Solar Powered Automatic Shrimp Feeding System

Asia Pacific Journal of Multidisciplinary Research
Vol. 3 No.5, 152-159
December 2015 Part II
P-ISSN 2350-7756
E-ISSN 2350-8442
www.apjmr.com

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Date Received: October 15, 2015; Date Revised: December 16, 2015

Abstract *- Automatic system has brought many revolutions in the existing technologies. One among the technologies, which has greater developments, is the solar powered automatic shrimp feeding system. For instance, the solar power which is a renewable energy can be an alternative solution to energy crisis and basically reducing man power by using it in an automatic manner. The researchers believe an automatic shrimp feeding system may help solve problems on manual feeding operations.*

The project study aimed to design and develop a solar powered automatic shrimp feeding system. It specifically sought to prepare the design specifications of the project, to determine the methods of fabrication and assembly, and to test the response time of the automatic shrimp feeding system.

The researchers designed and developed an automatic system which utilizes a 10 hour timer to be set in intervals preferred by the user and will undergo a continuous process. The magnetic contactor acts as a switch connected to the 10 hour timer which controls the activation or termination of electrical loads and powered by means of a solar panel outputting electrical power, and a rechargeable battery in electrical communication with the solar panel for storing the power.

By undergoing through series of testing, the components of the modified system were proven functional and were operating within the desired output. It was recommended that the timer to be used should be tested to avoid malfunction and achieve the fully automatic system and that the system may be improved to handle changes in scope of the project.

Keywords*: solar power, shrimp feeder, automatic*

INTRODUCTION

Shrimp pond culture system is an aquaculture business that exists in either a marine or freshwater environment, producing shrimp or prawns for human consumption. Shrimp yield in ponds can be increased by applying modern farming techniques such as intensification of culture operation through regularization of pond size, increased stock density, employment of aeration, and application of formulated feed. This will mean a considerable increase in financial and high technology inputs which most small farmers in the developing countries may not be able to afford.

It is a must for a pond farm business owner to consider shrimps' health: that they are fed regularly in controlled portions in order to maximize growth and vitality, without the risks of overfeeding. Shrimp farming is a business. Like any business, businessmen should assure the continuous increasing production of the harvests. Such necessities are so called automatic feeders for regulated time varying feeding system that influences the growth of the shrimps.

In most farms, feeding of shrimp is done by hand. This practice of manual feeding is very time consuming, especially for ponds of large areas. Problems arise from shrimps getting diseases from uncontrolled amount of feeds, resulting to unhealthy harvests.

The project is a feeder for the Vanname shrimps. The system is automatic in terms of dispensing the feeds, with regard to time. It will allow adjustable feed quantity and time helpful in maintaining the shrimp's health because of small portion feeding at scheduled intervals and precise feeding at appropriate times. This will also prevent overeating by releasing the right quantity of food, at scheduled times and assures well fed, healthy shrimps.

The research study performed evaluation of the existing MCU based solar powered chicken feeder and showed that there is a need to develop a different project by creating a new concept and idea on using solar energy as a source. A 10 hour timer is better to use than a smart relay in terms of feeding time program. It is adjustable on a continuous process and can be set into a new program depending on the shrimp's growth rate and the amount of shrimp in a pond.

The reviewed literature provided concepts which helped the proponents come up with different ideas in constructing this design project. The evolution of studies for the solar powered automatic shrimp feeding system e.g. of Lim et al. [3], up to the study of Arellano et al. 2013, helped the researchers to provide a highly developed output. From the study by Lim et al. [3],which implemented fuzzy logic algorithm in constructing the fish feeding mechanism, this project utilized a smart relay programming system. Also the study by Talib et al. [4] were parallel to this study except that the researchers used solar energy as a supply for the shrimps instead of fish. The food pellets of the shrimp are thrice larger than the fish food pellets.There was also a study by Talib et al. [4] which was a microcontroller unit based poultry feed dispensing system that aids the researcher to use a smart relay programming system. It has a microcontroller unit which provides numerous outputs. More study from Nazrul Hisyam [5] utilized robot as a medium to dispense food for livestock controlled by programmable logic controller while this project used a screw type conveyor. The robotic arm, in his study, would deliver feeds using a programmable arm, while in this study, the screw type conveyor would deliver the feeds using a rotating helical screw which transfers feeds from hopper to the dispensing device.

