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Research Article

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Design and Construction of Solar Powered Groundnut Oil Extractor

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Abstract: Groundnut is one of the important oil seed and food crops around the world that are used for both humans and livestock. In this work, a groundnut oil extracting machine was designed and fabricated. The aim of this work was to design and fabricate a solar powered groundnut oil extracting machine that is environmentally friendly and efficient. The procedures employed to achieve this include design stage, construction stage and testing. Its basic components are: a 1000w DC electric motor, gearbox, the extracting unit, the outlet (oil collector), solar panels, 12v DC batteries, charge controller, DC to DC converter and driving shaft. This system having designed and constructed, was able to process 20 measures of Groundnut paste per batch which yield 14 liter of groundnut oil.in 5 minutes this will reduce time spent in extracting oil from groundnuts paste which in turn will result the reduction in the cost of the oil. Also, since the machine is environmentally friendly and energy independent it could be used by people living in both urban and rural areas and as well contribute in work to protect ozone layer.

Keywords: Groundnut oil Extraction, Solar-powered machine, Oil seed processing, Environmental sustainability, Energy Efficiency, DC electric motor, gearbox, oil extraction unit, renewable energy, cost reduction, fabrication, design and testing.

1. Introduction

The quest for a drudge-free and sustainable technology that will be acceptable by the small and medium sale ground nut oil processors motivated the current study. The problems experienced by groundnut oil processors by the use of traditional methods have resulted to different technological interventions. These interventions were in form of machines that carry out the sub-processing activities Adesoji et al, (2013). Groundnut oil extraction involves removing oil content of the groundnut seed. Study conducted in Northern Nigeria revealed that 75% of the rural women engaged in groundnut oil extraction used the traditional method despite the drudgery and inefficiency involved. In view of this, different technological interventions were made by different researchers inform of; shelling, roasting, de-skinning and winnowing, kneading and screw press machines to avert the problems involved with the traditional method Nnanna et al., (2018).

Therefore, this study presented the findings of this technological interventions made by different researchers and also the limitations of this technologies were also identified and their recommendation which can be used as basis for further researches towards getting better and optimum performance on these different technologies (Lawan, 2015).

Efforts have been made by many researchers to improve the quality and quantity of the available groundnut varieties. It is a very important oil seed and food crop around the world for its nutritional and trade values

Shankarappa et al., (2003). Hammos (1994), Also observed that Groundnuts are almost exclusively processed in combination with the utilization of the residue for both human and animal consumption. In fact often the bye-product, a kind of a snack called Kulikuli in Nigeria and some other African countries, is usually the main product and the processing of the groundnut oil only as part of the process. Oil is extracted from ground nut through either traditional means (mostly dependent on human energy with about 20-30% of the oil extracted) or mechanical means with over 30% of the oil been extracted (Olaomi, 2008). Most vegetable oils are recovered by grinding, cooking, expelling and pressing, or by solvent extraction of the raw materials. The most common method of extracting edible oil from oilseeds is mechanical pressing of oilseeds (Bamgboye and Adejumo, 2007).

Vegetable oil expellers are of different types and forms which depends on design, construction and the raw materials they are to process. Alonge et al., (2004) develop a small scale screw press for groundnut oil extraction while a mechanical compression rig was developed by Olaniyan and Oje (2007) for shea butter extraction. Olaniyan (2010) Also developed a manually operated expeller for groundnut oil extraction and the performance of palm kernel oil (PKO) extracting machine that was evaluated by Olawepo-Olayiwole and Balogun (2004).

