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Design and Development of Mini-Groundnut Oil Extraction Machine for Domestic Purpose

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Abstract

A machine is designed to extract various types of oil from groundnuts. The primary purpose of this machine is to facilitate the extraction of oil using a mechanical extraction method, specifically employing a screw press mechanism to crush the seeds and extract the oil. The design prioritizes portability, ease of use, and high extraction efficiency. It comprises several components, including the frame, hopper, gear reduction unit, pulleys, bearings, and power shaft. Experimental results have demonstrated that this machine effectively extracts oil, making it suitable for small-scale oil production in rural and remote areas. Particularly for small- and medium-sized businesses, cost and efficiency factors drive the demand for novel groundnut oil expeller designs. To satisfy these requirements, the machine must be lightweight and reasonably priced. For these companies, the current groundnut oil expellers on the market are frequently too big and costly. They also have difficulties with operation and maintenance. Thus, in order to determine the requirements, a great deal of research and surveys have been carried out, which has resulted in the creation of the final design and specifications. Because of its design, usefulness, and affordability, this machine is anticipated to meet the needs of small- and medium-sized companies.

Keywords: Groundnut, machine, expeller, extraction efficiency, oil yield

INTRODUCTION

A groundnut oil expelling machine plays a crucial role in extracting oil from groundnut seeds using a roller mill, direct firing in barrels, and mechanical pressing with an engine-driven expeller. This expeller utilizes a horizontally rotating metal screw to feed oil-rich seeds into a barrel-shaped outer casing with perforated walls. The seeds are continuously fed into the expeller, where they undergo grinding, crushing, and pressing to extract the oil as they move through the device. The pressure applied by the machine ruptures the oil cells within the seeds, allowing the oil to flow through the perforations in the casing and into the oil outlet, where it is collected in a receiving container placed directly below.

The groundnut oil expeller operates on a screw mechanism, pressing the groundnuts through a barrel-like chamber. The groundnuts enter one end of the press, while the residual byproduct, or cake, exits the other end. The machine employs friction and continuous pressure from the screw to move and compress the groundnuts. The extracted oil passes through small openings that prevent the passage of groundnut fiber solids. After extraction, the groundnuts are transformed into a solid cake, which

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is removed from the machine. The remaining material, from which the oil has been extracted, is discharged through the cake outlet.

Larger units designed for processing higher volumes of oil are available for industrial use in bigger mills. The expeller can extract nearly 90% of the oil from the seeds, depending on the seed variety and the type of expeller used. However, the friction generated during the process can wear down the worm shaft and other internal components, potentially leading to failures of the main shaft. The necessity for groundnut oil expelling machines dates back to ancient times, driven by the demand for both domestic and commercial oil production. The oil content of groundnut seeds ranges from 45% to 55%, depending on the variety. The process of extracting oil from the seeds known as oil extraction, expelling, or expressing is performed using machines specifically designed for various sub-processing operations in traditional groundnut oil extraction. These include shelling, roasting, de-skinning, milling, and kneading machines. Additionally, there are machines specifically developed for extracting oil from shelled groundnut seeds, such as hydraulic presses and screw presses [1, 2].

BACKGROUND OF THE STUDY

This project focuses on designing and building a machine for extracting oil from groundnuts, also known as peanuts. Groundnuts are a crucial crop worldwide, valued for their nutritional and economic significance. The oil derived from these nuts is widely used for cooking and various other applications, making it an essential resource in many households. However, the process of extracting oil from groundnuts is complex and typically confined to industrial settings, making it difficult for many people to access.

The objective of developing a compact groundnut oil extraction machine is to bridge this gap by providing a convenient solution for oil extraction at home. The development process of this machine involves several key steps, including synthesis, design, specification of components, and selection of suitable materials [3–7].

