

COMPARATIVE EVALUATION OF HYBRID AGRO- PROCESSING UNIT OPERATED BY BULLOCK AND SOLAR POWER

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B.Tech. (Agril. Engg.)

**MASTER OF TECHNOLOGY
IN
AGRICULTURAL ENGINEERING
(FARM MACHINERY AND POWER ENGINEERING)**



**DEPARTMENT OF FARM MACHINERY AND POWER
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COMPARATIVE EVALUATION OF HYBRID AGRO- PROCESSING UNIT OPERATED BY BULLOCK AND SOLAR POWER

BY

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B. Tech. (Agril. Engg.)

A thesis submitted to

Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani

in partial fulfillment of the requirement for the degree of

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IN

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(FARM MACHINERY AND POWER ENGINEERING)



**DEPARTMENT OF FARM MACHINERY POWER ENGINEERING
COLLEGE OF AGRICULTURAL ENGINEERING & TECHNOLOGY
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2022

DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled, “**COMPARATIVE EVALUATION OF HYBRID AGROPROCESSING UNIT OPERATED BY BULLOCK AND SOLAR POWER**”, submitted by me is based on the actual work carried out by me under the guidance and supervision of **Dr. SMITA NATWARLAL SOLANKI**. The extent of information derived from the existing literature have been duly cited and referenced. The existing research work or its any part is not submitted anywhere else for the award of any degree or diploma.

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44 INTRODUCTION 1.1 Animal draft power Indian agriculture has relied significantly on animals that can withstand drought since ancient times. Recent advancements in automation and fuel-run machinery have reduced the acreage needed for draught system livestock production. Nevertheless, draught horses are still used to cultivate the ground on many marginal and small properties. Due to tiny holdings and hill farming, draught animal power (DAP) is still used on Indian farms, although the modernisation of agriculture has increased the use of mechanical power. Tractor use accounts for only 20% of all agricultural land; more than 55% of it is still worked by draught animals. Less than 300 hours are spent using bullocks annually. However, bullocks may be employed for roughly 800 hours annually. We know that bullock power is larger than one horsepower. To boost the employment of cattle in the state, stationary bullock-powered equipment with an approximate 1 horsepower (0.8 kW) of power are necessary for undertaking duties like milling wheat, removing chaff, expelling oil, milling and de-husking beans, making shevai and papad, etc. the financial benefits of adopting commercial energy sources in light of the current situation of escalating fuel prices. The technology also has the advantage of producing energy without polluting the environment. development of supplemental agricultural machinery for rotational (deshwina 2014). Draft animal is still a major source of farm power in Indian agriculture (Singh and Singh, 2013). Bullock and buffalo are the common draft animals found in our country with a total population of 55 million in 2008-09 (Anonymous, 2013).

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These animals perform different field operations and are also used for rural transportation.

It is observed that bullocks are generally utilized for about 300 hours in a year (Srivastava, 2000). They remain idle for rest of the time. When animals are used in a rotational mode of operation, the excess/idle animal power that is left over after tillage, sowing, and other field activities may be effectively used for various agroprocessing processes. This will lessen farmers' reliance on fossil fuels and power. The farmers will be able to earn additional money even while they are

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ABBREVIATIONS USED

A	-	Ampere
Ah	-	Ampere-hour
DC	-	Direct current
Engg.	-	Engineering
<i>et al.</i>	-	<i>Other</i>
fig.	-	Figure
h	-	Hour
ha	-	Hectare
ha/h	-	Hectare per Hour
hp	-	Horse Power
Kg	-	Kilogram
Km	-	Kilometer
Km h	-	Kilowatt hour
kN	-	kilo Newton
kW	-	Kilo Watt
kWh	-	kilo watt hour
m	-	meter
m/s	-	Meter per Second
m ²	-	Meter square
mA	-	Squire Ampere
m-Ah	-	milli Ampere
Min	-	Minutes
mm	-	Millimeter
rpm	-	Revolution per minute
Rs	-	Rupees
Rs/hr	-	Rupees per hour
S	-	Second
V	-	Volt
viz.,	-	Namely
W	-	Watts
Wh/kg	-	Watt hour per kilogram
W/m	-	Watt per meter Square
%	-	Percent
°C	-	Degree Celsius
VFD	-	Variable Frequency drive

THESIS ABSTRACT

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1	Title of the thesis	:	Comparative Evaluation of Hybrid Agro-processing Unit Operated by Bullock and Solar Power.
2	Name of candidate	:	Gethe Rohit Arun
3	Name of Research Guide	:	S. N. Solanki
4	Department	:	Farm Machinery and Power Engineering
5	College/University	:	College of Agricultural Engineering and Technology, VNMKV, Parbhani.
6	Degree to be awarded	:	M. Tech. (Farm Machinery and power)

ABSTRACT

In the present energy crises, it is necessary to harness the alternate/renewable 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. Efforts are made to designs and developed 3.0 kW solar power generation system working on Variable Frequency Drive to operate existing electrical power available with the machine. Performance evaluation of machine like papad making machine, grader cum cleaner, shevai machine, flour mill was started with respect to its output and working efficiency. Hence the agro processing unit base on the solar energy is undertaken to evaluate its performance of different processing machine up to 3 kW power. In Normal sunny dayswith average Radiation (410W/m^2) Motor output was fount Optimum (1440 RPM) for 5 hr. in one day Hence motor can be very well operated for five hours in a day. The papad making machine, grain grader cum seed cleaner was run one by one using motor of 1.5 kW. Shevai machine, flour mill was run one by one using motor of 2.238 kW. The cost analysis Showed that the operating cost for Solar powered papad making machine, grader cum seed cleaner, shevai machine, Flour mill was 93.41 ,67.53, 66.49, 65.46 Rs per hr. respectively. The papad making machine and Grader cum Cleaner with 2 Hp 3 Phase electric motor run on solar energy gives average output 8.2 kg/hr., 34.22 kg/hr. respectively in normal sunny

days. The Shevai making machine and Flour mill with 3-Hp 3-Phase electric motor run on solar energy gives average output 7.32 kg/hr. and 8.71 kg/hr. respectively in normal sunny days.

Keywords: Agroprocessing unit, Solar power, Bullock power, Atmospheric Factor, Current, Voltage, VFD, Power output, Motor rpm, Machine rpm, Cost Economics.

CHAPTER - I

INTRODUCTION

CHAPTER-I

INTRODUCTION

1.1 Animal draft power

Indian agriculture has relied significantly on animals that can withstand drought since ancient times. Recent advance in mechanization and fuel-run machinery have reduced the acre under draught animal cultivation system. Draught animals are still used to cultivate the land on many marginal and small properties. Due to small land holdings and hill farming, draught animal power (DAP) is still used on Indian farms, although the modernization of agriculture has increased the use of mechanical power. Tractor use accounts for only 20% of all agricultural land; more than 55% of it is still worked by draught animals.

Less than 300 hours of bullocks are annually used. However, bullocks may be potential of work for roughly 800 hours annually. We know that bullock power is near about one horsepower. To boost the utilization of animal in the state, there is need of suitable matching implement and stationary bullock-powered equipment with an approximate 1 horsepower (0.746 kW) of power are necessary for doing various operation like milling wheat, removing chaff, expelling oil, milling, de-husking beans, making shevai and papad, etc. The financial benefits of adopting commercial energy sources in light of the current situation of escalating fuel prices. The technology also has the advantage of producing energy without polluting the environment. (Deshwena *et al.* 2014).

Draft animal is still a major source of farm power in Indian agriculture (Singh and Singh, 2013). Bullock and buffalo are the common draft animals found in our country with a total population of 86 million in 2021 (Anonymous, 2022). These animals perform different field operations and are also used for rural transportation. It is observed that bullocks are generally utilized for about 300 hours in a year (Srivastava, 2000). They remain idle for rest of the time. When animals are used in a rotational mode of operation, the excess/idle animal power that is left over after tillage, sowing, and other field activities may be effectively used for various agroprocessing process. This will reduce farmers' reliance on fossil fuels and power. The farmers will be able to earn additional money even while they are not working in agriculture. Self-

help groups can also make money at the same time. The alternative to an electric motor or IC engine in isolated settlements on plains or hills where the electrical supply is irregular or unpredictable is small-capacity agro-processing equipment in rotational mode utilising animal power.

Farmer must maintain and care for their livestock throughout the year, whether or not they are working. Increased usage of draught animal can increase farmer's revenue while also reducing the reliance on commercial fuel, which are becoming increasingly expensive. One viable method of harnessing draught animals is to operate various stationary agroprocessing devices such as thresher, winnowers, chaff cutter, cane crusher, grain grinder, oil expeller, and so on.

Previously, significant study was conducted on the bullock pulled rotary mode agro-processing unit, and it is now time to assess and compare it to solar power.

1.2 Solar power

The energy that the sun provides, known as solar energy, is what keeps life on earth going. For many years, solar energy has been regarded as a significant source of energy and because to its availability, as a cost-effective source of energy. The ability to harness solar energy, however, has only recently been attainable thanks to technology and years of study. In both home and commercial contexts, solar energy is already effectively employed for a variety of purposes, including lighting, space technology, heating, cooling, and communication in actuality, one type of solar energy that is stored in biological matter is fossil fuels. Solar energy has grown in relevance to industry and home as a result of fossil fuels significant negative effects on the environment and related concerns of pollution and global warming.

The sun provides sustainable amount of the energy used for various purposes on earth for atmospheric system. Every minute the sun radiates about 5.68×10^{26} calories of energy and the earth intercepts only 2.55×10^{18} calories (NRF, 2010). This represents only 2000 millionth of the total solar energy sent into the space. The total solar energy is estimated to be 30,000 times greater than the total annual energy of the world (Mgbemu, 2005).

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. Both

directly and indirectly, such as in the form of wind energy, are accessible. 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 (Alok Baranwal *et al.* 2014).

The solar powered lawn mower operates on the same basis as previous early lawn mower technologies. The only distinction is the application of the energy source. It generates the energy required to operate the mower using a solar panel. It is anticipated that a lawn mower powered by solar energy will address a number of concerns that conventional lawn mowers powered by internal combustion engines and electric motors do not. By avoiding repeated fill-ups at the gas station and the risk of gasoline spills, it reduces downtime. There are no longer any harmful emissions into the atmosphere from internal combustion engines or gasoline spills. The solar powered lawn mower will aid in reducing the noise pollution that is caused by conventional types of lawn mowers as well as the air pollution. Additionally, it will assist in lowering the expense of operating and maintaining a lawn mower (Tanimola *et al.*, 2014).

The solar powered lawn mower operates on the same basis as previous early lawn mower technologies. The only distinction is the application of the energy source. It generates the energy required to operate the mower using a solar panel (Kulhariya *et al.* 2020).

1.3 Agro-processing unit

In the agro-processing plant, we use both bullock and solar power to drive the, papad making machine, shevai machine, seed grader cum cleaner and flour mill.

1.3.1 Why solar power is to be replaced by animal power

- a) Solar power is pollution free, freely available, inexhaustible in nature and causes no greenhouse gases to be emitted after installation.
- b) In some areas animal power is not easily available but at the same time solar energy is freely available.
- c) We installed anywhere the solar operated unit but limitation for installation in animal operated unit.

1.3.2 Constraints of animal power

Animal used for short life span, Power of output is low, not suitable for large

scale operation, Disease may affect the efficiency of animal These are constraints of using animal power. Huge amount of money is needed to feed and maintain the animal.

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 solar 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.

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

Considering the above fact, the present investigation entitled **“Comparative evaluation of hybrid agro-processing unit operated by bullock and solar power”**.

1. Design of solar photovoltaic system for agro-processing unit and its Performance evaluation.
2. Performance evaluation of bullock drawn rotary mode agro-processing unit.
3. Comparison of agro-processing unit operated by solar and bullock power in order to its efficiency and cost effectiveness.

CHAPTER – II
REVIEW OF LITERATURE

CHAPTER- II

REVIEW OF LITERATURE

This section briefly deals with the review of the research work carried out in India and abroad in relation to the objectives of the proposed study. An extensive review of research literature has been made on the lines of objectives contemplated to facilitate devising an appropriate methodology towards accomplishing the entire research topic. The information was published about the agro-processing unit operated by bullock and solar power is discussed in this chapter.

The review and information related to the study is presented under the following heads.

2.1 General

2.2 Bullock operated rotary mode power transmission units.

2.3 Climatic factor affects on solar power conversion process.

2.4 Solar power operated agricultural machines.

2.5 Power transmission in solar operated unit.

2.6 Selection of Solar Panel.

2.7 Selection of Motor.

2.8 Cost economics of rotary mode set up.

2.9 Cost economics of solar operated Unit

2.1 General

Phadtare *et al.* (2019) studied that application of renewable energy sources agriculture and agro based Industry. Effort to meet the increasing demand of 21st century world needs energy and food for its increasing population. Major requirement of food production is energy for agriculture and agro-based industries. The major demand of energy of agriculture and agro-based industries is meet by conventional sources such as fossil fuel, crude oil, grid power, coal etc. This source of energy produces carbon foot print, pollution, global warming, environmental and ecological degradation which causes environmental hazards. Also, the conventional sources are more costly and exhaustible in nature. In order to cope up with this situation we need to move towards sustainable sources of energy in agriculture and agro-based industries.

Bhatt *et al.* (2020) performed research on changes in physiological parameters of bullocks. During research found that Uttarakhand is one of the hill states of India that lies in the Central Himalayan region wherein agriculture & livestock form the basis of subsistent livelihood for the population. Livestock is an integral part of mountain agriculture moreover; bullocks are considered as the lifeline of farming in the hilly terrain as they prepare the field for carrying various agricultural activities. Therefore, a study was done to measure the field performance of bullocks in terms of field efficiency, work hours/day and work rate/ha and data was taken from 40 pairs of bullocks at the time of ploughing. Apart from that, data was taken through manual measurement on respiration rate, pulse rate and rectal temperature before and after one hour of ploughing.

2.2 Bullock Operated rotary mode agro-processing unit

Hallikeri *et al.* (1995) carried out research on performance of a bullock power operated chaff cutter. An experiment was conducted with a bullock powered rotary complex to operate a chaff cutter, suitable for a 1 hp. power source. A pair of khillari bullocks of 920 kg body weight was used in the study. The draft requirement for the chaff cutting operation was found to be well within the capacity of a pair result showed to operate a chaff cutter needs 1 hp by using a suitably designed gear box.

Swain *et al.* (2013) studied that bullock energy utilization through rotary mode power transmission system in operating potato peeler and slicer for chips making as value added product of potato. Use of bullocks for agricultural work is limited to tillage, sowing and transportation. The total annual use of bullocks in the state of Odisha is less than 300 hours even though the annual potential use is nearly 800 hours. To enhance the utilization of bullocks, there is a need of using bullock power operated stationary machines requiring about 1 hp (0.746 kW) power for doing various post-harvest operations in rotary mode like paddy threshing, paddy winnowing, chaff cutting, sugarcane crushing, groundnut decortications, oil expelling, pulse milling and de-husking etc.

Singh and Singh (2013) studied that the physiological response of Malvi breed bullocks in rotary mode power transmission system for electricity generation. In this paper physiological response of Malvi breed of bullocks in rotary power transmission system for electricity generation are described. The status and scope of various parameters of rotary power transmission system like torque, load/draft on animals and

charging time of batteries for electricity generation are also discussed. It has been found that efficiency of rotary power transmission system is 58% and the bullocks were not fatigue after 6 hours of work as they scored 16 points against the fatigue level score of 20 points.

Choudhary *et al.* (2016) presented research on physiological responses of bullocks in rotary transmission system for briquette production. Draught animals such as bullocks and he buffalo are the important source of energy for agricultural operations on small and marginal farms of Chhattisgarh, which constitute three fourth (75.77 %) portion of total land holding. Draught animals used in this region are small sized. In this paper physiological response of non-descriptive breed of bullocks of Chhattisgarh region in rotary power transmission system for briquette production are described.

Ghosal and Behera (2019) studied that draft bullock power utilization for sustainable rural livelihood and food security. Bullocks are the main source of power in Indian agriculture. Use of bullocks for agricultural work is limited to tillage, sowing and transportation in the state of Odisha, India. The total annual use of bullocks is less than 300 hours. But the potential use of bullocks in a year is nearly 800 hours. To enhance the utilization of bullock in the state, there is the need of suitable matching implements and bullock power operated stationary machines requiring around 1 hp (0.746 kW) power for doing various post-harvest operations like threshing, chaff cutting, sugarcane crushing, oil expelling, pulses milling and dehusking etc.

Latha *et al.* (2019) carried out research on development of bullock cart mounted electricity generation unit. draught animals are major source of motive power for majority of farmers. In India bullocks, buffaloes, camels, horses, mules and donkeys are common draught animals. These animals perform different field operations and are also used for rural transportation. In Indian agriculture, bullock farming operations are being carried out by small and marginal farmers and bullock power play an important role in many works. The availability of electric power in rural areas is a serious problem. The one way of utilizing bullock power could be for electricity generation to meet out the demand of the house hold purpose in villages. With this aim, the electricity generation unit was installed in the bullock cart and generated electricity was stored in battery. Alternator is used to produce current and that can be used for charging of battery.