In this work, a groundnut oil extracting machine will be design and fabricate. The aim of this work is to designed and fabricate a solar powered groundnut oil extracting machine that is environmentally friendly an efficient. The procedure employed to achieve this includes the design stage, construction stage and testing. Its basic components should be a DC electric motor, gearbox, the extracting unit, the outlet (oil collector) solar panels, DC batteries charge controller, DC to DC converter and driving shaft. The DC electric motor will be connected to a gearbox. When the DC electric motor is switched on the auger starts to rotate. At this point, the grinded ground nut paste will be poured into the mechanism inside the extracting chamber where the shaft propeller will turn the grinded ground nut for the oil extraction properly. The oil obtained is then collected through the oil collector. This system will be designed so as to process 20kg to 30kg of Groundnut pastes per batch so as to yield 14 to 20 liters of groundnut oil which depends on the quality of seed grinded. The machine after constructed will reduces time spent in extracting oil from ground nuts will result the reduction in cost of the oil. Also, since the machine is environmentally friendly and energy independent it could be used by people living in both urban and rural areas.

The study will address some of the challenges associated with the edible oil processing sector. Since the sustainability of edible oil milling process is determined by the processing technique used and the energy source adopted, then it has become a. Challenge and therefore the need to develop a sustainable system. Solar power, often known as energy from the sun, may be used to generate either heat or electricity, which could depend on need and technology employed. The study is aimed at design and construction of a solar powered groundnut oil Extraction machine, that is less labour intensive, environmentally friendly and safe to use in oil producing communities of both urban and rural areas.

2. Material and Method

The following are the components used for the design and construction of solar groundnut oil extractor; Solar panels 250w, Charge controller 16v-72v, DC-DC converter 60v, 51A, 1000w, DC motor 60v 1000w, Junction box, Connecting wires, Connecting cables, Solar Dc batteries 12v, 20-200AH, Iron drum, Angle iron 3 inchx4mm, Angle iron 2 inchx3mm, Bolts and nuts, Iron washers, Car gear box, Iron shaft, Bearing, Pulley, Belt, ¾ iron pipe, Paint, 12mm iron rod, A Delixi double gang switch 400v, 100A and DC motor controller.

DC Motor Basics

DC electric motors are powered by direct current (DC), which is a constant voltage and constant current. DC power is power that is available from batteries, through a DC power supply, or by driving an alternating current circuit through a commutator or rectifier. This current flows through a coil in a magnetic field (the field is placed inside permanents magnets) and produces a rotating force that turns the motor shaft.

Figure 1: DC Motor

Solar Panels

Although solar panels are a direct current source, the power available from the panel is not uniform. The amount of power produced at any given time depends on the amount of sunlight hitting the panel and the panel's ability to convert sunlight into electricity. To operate the DC motor with the power from the solar panel, there are a few components that can add to the system to make it more efficient.

Figure 2: Solar Panel

Maximum Power Point Monitor

Maximum power points are electrical devices that convert irregular direct current into voltage-regulated (or constant) direct current, increasing the power to the motor. These monitors help control the flow of electricity from the panel to the battery system. Without a maximum power point monitor, you can experience poor performance from your machine, especially when the sun is interrupted. Without a maximum power point monitor, the motor is exposed to the current rate from the solar panel. When the sun's rays hit the panel directly, the voltage increases and the motor can be put into a heavy state.

Battery system

Battery System Even if you don't need a battery system, it's still a good idea to have one. A battery is a backup power system that helps provide continuous power to the motor when the sun is out or completely out. After connecting the solar panels, the electricity generated by the solar panels first goes to the battery system and charges the batteries for later use, and then the motor runs on the power of the battery or batteries. Without a battery system, the motor is exposed to the current rates from the solar panel. If the panel output is less than the motor needs to draw, it can put the motor under excessive load, causing serious damage to the motor and the entire circuit.

Figure 3: 12V DC Battery

DC motor controller

A controller helps smooth the timing and adjusts and regulates the power delivered to the motor to maximize power output.

Charge controller

A solar charge controller is a device that controls the flow of electricity from solar panels to batteries and other electrical loads. It is a key component in solar power systems and is used in both on- and off-grid systems. A solar charge controller controls the battery voltage. It regulates the current and voltage to the solar panels. It charges the battery at the correct rate and level. Prevents overcharging of the battery. Prevents reverse flow when there is no sunlight.

Figure 4: Solar Charge controller

DC-DC Converter

DC to DC converters are devices that store electrical energy for a short period of time to convert direct current from one voltage level to another. In mechanical applications, they are an important interface between systems with different voltage levels.