This study differed from other studies, having distinctive characteristics that others did not have and a higher development of previous researches. This study offers solar power as a source of electricity and has three motors for the main drive motor, belt type conveyor motor and screw type conveyor motor. The timer for the feeder was designed to automatically dispense feeds.

The project design considered the provisions in the Philippine Electrical Code (PEC) which includes requirements for electrical installation, sizes of conductors, solar panel, provisions for alternate power source and storage batteries. The project also considered the standards given by the National Electrical Code (NEC) for motor capacity and safety standards for the wiring installation together with the National Electrical Manufacturers Association (NEMA) standards and requirements to ensure safe operation for batteries.

The project will be for pond farm business owners who need the project to reduce manpower and control the feeding system while having a huge harvest of healthy shrimps. Although there are helping tools used in relation to the improvement of advancement and production yet there is a need for further development to get hold of maximum business growth.

Feeders help optimize aquarium fish nutrition. Solar powered ensures proper nutrition for pond inhabitants with special dietary needs, therefore this solves the problem on shrimp diseases.

OBJECTIVES OF THE STUDY

This project study aimed to design and develop a solar powered automatic shrimp feeding system. Specifically, it sought to prepare the design plans and specifications in terms of General Description of the Project; Construction Layouts; Wiring Diagram and Design Computation and Analysis; to identify the methods of fabrication and assembly; to test the performance of the solar powered automatic shrimp feeding system as to its functionality and capability in terms of Procedures and Test Results.

The researchers designed and developed a solar powered automatic shrimp feeding system which automatically performs feeding system through a solar power source of energy. The system utilizes a 10 hour timer to be set in intervals preferred by the user and will undergo a continuous process. The magnetic contactor acts as a switch connected to the 10 hour timer which controls the activation or termination of electrical loads and powered by means of a solar panel outputting electrical power, and a rechargeable battery in electrical communication with the solar panel for storing the power. Another feature of the automatic shrimp feeding system is its feeding time program can be adjustable on a continuous process by the 10 hour timer. It is set into a new program after the shrimps have been harvested depending upon the amount of shrimps.

The system was designed to make shrimp feeding manageable and dependable for the end users. It was provided with a user friendly and safe and healthy mechanism of an automatic control system for shrimps.

RESULTS AND DISCUSSION

Project Design Plans and Specifications

In designing of the prototype, the general description of the project, construction layouts, schematic diagram, and design computation and analysis were considered.

General description of the project

The Solar Powered Automatic Shrimp Feeding System consists of two 100W solar panels which convert sunlight into electricity and then stored to a 12 volts 100Ah battery. The 12 DC volts is converted to AC voltages by a 600 W pure sine wave inverter which serves as the source to run the two 220 volts motors. The 20 A charge controller acts as a filter of excessive current entering the battery which prevents overloading and prolonging the battery's lifespan. The feeding scheme is timed by a 10 hour timer. It has two conveyors driven by its respective motor, the screw type conveyor with 90W gear motor and belt type conveyor with 40W motor. The 90w gear motor is equipped with a speed controller which decreases the speed of dispersing feeds by the screw conveyor. It also consists of two hoppers, the main hopper which is a plastic drum and the secondary hopper for the belt type conveyor.

Figure 1. The prototype

Figure 1shows the actual prototype and Figure 2displays the components from solar energy system to the auxiliary components. It also shows the position of the components in the prototype.

Construction layout

The construction layout provides the accomplishment of the Solar Powered Automatic Shrimp Feeding System. This layout is provided to know the proper installation and connection of the components for the complete operation of the project.

