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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 835-839

www.thepharmajournal.com
Received: 28-11-2022
Accepted: 31-12-202

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Application of solar energy for operating animal drawn agro-processing unit: Papad making machine

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Abstract
In the present energy crises, it is necessary to harness the alternate source of energy. India is blessed with abundant amount of solar energy which is freely available, in exhaustible pollution free and clean in nature. The agro-Processing unit based on Animal power can be face the difficulties in areas here animal population is not adequate, also it needs maintenance throughout the year with regard to health and hygiene of the animal, similarly it needs large space to construct rotary mode set up. An Efforts are made to designs and developed 3.0 kW solar power generation system working VFD to operate existing electrical power available with the machine. Performance evaluation of papad making machine is started with respect to its output and working efficiency. Hence the agro processing unit based on the solar energy is undertaken to evaluate its performance of different processing machine up to 3 kW power. The mean rpm of motor operated by the solar are found to be 1400. The mean rpm of the papad making machine shaft was observed to be 450. The mean output was found to be 10 kg/h were as the output of papad making machine operated by bullock power was 8 kg/h. The total cost of operation of papad making machine operated by solar power 79.26 observed while operating with 2 hp three phase motor.

Keywords: Papad making machine, solar intensity, VFD, power output, motor RPM, machine RPM, cost economics

Introduction
As the price of fossil fuels fluctuates, renewable energy is quickly becoming a more important source of energy. Solar energy is one of the most widely used renewable energy sources. The most plentiful energy source is solar energy. Which is clean, replenish able, non- polluting and abundantly available. The electromagnetic radiation that comes from the sun is energy. It has a 178 billion MW potential, which is around 20,000 times more energy than the world needs (Baranwal 2014) [4]. A portion of solar energy causes water to evaporate, resulting in rain and the formation of rivers and other things. A portion of it is used in photosynthesis, which is necessary for the survival of life on earth. Since the beginning of time, man has endeavoured to control this limitless energy source.

The sun supplies a sustainable quantity of energy utilized for numerous functions on Earth, including the atmospheric system. The sun emits around 5.68+1026 calories of energy each minute, but the earth intercepts only 2.55+1018 calories (Anonymous, 2010) [14]. This is barely a millionth of the total solar energy delivered into space. The total solar energy is predicted to be 30,000 times more than the entire yearly energy of the earth (Mgbemu, 2005) [15].

Agro-processing unit based on the animal energy can be operated by using solar energy in which different machine like papad making machine, Grain Grader cum cleaner, shevai making machine, flower mill, etc., can be operated by using three phase 2 hp electric motors. The study is undertaken to the performance evaluation of papad making machine drive 3 kW solar power generation unit.

Materials and Methods
Design of solar photovoltaic system for agro-processing unit and its Performance evaluation
A solar powered agro-processing unit consisted of different components. *viz*; solar panels, variable frequency drive, AC motor, papad machine

Selection of Solar Panel
Procedure for selection of size or capacity of solar panel was followed and it was designed as per the requirement of AC motor used for operating different machine in agro- processing unit

Following steps were followed for selection of panel
Step 1: Calculate power requirement
Step 2: Determine the size and number of panel according to power requirement.

Power requirement

$P = (I \times V \times 1.73 \times PF)/100$

Where,
P-power in kilowatt I-current
E-Voltage
PF-Power Factor

A total power requirement for papad making machine, grader cum seed cleaner and shevai making machine, flour mill was 1.5 kW, 1.5 kW, 2.238 kW, 2.238 kW by calculating the above formulae.
According to the power requirement, a 2 hp (1.5 kW) three phase and 3 hp (2.238 kW) three phase A.C motor was used as the source of power. The specifications of AC motor presented in Table no 2.

Size of solar panel
To calculate size of solar system, it is important to follow these steps:
Step 1: Calculate the Maximum total load that we want to run by Solar Panel.
We decide to run up to 3 hp motor. Then 2.328 kW load present in the system. but approx. 3 kW load is taken.
Step 2: Calculate size of solar panels based on electrical load.
We need to install panels of 3000 watts to run electrical load. We can go for 9 panels of 335 watts each. Then the total power output is 3015 W or 3 kW.