Deshvena and Solanki (2020) carried out research on the utilization of bullock energy by using rotary mode power transmission system in operating agro-processing unit (Shevai machine) In rural areas electricity is either unavailable or available for limited period. So, performing many activities with the help of animal driven rotary mode power can be a good alternative. The bullocks can be used in rotary mode power transmission system, post-harvest operations like mini rice mill, flour milling, chaff cutting, dal milling, groundnut decortications, oil extraction, threshing shevai making machine and other stationery operations. Draught animals are used for a limited period for agricultural work 40 to 50 days and the rest of the time they stand idle.

Deshvena and Solanki (2020) designed an efficient transmission system (Rotary mode) for post-harvest operation - grain cleaner cum grader. The bullock energy can be used in the rotary mode set up for post-harvest operations like grain cleaning and grading, chaff cutting, daal mill operations, flour milling and other stationery operations. The proposed research work presents the performance evaluation of the grain cleaner cum grader unit.

Shinde and Tekale (2020) studied the performance evaluation of animal driven rotary mode power transmission system to operate flour mill. The performance evaluation of animal driven rotary mode power transmission system for operating flour mill was undertaken at the site of the CAET, V.N.M.K.V., Parbhani. The work rest schedule of 1 hour work - ½ hour rest - 1 hour work - ½ hour rest - 1 hour work - ½ hr. rest - 1 hour work was followed. The speed (kmph), draft (kg), output (kg/hour), power developed (W), physiological responses and fatigue score of experimental bullocks in operations of flour milling were recorded.

Patel *et al.* (2021) studied the performance evaluation of a bullock operated rotary gear transmission system for paddy threshing. Annual use of draught animals needs to be increased to reduce the burden of maintenance cost of bullocks, which can be possible by using post-harvest machines in rotary mode. Performance evaluation of a bullock operated rotary gear transmission system was conducted for paddy threshing by a hold-on type paddy thresher with respect to various parameters namely rotary system, physiological and machine parameters at three different levels of working radii in rotary mode. The lowest draft requirement, highest speed of operation of bullocks and highest thresher drum speed were observed to be 454.34 N, 0.73 m sec^{-1} and

435.45 rpm respectively at 3.8 m working radius. At this working radius, the physiological parameters of working bullocks such as pulse rate, respiration rate and body temperature were found to be within sustainable loading capacity of the bullocks.

2.3 Solar power operated agricultural machine

Keskar *et al.* (2013) studied the electricity generation using solar power. Today energy is the main inspiration for socio-economic development. But due to incremental rate of environmental concern renewable energy provide a significant interest. This alternative power source is continuously achieving greater popularity due to continuous reduction in fossil fuels. It is the energy comes from sun, wind, rain etc. Among the non-conventional, renewable energy sources, solar energy affords great potential for conversion into electric power.

Sharma and Samuel (2014) carried out research on the development of Solar photovoltaic (SPV) powered vegetable-cum- fruit grader power from solar photovoltaic system was used for operation of a grader for grading of fruits and vegetables. A solar panel of 400 W (4 solar modules of 100 W each with open circuit voltage 18 V) was used to operate the system. The direct current (DC) power of the solar panel was used to run the 150 W DC motor of the grader. The grader was tested for grading of potatoes in three sizes. The output capacity of the grader was found as 600 kg/h. A 12 V/7 Ah battery may also be used to operate the grader in the absence of solar energy.so it was cheap and very useful for small scale farmers. It is usable to different crops like Beet, Asparagus, Cabbage, Carrot, Corn Okra, Onion, Pepper, Potato, Radish. This machine has great potential for increasing the productivity of planting.

Hussain *et al.* (2015) studied the utilization of solar energy in agricultural machinery engineering. Various solar energy collecting systems have been developed and analysed for agricultural applications. They include solar thermal and electric devices such as solar crop dryers, solar water pumps, solar greenhouse heating, ventilation for livestock, solar aeration pumps, solar electricity, and many more.

Aju *et al.* (2016) carried out study on development and performance evaluation of a trailed solar photovoltaic stand-alone system for rice threshing machine. A solar PV system was designed and used to power a vortex rice threshing machine. The

threshing machine was mounted on a two-wheel trailer that was designed and fabricated. The performance of the PV system and the threshing machine were evaluated and analyzed. The solar PV system was designed by first determining the power rating of the electric motor to be used on the thresher, from which the array sizing of the PV modules was determined. This also enabled the determination of the battery capacity, appropriate size of charge controller and inverter. The performance of the solar PV system was evaluation by measuring the insolation, current and voltage of the system from 0900 H – 1200 H daily from a sun meter, ammeter and voltmeter respectively and power output determined.

Vyas *et al.* (2017) conducted experiment on solar based multipurposed agriculture machine. Developed agriculture needs to find new ways to improve efficiency. One approach is to utilize available information technologies in the form of more intelligent machines to reduce and target energy inputs in more effective way than in the past. Precision farming has shown benefits of this approach but we can now towards a new generation of equipment. The advent of autonomous system architectures gives us the opportunity to develop a completely new range of agricultural equipment based on small machines that can do right thing, in the right place, at the right time, in the right way.

Bobde *et al.* (2017) studied that a review on solar operated Agri-cutter. The cost of fuel and the effect of emission of gases from the burnt fuel into the atmosphere, this necessitates the use of the abundant solar energy from the sun as a source of power to drive a Agri-cutter. A solar powered Agri-cutter was designed and developed, based on the general principle of mowing. The designed solar powered Agri-cutter comprises of direct current (D.C) motor, a rechargeable battery, solar panel, a stainless-steel blade and control switch. Mowing is achieved by the D.C motor which provides the required torque needed to drive the stainless-steel blade which is directly coupled to the shaft of the D.C motor. The solar powered Agri-cutter is operated by the switch on the board which closes the circuit and allows the flow of current to the motor which in turn drive the blade used for mowing. The battery recharges through the solar charging controller.

Bhalekar *et al.* (2017) developed portable solar operated pesticide sprayer. India is an agriculture-based country. Development of solar operated pesticide sprayer has following step and Selection of components like Solar panel, Dc pump, Battery, Nozzle,

Tank, Ac to Dc converter. The proposed system was tested with solar charging as well as Ac charging. Practically time required to charge battery is 6.23 hrs. Full charge battery continuously can run for 5-6 hrs. If we charge the battery in day with solar panel it sprays approx. 190-200 litres of pesticide. Weight of system can be also reduced by replacing aluminium strips by strong fibre/ plastic which can hold the solar panel. Solar panel can removable for night spraying.

Kandalkar *et al.* (2018) conducted research on solar operated multipurposed agriculture Machine. Energy demand is one the major thread for our country. Finding solutions, to meet the Energy demand is the great challenge for social scientist, engineers, entrepreneurs and industrialist of our country according to them, applications of non-conventional energy is the only alternate solution for conventional energy demand. Now a day the concept and technology employing this non-conventional energy becomes very popular for all kinds of development activities. One of the major area, which finds number applications are in agriculture sectors. Solar energy plays an important role in drying agriculture products and for irrigation purpose for pumping the well water in remote villages without electricity.

Dwivedi *et al.* (2018) designed and developed solar powered weeding machine. This paper focuses on the various techniques used for weeding purpose for agricultural implants which have a scope to be used in future. The implants used in conventional methods have some side effects. The effective properties of solar powered weeding machine are suitable for weeding purpose and have no side effects. It avoids the use of any chemicals and hence prevents the crops from chemicals. Weeds are harmful for the crops hence would be removed. The weed cutter is safe as all the materials used can be recycled and does not pollute the environment as it is driven by solar energy. It is not so complicated mechanism and can be run by anyone.

Waghmare *et al.* (2020) designed and fabricated Vedic flour milling machine powered by solar power. In India most rural people still use hand milling methods to prepare their daily food. This takes a lot of time and is an arduous work mainly carried out by women and children. Therefore, the introduction of motorized mills can improve their living conditions. However, typical diesel-driven mills have a capacity of 25 to 1,800 kg of grain per hour. Therefore, a new PV-driven stone mill with a millstone-diameter of 450 mm and a maximum capacity of 3 kg per hour was constructed and

optimized. By optimizing the design and operation of the mill the maximum power requirement could be reduced to less than 100 W.

Sutar and Bulate (2020) studied that solar powered multi-functioned electric tractor for agriculture usage. The next major step of mankind was to find new ways of turning energy from the Sun in usable energy for all sorts of activities after the enormous industrial revolution. For reality, by the conclusion of Earth history, sun does not die, this assumption is believed to be intermittent with certain forms of energy sources. The electric tractor system offers the opportunity to use renewable energy locally generated for agricultural applications in rural areas without (or with) grid connectivity. The idea of electrical tractor is already an economic and technologically feasible option with an exchangeable battery pack in equatorial regions that have a stable, low-cost power supply in the form of a PV plant today. The most notable implication is that electrical energy produced by a photovoltaic device in equatorial areas will not only sustain electric tractor activity, but may also lead to its investment recovery and provide the semi-arid family farmer with an extra income (if a way can be found to encourage the selling of surplus electricity). In certain ways, the output of an electric tractor is better than the normal combustion engine tractor. The energy tractor and transmission device, which are embedded in the diesel price of the combustion engine tractor, should be known as the expenditure in the electrical tractor.

Bhujade *et al.* (2020) studied that solar energy-based crop cutter. In our country energy crashes is the main trouble for the development for the farmers that may be in the terms of petroleum energy conventional energy like coal etc. Looking to the view of present scenario of energy demand and supply such a model is designed which will be useful for farmers in the field of cultivation. Present model is portable and is design only for farmers. There are many ways to expand or digitalized the present model for automation. The present model is powered by 100 WT, 24 V which is an old panel but in market there are many panels available which comes with the rating of 100W-24V, 100 W-12 V etc. The motor with less rpm is used in these models due to economical reason, but in future scope the motor can be upgraded with high speed. This model is design to cut the crop due to limitation of resources.

Kachott *et al.* (2020) carried out research on development of solar operated walking type power weeder. Power weeders are most commonly used machines for

removing weeds, to prevent them from competing with main crops. However, these power weeders are powered by either petrol or diesel engine. With the shortage of fossil fuel, its unavailability in rural areas and for reducing emission due to burning of fossil fuel, an alternative energy powered weeder is very much required. As solar energy was very available and weeding usually carried out during daytime, hence an attempt made to develop a solar energy operated weeder for dryland. It comprised of a powering system and a blade assembly. The power source included solar photovoltaic panel, solar charge controller, battery, motor charge controller and BLDC motor. The sweep type blade was used, which is mounted behind the main frame and power was given to the rear wheels by 750-watt 48-volt BLDC motor using a chain and sprocket drive. The performance of weeder was evaluated at three different forward speed of S1, S2 and S3 is 1.0 - 1.5, 1.5 - 2.0 and 2.0 – 2.5 km/h respectively. Total weight of weeder is 88 kg and total force required to push the weeder at 2.5 km/h was 107 kg (730 watt). Four batteries, each of size 12 V, 12 amp, powered the motor

Jae Heo *et al.* (2021) conducted research on case study of solar photovoltaic power plant site selection for infrastructure planning using a BIM-GIS-based approach. Evaluating the site-selection process for photovoltaic (PV) plants is essential for securing available areas for solar power plant installation in limited spaces. Although the vicinities of highway networks can be suitable for installing PV plants, in terms of economic feasibility, they have rarely been investigated because the impacts of various factors, including geographic or weather patterns, have not been analysed. In this respect, this study conducts a case study on selecting the site for PV-panel installation in the vicinity of a highway (e.g., slopes) by integrating geographic information system (GIS) and building information model (BIM) techniques.

Varma *et al.* (2021) performed experiment on review on solar power operated sieving machine. Agriculture is the backbone of Indian economy. Agriculture is basically an energy conversion industry. The different size of grains is separated by using sieving machine. This machine can be used to separate different in grain sizes. A sieve is a device for separating wanted elements from unwanted material or for characterizing the particle size distribution of a sample, typically using a woven screen such as a mesh or net. This project focuses in design, fabrication of the mechanical part of machine and the system of the sieve machine. To achieve this project objective, this

sieve machine body structure and mechanical system needs to concern some other criteria such as strength, safety and ergonomic design.

Sathyaprakash *et al.* (2020) examined that design and fabrication of solar power multipurpose agricultural machine. Agriculture being one of the major occupations in India, Agriculture plays a vital role in the Indian economy. Indian agriculture has registered impressive growth over last few decades. It is very essential to discover and implement new idea in this field, though lot of work has been done in this area. It is unfortunate that, these ideas are not being implemented properly in actual field. This is due to high cost and is complicated for rural people. Based on the overall performance of the machine we can definitely say that the project will satisfy the need of small-scale farmer, because they are not able to purchase costly agricultural equipment. The machine required less man power and less time compared to traditional methods, so if we manufacture it on a large scale its cost get significantly reduce and we hope this will satisfy the partial thrust of Indian agriculture. So, in this way we solve the labour problem that is the need of today's farming in India.

Matheswaran *et al.* (2021) studied that performance evaluation of standalone solar powered water irrigation system using DC pump. In the present scenario, the demand for agriculture is increasing abruptly due to the population in the world. In agriculture, irrigation plays a major role. As it requires electricity supply to irrigate the field, farmers find it an additional expense towards the electricity cost and also it is challenging to provide the uninterrupted supply to farmers. Though our government provides subsidies, the demand for electricity throughout the world is increasing. Especially as we tend to rely on agriculture for our daily life and considering the hardship faced by the farmers, nowadays people tend to move towards solar power but the existing grid connected system may lead to high cost, need of more space, and needs proper maintenance

Sarode and Mansuri (2022) carried out researched on solar operated sprayer pump system for farming. Solar powered sprayer hold promises toward the agriculture's unmechanized and drudging tasks of manually or small engine operated sprayer. The solar-powered sprayers also save crop cultivation cost and reduce environmental pollution. This review describes the current status of the solar-powered sprayer, flow chart and circuit diagram required for the successful development of the sprayer. The

capacity of solar panel varied from 10 W to 60 W. A very good relation was found between the size and weight of the solar panel with the power rating of the solar panel. The capacity of the spray tank was varied between 12 L to 16 L. However, there was no relation found between the capacity of the spray tank and power rating of the solar panel.

Bharath *et al.* (2022) carried out the experiment on multi-purpose farming machine using solar energy. In India almost 75% of people are depending on agriculture. This project is an eco-friendly and pollution free operation & are performed in the agricultural field like inter cultivation, seed sowing, good carrying and pesticides spraying etc. by using this machine we can reduce the most of the man power and the time. In agriculture it is very important to fill the gap between the farmers and the implementation of technology. Energy demand is one of the major threads for our Country. Finding solutions, to meet the energy- demand is the great challenges for social scientist, engineers, entrepreneurs and industrials of our country according to them, applications of non-convectonal energy is the only alternate solutions for convectonal energy demand. Now a day the concept and technology employing this non-conventional.

2.4 Climatic factor affects on solar power conversion process

Wei *et al.* (2017) reported that experimental study of efficiency of solar panel by phase change material cooling. The dependence of efficiency of photovoltaic panels on their temperature during operation is a major concern for developers and users. In this paper, a phase change material (PCM) cooling system was designed for a 60W mono-crystalline solar panel. Tealights candle was selected as the cooling medium. The solar irradiance was recorded using Kipp & Zonen CMP3 pyranometer and Meteon data logger. Temperature distribution on the surface of solar panel, output voltage and output current of solar panel were measured. The average irradiance throughout data collection was found to be 705 W/m² and highest irradiance was 1100 W/m². The average solar panel temperature was 43.6°C and a maximum temperature of 53°C was at the centre of solar panel. Results showed that average power output and efficiency of the solar panel were 44.4 W and 15%, respectively. It was found that the higher the solar irradiance, the lower the efficiency of solar panel and the higher the temperature and power output of solar panel. This is due to the fact that high irradiance results in high power input and high solar panel temperature. But high PV panel temperature reduces its power output.

Therefore, the increase of power input outweighs that of power output, which leads to the decrease of efficiency of solar panel with the increase of solar irradiance. Compared with solar panel without cooling, the power output and efficiency of solar panel did not increase with PCM cooling. It indicates that Tealights candle as PCM cooling is not efficient in improving the efficiency of solar panel in this study.

2.5 Power transmittion (conversion) in solar unit

Shirahatti *et al.* (2016) carried out the research on solar based variable frequency drive. Human beings are depending on agriculture for food. As irrigation process is totally depending on electricity therefore farmers are facing big problem because of power cut. Now a days solar based pump systems are used to overcome this problem. The conclusion of the project was found comparatively variable speed control technique is useful than other technique because of earth rotation the power generated by the stationary PV cells varies accordingly. Batteries are not needed which increases a cost. Generally, farmer use pump at day time in summer season. Three phase inverter is needed to convert DC from solar to AC. All reviewed papers designed open loop system. To make system automated a closed loop is necessary which take feedback from various parameters like speed of motor, voltage from solar panel, current from inverter, etc. We can also display all these data to compare performance. Thus, a closed loop system will help farmers for irrigation purpose.

2.6 Selection of solar panel

Bragard (2010) carried out research on Design and Implementation of a 5 kW Photovoltaic System with Li-Ion battery and additional DC-DC converter. The integration of photovoltaic (PV) generators in the grid is still an ongoing topic. The peak efficiency of today's power electronics is already above 98 %, therefore innovative aspects can grow from new ways of grid integration. This paper focuses on the combination of a 5 kW PV-generator with a li-ion battery. Compared to a classic PV system, an additional bidirectional D-DC converter is required to ensure the charge and discharge of the battery. The power management of the system can be controlled by the grid operator or according to the best profit defined in a feed-in tariff law for renewable energy. Special attention has to be paid to the efficiency of this DC-DC converter, due to the bidirectional energy passing before a grid injection is possible in case of energy

buffering. The development and design of the system was shown from the system perspective. Afterwards, the implementation and control of the battery converter, which is the innovative component, was given in more detail. Measurements proof the concept and show an attractive efficiency above 97 %.