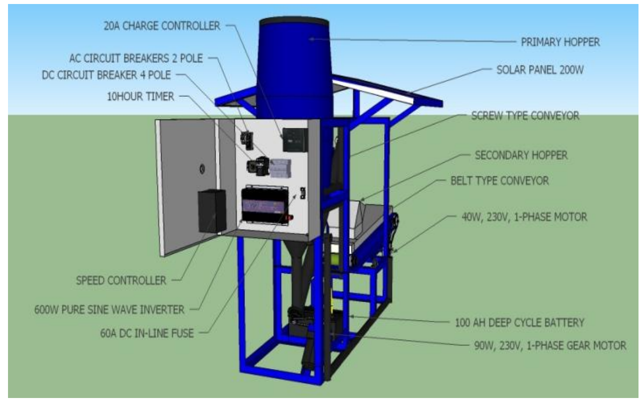

Figure 2. System components

The Solar Powered Automatic Shrimp Feeding System prototype has three main parts: the solar energy system, the conveyor assemblies and auxiliaries. The solar energy system consists of the solar panel, charge controller, battery and DC circuit breakers. Meanwhile, the conveyor assemblies include the screw type conveyor, belt type conveyor, the motor for each respective conveyor and the motor speed controller. The auxiliary components were composed of pure sine wave inverter, 10 hour timer, AC circuit breaker, plastic drum container and aluminum hopper. The perspective view of the project is shown in Figure 2. Along with it are the component's dimensions.

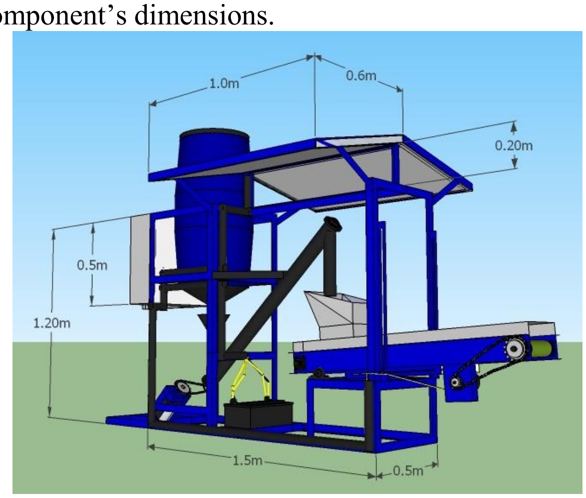

Figure 3 Prototype with dimensions

Figure 3displays the perspective view of the Solar Powered Automatic Shrimp Feeding System. The body of the prototype was made of mostly angle bars.

The screw type conveyor was mounted right above the belt type screw conveyor. The total length of the prototype is 1.5m and standing 1.4m. Auxiliary component such as 12 volts battery were installed separately and the pure sine wave inverter, 10hour timer, AC circuit breaker were housed in a metal sheet enclosure.

Wiring diagram

The wiring diagram of the solar energy system of the Solar Powered Automatic Shrimp Feeding System shown in Figure 4 is the connection of the solar panel, charge controller, battery, DC and AC circuit breakers, pure sine wave inverter and DC in-line fuse.

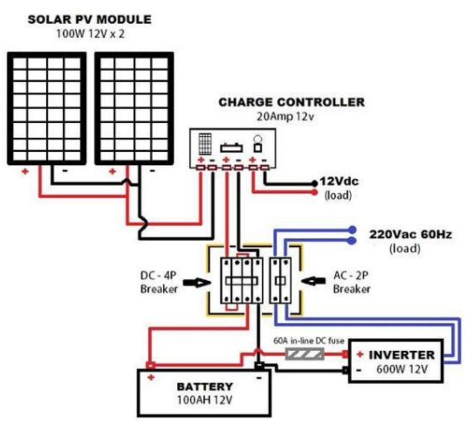

Figure 4. Solar System Wiring Diagram

As shown in the diagram, two solar panels are connected in parallel with each other and then linked to the charge controller. The charge controller is connected to the battery and the said connection is protected by a 4-pole DC circuit breaker. The pure sine wave inverter converts the DC volts from the battery and is protected by a DC in-line fuse. The 220V source from the pure sine wave inverter is protected by a 2-pole AC circuit breaker.

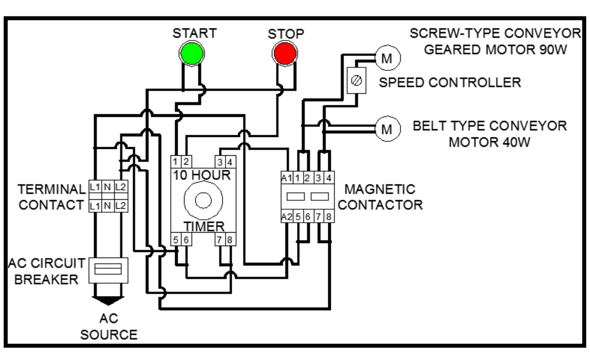

Figure 5. Motor Control System Wiring Diagram

Figure 5 shows the wiring diagram of the motor control system. The system is protected by an AC circuit breaker connected from the 220V source. The system utilized terminal contact to avoid messy wiring. The 10hr timer and magnetic contactor are energized by 220V and they are connected to each other. An indicator lamp was installed in the system to determine the start/stop sequence. The speed controller was connected in series with the screw type conveyor motor.