Testing of Solar Panel
Efficiency of panel, short circuit voltage, conversion efficiency of panel these parameters were studied during the testing of solar panel.

Testing of Solar Panel Efficiency of panel
The efficiency is the most commonly used parameter to compare the performance of one solar cell to another. Efficiency is defined as the ratio of energy output from the solar cell to input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incident sunlight and the temperature of the solar cell. Therefore, conditions under which efficiency is measured must be carefully controlled in order to compare the performance of one device to another.

Short circuit voltage
Large number of photovoltaic (PV) power plants connected to a power grid can bring significant impacts to fault currents and the operation of protection systems. Short-circuit current characteristics of a PV system with low voltage ride through (LVRT) capability under a symmetrical fault is studied. PV system short-circuit experiments with different voltage dips at high and low output power levels are designed and conducted. The experimental results provide useful and valuable references for researches of PV system short-circuit current characteristics, modeling and PV system short-circuit current contribution to a power grid. Then, based on the experiment all results, Steady State values, peak values and steady state short-circuit currents harmonic characteristics at different conditions are obtained and analyzed. It is found that, the DC component amplitude of a PV system short-circuit current is almost negligible compared with that of the power frequency component, which is different from conventional synchronous generator short-circuit current. Meanwhile, based on the LVRT control strategy and experimental results, the expression of steady-state short-circuit current RMS value is derived and verified, which provides an important basis for short-circuit current calculation of power system with large scale of PV plants.

Conversion efficiency of panel
Solar panels are usually able to process 15% to 22% of solar energy into usable energy, depending on factors like placement, orientation, weather conditions, and similar.

Atmospheric Parameter
Atmospheric parameters like Solar Radiation, Ambient Temperature, Atmospheric Humidity, Air Velocity these some are observed during the operation of papad machine on solar power.

Solar panel capacity
Solar panel is used to generate the electrical power which farther can be used to run the
A.C motor with help of VFD as well as Running different machine in agro processing unit. A solar panel of 335 W capacity the 36 Voltage and 8.95A current was selected. There was nine number of Solar panels to be selected. The panel are fixed on the roof top of agro processing unit.

Components of solar powered agro-processing unit Solar panel
The Nine solar panel of 335 W capacity configured to trap and convert the sun's energy into the useful power was used to run the motor for the different machine in agro processing unit. Solar panel was used for operating the different machine in agro processing unit.
The majority of modules use water based crystalline silicon cells or thin film cells based on cadmium telluride or silicon. Its power rating is an important consideration while selecting the solar panel as it determines the time taken to charge the battery.

Plate 1: Solar panel

AC Motor
A 415 V, 3 HP 3 Phase A.C. motor was used for operating different machine at 1440 rpm with 50 Hz frequency. The A.C. motor was fitted on Papad machine, Shevai machine,

Grader Machine one by one. Different size of pulley used for the different speed required for different machine. A compact size, rust proof, easy to clean and maintain and low electric consumption motor was used to reduce the weight.

Plate 2: Induction Motor

VFD

Controllers are VFD based which works on both Solar and Electricity, available in three phase low voltage and high voltage AC Motors Our controllers are designed with low maintenance cost. Its soft starter feature prevents hammering and increases life of the motor. Principle of VFD Pulse Width Modulated Variable Frequency Drives. When operated from a constant frequency power source (typically 50Hz), AC induction motors are fixed speed devices. A variable frequency drive controls the speed of an AC motor by varying the frequency supplied to the motor

Plate 3: VFD

Different machine like papad making machine, seed grader cum cleaner, shevai machine, Flour mill are selected to operating on solar power.