Delixi Double gang switch

A "Delixi Double Gang Switch" refers to a wall switch manufactured by the Delixi company that has two separate switches on a single plate, allowing you to control two different lighting circuits independently from a single location; It is basically a switch that allows you to turn on/off two separate lights with a single switching unit.

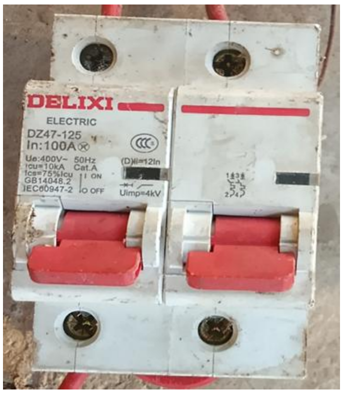

Figure 5: Double Gang Delixi switch

Design Methodology

This research work described the design and construction of solar groundnut oil extractor system. It features a solar panel, DC-DC converter, charge controller, Batteries and DC motor.

The solar groundnut oil extractor system has four main parts. The power supply unit, the energy storage unit, The Converter unit and the oil extraction unit. The power supply unit comprises of solar panel 250v which traps the solar radiations incidence on it and converts it to electrical DC energy. The energy storage unit comprises six DC batteries of 12v 20-200 AH each which when connected in series will give 60v 20AH. The converter unit comprises a DC-DC converter which converts the 60v 20AH to 60v 1000w. And the oil extraction unit which comprises of the car gear box, iron shaft, iron drum and a DC motor which rotates the shaft inside the iron drum to extract the oil from the ground nut paste.

Design calculations

The bottom of the kneading chamber will have three mixing rods (Stirrer fingers) attached perpendicularly to one another besides the stirrer shaft. And the mass of each stirrer finger is 1.2kg with a length of 0.26, and the stirrer shaft is 15kg, 1.15m, which will rotated with angular acceleration x rad/S² about their Centre. Therefore, the net Torgue required to extract oil from the groundnut paste can be calculated by considering the formula

$$\tau = I\,\alpha \tag{1}$$

Where

τ= Torgue in Nm

I = Moment of inertia Kgm²

α = Angular acceleration rad/S^2

Given

M_1 = 1.2Kg, L_1= 0.26m

M_2 = 1.2Kg, L_2= 0.26m

M_3 = 1.2Kg, L_3= 0.26m

M_4 = 15Kg, L_4= 1.15m

$$I = \frac{ML^2}{3} \tag{2}$$

$$\sum I = \frac{M_1L^2_1}{3} + \frac{M_2L^2_2}{3} + \frac{M_3L^2_3}{3} + \frac{M_4L^2_4}{3} \tag{3}$$

Where

$\sum I$ = *summation*

I = Moment of inertia

$M_{1,2,3}$ = *Mass of the stirrer finger*

$L_{1,2,3}$ = *Length of the stirrer finger*

M_4 = *Mass of the stirrer finger*

L_4 = *Length of the stirrer shaft*

Therefore $\sum = \frac{1.2 \times (0.26)^2}{3} + \frac{1.2 \times (0.26)^2}{3} + \frac{1.2 \times (0.26)^2}{3} + \frac{1.2 \times (1.15)^2}{3}$

= 0.24336 + 6.6125

= 6.85586

$\sum I = 6.86$

=> I = 6.86 Kgm^2

$$\text{But } \alpha = \frac{\omega}{t} \qquad 4$$

Where

ω is angular velocity

t is time in second

The DC motor chooses for the system is:

Power = 1000w

Voltage = 60v

Angular velocity ω = 150 rpm

And the gear ratio = 1:16 (i.e the rotational ratio of the stirrer shaft to DC motor)

Let x be the rpm of the stirrer shaft such that:

1:16

x:1500

=> 16x = 1500

$x = \frac{1500}{16}$

X = 93.75rpm

But

$$\omega = 2\pi f \qquad 5$$

Where

ω = Angular velocity

π = 3.142

f = x = 93.75rpm

Therefore: The Angular velocity of the rotating stirrer finger ω.

