Development And Installation Of A Solar-Powered Peanut Grinding Machine

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Abstract: Peanuts were one of the various crops that have been present in the country since Spanish colonial era. Popular confections made from peanuts include salted peanuts, peanut brittle and peanut butter (sandwiches, peanut candy bars and peanut butter cookies).The universally known peanut butter was invented in 1890. However, its production was a demanding and a physically challenging process. To cope up with the demand, the solution is through the use of a peanut grinding machine which significantly simplifies processing of nuts into paste. This is a machine used in the disintegration of solid particles or droplet size of a liquid present in suspension or emulsion. The project entitled, Development and Installation of Solar-Powered Peanut Grinding Machine aims to replace the conventional peanut grinding machine method because it consumes lot of time of making peanut butter. The machine has a maximum capacity of 5kg. Since peanuts have moisture content, the design of the prototype included burr grinder which produce fine ground peanuts. The machine was also made from stainless steel to keep the ground peanuts from possible contamination. To ensure the grinding process, the machine has a rotating mechanism which was driven by an AC induction motor at a speed of 1720rpm. The project used two solar panels of approximately 275 watts each for the continuity of supply, increase of production, less production cost, and reduced air pollutants emission. For the continuity of supply, increase of production, and less production cost, the machine was solar-powered.

Keywords: AC Induction Motor,Solar, Peanut Grinding Machine

Introduction

In recent years, the worldwide production of food products has been continuously increasing. This aggravates the demand for food processes and machineries to grow incrementally. And over the centuries, methods of food processing have been developed and are adopted to produce a more palatable food in accordance to the consumers preference. Such methods also aim at conserving the food for later use by increasing its shelf or storage life. Converting raw food stuff into well-cooked and well-preserved eatables for both humans and animals is implemented through food processing. Raw foods undergo various procedures so that it can be easily cooked and rendered into an attractive food stuff. Common methods used to convert raw food into processed food include drying, preservation, smoking, freezing, salting and roasting. These methods are done with primary procedures such as grinding to attain desired output. Grinding is a unit operation widely used in the food industry and designed to reduce the size of materials. Numerous industries rely on size reduction to improve performance or meet specific requirements. Common processed foods that undergo grinding as principal procedure are cereals, wheat, cocoa beans, coffee beans and nuts. Peanut industry has been one of the pioneer agricultural industries present in the country having a history of cultivation dating back to the Spanish colonial era. Peanuts have been grown since the 1870s but only become a commercial crop in the early 20th century. Peanut (Arachishypogea L.) or groundnuts, as they are known in some parts of the world, are the edible seed of legume. India is second largest producer of peanuts in the world, with total production of approximately 7.131 million metric tons per year. Peanut is technically considered as pea and belongs to the family (fabaceae) of bean or legume. Although a legume, it is generally included amongst the oilseeds due to its high oil content. (Suchoszek-Lukaniuk et al. 2011) In the Philippines, peanut is considered one of the major field legumes grown by local farmers. However, its production has been low and erratic with national average yield ranging only from 800 to 1000 kilograms per hectare. Batangas, as one of the agricultural lands in CALABARZON, has sugarcane and palay as major crops. Peanuts in the province are grown minimally for local consumption. Peanut production in the province is very small since peanut is not a common local crop. Utilization of large supplies of peanuts for production of peanut-based foods are imported from other provinces. Peanut is a highly nutritious food that contains about 25% protein, 48% lipid, 21% carbohydrate and other micro nutrients and is consumed worldwide for various purposes. One of the major utilization of peanuts is in production of peanut butter. Peanut butter is usually staple with bread and crackers. It can also be used as flavor variety in confectionary and dessert in the food industry. As one of the historical landmarks in Batangas, Taal offers various foods and crafts such as peanut butter which is proudly made by Pinag-isang Bisig ng Taaleño, a local community organization. The organization is comprised of an all-women member which presently has 10 active members and is funded by the local government unit of Taal. Pinag-isang Bisig ng mga Taaleño's peanut butter was produced through processes carefully done to attain the desired taste and texture. Shelled peanuts are open-pan roasted under fire. Peanuts are dry roasted in an open pan while being mixed simultaneously to prevent them from getting burnt. The peanuts are then cooled and blanched to remove the remaining seed coats. After