LITERATURE REVIEW

Chaimae studied the design of an efficient Jatropha oil expelling machine. The Jatropha oil expelling machine was designed with a capacity of 1000 kg/h and can expel oil at a rate of 2.2 m^3/h. The machine is powered by a 40 kW electric motor and is designed to operate for 8 working hours. The inclusion of a crusher and preheating system before pressing enhanced the performance of the expeller, achieving an efficiency greater than 90% [8].

Sreenatha Reddy et al. developed a mini-model of an oil expeller screw shaft and examined the effects of varying the compression ratio of the oil chamber along with the speed of the screw shaft. The experimentation was carried out using Pongamia and Jatropha seeds, with the compression ratio maintained between 14:1 and 21.5:1 while varying the shaft speed between 35 and 654 rpm. The study concluded that the compression ratio significantly impacts the performance of the oil expeller screw [9].

Aremu et al. presented the design of an oil expeller machine for kenaf. The designed machine has a capacity of 36.5 kg/h and is capable of extracting oil with an efficiency of up to 62.2%. The machine was designed to have optimal lubrication and easy maintenance [10].

Eliwa et al. studied the factors affecting the performance of a watermelon seed extraction and peel-cutting machine. The feed rate was varied between 20 and 40 kg/min. The results showed that seed losses and damage increased with an increase in cutting unit speed from 1.11 to 2.59 m/s, the time elapsed after harvesting, and the use of concaves with square holes. A small-scale machine for decoupling locust bean seeds revealed that the speed of the depulping machine affects depulping efficiency and membrane detachment efficiency. However, the machine speed had no significant effect on the percentage of seed loss, while the soaking time directly influenced membrane detachment efficiency [11].

Deli et al. conducted a research study on the effects of physical parameters in a screw press machine. The study focused on Sativa seeds using a KOMET screw oil expeller. Various nozzle sizes, shaft speeds, and shaft diameters were analyzed. The results showed that an 8 mm shaft diameter produced low yields, while an 11 mm shaft diameter operating at 65 rpm performed better. A nozzle size of 12 mm yielded consistent results. The study found that changes in physical parameters significantly affected oil yield, with an optimal yield of 22.27% recorded for an 8 mm shaft diameter and 19.05% for an 11 mm diameter [12].

Ibrahim et al. reviewed different technologies for oil extraction from agricultural products. The study covered various pre-processing techniques, including hull and shell removal, size reduction, moisture content adjustment, heat treatment, and pressure application. Both traditional and modern (improved) extraction methods were discussed in detail [13].

Haldar et al. conducted a study on oil expellers, emphasizing the availability of raw materials and design features. The research focused on the challenges associated with oil expeller design, its processes, and the development of sites for oil expeller industries [14].

Zamanzadeh et al. explored different failure analysis methods and material selection for oil expellers. The study covered failures in paints, coatings, plastics, and electronics, as well as corrosion-related failures. Principles of root cause analysis were applied within the study [15].

Olaniyan et al. designed an oil expeller screw press and tested it for oil extraction from palm kernels and soybeans. The expeller was powered by a 15 HP three-phase motor. The study recorded an average extraction efficiency of 13.48% for palm kernel oil and 22.79% for soybean oil. The results concluded that the mini expeller could be useful for small-scale oil production in communities [16].

Patil et al. presented a research study on the design and failure analysis of existing oil expeller shafts used for agricultural oil extraction. Various studies on screw shaft failures were examined. The review highlighted the potential for developing improved oil expeller shaft designs. The proposed research not only focused on identifying failures but also explored the development of oil expellers using traditional and computational techniques [17].

Bachman highlighted the historical necessity of developing groundnut oil expelling machines to meet domestic and commercial demands. The study emphasized that one of the primary motivations for research has always been the development of machinery to facilitate food production for humans and animals [18].

PROBLEM DEFINITION

Researchers have developed and built various types of groundnut oil expellers in different sizes, shapes, and materials, primarily for industrial applications. However, these expellers are expensive due to their advanced technology, making them inaccessible to small-scale and low-income oil millers. To support local small-scale millers, it is essential to design and manufacture compact groundnut oil expellers using locally available materials [19–22].