Table 1: Specification papad machine

Sr. No.	Overall Dimensions of papad making machine	
1	Length (mm)	55
2	Width (mm)	45
3	Height (mm)	65
4	Weight (kg)	90
5	Working efficiency (per cent)	90%
6	Power requirement (kW):	0.746
7	Capacity (kg/h):	10

Table 2: Specifications of the components of solar powered unit

Sr. No.	Components	Specification
1	Solar panel Brand	WS-335
	Maximum power (Pmax)	335.0
	Panel Dimension	1996*990 mm
	No of panel	9
	Short circuit current	9.25A
	Max power current	8.95A
	Max system voltage	1000V
2	Dc Motors Type	Induction motor
	HP	2.0
	Model	MY1016
	Rated current	3.8 A
	Speed	1440 rpm
	Voltage	415
3	VFD Brand	Crompton
	Power	2.2kW/3HP
	Input	1 Phase, DC 250-350V, 18A
	Output	3 Phase, 9.5A, 0-600 Hz

Performance evaluation of solar powered papad making machine

The developed solar power agro-processing unit was evaluated for its performance Machine like papad machine operated by solar. During the evaluation of the solar powered agro-processing unit, the following parameters were recorded.

Solar intensity

The solar intensity determines the amount of solar energy available in the location and the amount of energy generated by the solar panel can be known. It was measured by using a solar intensity meter. The solar intensity was measured during operation of papad making machine from 9:00 AM to 5:00 PM at every 1 hr. of interval.

Voltage generated

The average voltage produced by the solar panel during operation in garden and sports ground was measured using multi-meter.

Frequency of Current

The frequency of a current is how many times one cycle of the waveform is repeated per second, and is measured in hertz (Hz). Mains electricity has a sine waveform and a frequency of 50Hz.

Current

A flow of electricity which results from the ordered directional movement of electrically charged particles.

Atmospheric Temperature

Solar cells are sensitive to temperature changes. An increase in temperature reduces the band gap of the semiconductor, thus affecting most of the parameters of semiconductor material. The decrease in the band gap of a semiconductor with increase in temperature is an increase in the energy of electrons in the material.

RPM of Motor

RPM refers to the revolutions per minute of a motor. A tachometer (revolution-counter, tach, rev-counter, RPM gauge) is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine.

Performance evaluation of solar operated agro-processing unit

Name of Machine: Papad Machine

Table 3: Performance of papad making machine operating by solar power at no load

Sr. No.	Time	Atm. Temp. °C	Insolation W/m2	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm
1	9.00 am	29	297	2.0	311	1425	515
2	10.00 am	34	368	2.1	318	1436	529
3	11.00 am	37	384	2.1	354	1445	545
4	12.00 am	39	472	2.2	350	1449	548
5	1.00 pm	40	515	2.2	350	1447	543
6	2.00 pm	42	561	2.2	345	1445	551
7	3.00 pm	42	374	2.2	337	1438	534
8	4.00 pm	41	334	2.1	321	1404	503
9	5.00 pm	41	202	2.1	318	1391	491

First of all, the papad machine was operated at no load with the help of solar photovoltaic system in order to compare the experimental data with corresponding parameters during different climatic condition. The results are presented in table 3.

The solar intensity was varied from 297 to 561 Wm-2, the maximum solar intensity of 561 Wm-2 was recorded at 2 pm at a temperature of 42 0C. The Average solar intensity was 390 Wm-2 of the day. Voltage (V) and current (A) of solar panel was varied from 311 to 354 V and 2 to 2.2 A. Also, the Motor rpm vary according to the intensity of the solar radiation.

Solar powered agro-processing unit operated from morning 9.00 am up to evening 5.00 pm. The parameters selected to evaluate include motor speed and mechanical rpm of papad machine. The levels of variables at load selected for the study are presented in Table 3 The effects of operational parameters were studied to evaluate the performance of solar powered papad making machine. The difference in rpm at load and no-load condition of motor and machine pully for papad making machine was found 9.11 and 7.78 respectivly.