blanching, the peanuts are sent to grinding to be manufactured into peanut butter. Peanuts are sent through two sizes of grinders. The first grind was using a corn mill that produces a medium ground peanut. The ground peanuts are sent to colloid mill together with other ingredients such as corn oil, daricreme buttermilk, skimmed milk and white sugar. The ground peanuts with other ingredients are gone through the colloid mill for up to 3 times until it achieves a very fine texture. To produce a finer texture of peanut butter, peanuts go through prior grinding. Mechanized grinding machine is used to reduce the peanuts into very fine sizes. But due to limited budget for machineries, the organization was only using a corn mill as a peanut grinder which usually does not produce the needed sizes of grinded peanuts. In this regard, the researchers thought of creating a solar powered peanut grinding machine. This machine improved the peanut grinding method of the organization because it is a stored-energy electric grinder and produces finer sizes of peanuts. For a continuous supply, amplified production and low-cost production, the machine was solar-powered. It provided the community organization from Taal, Batangas an immense assistance for their production of peanut butter. The main objective of the study was to design, develop and install a solar powered peanut grinding machine. Specifically, the project aimed to attain the following objectives:

1. To evaluate the existing peanut grinding machine in terms of:
    1.1. Design;
    1.2. Construction;
    1.3. Operation;
    1.4. Areas of Improvement.
2. To determine the project's design requirements and considerations:
    2.1. Philippine Electrical Code (PEC);
    2.2. Institute of Electrical and Electronics Engineers (IEEE);
    2.3. National Electrical Manufacturers Association (NEMA).
3. To determine the project's solar energy resource and site assessment considerations:
    3.1. Technical;
    3.2. Environmental;
    3.3. Economical.
4. To prepare the design plans and specifications in terms of:
    4.1. General description of the project;
    4.2. Construction layouts;
    4.3. Circuit diagram;
    4.4. Design computation and analysis;
    4.5. Bill of materials and specification.
5. To present the overall financial study of the project in terms of:
    5.1. Cash operating cost;
    5.2. Total project cost;
    5.3. Projected income statement;
    5.4. Depreciation schedule;
    5.5. Payback period;
    5.6. Return of investment.
6. To identify the methods of fabrication and assembly:
    6.1. Materials and specifications;
    6.2. Machines and tools;
    6.3. Methods.
7. To evaluate the performance characteristics of the solar-powered peanut grinding machine taking into consideration the results on the following tests:
    7.1. Charging and Discharging Test;
    7.2. Performance Test.
8. To discuss the impact of the project to the society and the economy as a whole.

This study deals mainly on the design, development and installation of a Solar Powered Peanut Grinding Machine. The project study covered the project planning, designing, fabrication and assembly, installation and testing stages in the development of the prototype based on the design layout and schematic diagram, materials and specifications and evaluation of the effectiveness through actual testing. For an enhanced design of the grinding machine, a consultation to knowledgeable individual was done to attain the requirements of the machine. The mechanical components of the prototype included the conical burr grinder and the induction motor. The peanut butter producers consume 10 kg of peanut a day. To produce a fine-sized peanut from dry roasted peanuts, every grind holds a 5 kg mass of feed which consumed 2.238 kWh per day and hence, used a 1HP, 60 Hz induction motor. The conical burr grinder was used to achieve less than 0.1 mm colloidal particle size or fineness of the ground peanut (Coulson, 2002). The electrical components included the circuit breaker, and solar power components, comprised by battery, solar panel, inverter and charge controller. This system used three 275 watts polycrystalline type of solar panel. A 60-ampere rating charge controller was used to control the harnessed energy supplied to the batteries. An inverter was used to convert DC to AC current and it changes the voltage to 230 VAC. A mushroom head emergency stop was also included for emergency break of operation. For the development of the solar-powered peanut grinding machine, the fabrication was made according to the design specifications taking into consideration the availability of the above-mentioned components and economical aspect. The assembly of the components was done taking into consideration the safeguarding of the integral parts and make sure they were intact and undamaged. For the installation of the system, location of the beneficiary was evaluated. Placement of the solar panels was on the roof of the beneficiary's production place. The other components connected to the solar panels such as batteries and the grinding machine itself were placed inside the production place that gave the peanut butter makers a more convenient access. It also aided in the safeguarding of the components. Tests were conducted after the fabrication of the machine to evaluate the performance of the machine. The charging test was done to determine the efficiency of the solar power components. The discharging time, initial voltage, and the final voltage were also observed and included in the performance test to determine whether the solar power components can effectively supply the machine. Moreover, the performance test was done to determine the production rate of the machine. The researchers focused on the functionality of burr grinders as a peanut grinding machine powered by solar panels. The study does not cover other applications of burr grinder on other raw food stuffs. And it does not include the functionality of other grinders as a peanut grinding machine. The following

were the outcomes obtained after the development and installation of solar-powered peanut grinding machine:

1. The design of the existing grinding machine was not fully intended for peanut grinding. Since it was a corn mill, it was not that efficient for grinding peanuts. The construction of the existing peanut grinding machine was fabricated with a feeder which was too small to accommodate large amount of mass feed. In construction, the existing grinding machine was not efficiently constructed to produce a fine ground peanut butter because the machine was designed in repetitive process. In line with the operation of the existing grinding machine, it used AC (alternating current) as a source of power for the whole machine. That can cause pollution that may affect the environment. It also caused a financial problem for the beneficiary of the prototype since they are only an LGU supported community organization. In areas of improvements on the existing design, the proponents constructed a plan for improvement. The proponents planned a suitable machine in terms of designed and construction. Using a conical burr grinder to produce a fine ground peanut which is more efficient than flat burr grinder and designing a larger hopper which carry a 5kg maximum of peanuts. For the operation, the proponents used a solar energy source which is renewable. Using a renewable energy may help lessen the pollution in the environment and promote clean and reliable source of energy.
2. The provisions of the PEC provided the requirements on proper storage of batteries, circuit requirements and wiring methods for solar panel and other equipment. PEC provided guidelines for the proper size of wire to be used in the construction of the project. The provisions offered ensure quality of the device and considered as a guide for the development and operation of the project. IEC provided the quality assurance of the solar panel to ensure that this device functions well during the operation. The standards served as a basis in checking the quality of each solar panel used in the prototype. NEMA which published some standards with ANSI provided the safety standards of the battery to be used. It also provided procedures for testing the environmental performance of batteries.
3. The technical aspect of the site assessment provided reliable information on the amount of radiant energy that can be harnessed in a certain location. The location could harness enough solar energy to generate electricity even during ber months because the average irradiance level at reached 3.813kWh/kWpday. For the environmental aspect, the area is located at the town proper so the ability to capture radiant energy was large enough for the solar panel to generate energy needed to power certain device, machine, or even appliances at home. As for the technical aspect, since the prototype was equipped with solar panels, long term economic benefits of solar energy in this area can be improved for many residents.
4. The solar powered peanut grinding machine was designed for small scale ground peanuts processors to replace the typical peanut grinding method. To uphold the utilization of renewable energy sources and reduce the carbon footprint emission, the machine was designed through solar energy operation. The project was made up of five major components namely, solar panel, solar charge controller (SCC), battery, inverter, induction motor, and burr grinder. The design construction of the solar-powered peanut grinding machine was composed of isometric view, front view with dimension, right side view with dimension and the top view with dimension of the machine; isometric view and top view of the solar panel racking; isometric view and top view of the battery box; isometric view and the top view of the inverter; and the perspective view showing all the machine components. To guarantee that the project was accurately constructed, proper dimensions of the whole project were indicated. The circuit and block diagram of the project led to a better interpretation of the connection of the prototype. Each component was connected properly to ensure that the project functions well and to prevent faults to happen during operation. Two 275 W, solar panels were connected in parallel in order to draw maximum current. A solar charge controller (SCC) with a rating of 60A, 24V were connected to the solar panels. To isolate the solar panel when not in use, a 40A,24V DC circuit breaker was connected between the solar panel and the charge controller to isolate the solar panel. Four lead-acid batteries, each have a rating of 12V, 100Ah, were connected in the SCC to power the machine. All of the four batteries were connected in parallel. A circuit breaker was also connected between the battery bank and the SCC. To transform the DC power stored in the batteries, an inverter was connected in the SCC to produce AC electricity that powers the machine. As implied on the computations, the machine powered by two 275W solar panels are sufficient to make the whole project operate. The proponents used 60A, 24V solar charge controller where 130% of the ampere rating was added to the short circuit current of the solar panel. Four lead-acid batteries were used in the machine, each has a rating of 12V, 100Ah. The AC induction motor used was rated 0.75 HP, 24V, high torque and low speed that was sufficient to drive grinder. The bill of materials showed the specification and total cost of the material used in the project. The total cost was Php 72, 463.50. The most expensive component of the machine were the solar panels, which was Php 13,500.00, followed by the batteries which amounted to Php 12,800.00. The cheapest component were the bolts with nuts which was Php24.00 only.
5. The overall financial aspect was also done for the study. The total project cost was Php 74, 463.50 which includes the material cost, fabrication cost, maintenance and transportation cost. The total project cost was considered as the major expenses in the accomplishment of the economic outline of the solar-powered peanut grinding machine. The study was projected to have net income of Php 45,004.1023 by the end of its computed payback period which was 2 years and 2 months or approximately 3 years. Straight-line method of depreciation was used to compute for the depreciation schedule of the project. The amount of depreciation was Php 3,623.175.