Afrouzi *et al.* (2013) performed experiment on solar array and battery sizing for a photovoltaic building in Malaysia. Renewable energy plays an important role in the national energy policy especially in reducing greenhouse gas emissions. For a photovoltaic (PV) system, one important consideration is the cost of the system. One needs to select the best PV array from a range of selection, that is, the one which is the most efficient and with a best price. This article illustrates a method to compute the size and cost of a required PV array, and then after to compute the required battery for the case of a photovoltaic building in Malaysia. The computation is simulated using MATLAB integrated with suitable mathematical equations. The generated current and power of the PV array are calculated for daily solar irradiation in Malaysia. The computation enables the user to quickly compute the initial cost needed to be spent if a given PV system is to be installed. A typical building requiring 12 kWh daily energy with 6 kW peak demand load was shown to need at least 114 solar modules at a cost of about RM 53 k.

Balao and Sagbansua (2016) performed research on the selection of the best solar panel for the photovoltaic system design by using a Horse Power (hp). There have been numerous efforts by researchers worldwide cooperating to reduce the material costs of photovoltaic panels, efficient novel products and improve their energy efficiency and procreate innovative and practices based on photovoltaic system design technology. The aim of this paper is to select the best solar panel for the photovoltaic system design by using AHP (Analytical Hierarchy Process) from the multi-criteria decision-making methods. Among 200 W solar panel brands, the problem of selecting the best solar panel is evaluated, using fifteen electrical, three mechanicals, three economic, three customers and two environment related criteria. From this paper we conclude that material manufacturing process has the biggest priority among the environmental criteria. Under the customer satisfaction category, reliability is the criterion with the highest priority. After considering electrical, mechanical, financial, environmental and customer satisfaction performance of each panel we can conclude

that P_6 is the most suitable one that can be used in a solar plant. Although the results may be case specific, the proposed model can be tailored and applied to other cases in different locations or countries as a reference when selecting the most appropriate solar panels

Raut and Kulkarni (2020) conducted research on design and performance evaluation of proposed 2 kW solar PV rooftop on grid system in Odisha using PV system. Main factors driving towards renewable energy are the environmental effects and load demand of electricity. For residential as well as commercial applications, the primary purpose is to determine the methods driven by mathematical models for a gridtied solar PV system. In Odisha state the average value of solar irradiation is around 1156.39 W/sq. m. So, the solar rooftop plant of 1 kW will generate on yearly basis an average value of 4.8 kWh of electricity per day (taking into account 5.5 sunshine hours). For the generation of 1 kW, carbon dioxide discharges mitigated is 28 tonnes. So, the installation is comparable of planting 45 trees over the life time. In this paper by using PVsyst V6.84 software a case study of 2 kW installation of solar PV plant on rooftop is analysed for residential load utilization of 8.9 kWh/day. The simulation result gives available AC energy, used energy and excess energy.

El-Bayeh *et al.* (2021) studied that original multi-criterion decision-making algorithm for solar panels selection in buildings now a days, there are several thousand solar panels (SP) in the market. These panels vary in size, efficiency, cost, warranty, technology, etc. Selecting the best SP becomes complicated when other factors are added to the list, such as the available roof area, weather conditions, electricity tariffs, energy consumptions, etc. Therefore, it becomes crucial to propose an algorithm that selects the best SP for a specific client and provides the best combination of quality-cost-satisfaction. This paper presents an original multi-criteria decision-making algorithm based on the concept of Rank-Weight-Rank to select the best SP by considering many criteria. For validation purposes, our method is compared to TOPSIS, and it shows advantages, especially regarding the simulation time and the accuracy of the selection. Our approach is faster than TOPSIS, and the speed of finding the solution increases exponentially when the number of criteria and alternatives increases. Moreover, it is reliable and accurate since the probability is more than 78% for similarity of 90%-100% between both methods in selecting the same best alternative. Results

show that the highest SP efficiency and the most expensive ones are not the best alternatives, nor the lowest efficient neither the cheapest SPs are the worst alternatives.

2.7 Selection of motor

Inno devidson (2004) evaluated the performance of a solar-powered fractional hp universal motor. This paper describes the mathematical modelling and performance analysis of a fractional horsepower universal motor coupled to a photovoltaic fuel-cell generator. Results was three tests were carried out to analyse the performance of the universal motor supplied by three different sources namely: dc source, ac mains supply and the PV system. The maximum voltage supplied by the PV array panels installed in the laboratory was 55V, while the maximum current was 0.22 A. For the same terminal voltage and armature current the speed was lower for ac excitation compared with dc excitation. AC excitation produces pulsating torque and poor power factor. Poor power factor and lower speed are caused by the reactance voltage drop produced by field reactance.

Kashyap *et al.* (2013) carried out research on solar powered PMDC motor drive. In order to make solar energy competitive with the other forms of renewable energies, a better exploitation of its advantages especially environmental side, this will be possible only with the development of the less expensive and high output efficiency systems. In this paper, the modelling and simulation has been done in Simulink software available with MATLAB for a solar photovoltaic (PV) powered industrial type permanent magnet DC (PMDC) motor drive. In this work, a simple but efficient photovoltaic water pumping system is presented. It provides theoretical studies of photovoltaics' (PV) and its modelling techniques The model used for simulations of DC water pump gives results within a reasonable range. The accuracy of model is, however, uncertain because the parameters are only estimates. If tests could be run on the real water pump motor or an equivalent sized motor to determine reasonable entries to SIMULINK block parameters, this could lead to more accurate simulation runs. Also, simply increasing the size of system and using a larger motor (5 hp or above) could allow for better results in SUMILINK, though many PV water pumps rarely use such large motors.

2.8 Cost economics of rotary mode set up

Anonymous (2005) studied the data collected at Allahabad UAE centre in respect of the cost of operation of bull gear was found to be Rs. 47.05 per hour without

machines. This includes cost of bull gear and installation cost. The cost of operation was Rs. 58.20 per hour for chaff cutting, Rs 68.15 per hour for paddy threshing and Rs. 58.20 per hour for wheat threshing operation. The cost of operation was found to be Rs.57.60 in case of flour grinding. The cost of operation per kg output was Rs.0.21 for chaff cutting, Rs. 2.88 for flour grinding and Rs. 0.54 for paddy threshing and Rs. 0.83 for wheat threshing with chaff cutter.

Anonymous (2007) studied the UAE Pantnagar centre during electricity generation, concluded that, the cost of electric power generated by animal per kW was calculated to be Rs. 14.52. It is considered that the generation work shall be performed during idle period. The cost of storage of electricity was calculated to be Rs. 10.65 per hour of working at its full load capacity. The generation cum storage of electricity is feasible with animal power. However, the cost of storage is somewhat higher due to the fact that charging of battery was not achieved in continuous run. The cost of generation is lower because animals are used during idle period. The animal power complex can be installed in remote areas where the electric power is not available or in areas where electric power supply is not regular.

2.9 Cost economics of solar operated unit

Nigeria *et al.* (2014) designed and analyzed cost of a 0.75 kW solar powered water pumping system. Solar powered systems have been built for various applications ranging from public lighting to water supply units. Robust efforts have not been made in the systematic study of the effectiveness and viability of such systems as it applies to the Nigerian techno-economic situation. The objective of this study is to design a solar photovoltaic (PV) powered water supply system for rural areas in Nigeria using a village in Ibadan without electric grid connection as a case study. The methodology adopted for this study involves field survey and detail system design and analysis. The design of the solar powered system was based on the estimated daily water supply rate of 15,000 litres with a view to obtaining a cost-effective and energy-efficient system to drive it. Results obtained from the study showed that a 0.75 kW solar powered unit can supply the desired water quantity. Comparing the power supply costs of both systems over a 20-year life cycle showed that the generator powered system has a present value cost of over two times ($\geq 200\%$) that of the solar powered unit. In addition, the annual Carbon dioxide emission tonnage from the generator powered system is estimated to be about

3.2 tones whereas the solar powered system is emission free. The outcome of this study will find useful modularization applications in villages with similar characteristics and can also be easily adjusted to fit larger or smaller sized communities.

Mohammad *et. al* (2015) performed research on design, implementation and cost analysis of a solar powered water pump for multistore building. Electric motors are used to pump water in multistore building. Total power consumed by those motors is huge in urban area. By implementing a renewable energy source to run those motors can save energy from national grid. The purpose of this paper is to provide information about planning and installation of solar powered water pumping systems by using Thin Film PV (Photo Voltaic) Module. 20 panels of 95 Watt are mounted by using movable concrete pillar for flexibility. A 3D design was created by using Sketch up 3D to bring perfection in mounting solar panels. A three-phase inverter is used to operate with higher output voltage of Thin Film PV Module. To avoid starting torque and maintenance cost, a three phase 2 hp AC water pump is used for pumping water. A four storied building is considered to lift water from reserve tank on ground.

CHAPTER – III
MATERIALS AND METHODS

CHAPTER-III

MATERIALS AND METHODS

This chapter mainly deals with the details of methodology followed for the comparative evaluation of hybrid agro-processing unit operated by bullock and solar power. Development, pre-testing and performance trials work has been carried out at AICRP on Utilization of Animal Energy, College of Agricultural Engineering and Technology, VNMKV, Parbhani. The details are enumerated under the following sub heading.

4. Design of solar photovoltaic system for agro-processing unit and its performance evaluation.
5. Performance evaluation of bullock drawn rotary mode agro-processing unit.
6. Comparison of agro-processing unit operated by solar and bullock power in order to its efficiency and cost effectiveness.

In earlier time lot of research work has been carried out on the bullock drawn rotary mode agro-processing unit and efforts are made and compare with the solar powered agroprocessing unit.

3.1 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 making machine, seed grader cum cleaner, shevai machine and flour mill.

3.1.1 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.

3.1.1.1 Power requirement

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

Where,

P-Power (kW)

I-Current (A)

E-Voltage (V)

PF-Power Factor

A total power requirement for papad making machine, grader cum seed cleaner, shevai making machine and flour mill was 1.5 kW, 1.5 kW, 2.238 kW and 2.238 kW by calculating the above formulae.

According to the power requirement, 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 3.5

3.1.1.2 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 approximately. 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.

3.1.2 Testing of Solar Panel

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

3.1.2.1 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.

3.1.2.2 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 experimental 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.

3.1.2.3 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 and weather conditions.

3.1.3 Atmospheric Parameter

Solar radiation, ambient temperature, atmospheric humidity, wind velocity these atmospheric factors affect on the solar panel working.

3.1.3.1 Solar Radiation

Solar radiation, often called the solar resource or just sunlight, is a general term for the electromagnetic radiation emitted by the sun. Radiation data for solar electric

(photovoltaic) systems are often represented as kilowatt-hours per square meter (kWh/m^2). Direct estimates of solar energy may also be expressed as watts per square meter (W/m^2). The solar radiation was measured with the pyranometer installed at energy power unit CAET, VNMKV, Parbhani.

3.1.3.2 Ambient Temperature

Ambient temperature is the air temperature of any object or environment where equipment is stored. The adjective ambient means "relating to the immediate surroundings." Also sometimes referred to as the ordinary temperature or the baseline temperature, this value is important for system design and thermal analysis. The ambient temperature is measured with digital thermometer.

3.1.3.3 Atmospheric Humidity

Atmospheric humidity is the amount of water vapor carried in the air. It can be measured as vapor pressure, mixing ratio or specific humidity. Atmospheric humidity is measured with hygrometer.

3.1.3.4 Wind Velocity

The horizontal direction and speed of air motion called wind velocity. Here's where the wind comes in. The wind cools solar panels. Though it won't make or break your solar panel production overall, it does make a difference. Solar panels cooled by 1 degree Celsius are 0.05 percent more efficient. Wind velocity measured with the help of cup type Anemometer.

3.1.3.5 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, also running different machine in agroprocessing unit. A solar panel of 335 W capacity the 415 V voltage and 8.95 A current was selected. A solar panel required for operating 3 hp three phase motor was calculated as 2.348 kW, hence more than requirement of motor 2.348 kW output solar panels was selected.

3.1.4 Components of solar powered agro-processing unit

Solar panels, Variable frequency drive, AC motor, papad making machine, grader cum seed cleaner, shevai machine and flour mill these are main component of the

agro-processing unit.

3.1.4.1 Solar panel

There was nine number 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. The solar panel were placed on the roof top of the agro-processing shed. The panel was face with solar or geographic south, which is the direction towards the South Pole. Solar panel was used for operating the different machine in agro- processing unit. Solar panel is basically equipment which has solar cells attached to it. Its size varies a lot and lot can be as small as palm of hand and can be as huge as a door. Solar modules use the photons from the sun to generate electricity through photo voltaic effect. The all specifications of solar panels used in operating agroprocessing unit are given in table 3.5.



Plate 3.1 : Solar photovoltaic system for agro-processing unit

3.1.4.2 AC Motor

A 415 V AC motor was used for operating the machine at 1440 rpm. According to the power requirement, 2 hp 3 phase and 3 hp 3 Phase two different power motor was selected. The 2 hp 3 phase AC motor was fitted on papad machine, grader machine one by one and 3 hp 3 phase was fitted on shevai machine and flour mill one by one. Different size of pulley used for the different speed required for different machine. A compact size, rust proof, easy to clean, low maintenance and low speed high torque motor was used.

An AC motor is class of electrical machines that converts the alternate current electrical power into mechanical power. This mechanical energy is transferred to machine pulley which produces the required torque needed for operating different machine.



Plate 3.2 : Induction Motor

3.1.4.3 Variable Frequency Drives (VFD)

Controllers are Variable Frequency Drives 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 50 Hz), 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 3.3 : Variable Frequency Drive

3.2 Performance evaluation of solar powered agro-processing unit

The developed solar powered agro-processing unit was evaluated for its performance of machine like papad making machine, grain grader cum seed cleaner machine, shevai machine and flour mill operated by solar power. During the evaluation of the solar powered agro-processing unit, the following parameters were recorded.

3.2.1 Solar intensity

The solar intensity determines the amount of solar energy available in the location. It was measured by using a Pyranometer. The solar intensity was measured from 9:00 am to 5:00 pm at every 1 hr. of interval.

3.2.2 Voltage generated

The average voltage produced by the solar panel during the operation in agro processing unit was measured using multi-meter.

3.2.3 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 wave form and a frequency of 50 Hz.

3.2.4 Current

A flow of electricity which results from the ordered directional movement of electrically charged particles. Current was also measured using multi-meter.

3.2.5 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.

3.2.6 RPM of Motor

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

Table 3.1 : Specification Papad making 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)	1.5
7	Capacity (kg/h)	10

Table 3.2 : Specification of Grain cleaner cum grader machine

Sr.No.	Overall Dimensions of Grain Cleaner cum Grader machine	
1	Length (mm)	160
2	Width (mm)	55
3	Height (mm)	100
4	Weight (kg)	100-110
5	Number of sieves	2
6	Number of screens	2(80×55)
7	Power requirement (kW)	1.5
8	Capacity (kg/h)	35-40

Table 3.3 : Specification of Shevai machine

Sr.No.	Overall Dimensions of Shevai Machine	
1	Length (mm)	1260
2	Width (mm)	470
3	Height (mm)	900
4	Weight (kg)	70
5	Number of sieves plate:	01
6	Working efficiency (per cent)	90.1-95.2
7	Power requirement (kW)	2.238
8	Capacity (kg/h)	10

Table 3.4 : Specification Flour machine

Sr.No.	Overall Dimensions of Flour Mill	
1	Length (mm)	800
2	Width (mm)	550
3	Height (mm)	660
4	Weight (kg)	85
5	No of stones	2
6	Grinding efficiency (per cent)	89.4 - 94.3
7	Power requirement (kW)	2.238
8	Capacity (kg/h)	10-15

Table 3.5 : Specifications of the components of Solar powered agro-processing unit

Sr. No.	Components	Specification	
1	Solar panel	Brand	WS-335
		Maximum power (Pmax)	335.0 W
		Panel Dimension	1996×990 mm
		No of panel	9
		Short circuit current	9.25 A
		Max power current	8.95 A
		Max system voltage	1000 V
2	AC Motors	Type	Induction Motor
		HP	2.0/3.0
		Rated current	3.8 A
		Speed	1440 rpm
		Voltage	415
3	VFD	Brand	Crompton
		Power	2.2 kW/3 HP
		Input	1 Phase, DC 250-350 V, 18 A
		Output	3 Phase, 9.5 A, 0-600 Hz

3.2.6 Current generated

The average current produced by the solar panel during operating different machine was measured using multi-meter.

3.2.7 Voltage generated

The average voltage produced by the solar panel during operating different machine was also measured using multimeter.

3.2.8 Power produced

The power produced is calculated by the product of voltage and current generated in the solar panel during operating agroprocessing unit.

3.2.9 Instrumentation requirement

Tachometer, Pyranometer, Voltmeter, Ammeter Temperature Recorder Anemometer this instrument was used during the research work.