Can be calculated by substituting the above data in to equation 5.

ω = 2πf

ω = 2 x 3.142 x 93.75

ω = 589.10 rad/s

From equation 4

$\alpha = \frac{\omega}{t}$

=> $\alpha = \frac{589.10}{60}$

9.82 = rad/S^2

Also from equation 1

Ꚍ = I α

Ꚍ = 6.86 X 9.82

= 67.37 Nm

Hence the required torque is 67.37 Nm

Volume of groundnut per batch

Density is mathematically expressed as

$$P = \frac{M}{V} = \frac{M_g}{V_g} \qquad 6$$

Where

P = is the bulk density of groundnut

M_g = is the mass of groundnut

V_g = is the volume of groundnut

Having

$P = 800Kg$

$M_g = 40Kg$

$V_g = ?$

Now equation (6) can be used to calculate the volume of the groundnut.

$$V_g = \frac{M_g}{P_g}$$

$$V_g = \frac{40}{800} = 0.05m^3$$

$0.05m^3$ is the volume of the groundnut

Excess volume for oil circulation

Let 0.4m be excess height chosen for the oil circulation during the kneading process. And let 0.56m be the diameter of the kneading chamber, then the volume for the oil circulation during the kneading process can be calculated using the formula

$$V = \pi r^2 H = \underline{\pi}\ D^2\ H \qquad 7$$

Where

π is constant

V is volume in (m^3)

D is the system diameter (m)

H is the height of System (m)

Having

D = 0.56 m

$\pi = 3.142$

H = 0.4m

V = ?

Using equation 7

$$V_{eoc} = \frac{\pi}{4} D^2 H$$

$$= \frac{3.142}{4} \times (0.56)^2 \times 0.4$$

$= 0.0985m^3$ is the excess volume for oil circulation.

Total volume of the system

This is the volume of the groundnut paste plus the excess volume for oil circulation. Which can mathematically be expressed as

$$V_{tvs} = Vg + V_{eoc} \qquad 8$$

$= 0.05 + 0.0985$

$= 0.1485m^3$

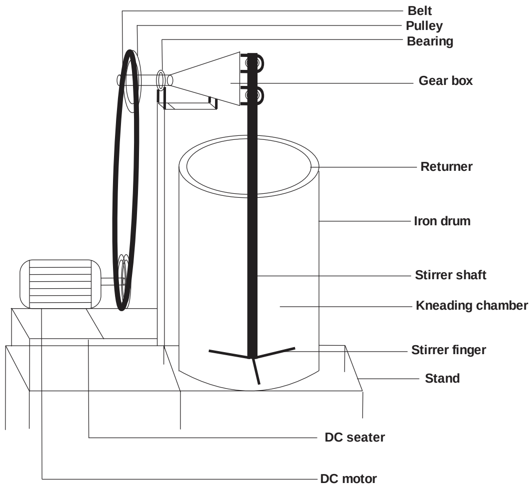

Figure 6: Schematic Diagram of Solar Powered Groundnut Oil Extractor

Bearing

Bearing are one of the most commonly used machine parts in Mechanical Engineering Constructions, because their rolling motion makes almost all movements easier and they help produce friction. Bearing have key functions: They transfer motion, i.e. they support and guid components which turn relative to one another. They also transmit forces.

3. Results

Testing of the Design and constructed system

It was important to test the system in order to know its performance and efficiency, in order to achieve this, multimeter was used in the measurements of the circuit parameters before connecting it to the DC source of the solar panel. This was done in order to avoid damage to the machine should short circuit occur due to wrong connection. Also in other to be sure that there was no open circuit or short circuit in the system, an electrical measuring instrument was used.

Figure 7: Fabrication Process of the System

Figure 8: System under Assembling

Final Test

After the preparatory test, the System was properly wired and assemble on the main frame. Having ensured that there was no open circuit or short circuit in the connection of the System, the performance of the System was tested with 20Kg of groundnut paste. The System was able to extract groundnut oil from the groundnut paste in 5 minutes, which shows that the machine is operating effectively.