Twenty years of depreciating the investment cost of the project proved that the solar-powered peanut grinding machine has no salvage value. The rate of return of the project is about 45.23%. The annual profit of the project was computed to be Php 25,890.475 using straight-line method of depreciation.

6. After the construction of the design layouts, the proponents proceeded to the fabrication and assembly of the project. Through the assembly of the machine, the fabrication of the machine parts with stainless steel took the longest time to finish since welding of materials were involved in the process. In contrast, the process that took the shortest time in the fabrication and assembly was the electrical connection of the components because there was a circuit diagram guiding the wiring connection. For the installation of the prototype, the machine parts were quite heavy to deliver which is why it took many people to carry and install them. The solar panel were to be placed on the roof of the location and was quite difficult to install since the panels were too heavy. The other components of the machine were conveniently installed inside the production area of the beneficiary.
7. Series of tests were conducted after the assembly of all the components which determined the efficiency and proved the functionality of the solar-powered peanut grinding machine. The tests include charging test and discharging test, and performance test. The charging test done through this prototype determined and evaluated the efficiency of the solar components in power generation. The performance test determined the production rate of the machine for three different masses with three trials each. In the charging and discharging test, the recorded data gave the idea that during cloudy days, the harnessing of solar energy was affected and yields to insufficient charging of the batteries, reaching only 80% of its charging capacity. While in the performance test, three trials were conducted for every 1kg, 3kg, and 5kg of peanut. It was observed that as the mass of the peanut to be grind increases, the operating time also increases. This showed that the relationship between the mass of the peanuts to be grind and the operating time is directly proportional. Moreover, the residuary that remained to be unground were almost less than 1 percent of the mass feeds. The battery voltage values showed that the machine operated from full charge capacity to 50% of battery charge. It was also inferred that the improved blade grinder was efficient since there was no need for repetitive process of grinding unlike the existing machine.
8. The project supports ways on how to lessen pollution since it is solar powered. The project has a great impact on the economy for it can ensure a high-quality ground peanuts that the machine could produce. The project will also be of immense help to small-scale entrepreneurs who want to venture into peanut-based food production industry. It will somehow lessen the manpower required in grinding peanuts for peanut butter production.

Based on the findings, the following conclusion are made:

1. The existing design is used to generate electricity through pumping of water, yet the project at time is less efficient due to the number of person who are using the hand pump and also extend force of the user. The purpose of the project is not only to provide lighting but to provide water from the community. Making the system to be powered up by solar panel to automatically pump water through the well will lessen the effort exerted by the people who are using the pump.
2. The standards of the regulatory boards as the PEC, NEMA, and IEE are the guides which ensured the development of the prototype is safe and functional.
3. The layout of the project made the operation of the system feasible. Some considerations are necessary such as source of sunlight, speed of the motor, portability and maintenance of the project.
4. On the financial aspects, return of investment in this project may take longer but it can bring in more revenue per year.
5. The design of the project meets the required output after construction with set-up of every component properly followed with minor revisions.
6. The amount of electricity produced is based on the sunlight produced is directly proportional to the output. The greater the sunlight gives by the sun, the greater its output will be.
7. The project promotes sustainability in preserving the environment for it is clean and free energy. As desired, it will help the people at BrgyDagatan, Taysan, Batangas to easily access the water through the hand pump. The project has a deep potential if given more time of study which will prove useful to society and the economy when applied to a large scale.