3.2.2.1 Tachometer

Tachometer was used to measure the rpm of motor shaft or machine rotating shaft. Digital laser or Contact type tachometer was used to determine the rpm of the rotor shaft.

3.2.2.2 Pyranometer

Pyranometers are radiometers designed for measuring the irradiance on a plane surface, normally from solar radiation and lamps. There are two types of pyranometers thermopile pyranometers and semiconductor pyranometers. The semiconductor pyranometer was used to measure solar intensity.

3.2.2.3 Voltmeter (AC)

A voltmeter is a device that measures voltages of direct current or alternating current on a scale commonly in volts, millivolts, or kilovolts.

3.2.2.4 Ammeter (AC)

An ammeter is a measuring instrument used to measure the current in a circuit. Electric currents are measured in amperes (A).

3.2.2.5 Temperature Recorder

A Temperature Recorder, also called temperature monitor, is a portable measurement instrument that is capable of autonomously recording temperature over a defined period of time. The digital data can be retrieved, viewed and evaluated after it has been recorded.

3.2.2.6 Anemometer

An anemometer is a device that measures wind speed and direction. Cup type Anemometer is used during whole research work.

3.3. Performance evaluation of bullock drawn rotary mode Agro processing unit.

Table 3.6 : Specification of agro processing unit

Sr.No.	Particulars	Dimensions
1	Wooden beam	114.3 mm diameter and 5.49 m length
2	Vertical input shaft	35 mm dia. and 81 cm long
3	Differential Gear Box	Box 1:5 speed ratio steps up type
4	MS wireframe rectangular box	1219.2 mm x 558.8 mm x 812.8 mm
5	Double groove V pulley	Double groove V pulley 45.72 cm diameter
6	Belt	B size
7	Double groove V pulley	11.43 cm diameter
8	Intermediate shaft	25 mm dia.
9	Underground shaft	25 mm dia. & 6 m long
10	Couple joint	25 mm inner diameter
11	Pedestal bearings	Closed type
12	Underground channel	6 x 0.3 x 0.3 m
13	Output shaft	25 mm dia. and 1.5 m long
14	single groove V pulley	45.72 cm diameter
15	single groove V pulley	20.32 cm dia.
16	Cement concrete action for Pedestal bearings	0.15 x 0.15 x 0.15 m

3.3.1 Experimental Set up

The experimental set-up consisted of an outdoor test track, bullocks, yoke, rotary power transmission system, underground shaft, output shaft and V groove pulleys, Agro processing units i.e., papad making machine, grader cum seed cleaner, shevai machine flour mill.

3.3.2 Selection of animals

Two healthy bullocks were selected for the study. The animals were chosen based on their body weight rather than their age. The studies were carried out on a pair of test bullocks aged 7-8 years of a local breed. The total weight of the bullock pair was 870 kg. The accuracy and quality of an animal's work are dependent on training, consistent practise, and effective guidance. The test bullocks were first hesitant to

perform in rotating motion; they responded negatively and became difficult to control. As a result, they needed to be taught by a skillful stockman or operator over whom they could be controlled. Trainers used a lightly stick on their headquarters to encourage them to follow the correct path until they became familiar with it. The coordination between their walking speeds was also very poor initially because the inner bullock has to walk as compared the outer bullock. The path followed was also not a circularly perfect. Many times, they wanted to get free of the yoke. During the first fifteen days, the experimental bullocks was generally groaned and slavered as they worked. After training the bullocks became accustomed to the pattern of the experiment and their strange behaviour was largely disappeared. The bullocks were provided fodder and feed on a daily basis, as is advised of expert, throughout the trial, the animal pair health was good.

3.3.3 Test track

Test track was a circular piece of land of 5.50 m radius. The soil was well compacted levelled and cleaned to remove any stone in the path of the bullocks. The entire track was raised by (10) cm from adjacent land. The gear unit of the developed power transmission unit was mounted on an MS angle frame firmly grouted by cement concrete mortar with studs at the centre of the test track (Deshvena *et al.* 2013).

3.3.4 Power Transmission System

The power transmission system transfers the muscular power of the animal into mechanical energy. It was mainly made up of a horizontal hitch beam, a gearbox, shafts, and pulleys. The gearbox was installed at the test track's middle. The different components of the transmittion unit are described below.

3.3.4.1 Beam

A wooden beam of 127.2 mm diameter and 5.0 m length were used as input shaft of the power transmission system to give drive to the gear box through animal power (Deshvena *et al.* 2013).

3.3.4.2 Power transmission unit

As per the literature available, the speed requirement for operating different agro processing units is between 100-1000 rpm. Accordingly various combinations of pulleys were selected to raise the slow-moving speed of animals (average 2 rpm) in the range of

1000-1200 rpm required to operate low speed agro processing units (Deshvena *et al.* 2013).

3.3.4.3 Gear unit

As per the literature available, the speed requirement for small capacity agro processing machines operating is in between 800-1000 rpm. Accordingly various combinations of spur gear, bevel gear and pulleys were selected to raise the slow-moving speed of animals (average 2 rpm) in the range of 1000-1200 rpm required to operate small capacity agro-processing machines (Deshvena *et al.* 2013).

3.3.5 Evaluation of power transmission system

The developed power transmission system was assessed by computing the power, draft, and output. The load was applied only when the bullocks had reached the desired operating speed. The dynamometer was mounted between the yoke and the beam, such that the pull exerted by the bullocks was applied to the beam via the dynamometer, which recorded the instantaneous pull acting at the beam. The recorded draft was used to calculate input power. Test bullocks were hitched and allowed to move in a circular track. The system was tested under no and full load. The resulted draft was measured with a dynamometer.

3.3.6 Physiological responses of Bullocks

The trials were carried out with the help of a yoke. The tests were conducted during the summer (March-April) season. The following schedule was used during the trials. 0.5 hr work + 1 hr rest + 0.5 hr work + 1 hr rest + 0.5 hr work

During the rest period, the animals were housed in a shed and fed and watered. The ambient temperature began to drop in the evening session, and animals worked until natural light was available. As a result, the animals worked for an average of 3-4 hours per day. Initial values include physiological responses such as respiration rate, pulse rate, and body temperature that were measured at the start of work in both sessions. Then, after every half hour of work, the bullocks' physiological reactions and physical symptoms were recorded individually. The bullock moving in outside the circle was referred to as the outer bullock, while the one moving inside was referred to as the inner bullock. The average speed was also calculated.

3.3.7 Performance Evaluation for operating selected agro processing unit by bullock power

Inner and outer bullock (B₁ & B₂) physiological behaviour in rotating mode of operation for agro processing units was studied. The test was conducted on the test track for a continuous half-hour work duration. Selected agro-processing Machines were operated in rotating mode by using bullock power. A 1 hp motor may be used to power the specified agro-processing machine. The experiment took 30 minutes and measured physiological responses such as respiration rate, pulse rate, and body temperature of red Kandhari bullocks (pair weight of bullocks is 870 kg.) of Maharashtra at half-hour interval and calculation of draft to know their comfortable working without harming any health hazards one person was employed for work in the selected agro-processing machine and one bullock operator was hired for handling a pair of bullocks in the test track of rotary unit. The standard technique was used for measurement of the different parameters. The experiment was conducted for three replications of 30 minutes following observation were taken at half-hour.

3.3.8 Physiological observation

The physiological observations were recorded according to the method given by Miller and Robertson (1959).

3.3.8.1 Pulse rate

Pulse rate was measured by placing the index or second finger on the coccygeal artery beneath the tail of bullocks and the number off beats per minute was counted. The pulse rate was measured at the start of work and at hourly interval in both the sessions.

3.3.8.2 Respiration rate

The respiration rate was measured by counting the number of hot gushes exhaled per minute by placing the palm of hand near the nostrils of the bullocks. The respiration rate was measured at the start of work in both the session and thereafter every hour of work.

3.3.8.3 Body temperature

The body temperature of the bullocks was measured by inserting the clinical thermometer 40 to 50 mm inside, in the rectum of bullocks for two-minute duration. The

body temperature was measured at the start of work in both the session and there after every hour of work.

3.3.8.3 Physical symptoms

In addition to physiological parameters, physical symptoms such as frothing, tongue protrusion, excitement and leg un-coordination were also observed to access the fatigue in bullocks.

3.3.8.4 Fatigue Score Card

A fatigue score card suggested by Upadhyaya and Madan (1985) was used to indicate comparative stage of fatigue of bullocks. The physiological parameters, namely, pulse rate, respiration rate and body temperature earn one fatigue point each which can accumulate to a maximum of 5 points for a particular parameter. Similarly, five physical symptoms have also been related to fatigue in respect of frothing, leg un-coordination, excitement, inhibition of progressive movement and tongue protrusion. It has been suggested that when the grand total of such accumulated fatigue points is less than 20, an animal could be considered safe from physical stress.

3.3.9 Work performance

3.3.9.1 Draft

A dynamometer connected between the yoke and the beam is used to measure pull. Draft was calculated by multiplying the pull into the angle made by the animal with the direction of travel.

Where,

$$D = P \times \cos\theta$$

D = Draft in kgf.

P = Pull in kgf.

θ = Angle between line of pull and horizontal

3.3.9.2 Speed

Speed is calculated with the help of following formula:

$$S = \frac{L}{T} \times 3.6$$

Where, S = Speed in km/hr.

L = Distance moved or travelled in meter

T = Time required by the bullock to travel certain distance in Second

3.6 = Conversion factor for km/hr.

3.3.9.3 Horse power

Horse power is the multiplication of draft and speed. Values of the horse power computed as per Kibler and Broody (1945) from equation.

$$\text{Horse power (hp)} = \frac{D \times S}{75}$$

D = Draft developed, kg

S = Speed of bullock, m/s

3.3.9.4 Evaluation of power transmission system

The developed power transmission system will be evaluated by computing the power, draft and output. The load is applied only after the bullocks attained the desired working speed. The dynamometer is mounted between yoke and beam, such that the pull exerted by the bullocks is applied to the beam through the dynamometer and which showed the instantaneous pull acting at the beam. The recorded draught was used to calculate input power. Test bullocks will be hitched allowed to move on a circular track. The system will be tested at no load and loads. The resulted draft was measured using dynamometer.

3.3.10 Measuring instrument

Following are some instruments which were used during the testing of developed rotary transmission system;

3.3.10.1 Dynamometer

The drawbar power required to pull the shaft was measured by using dynamometer. It is usually placed between the animal yoke and the shaft to be pulled through the rope. Some considerations were made such as yoke is movable on the beam on front and back position so that total pull act on the dynamometer. As the bullock moves the pull was indicated on the screen of dynamometer.

3.3.10.2 Tachometer

The tachometer used to measure rpm of rotating output shaft.

3.3.10.3 Measuring Tape

A measuring tape was used for measuring the dimensions of set up for the proper installation of machineries of the planting track dimension.

3.3.10.4 Stop Watch

A stop watch used to measure the travelling speed of bullock. It was also used measuring the respiration and pulse rate count in one minute. The stop watch was used for recording the time duration of the pumping. The stopwatch used has the precision to measure the time up 1 micro second.

3.3.10.5 Vernier Caliper

Vernier caliper was used for measuring the smaller dimension of the system component.

3.3.10.6 Digital Thermometer

A digital thermometer was used for measurement of body temperature of bullock.

3.4 Comparison of agro-processing unit operated by solar and bullock power in order to its cost effectiveness

3.4.1 Economics of developed solar powered Agro-Processing Unit

The cost of operation of solar powered Agro-Processing Unit was calculated based on the fixed and variable cost. The price of components estimated for the development of solar powered agro-processing unit was presented in Appendix B.

Economics of the solar powered agro-processing unit was presented in Appendix A-D. The economics of developed solar powered machine was compared with the bullock, electrically powered machine.

Assumption:

Average life of solar panel	10 yrs.
Average life of VFD	10 yrs.
Life of machines in agro-processing unit	10 yrs.
Salvage value	10 percent per annum
Shelter and insurance	2 percent of initial cost
No. of Laboure required	1

A) Fixed cost:

i) Depreciation (D):

Depreciation was calculated by using following formula,

$$\text{Depreciation} = \frac{C-S}{L \times H} \quad \text{.....i}$$

Where,

D= depreciation per hour C= capital investment

S= salvage value, 10% of capital investment

H= number of working hours per year

L= life of the machine years

ii) Interest (I)

Interest was calculated on the average investment of the machine taking in to consideration the value of the machine in first and last year. It was taken 10% of development cost.

Were,

$$\text{Interest (I)} = \frac{C+S}{2} \times \frac{i}{H} \quad \text{..... ii}$$

Where,

I= interest per hour

i= 10% of interest per hour

iii) Shelter and Insurance:

Insurance and shelter charges taken as 2 per cent of the original cost iii

Total fixed cost = (i + ii + iii) Rs/hr. (a)

A) Operational cost

i) Repair and maintenance costs:

Repair and maintenance cost was taken 10% of the initial cost of the machine per year.

ii) Wages cost:

Wages cost was calculated on the actual wages of the worker.

Rs. 400/ day of its required for skilled Laboure, 8 hours taken for one day

Total operating cost = (i+ ii) Rs/hr. (b)

Total operation cost of solar powered machine per hr.

= Fixed cost + Operating cost total operation cost

= (a + b) Rs/hr.

3.4.2 Economic of agro processing unit operated by Bullock Power:

In order to work out economic viability; fixed cost and operating cost was calculated. The following assumptions were made.

Assumptions:

Useful life of power transmission system and machines	10 yrs.
Useful life of bullocks	10 yrs.
Salvage value of power transmission unit	10 per cent
Rate of interest	14 per cent per annum
Shelter and insurance for bullocks	1.5 per cent per annum
Laboure charges	Rs. 400/- per day

Cost estimation was done under two heads fixed cost and variable cost. Fixed cost consists of cost of power transmission system, pair of bullocks, civil work (earth work) and installation of transmission unit, plastering etc. and their depreciations. Variable cost consists of Laboure charges, maintenance of mechanical systems, feed fodder etc. Total expenditure was calculated as sum of fixed cost and variable cost.

A. Fixed Cost:

1. Cost of machine

2. Depreciation (Rs. /hr)

$$= (C-S) / (L \times H)$$

3. Interest (Rs. /h)

$$= ((C+S) / 2) \times I / H$$

$$\text{Total fixed cost} = 2 + 3$$

B. Operating Cost:

1. Operators cost

$$= \text{Wage of operator} / \text{Working hours}$$

2. Repair and maintenance

$$(\text{Rs/hr}) = 4 \text{ per cent of initial cost}$$

$$\text{Total operating cost} = 1+2$$

Total Cost:

$$= \text{Fixed Cost} + \text{Operating cost}$$

Where,

C = Initial cost or cost of machine, Rs.

H= Annual use of machine, hr.

I = Interest rate, per cent

L = Total life of machine, yrs.

S = Salvage v

CHAPTER – IV

RESULTS AND DISCUSSION

CHAPTER-IV

RESULTS AND DISCUSSION

In this chapter, the results pertaining to perform comparative evaluation of Agroprocessing unit operated by bullock and solar power. The results are analyzed using the statistical method. The Comparison between the cost of operation of developed solar powered Agroprocessing unit and Agroprocessing unit operated by Bullock is presented in this chapter. The results are presented in the following headings.

1. Design of solar photovoltaic system for agro-processing unit and its Performance evaluation.
2. Performance evaluation of bullock drawn rotary mode agro-processing unit.
3. Comparison of agro-processing unit operated by solar and bullock power in order to its efficiency and cost effectiveness.

4.1 Design of solar photovoltaic system for agro-processing unit

The solar panel are placed on the agroprocessing shed with facing toward the south direction. Specification of the solar panel is given in the table 3.5. A solar panel of 335 W capacity, 36 V and 8.95 A current was selected. There are 9 number of 335 W solar panel was selected for operating 3 kW motor. The papad making machine and grain grader cum seed cleaner was run one by one using motor of 1.5 kW. Shevai machine and flour mill was run one by one using motor of 2.238 kW.

These are some important specifications of panel.

Dimension of panel - 1960×990 mm

Weight of panel - 22.0 kg

Number of solar panel - 9

Total Output - 3015 W

4.1.1 Performance evaluation of solar operated agro-processing unit

4.1.1.1 Name of Machine: Papad Machine

Table 4.1 : Performance of papad making machine operating by solar power at no load

Sr. No.	Time	Atm. Temp. °C	Insolation W/m ²	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 4.1.1.

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 °C. 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 4.1.2 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 pulley for papad making machine was found 9.11 and 7.78 respectively.

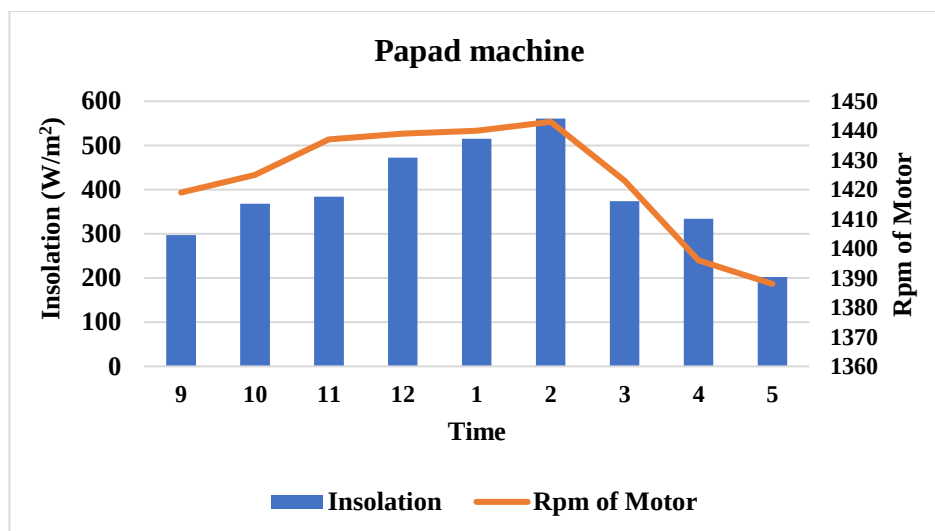


Fig 4.1 : Relation between solar intensity and motor rpm Vs time for papad making machine

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 decreases 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.