Design Computation and Analysis

Computations were made in determining the components and design to be used in building the prototype. Different factors were considered and used in proper sizing of the components and materials in the design of the prototype.

Sizing of the belt type screw conveyor motor

Researchers computed the parameters for choosing the proper rating of the belt type screw conveyor motor to be used. According to Suvo (2010), the equation for sizing the motor is given by the equation

Motor size = $(T_b \times V_0)/ k_d$

Where: T_b = belt tension

V_0 = linear velocity

K_d = drive efficiencies for motor operation

In order to get the size of the motor, the researchers determined first the overall length of the conveyor belt using the circumference of the roller. The belt type screw conveyor consists of two rollers with a diameter of 6cm.Using the formula for getting the circumference of a circle, $C = 2\pi r$, the circumference of the rollers is 18.8496 cm.

The length of the belt was used to determine the linear velocity of the belt type conveyor. The length of the conveyor belt is 252. 85 cm using the formula according to Behabelt,

Length of the belt = (length of the conveyor x 2) – (radius of rollers x 2) + (circumference)

The belt type conveyor system has a 1:3 gear ratio, the belt conveyor has a 6 inch diameter gear. One revolution of the conveyor motor equals to 15.96 cm which is equal to the circumference of the gear motor using the following equation:

Circumference of belt type conveyor gear = 2π x (diameter of the roller / 2)

Circumference of gear motor = (Circumference of belt type conveyor gear / 3)

The number of revolution of motor is 15.84, which is equal to the complete revolution of the conveyor belt using the equation:

Revolution of conveyor belt = length of belt / circumference of the gear motor

The researchers decided to use 1400 rpm as the minimum operating speed of the motor. The angular velocity of the belt type conveyor motor is 88.36 rpm using a 1400 rpm motor through the equation,

Belt type conveyor motor rpm = (motor speed / equivalent revolution of conveyor belt)

The linear velocity is 11.6 m/s, which was computed using the equation

V_0 = radius of conveyor belt x rpm x conversion factor 0.10472

The conveyor belt tension is 3.24 N, which was computed using the equation (Suvo, 2010)

$T_b = 1.37 \times f \times L \times g \{2mi + [2mb + mm]\} \cos\theta + H \times g \times mm$

Where:
T_b = Belt Tension (N)
f = coefficient of friction (see table 4.0)
L = conveyor length in (m)
g = acceleration due to gravity (9.81 m/s^2)
mi = load due to the idlers (kg/m)
mb = load due to the belt (kg/m)
mm=load due to the conveyed materials (kg/m)
θ = inclination angle of the conveyor in (°)
H = vertical height of the conveyor (m)

The researchers used belt driven roller for the belt type conveyor. Since the belt conveyor had no idler, the mi was zero. For computing the belt tension the researchers assumed the belt type conveyor is at 0° inclination angle, so the θ and H will be zero.After getting all the parameters and using the equation mentioned above, the computation resulted to the motor size of 39 W.

The researchers decided to use 40 W, 230 V, 1400 rpm AC motor for the belt type conveyor.

Sizing of solar panel

The researchers determined the size of solar panel by the use of conventional computation for the said component.

Screw Type Conveyor Motor: 90 W
Belt Type Conveyor Motor: 40 W
Total Load = 130 W x 1.25 = 162.5 W

The researchers used two solar panel with the rating of the following P_{max} = 100W, $V_{max(open\ circuit\ voltage)}$ = 22.5 V, I_{max}= 5.38 A; nominal voltage was 12V.

Sizing of charged controller and DC circuit breaker

The researchers came up with the size of charged controller using the parameter computed in the sizing of solar panel.

Solar panel: 100 W + 100 W = 200 W
Battery: 12 VDC
Ampere Rating = (200 W / 12 VDC) x 1.25 = 20.8333 A

Twenty-five (25) percent of the ampere rating should be added to take account the special conditions that could occur causing the solar panel array to produce more power than it is normally rated (e.g. due to sunlight's reflection off of water, extraordinarily bright conditions, etc.).