Many oil extraction devices are bulky and immobile, while the cost of mini oil machines remains prohibitively high. The quality of oil produced by homemade machines varies significantly, with some devices yielding oil that is unfit for consumption or lacking the desired taste and nutritional value. Although numerous homemade oil extraction devices exist, they often fail to extract oil efficiently from various seeds, resulting in low yields and wasted resources. A common issue with these homemade devices is their limited capacity, which prevents the efficient processing of large quantities of seeds or nuts [23].

Today, various challenges are encountered in the oil extraction process. In response to market research and our commitment to promoting human health and a healthier lifestyle, we have developed a mini-groundnut oil extraction machine for domestic use. This machine enables convenient oil extraction at home, tailored to individual needs.

OBJECTIVES

1. To design groundnut oil extracting machine that will reduce labor input when compared to the traditional methods.
2. Easy to install, operate and maintain and lowest price.
3. Simple equipment selection and small land requirements.
4. Easy to operate, clean, move, and store.

SCOPE OF THE STUDY

This study involves the development of a groundnut oil extraction machine using locally sourced materials, designed for small-scale farmers, aiming to achieve a higher oil yield compared to existing machines, along with comprehensive performance testing. By focusing on these areas, the study aims to provide an efficient, cost-effective, and user-friendly solution for small-scale farmers to improve their groundnut oil production [24–26].

METHODOLOGY

The approach employed in carrying out this work is as follows:

1. *Investigating groundnut properties:* Examining the physical properties of groundnuts to determine the optimal oil extraction method.
2. *Design concept and procedure:* Developing a design concept and procedure that emphasizes importance, function, performance, cost of fabrication, ease of operation, and maintainability.
3. *Identifying and improving deficiencies:* Identifying any deficiencies in the design concept and proposing improvements for better future performance.
4. *Design:* Analyzing the design to determine essential machine parameters, including efficiency, torque, shaft size, and speed.
5. *Machine fabrication:* Fabricating the machine using manufacturing techniques such as machining, welding, fitting, and assembling.

JUSTIFICATION

The development of groundnut oil extractor will help to bridge the supply demand gap of vegetable oil and thereby enhancing the sector. It will also reduce the waste encountered while using other screw press designed for other oil seed for groundnut. The use of locally sourced material in the fabrication of this machine makes it affordable to low-income earners of our communities and also ease in operation and maintainability [27–30].

DESIGN

Hopper Design

Hopper is a funnel-shaped device used to move material from one receptacle to another. It is a large, pyramidal or cone shaped container used in industrial processes to hold particulate or flow-able material of any sort (like dust, gravel, nuts or seeds) and dispense these from the bottom when needed.

Assembly Diagram

The assembly diagram shows the integration of the gear motor, screw barrel, heating coil, sprockets, bearings, and frame, ensuring proper alignment and smooth operation of the oil extraction machine. (Figure 5).

Working

A screw press is a type of machine that operates like a screw, pressing oil seeds through a barrel-shaped chamber. Materials are introduced into one end of the press, while the by-products are expelled from the other. The mechanism employs the force of friction and the continuous rotation of the screw to crush and compact the seed material. Initially, when the machine is activated, the heating element and the motor begin to function. Once the heating element reaches the desired temperature, we place the grate in the hopper. The nuts are then inserted into the screw and barrel. As the screw turns, the nuts are compressed. The by-products are expelled from the front, and the oil is collected from the back. The process of extracting oil from the seeds is known as oil extraction, which involves separating the triglyceride (TAG) lipids from the extracted and concentrated algae biomass. This can be achieved through various mechanical or chemical methods (Figures 1–6) [31, 32].