To maximize use and generation of energy for the solar powered water pump, the researchers recommend the following, which may be worked on by the next set of researchers:

1. The better motor specification should be high speed and high torque and low voltage to make the machine more efficient.
2. The Solar Powered Water Pump should have a tank storage system with the level sensorsand microcontroller that turns on/off the motor. When the water reaches its maximum level and turns off when it reaches the maximum level.
3. The position of the solar panel should be in angular position that tracks the un across the sky throughout the day using a solar tracker. A sensor mounted on the top corner of the solar panel that tracks the position of the sun and an electric motor moves the tracker so that the array can generate the maximum amount of power.
4. An additional battery which will be connected parallel to the existing should be added to secure the reliability of the machine.
5. The DC motor should be mounted on a thicker steel plate to avoid too much vibration and reduce noise.
6. The proponents recommend having a filtration system in order to produce portable water pump from the deep well that will be useful during calamities.

7. Since the batteries were able to sustain the function of the project, the proponents recommend having a 12Vdc 8W LED bulb as an additional load to guide the people during night time.

Bibliography

A. Published Materials

1. Arellano, et. al. (2011). Design and Development of Adjustable Peanut Grinding Apparatus. Batangas State University
2. Boongaling et.al. (2016). Design and Development of a Copra Grinding Machine. Batangas State University 2015

B. Unpublished Materials

1. Singh et.al. (2011). Wet Grinding Characteristics of Soybean for Soymilk Extraction
2. Rollan Ian-A. (2009). Pepper Grinder

C. Web Sources

[1]. Amplification; Retrieved from: http://www.electronics-tutorials.ws

[2]. Autonomy; Retrieved from: https://en.wiktionary.org

[3]. Charge Controllers; Retrieved from: http://www.dictionaryofconstruction.com

[4]. Czochralski process; Retrieved from: https://www.revolvy.com

[5]. Detrimental; Retrieved from: https://www.ncbi.nlm.nih.gov

[6]. Fossil Fuel; Retrieved from: http://www.bbc.co.uk

[7]. Fresnel lenses; Retrieved from: http://www.yourdictionary.com

[8]. Peanut; Retrieved from: https://www.britannica.com/plant

[9]. Peanut; Retrieved from: https://www.bureauofplantindustry.gov.ph

[10]. Retrieved from: https://www.sciencedirect.com

[11]. The Peanut Industry; Retrieved from: https://www.peanutsusa.com/about-peanuts/the-peanut-industry3.html

[12]. Retrieved from: https://athenaeum.libs.uga.edu/bitstream/handle/10724/12051/RB437.pdf

[13]. (Opulencia, 1962; Cadelina, 1964; Lalap 1972;). (Lalap, 1972). (Velasco et al., 1972; Cagampang and Lantican, 1975).

[14]. Retrieved from: https://www.huffingtonpost.com/2012/03/21/cooking-termsvdefined_n_1367143.html

[15]. Retrieved from: Laura Lee (2001). The name's familiar II. Pelican Publishing Company

[16]. Sugar Grinding; Retrieved from: https://www.praterindustries.com/applications

[17]. Retrieved from: https://www.santos.fr/en/products/coffee/moulin-a-cafe-boutique/coffee-grinder/01BAR/

[18]. Solar Energy Power Generation; Retrieved from: https://www.electronicshub.org

[19]. Pulley; Retrieved from: http://eschooltoday.com/science/simple-machines/what-is-a-pulley.html

[20]. Switches; Retrieved from: http://www.efxkits.com/blog/types-of-switches-with-applications

[21]. Motor; Retrieved from: https://www.rs-online.com/designspark/different-types-of-motors-and-their-use

[22]. Induction Motor; Retrieved from: https://www.electrical4u.com/induction-motor-types-of-induction-motor/

[23]. Solar Panel; Retrieved from: http://www.qrg.northwestern.edu/projects/vss/docs/power/1-what-are-solar-panels.html

[24]. Solar Panel; Retrieved from: http://solenergy.com.ph/solar-power-philippines-all-about-solar-panels

[25]. Retrieved from: https://www.brighthubengineering.com/hvac/61103-evaporators-for-refrigeration-and-air-conditioning-applications/

[26]. Inverter; Retrieved from: http://www.instructables.com/id/YOUR-GUIDE-TO-DC-to-AC-POWER-INVERTERS/

[27]. Circuit Breaker; Retrieved from: https://www.electrical4u.com/electrical-circuit-breaker-operation-and-types-of-circuit-breaker/

[28]. Retrieved from: http://www.taal.ph

[29]. Retrieved from: http://www.wowbatangas.ph

[30]. Peanut in the Philippine Food System; Retrieved from: http;//crsps.net/wp-content/downloads/Peanut/Inventorid%208.8/7-1998-7-1684.pdf