Design and Development of an Integrated Coconut Grater and Milk Extractor

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Abstract:
This project focuses on the design and development of an integrated coconut grater and milk extractor, tailored to meet the requirements of domestic users and small-scale industries. Coconut milk extraction from the kernel is usually done in two processes and with two different machines. First, the coconut meat is crushed into smaller pieces using a grater and then the grated meat is taken to an extracting device where the milk will be removed from the meat. This makes the process a bit cumbersome and time consuming. The machine employs a dual-motor system to separate the grating and milk extraction functions. A 220-volt AC motor with 0.25 horsepower and 1440 rpm is dedicated to grating operations, ensuring high-speed and consistent performance for breaking down coconut shells and kernels into fine particles. For milk extraction, a 12-volt DC motor rated at 90 watts is used, powered by a rechargeable 12-volt, 7 Ah battery. This setup ensures energy efficiency and portability, allowing the device to operate in areas with limited access to electricity.

To achieve smooth power transmission and optimal torque, a spur gear mechanism with a gear ratio of 1:8 is employed. This mechanism amplifies the torque generated by the motors, ensuring efficient operation under varying loads. The grated coconut is transported using a screw conveyor with a screw diameter of 60 mm and a length of 8 inches. This conveyor system is designed to ensure continuous, clog-free material flow from the hopper to the extraction unit. The hopper, designed with an appropriate angle and capacity, facilitates easy feeding of coconut pieces, minimizing spillage and ensuring uniform feeding. Two shafts are incorporated into the design: a 50 mm diameter shaft for mounting and supporting the grating mechanism and a 20 mm diameter shaft for the conveyor and extraction assembly. These shafts are made from durable materials to withstand the operational stresses and ensure stability and alignment during operation.

The machine's design focuses on ergonomics and ease of use, ensuring safety and convenience. It is compact and lightweight, making it portable and suitable for both households and small enterprises. The grating mechanism produces uniform coconut shreds, while the extraction unit efficiently separates milk, reducing wastage. With its energy-efficient design and dual-power source capability, the device provides a cost-effective and sustainable solution for coconut processing, catering to both urban and rural users.

This innovation not only improves efficiency and productivity in coconut processing but also promotes local economic development by empowering small-scale businesses with affordable and reliable technology.

Keywords: Coconut grater, Milk extractor, Dual – motor system, Small – scale industries, Spur gear mechanism.

1.Introduction:

Coconut (cocos nucifera) is a member of the family arecaceae (palm family) and the only species of the genus cocos. It is one of the main sources of income for many coconut farmers especially in lowland places. The Philippines has about 2.9 million hectares of coconut plantation and one third of its population depends in coconut farming, production, processing and marketing for livelihood purposes. Coconut can be considered as one of the major crops in many provinces in the Philippines because of its abundant supply in the market. Many surveys conducted and have shown the entire parts of the coconut may be used for different purposes. Its fresh grated meat has many uses to food processing and households, particularly in preparation of pastries, cakes, production of coconut milk and oil to be used as important ingredients for many goods that can be seen in the markets. It was revealed by Banson (1982) that the fresh grated coconut is often used for food preparation. The coconut meat has to be grated and extracted to produce cream or oil (Christian 2021).

Coconut milk is the aqueous extract from the coconut kernel usually gotten by grating and mechanically compressing the kernel (Henrietta, 2022). Coconut milk is a milky white oil-in-water emulsion. It is obtained from extraction of coconut flesh with or without added water (Tansakul, 2005). The coconut milk is very rich in fat, proteins, vitamins, minerals and sugar. Coconut grating is done to reduce the particle size of the coconut meat to enable extraction of the coconut milk. There are various types and designs of graters used over the years for coconut grating. These are the traditional graters, hand graters, rotatory graters and the industrial graters (Raj et al., 2016). Pressing and de – watering is the process of pressing or sequencing of the grated coconut to obtain the milk. The traditional way of expelling coconut milk is done in a muslin cloth and the hand squeezed (Raj et al., 2016).