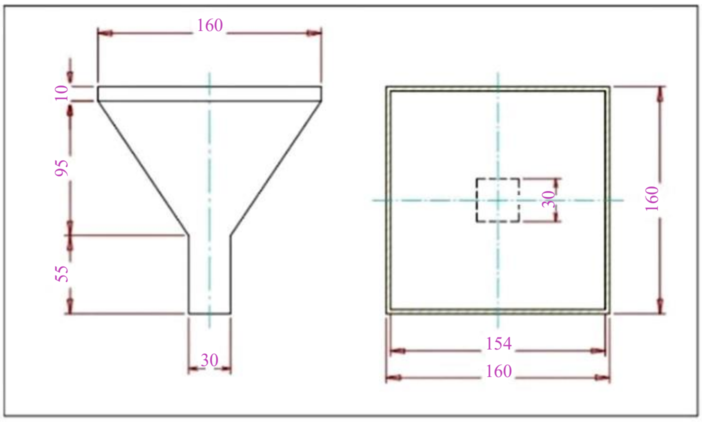

Figure 1. Hopper design.

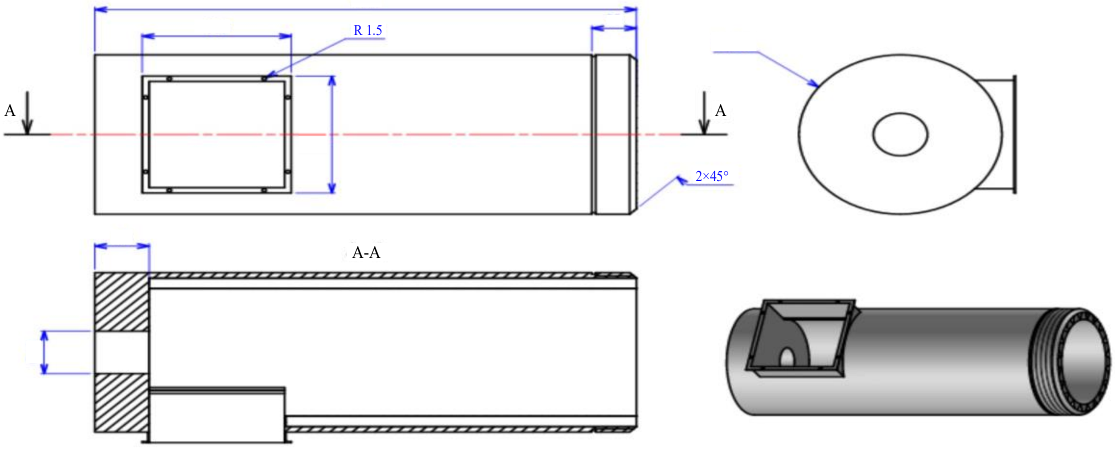

Figure 2. Cylindrical barrel.

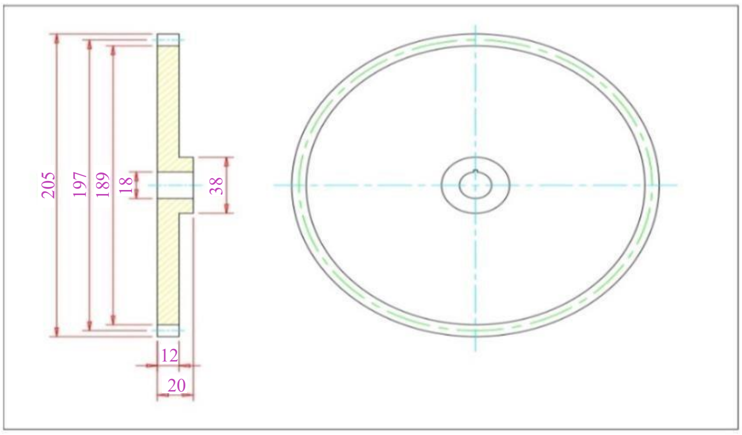

Figure 3. 2D figure of the cylindrical barrel.