The researchers used 20 A charged controller, since it is the nearest to the ampere rating and 25AT, 4 poles, 12 V DC circuit breaker.

Sizing of pure sine wave inverter and its fuse

Seeing that the total load of the prototype is 130W, the researchers used 600W/12V pure sine wave inverter since the prototype operates at 12V battery and also for the reason of further load expansion like lightings for prototype illumination.

For fuse rating, 600W / 12 VDC = 50 A

The researchers used 60 A in-line DC fuse. An in-line DC fuse is the fuse for automobile for its sound amplifier and power inverter and is connected in series at the positive wire. It is the fuse recommended to be used by the manufacturer.

Sizing of the battery

Researchers provided batteries based on the parameters computed in the sizing of solar panel to suit the motor’s demand.

The battery was actually rated in Ampere – hour (Ah) and computed in a worst case scenario that the solar panel is not available due to insufficient sunlight.

The battery at fully charged condition was assumed to be used 100 minutes continuously. Therefore:

Amp-hour = (50 A) x (100 min.)(1hr/60min) = 83.3333 Amp-hour

Researchers used one 12 V, 100Ah Deep Cycle battery.

Methods of Fabrication and Assembly

The methods of fabrication and assembly were divided into three parts. The first part was the preparation of materials and equipment wherein the components were tested to ensure their functionality and effectivity. Second was the assembly of electronic components that dealt with connection of each component along with the proper position according to the corresponding circuit diagram and included both the wiring connections on solar and motor system and other hardware devices installed in the system. The process also had mechanical assembly which included the proper mounting of electrical motors and other electrical equipment and the installation of the solar powered automatic shrimp feeding system.

Methods of Testing

The project used the engineering planning, design and experimental type of research. The proponents conducted the testing to guarantee that the device worked properly and met all the requirements functionalities.

1. Unit testing was the first stage where the individual parts were checked to verify if each of them functioned properly before being installed.
2. The 10 hour timer was evaluated to know if it met the required input and desired output specifically the amount of feeds discharge in the set of intervals.
3. The voltage of the solar panel in full view of the sun was tested to know the angle of the panel relative to the sun that would make a difference in the output. The efficiency of the solar energy harvesting was tested.

$$Rate\ of\ charging = \frac{Voltage\ Reading}{Time\ elapsed}$$

$$Rate\ of\ discharging = \frac{Available\ output}{Total\ Time\ of\ Usage}$$

4. The main controller was switched and checked if the units functioned as operated automatically.
5. Another test performed was the amount of time required for the battery to charge up from the collected energy in the solar panels. Table for trials were made for every duration of charging and discharging of the batteries.
6. The magnetic contactor relay was checked for the start-up and as stopper for dispensing of feeds. When malfunction occurred, the program was evaluated again. Every step was repeated until it worked properly.

Test Results

The following were the results on the tests done on the Solar Powered Automatic Shrimp Feeding System. Table 1shows the battery charging test and table 2 shows the functionality test.

Table 1. Battery Charging Test

Charging Time (Date, Time)	Duration (hrs)	Rate of Charging	Voltage (V)	Ampere (A)	Discharging Time Duration (hr)
Feb. 15					
2:00 pm	3	4.2	12.6	10.32	9.69
5:15 pm	6	2.08	12.48	10.42	9.6
Feb. 16					
10:15 am	3	4.35	13.04	9.96	10.03
2:15 pm	6	2.15	12.91	10.07	9.93
Feb. 22					
2:30 pm	3	4.29	12.87	10.10	9.9
6:00 pm	6	2.13	12.77	10.18	9.82
Feb. 23					
6:30 am	3	4.24	12.73	10.21	9.79
10:15 am	6	2.17	13.02	9.98	10.02

Table 1 shows results on battery charging test. Four days of trials were made to test the charging and discharging of the batteries. On the first day of testing, the batteries were charged for 3 hours and the proponents started the program at 2 pm. They learned that the 3-hour charging of batteries was sufficient to make cycles of the program for a day. These three-hour charging and discharging tests lasted for four days, during weekends.