Modern expellers are majorly of two types as classified by (UNIFEM, 1897). They are the hydraulic presses and the screw presses. A screw press is used in the separation of liquids from solids or for the extraction of liquids in a solid. The liquid is expelled through a screen that surrounds a compression screw (Firdaus et al., 2017). The grater is made up of stainless sheet metal with closely packed and randomly arranged teeth. A transmission shaft is inserted through the cylindrical disc and driven by an electric motor (Edem and Elijah, 2016). The design used is a helical screw flight of uniform pitch fixed on a conical shaped shaft, supported by two bearings and enclosed in a barrel (Oyinloda, et al., 2004). In application in food alone, the extraction of coconut meat is usually done manually by small industries and mechanically by some medium scale industries. Hence, we design and fabricate a simple coconut grater and milk extraction machine which is fully automated with the less involvement of manual work.

2.Material and Methods:

2.1 Materials:

The major parts that are effectively employed in the design and the fabrication of the coconut grater and milk extraction machine are described below:

- Battery,
- Spur gear,
- Screw conveyor setup,
- Hopper,

- Blading,
- Shaft,
- AC Motor,
- DC Motor.

2.1.1 BATTERY

Battery energy storage systems, comprising lead-acid batteries, power conversion systems, and control systems. They are used by power generating utilities power distributing utilities, and major power consumers Anderson, (1993). The machine uses a 12-volt rechargeable battery with a 7 Ah, which, once fully charged, lasts for 40 minutes. A battery charger is used to recharge the system. The coconut grater and milk extraction machine typically use a rechargeable battery, often 12V, to power the motor. These batteries are designed for portability and efficient performance, allowing the machine to operate without a direct power source. A single charge generally lasts for a specific duration, such as 30–40 minutes, depending on usage. The battery is recharged using a compatible charger, making the machine suitable for both household and small-scale commercial purposes.

2.1.2 SPUR GEAR

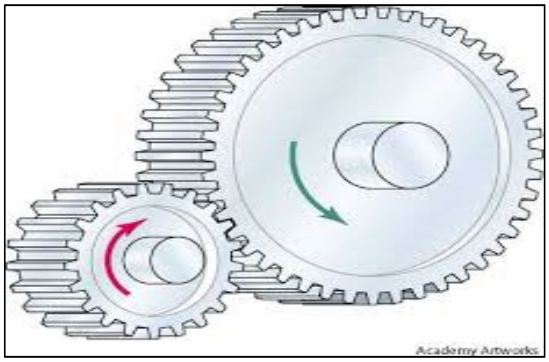

Figure 2.1: Spur Gear

A method to calculate spur gear system power loss for a wide range of gear geometries and operating conditions is used to determine design requirements for an efficient gearset. Gear reducers are frequently used to provide speed and torque conversions from a rotating power source to connected mechanical devices. There are internal and external sources of excitations for the gear set. The internal one is induced by the time varying mesh stiffness. Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with teeth projecting radially. The spur gear operates with a 1:8 ratio is shown in figure 2.1. Though the teeth are not straight-sided (but usually of special form to achieve a constant drive ratio, mainly involute but less commonly cycloidal), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears mesh together correctly only if fitted to parallel shafts (Anderson and Loewenthal, 1982).

2.2 MOTOR

2.2.1 DC MOTOR

A DC motor is an electrical machine that converts direct current (DC) electrical energy into mechanical energy. It operates based on the principle that a current-carrying conductor placed in a magnetic field experiences a force (Gambhir, 2013). DC motors are widely used for their

precise speed control and high starting torque. DC Motor was introduced with three main components: the stator, rotor, and commutator. This DC Motor used for extruding purpose in 12V 90 watt.

2.2.2 AC MOTOR

An AC motor is an electrical machine that converts alternating current (AC) electrical energy into mechanical energy. It operates on the principle of electromagnetic induction, where a magnetic field is generated by the AC power, causing the rotor to spin (Xu (2018). AC motor drives are expanding in areas ranging from industrial applications to household electrical appliances. It includes lower cost, increased reliability, reduced hardware complexity, better noise immunity, and less maintenance requirements. AC Motor for scrubbing with 220Volt,0.25 hp and 1440 rpm. AC Motor used for scrabbing purpose

