006 \times \dot{m} \times (h_1 - h_2)$$

6.2 Humidity sensor

The energy source for adiabatic drying is the sensible heat of a stream of air aimed at a bed or a stream of moist solids. Heat transfer in this situation is what regulates drying. Some of the moisture in the solids is evaporated by heat that travels from the air to them. A measurement of the wet-bulb temperature is essential because the sensible heat loss in this process is equal to the latent heat associated with the increased drying activities of the air [8].

Moisture Ratio of Air:

$$\omega = \frac{m_{\text{water vapor}}}{m_{\text{dry air}}}$$

Collector Efficiency Factor:

$$F_{\text{R}} = \frac{U \times A_{\text{collector}}}{\dot{m} \times C_p}$$

6.3 Temperature for Dryer

Table – 6.1: Temperature for Drye

Varieties	Starting Moisture	Final Moisre	Highest Temperature
Cabbage	85	7	63
Corn	75	7	70
Wheat	80	5	55
Cauliflower	85	15	55
Carrot	8	18	65

Drying Rate

$$\dot{m}_{\text{drying}} = A_{\text{drying}} \times \frac{dX}{dt}$$

Temperature inside the Drying Chamber:

$$T_{\text{chamber}} = T_{\text{ambient}} + \frac{Q_{\text{heat}}}{m_{\text{air}} \times C_p}$$

Collector Heat Removal Factor:

$$F_{\text{R}} = \frac{U \times A_{\text{collector}}}{U \times A_{\text{collector}} + \dot{m} \times C_p}$$

Collector Heat Removal Factor for Different Flow Patterns:

$$F_{\text{R}} = \frac{U \times A_{\text{collector}}}{U \times A_{\text{collector}} + \dot{m} \times C_p} \times \left(\frac{L}{W}\right)$$

7. SOLAR PANEL

The air inside the collection plate warms up as solar radiation strikes it. As it rises, the hot air enters the collector. As a result, air is moved by natural convection. The material that needs to be dried is arranged vertically on trays inside the drying chamber.

The collection plate's interior air warms up as solar radiation strikes it. The heated air rises and enters

the collector. Therefore, air is moved via natural convection. The drying material is piled vertically on trays inside the drying chamber. A typical home has more than enough roof space for the required number of solar panels to create enough solar electricity to meet all of its energy needs [16, 17]. Any extra electricity produced is fed back into the main power grid, which reduces nighttime electricity use [9].
Solar Radiation Intensity Calculation:

$$I_{\text{total}} = I_{\text{direct}} + I_{\text{diffuse}}$$

Solar Collector Efficiency:

$$\eta_{\text{collector}} = \frac{T_{\text{collector}} - T_{\text{ambient}}}{I_{\text{total}} \times A_{\text{collector}}}$$

Effective Solar Radiation on the Drying Surface:

$$I_{\text{eff}} = I_{\text{total}} \times \sin(\theta)$$

Energy Balance of the Drying Chamber:

$$Q_{\text{in}} = Q_{\text{solar}} + Q_{\text{conv}} + Q_{\text{rad}} + Q_{\text{cond}}$$

After that, electricity is pulled from the battery bank to the inverter, which transforms the direct current (DC) into alternating current (AC), which can be used for devices that do not operate on DC. Solar panel arrays can be sized to fulfill even the most strict criteria for electrical load with the aid of an inverter.
The AC current can be utilized to power loads in residential or commercial structures, recreational vehicles and boats, remote cottages, residences, remote traffic controls, telecommunications equipment, oil and gas flow monitoring, RTU, SCADA, and a wide range of other devices.

8. BATTERY

12-volt batteries are available in a large variety of sizes depending on the amp hours they are designed to deliver. Like those in cars, they could be large and exceedingly heavy. As with the batteries used in some yard-operated electrical vehicles, they could also be quite small. Alkaline batteries for 12-volt systems come in non-rechargeable and rechargeable varieties [10]. This battery is widely used in a range of outdoor applications where additional power is required for proper operation. However, using a rechargeable battery may be suggested if the electronic item is used regularly. Non-rechargeable batteries are often purchased. A fully charged 12-volt battery has a reading range of up to 14 volts.

9. INVERTER

A 12V 200ah battery and a 2000W inverter can power a 12 inch concrete cutter for an hour before the battery is almost totally used. If you need a powerful lithium battery for power tools,
The expert Power 200ah 12V LiFePO4 battery should be a respectable choice. To gauge battery capacity, utilize amps. Multiplying the voltage by the amp capacity yields the battery's wattage. The drive saw should require 1500 watts with a 3000 watt surge. Your inverter has a 4000 surge watt capability, therefore it is not a problem. A 24V 125ah battery can run a 1500 worm drive saw for two hours [11].

10. LCD DISPLAY

Red, blue, and green (often referred to as RGB) are the three sub pixels that make up a pixel. A display is made up of millions of pixels, and the number of pixels is usually used to describe a display's quality. For instance, a 4K display is made up of 3840 by 2160 or 4096 by 2160 pixels. Liquid Crystal Displays will display the temperature and humidity [12]. Each form of display controls pixels in a unique way, including CRT, LED, LCD, and more modern sorts of displays. In a nutshell, LCD have a backlight. To regulate the light for any pixel on the grid, a current is delivered through two conductors.

11. RESULT AND DISCUSSION

To prevent microbial growth, drying is done in order to ensure safe storage. Low storage temperatures are also strongly advised to prevent adverse responses, particularly the development of mites and insects. 18°C is a good maximum storage temperature. The largest dryers, which are of the continuous kind, are typically employed "Off-Farm" in lifts: In Europe, cross-flow dryers are favored; in the US, mixed-flow dryers. Grain dried in continuous flow dryers can be produced at a rate of up to 100 metric tonnes per hour. In continuous dryers, the depth of grain that the air must pass through varies from roughly 0.15 m in mixed flow dryers to roughly 0.30 m in cross-flow dryers [13].

12. CONCLUSION

A fan can be used to increase the efficiency of the sunlight-based dryer's intense motion drying cycle. It can replicate the temperature, velocity, density, and radiation inside and on the dryer, making it a crucial component of the design. The drying rate was shown to increase when wooden skewers were used in place of standard trays. At the conclusion of the day, it was discovered that the total difference in moisture content was 3.1%, which is substantial given that the rate of drying rapidly declines over time [14]. The greatest quality in terms of diversity, flavor, and form when compared to drying at 0.5 and 2 m/s wind speed when the weather and surrounding conditions were essentially the same for each. Future research will utilize the method to reduce time while the load (dryer) generates heat to dry the materials and shield them from dust and pests. This approach is recommended to stop components from rotting.

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