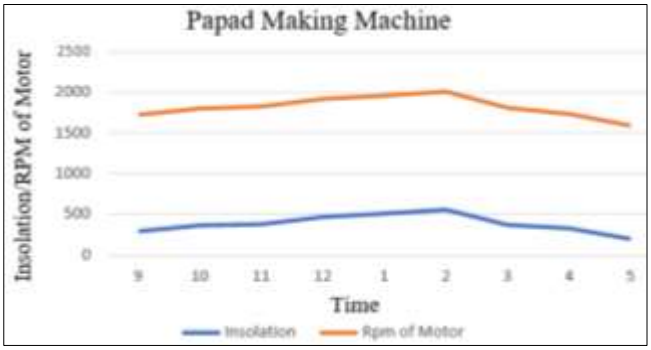

Fig 1: Relation between solar intensity and motor rpm Vs time for papad making machine

The reading was taken between morning 9.00 am to 5.00 pm evening, during these period it was observed that as the time increases temperature and solar intensity is increases up to 2 pm then after that time temperature and solar intensity goes on decreasing slowly. Also, it is found that as solar intensity increases motor rpm also increases or as solar intensity decreases motor rpm deceases vice versa, hence it is concluded that motor rpm is directly proportional to the solar intensity. The maximum solar intensity of 561 Wm-2 was recorded at 2 pm at that time the motor rpm at no load was 1451 and minimum solar intensity was found at the time of morning and evening i.e., 202 Wm-2 at 5 pm.

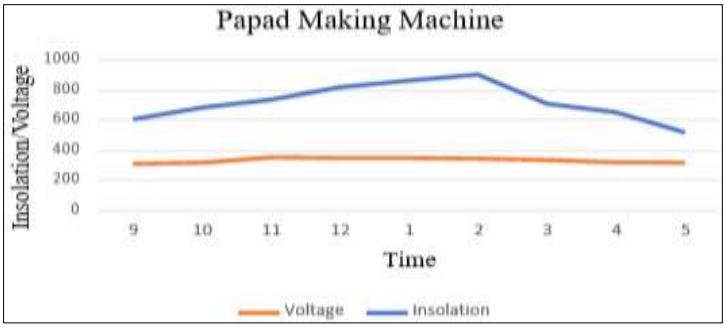

Fig 2: Relation between solar intensity and voltage Vs time for papad making machine

In normal insolation during the project period, it is observed that as solar radiation increases the voltage also increase and vice versa but at certain time voltage appears more than required hence the papad making machine can easily run for minimum 5 hrs. daily from 10 am to 5 pm.

Table 4: Performance of Papad making machine operating by solar power at load

Sr. No.	Time	Atm. Temp. (°C)	Insolation (W/m2)	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm	Output (kg/hr)
1	9.00 am	29	297	2.2	311	1419	507	7.5
2	10.00 am	34	368	2.3	318	1425	521	8.1
3	11.00 am	37	384	2.3	354	1437	535	8.3
4	12.00 am	39	472	2.4	350	1439	538	8.7
5	1.00 pm	40	515	2.5	350	1440	533	8.4
6	2.00 pm	42	561	2.5	345	1443	541	8.6
7	3.00 pm	42	374	2.4	337	1423	522	8.3
8	4.00 pm	41	334	2.3	321	1396	497	8.1
9	5.00 pm	41	202	2.3	318	1388	483	7.8
Average Output								8.2 Kg/hr

The mean output was found to be 8.2 kg/hr from papad machine was run by Solar power operated 2 Hp (1.5 kW) Motor.

Plate 4: Performance evaluation papad making machine

Plate 5: Papad obtained from papad machine operated by solar photovoltaic system

Conclusion

The existing machine in agro processing unit like papad making machine, run on the designed solar photovoltaic system.

In Normal sunny days with average Radiation (520W/m2) Motor output was fount Optimum
(1440 RPM) For 5 hr. in one day.

The maximum solar intensity 561 W m-2 was recorded at 2 pm at that time the motor RPM was 1451 and minimum solar intensity was found at the time of morning and evening that was i.e., 202 W m-2 at 5 pm.

The cost analysis Showed that the operating cost For Papad Making Machine, was 79.26 Rs per hr**.**

The papad making machine with 2 HP 3 Phase electric motor run on solar energy gives average output 8.2 kg in normal sunny days.

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