The same program was set on the four days of trials having six (6) hours charging time. In this test, the proponents started the program at 5:15 pm and learned that the rate of charging became lower not at peak hours or when the sun was not around, resulting

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com
Asia Pacific Journal of Multidisciplinary Research, Vol. 3, No. 5, December 2015

into lower discharging time duration. The discharging time duration of the battery was computed by dividing the battery ampere-hour to the computed current of the load.

This means that as the charging time become longer, the discharging time of the battery connected to the load also became longer.

Table 2. Functionality Test

Trial	Time	Time of dispersing (min)	Amount of Feeds Dispersed (kg)
1	6:00 AM	3.51	2
2	10:00 AM	3.41	2
3	2:00 AM	3.39	2
4	5:00 AM	3.43	2
5	9:00 AM	3.47	2

Table 2 contains the test results of the solar powered automatic shrimp feeder's performance upon setting it to perform its task on the feeding basis. Five trials were made in a corresponding time. As the time arrived on the set time, the conveyor started its operation with the duration set by the proponents to last. And in the second and third times set by the proponents, the conveyor also operated at its desired output. This means that the model worked on the desired output of 2kg and the time interval of 4 hours which was set by the proponents.

Summary of Findings

The preparation of the project's electrical plan and specifications was of great significance in lessening the errors in fabricating the completed project. Selecting the right parts of the feeder was considered for more efficient output. The Solar powered automatic shrimp feeding system consisted of 2-100W of solar panel, 1 100AH 12V battery, charge controller, inverter, 1 40W AC motor for belt conveyor and 90W AC motor for screw conveyor. The generated electricity stored into 12 volt battery that was connected in series and served as the source of power to run the prototype. The feeds were filled to the hopper then partially driven into the screw conveyor then distributed by the belt conveyor through small portions. The existing wheel paddle in the pond scattered the feeds throughout the entire pond area. The project used local market and internet based available spare parts and auxiliary components. The materials, components and miscellaneous cost of the prototype amounted to P78, 096. 00.

The methods for fabrications and assembly were followed such as construction of the body from the hopper and the conveyors especially for slots of motor, battery and the frame of the solar panels, mounting and bolting of motor, wiring connections and lastly installation of the auxiliary component such as charge controller, battery, switch, contactor, circuit breakers and dc in line fuse. The researchers used materials based on the prepared design plan, schematic diagram and installation procedures that the researchers had prepared. Instead of a smart relay program, the researchers used a 10 hour timer for them to be able to alter the program as the shrimps mature. Due to the big difference of pond 1 and pond 2, from their dimensions to the amount of shrimps inside them and their time of harvest, the beneficiary limited the researchers to construct the feeder for one pond only, so the 180 degree turn was eliminated, but instead made the prototype adjustable for future purposes.

The test applied the proper method of testing using experimental procedure. The solar powered automatic shrimp feeder ran for only 3 minutes for a 2kg feeds every 3-4 hours which explained the discharging time of the battery became longer that it was not necessary to have a backup supply. And as the charging time became longer, the discharging time also lasted longer. Also, the shrimp feeding system was assessed as an efficient project as it responded exactly to the time set by the user.

CONCLUSION AND RECOMMENDATION

Knowing the design plans and specifications, the right tools and preparing it at hand before the fabrication are very important because it lessened the time in assembling the prototype.

It is important to include all the necessary available materials and follow the preparation plan to ensure the reliability and performance of the prototype.

The performance of the prototype depends upon the amount and size of shrimps inside the pond. As the shrimps grow and accumulate, amount of feeds will increase so is the feeding time program.

It is recommended that in order to store reliable energy from the sun, the researchers recommend using a Deep Cycle Lead-Acid Battery with high ampere-hour rating.

For a more effective rotation of motor, the researchers recommend use of a variable speed controller for AC motor to manipulate or control the rotational forces or speed of the motor.

Lighting fixture for proper illumination of the area that will be subjected in troubleshooting may be added.

The timer to be used should be tested to avoid malfunction and achieve the fully automatic system.

Since the automated shrimp feeder was only applied to a single pond of shrimps, application of the timer should be functional to all layers of the pond.

In order to increase the efficiency of the conveyor system, higher motor rating must be equipped.

Since the prototype was installed with a stand, the researchers recommend placing the prototype in parallel with the direction of air flow and a smaller degree inclination is needed to avoid wastage of feeds.

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