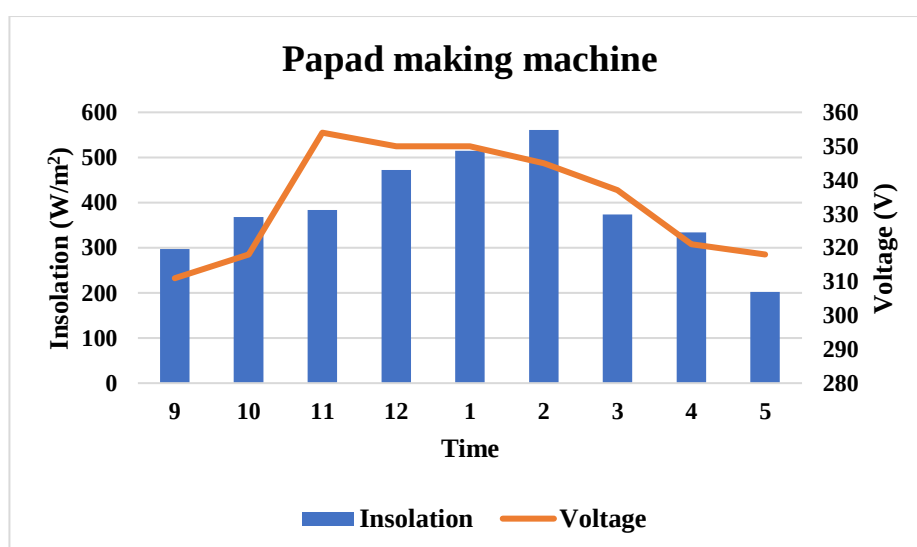


Fig 4.2 : Relation between solar intensity and voltage Vs time for papad making machine

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

Sr. No.	Time	Atm. Temp. (°C)	Insola-tion (W/m ²)	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 4.1 : Performance evaluation papad making machine



Plate 4.2 : Papad obtained from papad machine operated by solar photovoltaic system

4.1.1.2 : Name of Machine: Grain grader cum seed Cleaner

Table 4.3 : Performance of grain grader cum seed cleaner 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	26	286	2.1	277	1397	302
2	10.00 am	29	345	2.1	312	1410	318
3	11.00 am	29	583	2.1	356	1445	337
4	12.00 pm	29	610	2.1	348	1446	337
5	1.00 pm	30	713	2.2	366	1449	348
6	2.00 pm	30	642	2.1	342	1448	244
7	3.00 pm	30	507	2.0	333	1440	332
8	4.00 pm	30	432	2.0	318	1442	321
9	5.00 pm	30	295	2.0	309	1427	313

Sorghum seed was selected for grading by the solar powered grader there was three grade obtained while grading is shown in plate 4.6.

First of all, the seed grader cum cleaner machine was operated at no load with help Solar photovoltaic System in order to compare the experimental data with

corresponding parameters during different climatic condition. The results are presented in table 4.1.3

The solar intensity was varied from 286 to 713 Wm^{-2} , the maximum solar intensity of 713 Wm^{-2} was recorded at 2 pm at a temperature of 30 $^{\circ}\text{C}$. The Average solar intensity was 490.33 Wm^{-2} of the day. Voltage (V) and current (A) of solar panel was varied from 277 to 366 V and 2 to 2.2 A.

Solar powered seed grader cum cleaner operated from morning 9.00 am up to evening 5.00 pm. The parameters selected to evaluate include motor speed and mechanical rpm of grain grader cum seed cleaner machine. The levels of variables at load selected for the study are presented in Table 4.1.4 The effects of operational parameters were studied to evaluate the performance of solar powered seed grader cum cleaner. The difference in rpm at load and no-load condition of motor and machine pulley for grain grader cum seed cleaner was found 11.55 and 8.84 respectively.

The reading was taken from morning 9.00 Am to 5.00 Pm evening, during these period it was observed that as per the time increases temperature and solar intensity is increases up to 2 pm then after that time temperature and solar intensity goes on decreasing. Also found that solar intensity increases motor rpm also increases, hence its observed that motor rpm is directly proportional to the solar intensity.

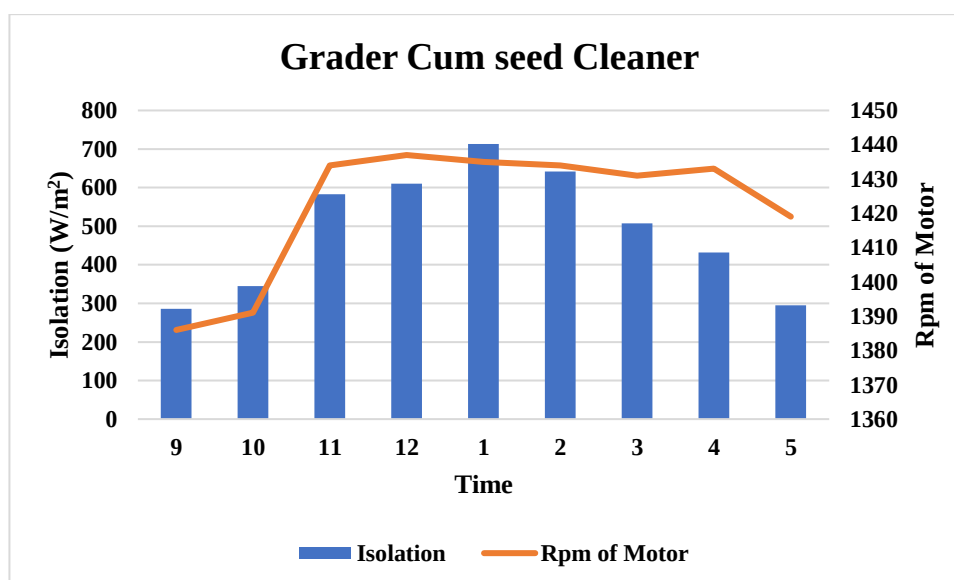


Fig 4.3 : Relation between solar intensity and motor rpm Vs time for grain grader cum seed cleaner

From the graph while operating the seed grader cum cleaner by the solar power it was found that the direct relation between the solar radiation and the motor rpm. At load condition it was found that the seed grader cum cleaner machine can be easily operated, at the lowest Intensity of 286 W/m². Hence grain grader can run for minimum 5 hrs. daily from 9 am to 5 pm.

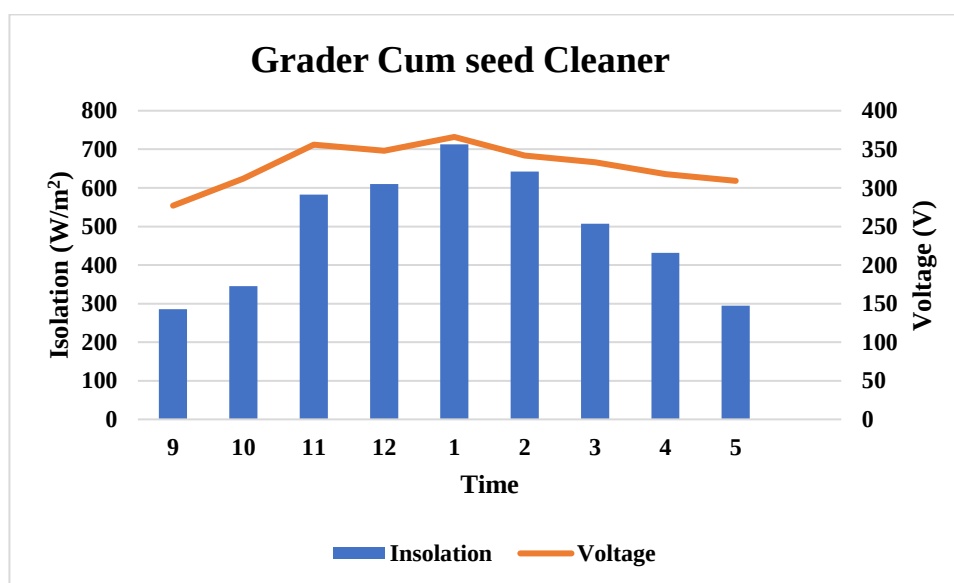


Fig 4.4 : Relation between solar intensity and voltage Vs time for grain grader cum cleaner

Table 4.4 : Performance of grain grader cum seed cleaner operating by solar power at load

Sr. No.	Time	Atm. Temp. °C	Insolation (W/m ²)	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm	Output (kg/hr)
1	9.00 am	26	286	2.1	277	1386	295	22
2	10.00 am	29	345	2.1	312	1391	312	34
3	11.00 am	29	583	2.1	356	1434	326	37
4	12.00 pm	29	610	2.1	348	1437	328	40
5	1.00 pm	30	713	2.2	366	1435	336	42
6	2.00 pm	30	642	2.1	342	1434	321	45
7	3.00 pm	30	507	2.0	333	1431	324	31
8	4.00 pm	30	432	2.0	318	1433	316	30
9	5.00 pm	30	295	2.0	309	1419	303	27
Average Output								34.22 Kg/hr

The mean output was found to be 34.22 kg/hr from grain grader cum seed cleaner was run by Solar power operated 2 Hp (1.5 kW) Motor.



Plate 4.3 : Motor pully rpm of grader



Plate 4.4 : Machine pully rpm of grader



Plate 4.5 : Grain grader cum seed cleaner



Plate 4.6 : Three grade of sorghum obtained from the solar powered grader cum cleaner

4.1.1.3 : Name of Machine: Shevai making machine

Table 4.5 : Performance of Shevai making machine operating by solar power at no load

Sr. No.	Time	Atm. Temp. °C	Insolation (W/m ²)	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm
1	09.00 am	26	323	3.1	322	1412	373
2	10.00am	26	343	3.1	331	1420	388
3	11.00 am	27	399	3.3	333	1437	392
4	12.00 pm	28	423	3.4	338	1444	394
5	01.00 pm	29	519	3.5	336	1450	396
6	02.00 pm	29	396	3.5	332	1437	388
7	03.00 pm	29	327	3.4	323	1418	382
8	04.00 pm	28	298	3.3	319	1407	364
9	05.00 pm	27	212	3.2	307	1401	359

The Shevai machine was operated with help solar photovoltaic system in order to compare the experimental data with corresponding parameters during different climatic condition. The results are presented in table 4.1.5

The solar intensity was varied from 212 to 519 W m⁻², the maximum solar intensity of 519 W m⁻² was recorded at 1 pm at a temperature of 29⁰ C. The Average solar intensity was 360 Wm⁻² of the day. Voltage (V) and current (A) of solar panel was varied from 307 to 338 V and 3.1 to 3.5 A respectively.

Solar powered shevai machine was operated from morning 9.00 am up to evening 5.00 pm. The parameters selected to evaluate include motor speed and mechanical rpm of shevai machine. The levels of variables at load selected for the study are presented in Table 4.1.6 The effects of operational parameters were studied to evaluate the performance of solar powered shevai machine. The difference in rpm at load and no-load condition of motor and machine pulley for shevai making machine was found 11.34 and 8.89 respectively.

The reading was taken from morning 9.00 am to 5.00 pm evening, during these Period it was observed that as per the time increases temperature and solar intensity is increases up to 1 pm then after that time temperature and solar intensity goes on decreasing. Also, found that solar intensity increases motor rpm also increases, hence its observed that motor rpm is directly proportional to the Solar intensity.

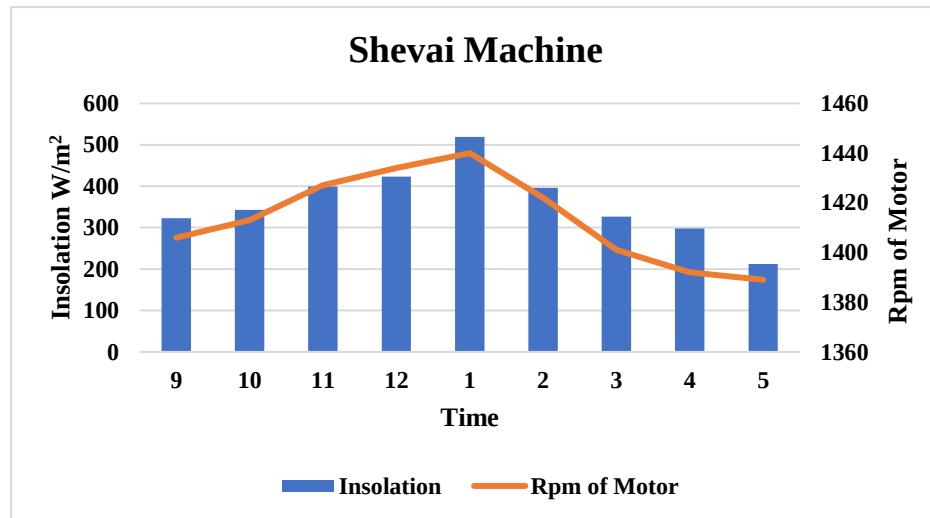


Fig 4.5 : Relation between solar intensity and motor rpm Vs time for shevai machine

From the graph while operating the shevai machine by the solar power it was found that the direct relation between the solar radiation and the motor rpm. At load condition it is found that shevai machine can be easily operated, at the lowest Intensity of 212 W/m². Hence it can be run minimum of 5 hrs. daily from 9 am to 5pm.

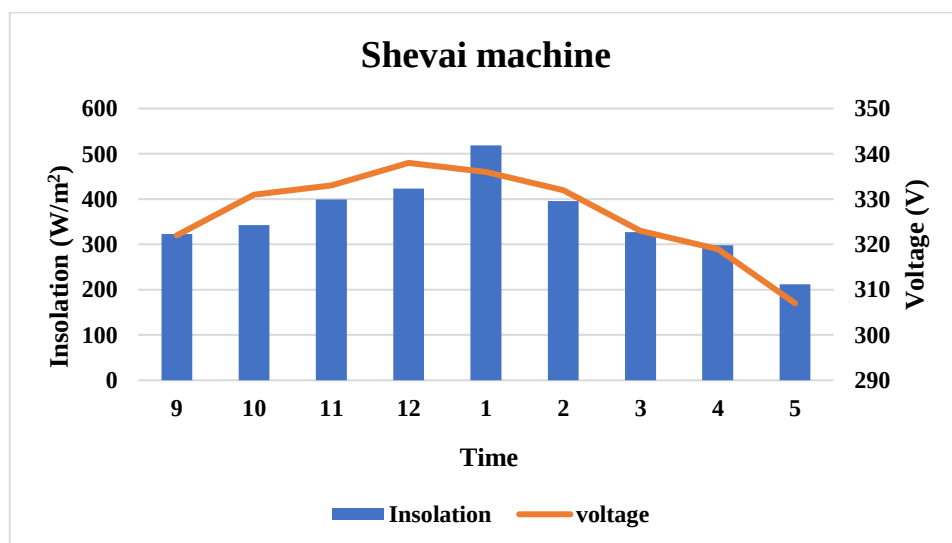


Fig 4.6 : Relation between solar intensity and voltage Vs time for shevai machine

4.1.1.3 : Name of Machine: Shevai making machine

Table 4.6 : Performance of Shevai making machine operating by solar power at load

Sr. No.	Time	Atm. Temp. °C	Insolation (W/m ²)	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm	Output (kg/hr)
1	09.00 am	26	323	3.4	322	1406	363	7.61
2	10.00am	26	343	3.6	331	1413	378	7.95
3	11.00 am	27	399	3.7	333	1427	382	8.84
4	12.00 pm	28	423	3.8	338	1434	384	8.97
5	01.00 pm	29	519	4.0	336	1440	386	9.13
6	02.00 pm	29	396	3.4	332	1422	378	8.81
7	03.00 pm	29	327	3.4	323	1401	372	8.53
8	04.00 pm	28	298	3.3	319	1392	364	8.34
9	05.00 pm	27	212	3.3	307	1389	349	7.42
Average Output								8.4 Kg/hr.

The mean output was found to be 8.4 kg/hr from Shevai machine run by 3 hp (2.24 kW) solar power operated motor.



Plate 4.7 : Solar operated shevai machine under operation



Plate 4.8 : Shevai obtained using solar power

4.1.1.4 Name of Machine: Flour mill

Table 4.7 : Performance of Flour mill operating by solar power at no load

Sr. No.	Time	Atm. Temp. °C	Insolation (W/m ²)	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm
1	09.00 am	26	281	3.2	331	1431	642
2	10.00 am	28	394	3.3	343	1470	696
3	11.00 am	28	448	3.3	343	1472	698
4	12.00 pm	29	457	3.3	347	1475	699
5	01.00 pm	30	508	3.3	349	1475	701
6	02.00 pm	31	536	3.3	345	1476	700
7	03.00 pm	31	417	3.2	344	1474	701
8	04.00 pm	30	312	3.2	332	1471	698
9	05.00 pm	29	208	3.1	319	1427	679

The Flour mill was operated 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 4.1.7

The solar intensity was varied from 208 to 536 W m⁻², the maximum solar intensity of 508 W m⁻² was recorded at 2 pm at a temperature of 31°C. The Average solar intensity was 395 Wm⁻² of the day. Voltage (V) and current (A) of solar panel was varied from 319 to 349 V and 3.1 to 3.3 A. respectively.