2.3 SCREW CONVEYOR SETUP

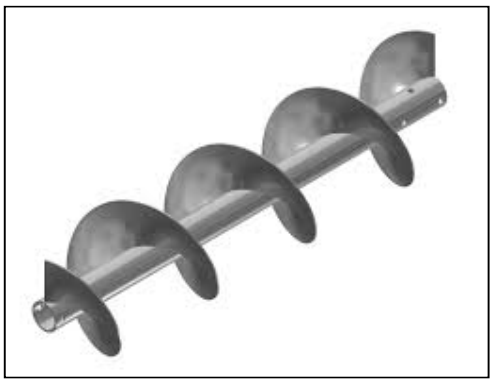

Figure 2.2: Screw Conveyor Setup

A screw conveyor is a mechanism that uses a rotating helical screw blade, called a "flighting. Dimensional analysis was used to develop general prediction equations for the volumetric capacity and the specific power requirements of screw conveyors. The screw was 60 mm diameter and 8inch length is shown in figure 2.2. Screw conveyors in modern industry are often used horizontally or at a slight incline as an efficient way to move semi-solid materials, including food waste. The first type of screw conveyor was the Archimedes' screw, used since ancient times to pump irrigation water. The same setup is used in order to separate the coconut pulp and the coconut milk. The pulp is collected on one side and the milk is extracted on the other side.

2.4 HOPPER

A hopper is a container or receptacle used in various industries to store, feed, or transport bulk materials. It typically features a wide opening at the top for easy loading and a tapered bottom to control the material flow, often leading to a conveyor belt, processing unit, or dispensing mechanism. Hoppers are one of the most popular devices implemented to allow precise flow control mechanism when dispensing granulate materials from containers. In this work, we study the influence of the hopper angle on the main two variables that determine the flow rate: the solid-fraction and the velocities of the particles Sabnavis (2004).

2.5 SHAFT

A shaft is a mechanical component used to transmit rotational power or motion between different parts of a machine. It serves as the axis of rotation and is critical in transferring torque from a power source, like a motor, to various mechanical elements, such as gears, pulleys, or

wheels (Sabnavis, 2004). Shafts are amongst components subjected to perhaps the most arduous working conditions in high-performance rotating equipment used in process. One shaft with 50 diameter and other with 20diameter.

2.2. Methods:

2.2.1 Working Principle

The experimental setup of our project consists of a simple frame on which the grater and the milk extractor setup are mounted. At the top of the frame a grater is fixed which is used to grate the raw coconut meat. The motion to the grater is provided with the help of the DC motor operated by a battery. Lower portion of the frame is provided with the screw conveyor which is used to separate the coconut waste and the coconut milk. The motion to the screw conveyor is provided with the same motor through a set of spur gears. The motor is switched on so that the grater and the screw conveyor setup attain motion. Then the coconut is fed to the grater manually so that the coconut meat is grated and falls upon the screw conveyor such that the pulp and the milk are separated. The pulp is carried by the helical screw inside the conveyor and is discharged on one side of the conveyor setup. The setup is built in such a way that the milk is separated and is collected on the other end of the setup. The same process is repeated so that the coconut milk can be extracted within short period of time.

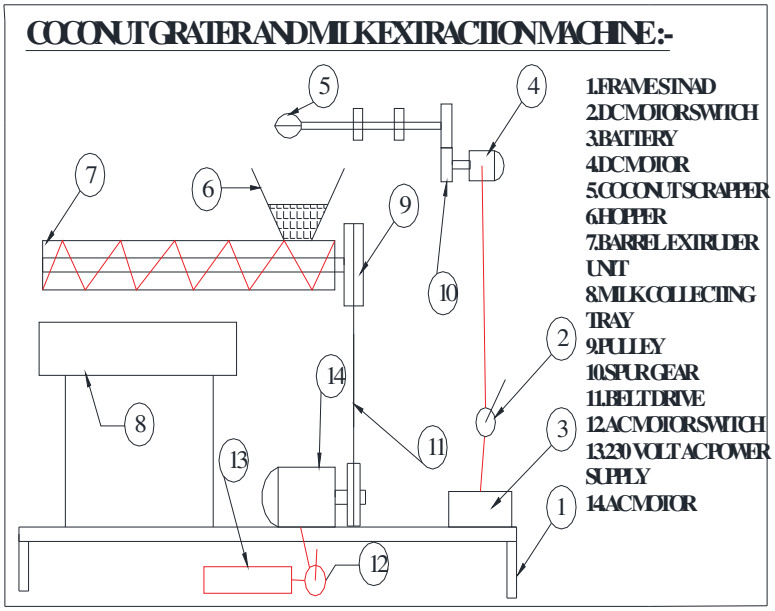

Figure 2.3 : 2D DRAWING

In this section, the overall design of the integrated coconut grating and milk extracting machine will be showcased in different types of views. The design will be collectively discussed and the accessory parts of lesser significance will be featured as well. The mechanism is greatly understood with the machine being assembled and constrained movements of the sprockets, spur gears and rollers are easily visualized. Improved features of some parts can be also noticed which were not emphasized in motion and load analyses.