Figure 9: Preliminary test of the System

Stages of Operation

Measuring the weight of the Groundnut

The operation start by measuring the quantity of groundnut to be kneaded per batch, on a top-loading digital balance, which is usually used for measuring larger quantities of materials. And the mass of the groundnut was measured 20Kg.

Frying

The groundnut was fried through local means by using fire woods, three stones and a frying pan. After the set up, groundnut was added into the frying pan and was stir frequently to ensure even cooking for some time, until the groundnut in the frying pan turns golden brown and the skins comes off easily. Before turning out the groundnut to complete the skinning process.

Grinding

This is the process by which the ground nut is being crushed inside a machine into small particles or a fine paste, through friction and other forces between some movable and fixed parts of the grinding machine.

Figure 10: Grinding Process of the Groundnut Seed into Groundnut Paste

Kneading

The mechanical kneading process was automatically employed, reason being that as the extracts oil from the groundnut paste, is simultaneously going with kneading process in the chamber or oil extraction unit.

Kneading is the third of the four main stages of Kuli Kuli making. In baking industry, mixing refers to a series of stages that are responsible for transforming groundnut paste into dough.

Figure 11: Kneading process, system loaded with 20 Kg ground nut paste

Figure 12: Kneading process completed ready to separate oil

Figure 13: Kneading process, product removed from the kneading chamber into a rubber basin

Oil Separation Process

Oil separation in natural groundnut paste or butter, where the oil rises to the top of the kneaded groundnut paste inside. The kneading chamber, is later discharge through the oil discharge channel on the kneading chamber into a container. The separation occur because natural groundnut paste lacks stabilizers, therefore allowing the groundnut oil to separate.

Figure 14: Oil removal process after kneading

System performance

The performance of solar groundnut oil extractor system is efficient, less labour intensive in operation, faster, easy to operate and durable. The system operation does not need operator to have deep knowledge of electrical and electronics before operating. The system performance is faster than the hand kneading process since 20Kg of groundnut paste was kneaded in 5 minutes, which could have taken more thank 2 hours using hand or traditional method. So this save more time and energy.

System description

Figure 18 shows the overall system set for operation, Figure 15 shows the system under assembly, Figure 16 shows the preliminary test of the system, the system was switched on for test without load. Figure 17 is the kneading process, the machine or system was switched on with load foe the complete processes.

Figure 15: The overall System

Result

A unit of solar powers groundnut oil extractor machine that could be used in both urban and rural areas that is less labor intensive in operation with high efficiency was designed and fabricated. The system has the ability to handle 20Kg – 30 Kg of grinded groundnut seeds or groundnut paste per batch.

Summary

The aim of this research was to design and construct solar powered groundnut oil extractor machine that uses solar energy i.e. renewable energy instead of mechanical energy of Electrical energy that are not renewable. In summary this sola powered groundnut oil extractor machine that uses sun as it's primary source of energy. Has been successfully designed and constructed. This would replace the traditional methods of oil extraction from groundnut that uses equipment's like iron buckets, rubber buckets etc. Which is labor intensive, les efficient and time consuming. Therefore it can be said the objectives of this research work have been successfully achieved in terms of designing, fabrication and performance.

Conclusion

Solar powered groundnut oil extractor system was designed, fabricated and evaluated in the faculty of Science Departments of Physics Adamawa State College of Education Hong, Nigeria. The System which consist of power generating unit, energy storage unit and oil extractor unit, has the ability to handle 20 Kg to 30 Kg of groundnut paste per batch. The System is very easy to operate and less labor intensive in operation. The oil produce are of very good quality.

Recommendation

This research work titled design and construction of solar powered groundnut oil extractor System can be further improved upon, especially by scaling the kneading unit and fixing tires that could make the System movable that were not involved in this construction. We therefore recommend those that may wish to continue from this stage where we stop may consider our recommendations and other things necessary for upgrade of the System.

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