Solar powered flour mill was operated from morning 9.00 am up to evening 5.00 pm. The parameters selected to evaluate include motor speed and mechanical rpm of Flour mill. The levels of variables at load selected for the study are presented in Table 4.1.8 The effects of operational parameters were studied to evaluate the performance of solar powered flour mill. The difference in rpm at load and no-load condition of motor and machine pulley for flour mill was found 16.22 and 14.11 respectively.

The reading was taken from 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. Also, it is found that solar intensity increases motor rpm also increases, hence it is observed that motor rpm is directly proportional to the solar intensity.

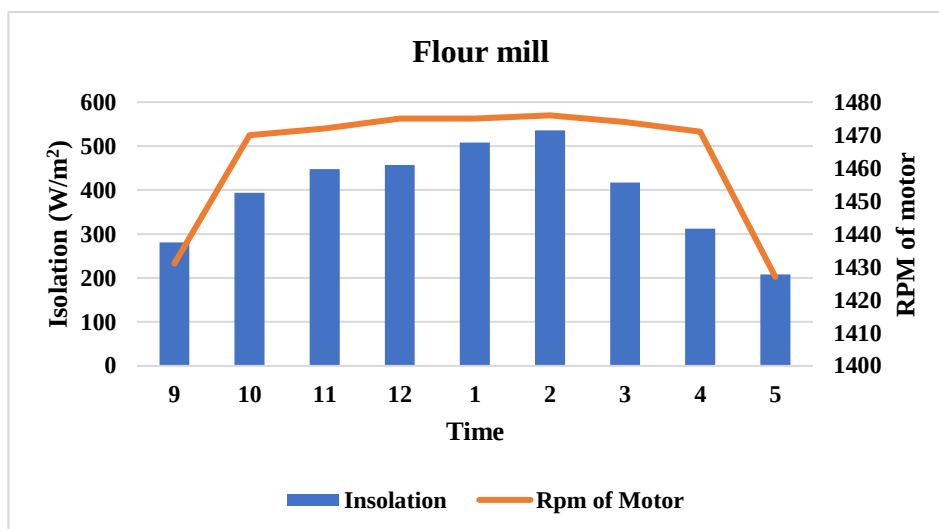


Fig 4.7 : Relation between solar intensity and motor rpm Vs time for flour mill

From the graph while operating the flour mill by the solar power it was found that the direct relation between the solar radiation and the motor rpm. At load condition it is found that seed grader cum cleaner machine can easily operate, at the lowest Intensity of 208 W/m². Hence then flour mill can run for minimum 5 hrs. daily. from 9 am to 5 pm.

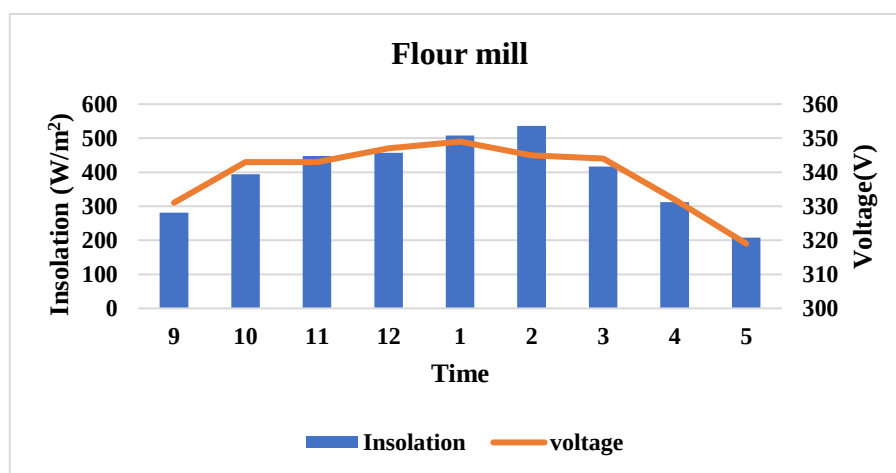


Fig 4.8 : Relation between solar intensity and voltage Vs time for flour mill

The mean output was found to be 8.71 kg/hr from flour mill run by 3 hp (2.24 kW) solar power operated motor.

Table 4.8 : Performance of Flour mill operating by solar power at load

Sr. No.	Time	Atm. Temp. °C	Insolation (W/m ²)	Current (I)	Voltage (V)	Rpm of Motor	Mechanical Rpm	Output (kg/hr)
1	09.00 am	26	281	3.2	331	1422	634	8.51
2	10.00 am	28	394	3.3	343	1456	683	8.67
3	11.00 am	28	448	3.3	343	1458	685	8.84
4	12.00 pm	29	457	3.3	347	1461	687	9.21
5	01.00 pm	30	508	3.3	349	1463	693	9.17
6	02.00 pm	31	536	3.3	345	1454	682	9.08
7	03.00 pm	31	417	3.2	344	1451	684	8.54
8	04.00 pm	30	312	3.2	332	1448	671	8.43
9	05.00 pm	29	208	3.1	319	1412	668	8.00
Average Output								8.71 kg/hr



Plate 4.9 : Rpm measuring of flour mill motor



Plate 4.10 : Solar operated flour machine



Plate 4.11 : Flour mill under operation using solar power

4.2 Performance evaluation of bullock drawn rotary mode Agro processing unit.

4.2.1 Performance Evaluation for Operating Selected Agro Processing Units:

The comparative physiological behavior of inner and outer bullock (B_1 & B_2) in rotary mode of operation for agro processing units were observed. The test was carried out on the test track for continuous half an hour of work duration. Selected Agro-Processing Machine was used for operation by using bullock power in rotary mode of operation.

1. Rotary Gear Parameter.

- a) Power transmission system.
- b) Gear ratios at various units of the rotary system

2. Bullock Parameter Load Condition.

- a) Speed of bullock
- b) Average draft
- c) Power output
- d) Physiological responses

3. Machine Parameter

- a) rpm of shaft of the machine
- b) working efficiency per cent

4.1.2 Performance Evaluation of Papad Machine:

4.1.2.1 Performance Evaluation of Papad Machine operated at no load conditions

The data on performance evaluation of papad machine in rotary mode has been presented in table No.4.2.1 the draft requirement varied 372 N in the beginning to 352.8 N at the end. The mean draft was 343 N which were 3.94 per cent of bodyweight of the bullocks. The increase in respiration rate, pulse rate as usual decreased with duration the mean respiration rate, pulse rate, body temperature of B_1 and B_2 were found to be 36.8 and 37.0 bpm, 37.2 and 37.1 bpm, 37.7 and 37.07 °c respectively. The rpm of

bullocks was 69 to 63 and gradually decreased with duration in three trials of, 30 minutes.

The mean rpm of the papad machine shaft was observed to be 236.6. The output of machine gradually decreased with duration may be due to decrease in the speed of shaft of the papad machine. The mean output was found to be 5.76 kg/h were as the output of papad machine operated with electric motor was 10 kg/h the mean power output from bullock was found to be 0.439 kW. This indicated that the bullock could easily do in rotary mode the papad making operation and their utilization could be enhanced. The lower value of working efficiency may be attributed due to minimizing the rotation of papad making plate and both rollers by the non-uniform speed of bullocks during working of the papad machine.

Table 4.9 : Performance evaluation of Papad Machine

Parameters	At no load								Mean	
	Duration, h									
	In		0.5		1.0		1.5			
	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂
Respiration rate, bpm	14	17	27	28	33	36	35	37	27.25	29.5
pulse rate, bpm	47	48	50	51	53	55	54	56	51	52.5
Body temp, °C	36.8	37.0	37.2	37.1	37.7	37.5	37.9	37.8	37.4	37.35
Draft, kg	-		38		35		37		36.6	
% Body weight	-		4.31		3.97		4.20		4.10	
Draft, N	-		372		343		362		359	
Rpm of bullocks/0.5h	-		69		66		63		66	
Speed, m/s	-		1.32		1.26		1.20		1.26	
Speed, km/h	-		4.76		4.55		4.35		4.55	
rpm at m/c shaft	-		240		250		220		236.6	
Power output of Bullock (kW)	-		0.491		0.432		0.435		0.452	
Output (Kg/h)	-		5.44		6.21		5.65		5.76	

4.1.2.2 Performance Evaluation of Seed Cleaner Cum Grader operated at load conditions

Table No.4.2.2 presents data on the performance evaluation of a seed cleaner cum grader in rotary mode. The draft demand ranged from 470.4 N at the start to 450.8 N at the conclusion. The mean draught was 439.7 N, or 5.05 percent of the bullocks' mass. The mean respiration rate increased while the pulse rate fell as expected. The pulse rates of B₁ and B₂ were 49 bpm and 44 bpm, 57 bpm and 52 bpm, respectively. There was little variance in B₁ and B₂ mean body temperatures were 36.5 and 36.33 °C, respectively. In three 30-minute trials, the bullocks' rpm ranged from 64 to 61 and steadily declined with

The mean rpm of the seed cleaner cum grader shaft was observed to be 323.66. The output of machine gradually decreased with duration may be due to decrease in the speed of shaft of the seed cleaner cum grader. The mean output was found to be 15.33 kg/h were as the output of seed cleaner cum grader operated with electric motor was 40 kg/h. The mean power output from bullock was found to be 0.445 kW. This indicated that the bullock could easily do the cleaning operation and their utilization could be enhanced. The lower value of working efficiency may be attributed due to obstruction in the in the reciprocating motion of graders sieves of Seed cleaner cum grader by the non-uniform speed of bullocks during working of the seed cleaner cum grader. The operation of seed cleaner cum grader was found to be feasible considering the draftability of Red Kandhari bullocks and its output capacity.

Table 4.10 : Performance evaluation of Seed Cleaner cum grader in rotary mode at load

Parameters	At load								Mean	
	Duration, h									
	In		0.5		1.0		1.5			
	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂
Respiration rate, bpm	19	18	22	23	27	28	31	33	24.75	25.50
pulse rate, bpm	49	44	57	52	62	53	61	60	57.25	56
Body temp, °C	38.7	36.8	35.8	36.9	37.1	39.2	34.4	32.4	36.5	36.33
Draft, kg	-		47		46		42		45	
% Body weight	-		5.54		4.67		5.12		5.11	
Draft, N	-		471.3		395		452.8		439.7	
Rpm of bullocks/0.5h	-		63		64		61		62.66	
Speed, m/s	-		1.31		1.42		1.27		1.33	
Speed, km/h	-		4.59		4.94		4.23		4.58	
rpm at m/c shaft	-		324		331		316		323.66	
Power output of Bullock (kW)	-		0.621		0.486		0.546		0.445	
Output (Kg/hr.)	-		18		13		15		15.33	

4.1.2.3 Performance Evaluation of Shevai machine operated at load conditions:

The data on performance evaluation of flour mill in rotary mode has been presented in table No. 4.2.3 the draft requirement varied 509 N in the beginning to 450.8 N Reduced. The mean draft was 476.9 which were 5.52 per cent of body weight of bullocks. The increase in respiration rate, pulse rate as usual increased with duration the mean Respiration rate, pulse rate of B₁ and B₂ was observed and 31.75 bpm, 56.0 and 55.0 bpm respectively. There was not much variation in the Body temperature of B₁ and B₂ 38.07 and 38. 17°C. The rpm of bullocks was 66 to 61 and gradually decreased with duration in three trials of, 30 minutes.

The mean rpm of the flour mill shaft was observed to be 710. The output of machine gradually decreased with duration may be due to decrease in the speed of shaft of the flour mill. The mean output was found to be 8.13 kg/ h were as the output of flour mill operated with electric motor was 10 kg/h. The mean power output from

bullock was found to be 0.550 kW. This indicated that the bullock could easily do the grinding operation and their utilization could be enhanced. The lower value of working efficiency may be attributed due to obstruction in the rotation of grinding stones of flour mill by the non-uniform speed of bullocks during working of the flour mill. The operation of flour mill was found to be feasible considering the draft ability of Red Kandhari bullocks and its output capacity. The mean speed of bullock was found to be 4.48 km/h.

Table 4.11 : Performance evaluation of shevai machine at load

Parameters	At load								Mean	
	Duration, h									
	In		0.5		1.0		1.5			
	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂
Respiration rate, bpm	15	16	28	30	38	39	40	42	30.25	31.75
pulse rate, bpm	48	43	53	51	59	56	64	66	56	55
Body temp, °C	37.6	38.7	37.7	40.9	37.8	37.9	38.5	41.5	37.45	37.6
Draft, kg			52		46		48		48.6	
% Body weight			5.90		5.22		5.45		5.52	
Draft, N			509.6		450.8		470.4		476.9	
Rpm of bullocks/0.5h			66		63		61		63	
Speed, m/s			1.26		1.30		1.17		1.24	
Speed, km/h			4.55		4.69		4.21		4.48	
rpm at m/c shaft			700		720		710		710	
Power output of Bullock (kW)			0.585		0.527		0.540		0.550	
Output (Kg/hr.)			7.5		9.0		8.0		8.13	

4.1.2.3 Performance Evaluation of Flour mill operated at load conditions:

The data on performance evaluation of shevai machine in rotary mode has been presented in table No.4.2.4 the draft requirement varied 460.6 N in the beginning to 382.2 N at the end. The mean draft was 418.13 IN which was 4.80 percent of body weight of the bullocks. The increase in respiration rate, pulse rate by decreased with duration. The mean respiration rate, pulse rate, body temperature of B₁ and B₂ were found to be 37.7 and 40.9 bpm, 37.8 and 37.9 bpm, 38.5 and 37.45 °c respectively. The rpm of bullock from 30 min. of trials was initially 65 and reduced to 60 at load condition.

The mean rpm of the shevai machine shaft was observed to be 150. The output of machine gradually decreased with duration may be due to decrease in the speed of shaft of the shevai machine. The mean output was found to be 7.83 kg/h were as the output of shevai machine operated with electric motor was 10 kg/h. The average power output from the bullock over three time 30 minutes of working in Shevai machine were 0.498 Kw. This indicated that the bullock could easily do the operation and their utilization could be enhanced. The lower value of working efficiency may be attributed due to the non-uniform speed of bullocks during working of the shevai machine. The operation of shevai machine was found to be feasible considering the draft ability of Red Kandhari bullocks and its output capacity.

Table 4.12 : Performance of Flour mill in rotary mode of operation at load

Parameters	At load								Mean	
	Duration, h									
	In		0.5		1.0		1.5			
	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂
Respiration rate, bpm	16	17	27	29	35	38	38	39	26.5	28.5
pulse rate, bpm	48	49	50	52	52	55	57	59	51	52.5
Body temp, °C	37.6	37.7	37.7	37.9	37.8	37.9	38.5	38.5	37.45	37.62
Draft, kg	-		47		39		42		42.66	
% Body weight	-		5.34		4.43		4.77		4.84	
Draft, N	-		460.6		382.2		411.6		418.13	
Rpm of bullocks/0.5h	-		65		62		60		62.33	
Speed, m/s	-		1.24		1.18		1.15		1.19	
Speed, km/h	-		4.46		4.24		4.28		4.32	
rpm at m/c shaft	-		138		160		150		150	
rpm at Rack Pinion shaft	-		67		79		74		73.33	
Power output of Bullock (kW)			0.571		0.450		0.473		0.498	
Output (Kg/hr.)	-		7.5		9.0		7.0		7.83	

4.3 Comparison of agro-processing unit operated by solar and bullock power in order to its efficiency and cost effectiveness.