3.Results and Discussion:

3.1 3D DESIGN or Front, Top, Right Side and Section Views of the Machine:

The main components except the extractor screw and radial bearing can be seen from the front view as shown in Figure 2.4, 2.5, 2,6 & 2,7. The view emphasizes the geometry of the frame that is composed of three decks. The light blue portion is made of acrylic which covers the side portion of the machine to improve the aesthetics and may block the debris during the operation.

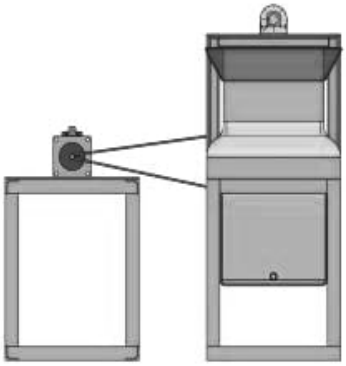

Figure 3.4 Front View

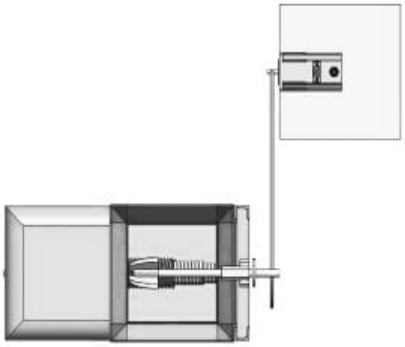

Figure 3.5 Top View

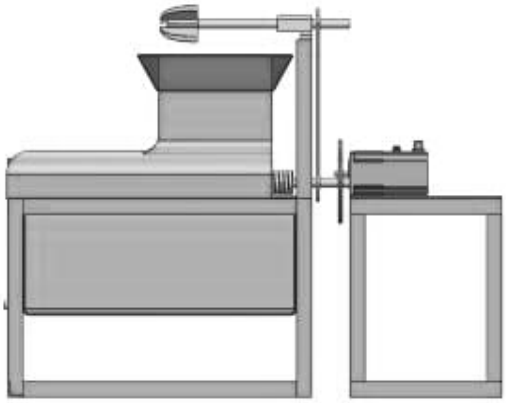

Figure 3.6 Side View

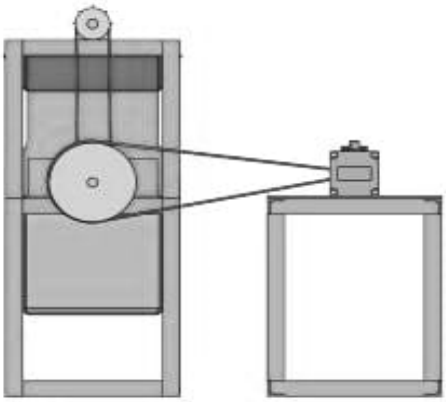

Figure 3.7 Back View

There were certain parts that cannot be seen directly of the three aforementioned views such as the rotary grater, radial bearing and the extractor shaft. Considering a plane cut through the middle of the machine in vertical direction, the section view in Fig 3.6 & 3.7 is also presented to better understood the overall mechanism of the machine. A three-dimensional figure determines the realistic arrangement of all the components assembled together. The individual components were disassembled to provide a good background of their arrangement. The frame is stationary and all the parts were successively installed on the frame beginning from the extractor section up to the grater section. The final part that was attached was the grater hopper on the top-most portion of the assembly.

4.CONCLUSION

In conclusion, the design and development of the coconut grater and milk extractor serve as an innovative solution to streamline the traditionally labour-intensive process of grating coconuts

and extracting coconut milk. Through careful engineering and material selection, the device was optimized for efficiency, user safety, and ease of operation, making it accessible for both domestic and small-scale commercial use. The integration of ergonomic design features and automated components reduces manual effort and increases productivity, while ensuring minimal wastage of coconut meat and milk. Furthermore, the device's compact form factor and durability make it a sustainable solution in environments where coconut is a key ingredient, contributing to time savings and enhancing the overall coconut processing experience. This project not only demonstrates the effective application of mechanical principles but also meets the practical needs of coconut-based industries, offering a scalable and cost-effective tool that improves traditional practices.

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