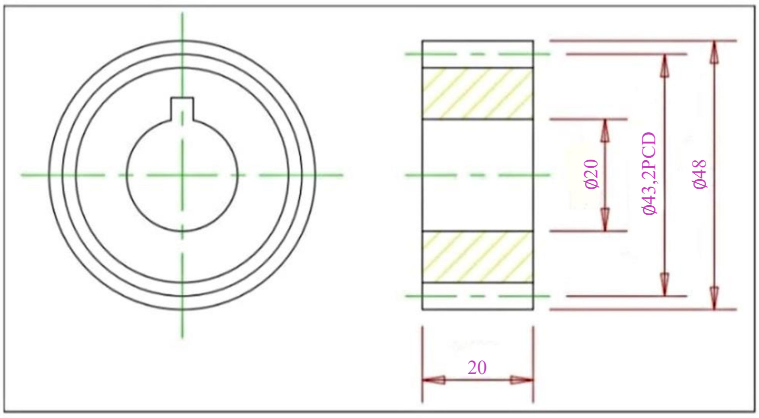

Figure 4. Chain sprocket design.

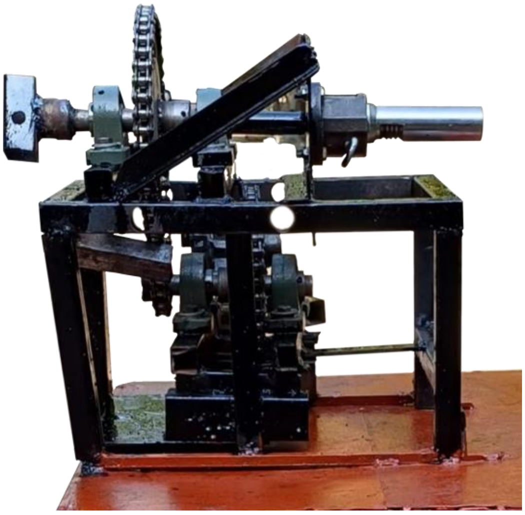

Figure 5. Completed work.

Figure 6. Oil extraction machine.

Table 1. Bill of materials.

S.N.	Part Name	Quantity	Total Cost (Rs)
1	Gear motor	1	2000
2	Screw and barrel	1	2300
3	Cotter, pin, mount	1	1100
4	Heating coil	1	300
5	Chain sprockets	2	700
6	Bearing(s)	3	350
7	Handle rod	1	200
8	Pillow block	2	500
9	Miscellaneous cost	-	2000
Total cost			Rs 9450

The Mini-Groundnut Oil Extraction Machine for domestic use has been designed and developed keeping in mind cost-efficiency, simplicity, and reliability. The machine consists of several essential components, each contributing to the overall functionality and performance.

RESULTS AND DISCUSSION

An evaluation was conducted to assess the machine's performance. During the test, the machine was operated for 10 minutes using a three-phase, 1470 rpm, 11.2 kW electric motor. After 10 minutes of operation, 2500 g of well-dried groundnut seeds were loaded into the machine through the feed hopper. The cone ejector clearance was set to 1.0 mm using the adjusters (Table 1).

Bill of Materials

A Bill of Materials (BOM) is a comprehensive list of all the materials, components, and parts required to manufacture a product, along with their quantities and specifications.

CONCLUSIONS

Our equipment offers the most affordable options on the market while maintaining superior quality. High-quality products ensure customer satisfaction and retention while minimizing costs and risks associated with defective product replacements. Our machines support the philosophy of producing and consuming locally, encouraging customers to prioritize abundance over singular wealth. Additionally, we provide durable and eco-friendly machinery that is gentle on the environment.

We developed a reliable and easy-to-maintain equipment for oil extraction. As a result, all our objectives have been clearly articulated in this project. In summary, the mini oil mill is a collection of devices designed to extract oil from seeds such as groundnuts, sesame, sunflower, cotton seeds, and more. Through this project, we efficiently extract groundnut oil, producing clean oil suitable for household use. Furthermore, the oil mills we design and develop for the commercial sector not only contribute to income generation in rural areas but also create numerous job opportunities within villages.

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