4.3.1 Capacity of Different Machine (Comparative Efficiency)

Table 4.13 : Capacity of Different Machine Operated by the Solar Power bullock power with Reference Rated Output

Sr. No.	Name of Machine	Output from Solar powered machine (kg/hr.)	Output from Bullock powered machine (kg/hr.)	Capacity of Solar powered machine (%)	Capacity of Bullock powered machine (%)
1	Papad making Machine	8.2	5.76	80.20	57.60
2	Seed Grader cum Cleaner	34.22	17.33	85.55	42.50
3	Shevai machine	8.4	8.13	84.00	80.13
4	Flour mill	8.71	7.83	87.10	78.30

4.3.2 Comparison of agro-processing unit operated by solar and bullock power in order to its cost effectiveness.

4.3.2.1 Total cost of Operation of Agro-Processing Unit Operated by Solar Power.

a) Total cost of Operation of Papad Machine:

Total cost of operation of papad machine operated by solar power
= (Operating Cost of Solar panel per hr.) + (Operating Cost of motor per hr.) +
(Operating Cost of VFD per hr. + (Operating Cost of papad machine per hr.) + Labour
Charges Per hr.
= 5.83+1.55+4.97+31.06+50
= **93.41 Rs. /hr.**

b) Total cost of Operation of Seed Grader cum Cleaner Machine:

Total cost of operation of seed grader cum cleaner operated by solar power
= (Operating Cost of Solar panel per hr.) + (Operating Cost of motor per hr.) +
(Operating Cost of VFD per hr. + (Operating Cost of Seed Grader cum Cleaner
machine per hr.) + Labour Charges Per hr.
= 5.53+1.55+4.97+5.18+50
= **67.53 Rs. /hr.**

c) Total cost of Operation of Shevai machine:

Total cost of Operation of shevai machine Operated by Solar Power
= (Operating Cost of Solar panel per hr.) + (Operating Cost of motor per hr.) +
(Operating Cost of VFD per hr. + (Operating Cost of shevai per hr.) + Labour Charges
Per hr.
= 5.53+1.55+4.97+4.14+50
= **66.49 Rs. /hr.**

d) Total cost of Operation of Flour mill:

Total cost of Operation of flour mill Operated by Solar Power
= (Operating Cost of Solar panel per hr.) + (Operating Cost of motor per hr.) +
(Operating Cost of VFD per hr. + (Operating Cost of flour mill per hr.) + Labour
Charges Per hr.
= 5.53+1.55+4.97+3.11+50
= **65.46 Rs. /hr.**

4.3.2.2 Total cost of Operation of Agro-Processing Unit with Bullock operating rotary power transmission.

a) Total cost of Operation of Papad Machine:

Total cost of Operation of Papad Machine Unit with rotary power transmission unit with pair of bullock
= (Cost of power transmission system) + (cost of Papad making Machines) + (cost of operation of pair of bullocks)
= 31.17+31.06+53.83
= **166.06 Rs. /hr.**

b) Total cost of Operation of seed Grader cum Cleaner Machine:

Total cost of Operation of Seed cleaner cum Grader:
Total cost of Operation of Seed cleaner cum Grader Unit with rotary power transmission unit with pair of bullocks
= (Cost of power transmission system) + (cost of seed Grader cum Cleaner Machines) + (cost of operation of pair of bullocks)
= 31.17+5.18+ 53.83

= Rs. 140.18 Rs. /hr.

c) Total cost of Operation of Shevai machine:

Total cost of Operation of Shevai machine:

Total cost of Operation of shevai machine Unit with rotary power transmission unit with pair of bullocks

= (Cost of power transmission system) + (cost of shevai Machines) + (cost of operation of pair of bullocks)

= 31.17+4.14+ 53.83

= Rs. 139.14 Rs. /hr.

d) Total cost of Operation of Flour mill:

Total cost of Operation of flour mill:

Total cost of Operation of flour mill Unit with rotary power transmission unit with pair of bullocks

= (Cost of power transmission system) + (cost of flour mill) + (cost of operation of pair of bullocks)

= 31.17+3.11+ 53.83

= Rs. 138.11 Rs. /hr.

4.3.2.3 Total cost of Operation of Agro-Processing Unit with Electrical power

Electricity charges for motor

1 Hp Motor x 746 watts

= 746 ÷ 1000

= 0.746 kW

Let's assume efficiency of motor 92% then we get,

= 0.746 ÷ 0.92

= 0.810

For 1 Unit of Meter Reading rated charges 7.00 Rs /- For Domestic purpose.

For 1 HP

= 0.810 x 7.00

$$= 5.67 \text{ Rs/kWh}$$

$$= 5.67 \text{ Rs/hr.}$$

For 2 HP

$$= 0.810 \times 7.00 \times 2$$

$$= 11.34 \text{ Rs/hr.}$$

For 3 HP

$$= 0.810 \times 7.00 \times 3$$

$$= 17.01 \text{ Rs/hr.}$$

a) Total cost of Operation of papad making machine

Total cost of Operation of Electrically operated Papad Machine

= (Electricity charges) + (Operating Cost of motor per hr.) + (Operating Cost of papad machine per hr.) + Labour Charges Per hr.

$$= 11.34 + 1.55 + 31.06 + 50$$

$$= \mathbf{93.95 \text{ Rs. /hr.}}$$

b) Total cost of Operation of grain Grader cum seed Cleaner Machine

Total cost of Operation of Electrically operated seed Grader cum Cleaner Machine

= (Electricity charges) + (Operating Cost of motor per hr.) + (Operating Cost of grain Grader cum Cleaner Machine per hr.) + Labour Charges Per hr.

$$= 11.34 + 1.55 + 5.18 + 50$$

$$= \mathbf{Rs. 68.07 \text{ Rs. /hr.}}$$

c) Total cost of Operation of shevai machine

Total cost of Operation of Electrically operated shevai machine

= (Electricity charges) + (Operating Cost of motor per hr.) + (Operating Cost of shevai machine per hr.) + Labour Charges Per hr.

$$= 11.34 + 1.55 + 4.14 + 50$$

$$= \mathbf{Rs. 67.03 \text{ Rs. /hr.}}$$

d) Total cost of Operation flour mill

Total cost of Operation of Electrically operated flour Machine

= (Electricity charges) + (Operating Cost of motor per hr.) + (Operating Cost of flour mill per hr.) + Labour Charges Per hr.

$$= 11.34 + 1.55 + 3.11 + 50$$

= Rs. 66 Rs. /hr.

Table 4.14 : Cost of operation of Solar power operated machines in Rs/hr.

Sr.No.	Cost	Papad Making Machine (Rs/hr)	Seed Grader cum Cleaner (Rs/hr)	Shevai making machine (Rs/hr)	Flour mill (Rs/hr)
1	Cost of operation (Fixed cost + Operating cost)	31.06.	5.18	4.14	3.11
2	Operating cost of Solar panel	5.83			
3	Operating cost of Solar Motor	1.55		1.66	
4	Operating cost of VFD	4.97			
5	Labour Charges	50			
6	Total operating cost of each machine	93.41	67.53	66.6	65.57

Table 4.15 : Cost of operation of Bullock power operated machines in hour

Sr.No.	Cost	Papad Making Machine (Rs/hr)	Seed Grader cum Cleaner (Rs/hr)	Shevai making machine (Rs/hr)	Flour mill (Rs/hr)
1	Cost of operation (Fixed cost + Operating cost)	31.06	5.18	4.14	3.11
2	Cost of operation of pair of bullocks	53.83			
3	Cost estimation of power transmission unit	31.17			
4	Labour charges	50			
5	Total operating cost of each machine	166.06	140.18	139.14	138.11

Table 4.16 : Cost of Operation of Electrically powered machines in hour

Sr.No.	Cost	Papad Making Machine (Rs/hr)	Seed Grader cum Cleaner (Rs/hr)	Shevai making machine (Rs/hr)	Flour mill (Rs/hr)
1	Cost of operation (Fixed cost + Operating cost)	31.06	5.18	4.14	3.11
2	Cost of electricity	11.34 (For 2Hp)		16.8 (For 3 Hp)	
3	Cost of operation for motor (Fixed cost + Operating cost)	1.55 (For 2Hp)		1.66 (For 3 Hp)	
4	Labour charges	50			
5	Total operating cost of each machine	93.95	68.07	72.6	71.57

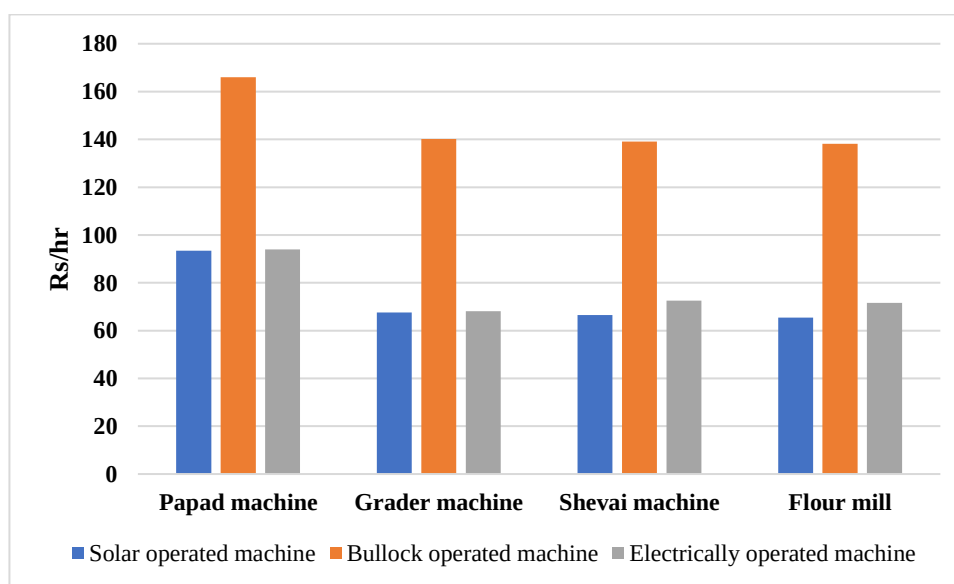


Fig 4.9 : Comparison between the cost of operation between solar power, bullock power and electrical power

CHAPTER – V

SUMMARY AND CONCLUSIONS

CHAPTER-V

SUMMARY AND CONCLUSION

In the present energy crises, it is necessary to harness the alternate/renewable 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 face the difficulties in areas where 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. To overcome on above problem the efforts are made to design and development of the agro processing unit based on solar energy at AICRP on Utilisation of Animal Energy, CAET VNMKV., Parbhani. Developed agro processing unit based on the solar energy is undertaken to evaluate its performance for different processing machine up to 3 kW power. Performance evaluation of machine like papad making machine, grain grader cum seed cleaner, shevai machine and flour mill was taken with respect to its output and working efficiency. The papad making machine, grain grader cum seed cleaner was run one by one using motor of 1.5 kW. Shevai machine, flour mill was run one by one using motor of 2.238 kW.

Agroprocessing unit based on bullock operated rotary mode was already developed at the site of the AICRP on Utilisation of Animal Energy, CAET, VNMKV, Parbhani. Different existing machine like papad making machine, grain grader cum seed cleaner, shevai machine, flour mill operated by bullock for their operation. Then the outputs of these machineries from in different power sources like solar, animal, electrical were compared. Further, cost economics of developed animal driven transmission system and designed solar photovoltaic for various agro processing machines were calculated and compared.

Conclusion

Based on the research work carried out, the following conclusions were drawn:

1. The existing machine in agro processing unit like papad making machine, gain grader cum seed cleaner, shevai machine and flour mill can run on the designed solar photovoltaic system.

2. In normal sunny days with average radiation of (410 Wm^{-2}) motor output was found optimum (1440 RPM) for 5 hr. in one day. Hence motor can be very well operated for five hours in a day.
3. The cost analysis showed that the operating cost for solar powered papad making machine, grader cum seed cleaner, shevai machine and flour mill was 93.41, 67.53, 66.49 and 65.46 Rs per hr. respectively.
4. Operating cost for animal powered papad making machine, grader cum seed cleaner, shevai machine and flour mill was 166.06, 104.18, 139.14, 138.11 Rs per hr. respectively.
5. The papad making machine and grader cum cleaner with 2 hp 3 Phase electric motor run on solar energy gives average output 8.2 and 34.22 kg per hr. respectively in normal sunny days.
6. All machine can be operated economically on solar power as compared to animal.
7. The shevai making machine and flour mill with 3 hp 3 phase electric motor run on solar energy gives average output 7.32 and 8.71 kg per hr. respectively in normal sunny days.
8. Average output from bullock powered rotary mode papad making machine, grader cum seed cleaner, shevai machine and flour mill was 6.1, 17.33, 8.13 and 7.83 kg per hr. respectively was recorded.

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APPENDICES

APPENDIX – A

Specifications of the components of solar powered agro-processing unit

Sr. No.	Components	Specification	
1	Solar panel	Brand	WS-335
		Maximum power (Pmax)	335.0
		Panel Dimension	1996×990mm
		No of panel	9
		Short circuit current	9.25 A
		Max power current	8.95 A
		Max system voltage	1000 V
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	2.2 kW/3 HP
		Input	1 Phase, DC 250-350 V, 18 A
		Output	3 Phase, 9.5 A, 0-600 Hz

The specification of Papad machine is as under:

APPENDIX – B

Specification of selected agro processing unit

A. Specification of Papad machine

The specification of Papad machine is as under:

Sr. No.	Particulars	Dimension
1	Manufactured by	Maa Durga Plastic Products, Akola
2	Overall dimension (L×B×H)	12×18×32 cm
3	Speed Requirement	710 RPM
4	Power Requirement	2 HP
5	Type of Plate Placed	Vertical
6	No of Pressing Roller	2(Two)
7	Output Capacity	8-10 kg/hr.

B. Specification of Seed cleaner cum Grader

The specification of Seed cleaner is as under:

Sr. No.	Particulars	Dimension
1	Manufactured by	CIAE, Bhopal
2	Overall dimension (L×B×H)	160 x 55 x 100 cm
3	Speed Requirement	320 rpm
4	Power Requirement	2 HP
5	Feed type	Manual Type
6	No. sieves	2 Two
	Output Capacity	40 kg/hr.

C. Specification of Shevai Machine

The specification of Shevai Machine is as under:

Sr. No.	Particulars	Dimension
1	Manufactured by	Maa Durga Plastic Products, Akola
2	Overall dimension (L×B×H)	105×47×126 cm
3	Speed Requirement	150 rpm
4	Power Requirement	3 Hp
	Output Capacity	8-10 kg/hr.

D. Specification of Flour Mill

The specification of Flour Mill is as under:

Sr. No.	Particulars	Dimension
1	Manufactured by	Vijay Engineering, Narayangaon, Pune
2	Overall dimension (L×B×H)	37×36×93 cm
3	Speed Requirement	710
4	Power Requirement	1 hp
5	Type of stone grinder	vertical
6	Output Capacity	8-10 kg/hr.

APPENDIX – C

Cost of selected agro processing machine:

The cost of different machine is as under:

Sr.No.	Machine	Cost
1	Papad machine	150000
2	Grader cum seed cleaner	25000
3	Shevai machine	20000
4	Flour mill	15000
5	Solar panel	84420
6	VFD	72000
7	Induction motor 3 Phase 2 HP	12000
8	Cost of bullock power transmittion unit	60000

APPENDIX – D

Cost economics of developed solar powered Agro Processing unit.

1) Cost of Papad Machine

A) Fixed Cost:

Total cost of Papad Machine = Rs.150000/-

No. of working hours = 1000 hrs.

a) Annual interest cost/hr.

$$= \frac{(150000+15000) \times 0.14}{2 \times 1000}$$

= Rs. 11.55 per hour

b) Depreciation @ 10 % cost:

$$= \frac{150000 - 15000}{10 \times 1000}$$

= Rs. 13.5 per hour

∴ Total fixed cost = 25.05 Rs/hr.

B) Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{150000 \times 0.04}{1000}$$

= Rs. 6 per hour

Total cost of operation of Papad Machine:

= Fixed cost + Operating cost

= 25.05 + 6

= **Rs. 31.06 per hour**

2) Cost of seed cleaner cum Grader machine

Fixed Cost:

Total cost of seed cleaner cum Grader machine = Rs.25000/-

No. of working hours = 1000 hrs.

c) Annual interest cost/hr.

$$= \frac{(25000+2500) \times 0.14}{2 \times 1000}$$

= Rs. 1.925 per hour

d) Depreciation @ 10 % cost:

$$= \frac{25000 - 2500}{10 \times 1000}$$

= Rs. 2.25 per hour

∴ Total fixed cost = 4.18Rs. /hr.

B] Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{25000 \times 0.04}{1000}$$

= Rs. 1 per hour

Total cost of operation of seed cleaner cum Grader machine:

= Fixed cost + Operating cost

= 4.18 + 1

= Rs. 5.18 per hour

3) Cost of shevai machine

Fixed Cost:

Total cost of shevai machine = Rs.20000/-

No. of working hours = 1000 hrs.

e) Annual interest cost/hr.

$$= \frac{(20000+2000) \times 0.14}{2 \times 1000}$$

= Rs. 1.54 per hour

f) Depreciation @ 10 % cost:

$$= \frac{20000 - 2000}{10 \times 1000}$$

= Rs. 1.8 per hour

∴ Total fixed cost = 3.34 Rs. /hr.

B] Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{20000 \times 0.04}{1000}$$

= Rs. 0.8 per hour

Total cost of operation of shevai machine:

= Fixed cost + Operating cost

= 3.34 + 0.8

= **Rs. 7.2 per hour**

4) Cost of Flour mill

B) Fixed Cost:

Total cost of Papad Machine = Rs.15,000/-

No. of working hours = 1000 hrs.

g) Annual interest cost/hr.

$$= \frac{(15000+1500) \times 0.14}{2 \times 1000}$$

= Rs 1.16 per hour

h) Depreciation @ 10 % cost:

$$= \frac{15000 - 1500}{10 \times 1000}$$

= Rs. 1.35 per hour

∴ Total fixed cost = 2.51 Rs/hr.

B) Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{15000 \times 0.04}{1000}$$

= Rs. 0.6 per hour

Total cost of operation of Papad Machine:

= Fixed cost + Operating cost

= 2.51 + 0.6

= **Rs. 3.11 per hour**

5) Cost of Solar panel

Fixed Cost:

Total cost of Cost of Solar panel

= Rs.84420/-

No. of working hours = 3000 hrs.

i) Annual interest cost/hr.

$$= \frac{(84420+8442) \times 0.14}{2 \times 3000}$$

= Rs. 2.17 per hour

j) Depreciation @ 10 % cost:

$$= \frac{84420 - 8420}{10 \times 1000}$$

= Rs. 2.53 per hour

∴ Total fixed cost = 4.7 Rs. /hr.

B] Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{84420 \times 0.04}{3000}$$

= Rs. 1.13 per hour

Total cost of operation of Solar panel:

= Fixed cost + Operating cost

= 4.7 + 1.13

= **Rs. 5.83 per hour**

6) Cost of motor

Fixed Cost:

Total cost of Papad Machine = Rs.12000/-

No. of working hours = 3000 hrs.

k) Annual interest cost/hr.

$$= \frac{(12000+1200) \times 0.14}{2 \times 3000}$$

= Rs. 0.308 per hour

l) Depreciation @ 10 % cost:

$$= \frac{12000 - 1200}{10 \times 3000}$$

= Rs. 1.08 per hour

∴ Total fixed cost = 1.39 Rs. /hr.

B] Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{12000 \times 0.04}{3000}$$

= Rs. 0.16 per hour

Total cost of operation of Solar motor:

= Fixed cost + Operating cost

$$= 1.39 + 0.16$$

= Rs. 1.55 per hour

7) Cost of VFD:**A] Fixed Cost:**

Total cost of Papad Machine = Rs.72000/-

No. of working hours = 3000 hrs.

m) Annual interest cost/hr.

$$= \frac{(72000 + 7200) \times 0.14}{2 \times 3000}$$

= Rs. 1.85 per hour

n) Depreciation @ 10 % cost:

$$= \frac{72000 - 7200}{10 \times 3000}$$

= Rs. 2.16 per hour

∴ Total fixed cost = 4.01 Rs. /hr.

B] Operating Cost:

Repair and maintenance @ 4 % of price

$$= \frac{72000 \times 0.04}{3000}$$

= Rs. 0.96 per hour

Total cost of operation of Papad Machine:

= Fixed cost + Operating cost

$$= 4.01 + 0.96$$

= Rs. 4.97 per hour

8) Labour Charges

For one day 350 Rs/day.

Working hour of labour =8 hr. in one day

Labour charges per hr.=50 RS

9) Electricity charges for motor

1 Hp Motor x 746 watts

$$= 746 \div 1000$$

$$= 0.746 \text{ kW}$$

Let's assume efficiency of motor 92% then we get,

$$= 0.746 \div 0.92$$

$$= 0.810$$

For 1 Unit of Meter Reading rated charges 7.00 Rs /- For Domestic purpose.

For 1 HP

$$= 0.810 \times 7.00$$

$$= 5.67 \text{ Rs/kWh}$$

$$= 5.67 \text{ Rs/hr.}$$

For 2 HP

$$= 0.810 \times 7.00 \times 2$$

$$= 11.34 \text{ Rs/hr.}$$

For 3 HP

$$= 0.810 \times 7.00 \times 3$$

$$= 17.01 \text{ Rs/hr}$$

Observation Tables

Papad Making Machine at No Load, Month: May (Day - 1, 2, 3)

Time	Atm. Temp. (°C)				Insolation (W/m ²)				Current (I)				Voltage (V)				Rpm of Motor				Mechanical Rpm			
	T ₁	T ₂	T ₃	T _{av}	I _{n1}	I _{n2}	I _{n3}	I _{n(av)}	I ₁	I ₂	I ₃	I _{av}	V ₁	V ₂	V ₃	V _{av}	R ₁	R ₂	R ₃	R _{av}	M ₁	M ₂	M ₃	M _{av}
9 am	29	27	31	29	290	282	319	297	2.0	1.9	2.1	2.0	307	303	323	311	1421	1417	1437	1425	513	511	521	515
10 am	34	33	35	34	369	362	373	368	2.1	2.0	2.2	2.1	311	304	330	318	1432	1428	1448	1436	527	525	535	529
11 am	37	35	39	37	382	372	397	384	2.1	2.0	2.2	2.1	346	346	366	354	1441	1437	1457	1445	543	541	551	545
12 pm	39	38	40	39	471	459	486	472	2.2	2.1	2.3	2.2	346	342	362	350	1445	1445	1457	1449	546	544	554	548
1 pm	40	39	41	40	516	483	546	515	2.2	2.1	2.3	2.2	347	343	362	350	1445	1443	1453	1447	541	539	549	543
2 pm	42	41	43	42	567	539	577	561	2.2	2.1	2.3	2.2	341	337	357	345	1444	1440	1451	1445	549	547	557	551
3 pm	42	42	42	42	377	348	397	374	2.2	2.1	2.3	2.2	333	329	349	337	1434	1430	1450	1438	532	530	540	534
4 pm	41	41	41	41	312	352	338	334	2.1	2.0	2.2	2.1	317	313	332	321	1400	1396	1416	1404	501	499	509	503
5 pm	41	41	41	41	201	197	209	202	2.1	2.0	2.2	2.1	314	310	330	318	1387	1383	1403	1391	489	487	497	491

Papad Making Machine at Load, Month: May (Day - 1, 2, 3)

Time	Average Temperature T _{av}	Average Intensity I _{n(av)}	Average Current I _{av}	Average Voltage V _{av}	Rpm of Motor				Mechanical Rpm				Output (kg/hr)			
					R ₁	R ₂	R ₃	R _{av}	M ₁	M ₂	M ₃	M _{av}	O ₁	O ₂	O ₃	O _{av}
9 am	29	297	2.0	311	1415	1411	1431	1419	505	503	513	507	7.3	7.1	8.1	7.5
10 am	34	368	2.1	318	1421	1417	1437	1425	519	517	527	521	7.9	7.7	8.7	8.1
11 am	37	384	2.1	354	1433	1429	1437	1449	533	531	541	535	8.1	7.9	8.9	8.3
12 pm	39	472	2.2	350	1435	1431	1439	1451	536	530	544	538	8.5	8.3	9.3	8.7
1 pm	40	515	2.2	350	1436	1432	1440	1452	531	529	537	533	8.2	8.0	9.0	8.4
2 pm	42	561	2.2	345	1439	1438	1446	1449	539	537	547	541	8.4	8.2	9.2	8.6
3 pm	42	374	2.2	337	1419	1415	1423	1435	520	518	528	522	8.1	7.9	8.9	8.3
4 pm	41	334	2.1	321	1392	1388	1396	1408	495	493	503	497	7.9	7.7	8.7	8.1
5 pm	41	202	2.1	318	1384	1380	1388	1400	481	479	489	483	7.6	7.4	8.4	7.8

Seed Grader machine at No Load, Month: August (Day - 1, 2, 3)

Time	Atm. Temp. (°C)				Insolation (W/m²)				Current (I)				Voltage (V)				Rpm of Motor				Mechanical Rpm			
	T ₁	T ₂	T ₃	T _{AV}	I _{n1}	I _{n2}	I _{n3}	I _{n(av)}	I ₁	I ₂	I ₃	I _{av}	V ₁	V ₂	V ₃	V _{AV}	R ₁	R ₂	R ₃	R _{AV}	M ₁	M ₂	M ₃	M _{AV}
9 am	24	28	26	26	278	298	280	286	2.0	2.2	2.1	2.1	266	284	381	277	1391	1413	1387	1397	300	308	298	302
10 am	27	31	29	29	337	359	339	345	2.0	2.2	2.1	2.1	310	319	316	312	1403	1422	1405	1410	316	324	314	318
11 am	27	31	29	29	575	597	577	583	2.0	2.2	2.1	2.1	345	363	360	356	1443	1447	1445	1445	334	344	333	337
12 pm	27	31	29	29	602	624	604	610	2.0	2.2	2.1	2.1	337	355	352	348	1443	1449	1446	1446	334	344	333	337
1 pm	29	31	30	30	705	727	709	713	2.1	2.3	2.2	2.2	355	373	370	366	1444	1455	1448	1449	346	354	344	348
2 pm	29	31	30	30	634	665	636	642	2.1	2.1	2.1	2.1	331	349	346	342	1444	1453	1447	1448	342	350	340	344
3 pm	29	31	30	30	499	521	501	507	1.9	2.1	2.0	2.0	322	340	337	333	1433	1448	1439	1440	330	338	328	332
4 pm	29	31	30	30	424	446	425	432	2.0	2.0	2.0	2.0	307	325	322	318	1433	1445	1439	1440	319	327	317	321
5 pm	29	31	30	30	287	309	289	295	2.0	2.0	2.0	2.0	298	316	313	309	1420	1439	1422	1427	311	319	309	313

Seed Grader machine at Load, Month: August (Day - 1, 2, 3)

Time	Average Temperature T _{av}	Average Intensity I _{n(av)}	Average Current I _{av}	Average Voltage V _{av}	Rpm of Motor				Mechanical Rpm				Output (kg/hr)			
					R ₁	R ₂	R ₃	R _{av}	M ₁	M ₂	M ₃	M _{av}	O ₁	O ₂	O ₃	O _{av}
9 am	26	286	2.1	277	1380	1400	1378	1386	293	301	291	295	21.4	23.6	21	22
10 am	29	345	2.1	312	1385	1405	1383	1391	310	318	308	312	33.4	35.6	33	34
11 am	29	583	2.1	356	1428	1448	1426	1434	324	332	322	326	36.4	38.6	36	37
12 pm	29	610	2.1	348	1431	1451	1429	1437	326	334	324	328	39.4	41.6	39	40
1 pm	30	713	2.2	366	1429	1449	1427	1435	334	342	332	336	41.4	43.6	41	42
2 pm	30	642	2.1	342	1428	1448	1426	1434	319	327	317	321	44.4	46.6	44	45
3 pm	30	507	2.0	333	1425	1445	1423	1431	322	330	320	324	30.4	32.6	30	31
4 pm	30	432	2.0	318	1427	1447	1425	1433	314	322	312	316	29.4	31.6	29	30
5 pm	30	295	2.0	309	1413	1433	1411	1419	301	309	299	303	26.4	28.6	26	27

Shevai Machine at No Load, Month: August (Day - 1, 2, 3)

Time	Atm. Temp. (°C)				Insolation (W/m²)				Current (I)				Voltage (V)				Rpm of Motor				Mechanical Rpm			
	T ₁	T ₂	T ₃	T _{AV}	I _{n1}	I _{n2}	I _{n3}	I _{n(av)}	I ₁	I ₂	I ₃	I _{av}	V ₁	V ₂	V ₃	V _{AV}	R ₁	R ₂	R ₃	R _{AV}	M ₁	M ₂	M ₃	M _{AV}
9 am	29	25	24	26	337	317	315	323	3.1	3.1	3.1	3.1	333	318	315	322	1415	1410	1411	1412	379	369	371	373
10 am	29	25	24	26	357	337	335	343	3.2	3.1	3.0	3.1	342	327	324	331	1423	1418	1419	1420	394	384	386	388
11 am	30	26	25	27	413	393	391	399	3.4	3.2	3.3	3.3	344	329	326	333	1440	1435	1436	1437	398	388	390	392
12 pm	31	27	26	28	437	417	415	423	3.5	3.3	3.4	3.4	349	334	331	338	1447	1442	1443	1444	400	390	392	394
1 pm	32	28	27	29	533	513	511	519	3.6	3.4	3.5	3.5	347	332	329	336	1453	1448	1449	1450	402	392	394	396
2 pm	32	28	27	29	410	390	388	396	3.6	3.4	3.5	3.5	343	328	325	332	1440	1435	1436	1437	394	384	386	388
3 pm	32	28	27	29	341	321	319	327	3.4	3.4	3.4	3.4	334	319	316	323	1421	1416	1417	1418	388	378	380	382
4 pm	31	27	26	28	312	292	290	298	3.4	3.2	3.3	3.3	330	315	312	319	1410	1405	1406	1407	370	360	362	364
5 pm	30	26	25	27	226	206	204	212	3.2	3.2	3.2	3.2	318	303	300	307	1404	1399	1400	1401	365	355	357	359

Shevai Machine at Load, Month: August (Day - 1, 2, 3)

Time	Average Temperature T _{av}	Average Intensity In(av)	Average Current I _{av}	Average Voltage V _{av}	Rpm of Motor				Mechanical Rpm				Output (kg/hr)			
					R ₁	R ₂	R ₃	R _{av}	M ₁	M ₂	M ₃	M _{av}	O ₁	O ₂	O ₃	O _{av}
9 am	26	323	3.1	322	1412	1404	1402	1406	371	360	358	363	8.21	7.41	7.21	7.61
10 am	26	343	3.1	331	1419	1411	1409	1413	386	375	373	378	8.55	7.75	7.55	7.95
11 am	27	399	3.3	333	1433	1425	1423	1427	390	379	377	382	9.44	8.64	8.44	8.84
12 pm	28	423	3.4	338	1440	1432	1430	1434	392	381	379	384	9.57	8.77	8.57	8.97
1 pm	29	519	3.5	336	1446	1438	1436	1440	394	383	381	386	9.73	8.93	8.73	9.13
2 pm	29	396	3.5	332	1428	1420	1418	1422	386	375	373	378	9.41	8.61	8.41	8.81
3 pm	29	327	3.4	323	1407	1399	1397	1401	380	369	367	372	9.13	8.33	8.13	8.53
4 pm	28	298	3.3	319	1398	1390	1388	1392	372	361	359	364	8.94	8.14	7.94	8.34
5 pm	27	212	3.2	307	1395	1387	1385	1389	357	346	344	349	8.02	7.22	7.02	7.42

...

Flour mill at No Load, Month: May (Day - 1, 2, 3)

Time	Atm. Temp. (°C)				Insolation (W/m²)				Current (I)				Voltage (V)				Rpm of Motor				Mechanical Rpm			
	T ₁	T ₂	T ₃	T _{AV}	I _{n1}	I _{n2}	I _{n3}	I _{n(av)}	I ₁	I ₂	I ₃	I _{av}	V ₁	V ₂	V ₃	V _{AV}	R ₁	R ₂	R ₃	R _{AV}	M ₁	M ₂	M ₃	M _{AV}
9 am	28	23	27	26	292	274	277	281	3.3	3	3.3	3.2	337	327	329	331	1436	1428	1429	1431	652	636	638	642
10 am	30	25	29	28	405	387	390	394	3.4	3.1	3.4	3.3	349	339	341	343	1475	1467	1468	1470	706	690	692	696
11 am	30	25	29	28	459	441	444	448	3.4	3.1	3.4	3.3	349	339	341	343	1477	1469	1470	1472	708	692	694	698
12 pm	31	26	30	29	468	450	453	457	3.4	3.1	3.4	3.3	353	343	345	347	1480	1472	1473	1475	709	693	695	699
1 pm	32	27	31	30	519	501	504	508	3.4	3.1	3.4	3.3	355	345	347	349	1480	1472	1473	1475	711	695	697	701
2 pm	33	28	32	31	547	529	532	536	3.4	3.1	3.4	3.3	351	341	343	345	1481	1473	1474	1476	710	694	696	700
3 pm	33	28	32	31	428	410	413	417	3.3	3	3.3	3.2	350	340	342	344	1479	1471	1472	1474	711	695	697	701
4 pm	32	27	31	30	323	305	308	312	3.3	3	3.3	3.2	338	328	330	332	1476	1468	1469	1471	708	692	694	698
5 pm	31	26	30	29	219	201	204	208	3.2	2.9	3.2	3.1	325	315	317	319	1432	1424	1425	1427	689	673	675	679

Flour at Load, Month: May (Day - 1, 2, 3)

Time	Average Temperature T _{av}	Average Intensity In(av)	Average Current I _{av}	Average Voltage V _{av}	Rpm of Motor				Mechanical Rpm				Output (kg/hr)			
					R ₁	R ₂	R ₃	R _{av}	M ₁	M ₂	M ₃	M _{av}	O ₁	O ₂	O ₃	O _{av}
9 am	26	281	2.1	331	1429	1418	1419	1422	643	629	630	634	9.01	8.11	8.41	8.51
10 am	28	394	3.2	343	1463	1452	1453	1456	692	678	679	683	9.17	8.27	8.57	8.67
11 am	28	448	3.3	343	1465	1454	1455	1458	694	680	681	685	9.34	8.44	8.74	8.84
12 pm	29	457	3.3	347	1468	1457	1458	1461	696	682	683	687	9.71	8.81	9.11	9.21
1 pm	30	508	3.3	349	1470	1459	1460	1463	702	688	689	693	9.67	8.77	9.07	9.17
2 pm	31	536	3.3	345	1461	1450	1451	1454	691	677	678	682	9.58	8.68	8.98	9.08
3 pm	31	417	3.3	344	1458	1447	1448	1451	693	679	680	684	9.04	8.14	8.44	8.54
4 pm	30	312	3.2	332	1455	1444	1445	1448	680	666	667	671	8.93	8.03	8.33	8.43
5 pm	29	208	3.2	319	1419	1408	1409	1412	677	663	664	668	8.5	7.6	7.9	8.0

CURRICULUM VITAE

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Name of Candidate : Gethe Rohit Arun
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Academic Qualification

Course/ Degree	Name of college/Institute	University/ Board	Year of passing	Percentage (%)/CGPA	Class/ Grade
SSC	Shri D. G. Saraf Vidyalaya, Sangamner.	Maharashtra state board	2014	83.84 %	First class
HSC	Dr. D. A. Ohara Junior College, Sangamner.	Maharashtra state board	2016	72.15 %	First class
B. Tech (Agricultural Engineering)	Collage of Agricultural Engineering and Technology, Maldad.	Mahatma Phule Krishi Vidyapeeth	2020	80.60%	First class

Place: Parbhani

Date: 03/ 02/2023

Gethe Rohit Arun