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Research Article

Design of an Automatic Jatropha Seed Oil Extraction Machine

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Abstract

In light of the current global economic crisis and environmental pollution issues, this project focuses on the extraction of essential oil from jatropha seeds, with a particular emphasis on extraction technology. Jatropha curcas (jatropha) is recognized as a promising feedstock for biodiesel due to its adaptability to semi-arid lands. The biodiesel industry is rapidly expanding in response to rising petroleum prices and growing concerns about global climate change, positioning jatropha as a productive and effective source of essential oil. In Ethiopia, where petrol is primarily imported at high costs, the development of essential oil production is crucial for reducing expenses. This thesis is significant for several reasons: it promotes the cultivation of jatropha trees to help farmers generate income, provides manufacturers with a low-power, space-efficient oil extraction machine, and encourages the government to prioritize the production of essential oils (biodiesel) through simplified and cost-effective systems. The primary objective of this study is to enhance oil production, improve efficiency, and minimize time wastage. Addressing pressing environmental concerns, this thesis highlights the environmental benefits of biodiesel. While diesel fuel emits 9% CO_2, biodiesel emits only 1.33%. Additionally, diesel emits 5% O_2 compared to biodiesel's 17.67%, illustrating its positive impact on environmental balance. Notably, biodiesel produces 0% CO emissions, making it a significant contributor to reducing greenhouse gas emissions and promoting environmental sustainability. This paper reviews global research on jatropha seed oil extraction, mentioning technologies such as the Komet oil press and Rose Downs's oil press, which use components like screws, gearboxes, feeding sections, bearings, and screw shafts. However, our design differs from these systems in specific components and an extraction method employed.

Keywords

Biodiesel, Emission, Extraction, Jatropha, Pollution

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1. Introduction

The global need for fuel has increased significantly with the development and progress of the world. Many systems and technologies rely heavily on fuel, particularly diesel fuel for diesel engine systems. However, there is a growing demand for renewable, sustainable, and abundant fuel sources. Biodiesel, derived from natural oils like Jatropha oil, is an alternative fuel for diesel engines [2].

The biofuels industry has experienced rapid growth due to high petroleum prices and increasing concerns about global climate change. In different regions, various biofuels have been successfully commercialized with government support.

For instance, ethanol from sugarcane in Brazil and corn in the United States, as well as biodiesel from rape seed in European Union countries, have emerged as substitutes for petroleum products [8].

In Ethiopia, Jatropha curcas (jatropha) is considered a highly viable biodiesel feedstock, primarily due to its adaptability to semi-arid lands [16].

The oil content in jatropha seeds ranges from 32% to 40%, with an average of 34%. However, the seeds contain toxins, such as phorbol esters, curcin, trypsin inhibitors, lectins, and phytates, which make the seeds, oil, and seed cake non-edible unless detoxified [6].

Jatropha cultivation can be profitable due to its high oil content, with the seeds containing approximately 50-60% oil [12].

Jatropha is among the crops that hold immense promise for biodiesel production. Its proponents argue that it does not compete directly with food production since the entire plant is toxic and non-edible [11].

Moreover, its ability to grow on degraded soil, resistance to drought and pests, enables cultivation on land unsuitable for food production [1].

Figure 1. *Jatropha plant with matured seed [15].*

2. Statement of the Problem

The previous oil extraction machines have encountered several key issues.

Low quality and quantity of oil: The earlier machines have struggled to produce oil of satisfactory quality and in sufficient quantities. This can hinder the overall productivity and effectiveness of the oil extraction process.

Low efficiency: The efficiency of the oil extraction machines has been relatively low, resulting in suboptimal extraction rates. This can lead to wastage of resources and increased operational costs.

Time wastage: The earlier machines have been associated with significant time wastage during the oil extraction process. This can impact productivity and delay the availability of the extracted oil for further processing or usage.

High manpower requirement: The manpower required to operate the earlier oil extraction machines has been excessive. This not only increases labor costs but also limits scalability and efficiency in larger-scale operations.

Sound and environmental pollution: The previous machines have been known to generate high levels of noise during operation, leading to noise pollution in the surrounding environment. Additionally, they may contribute to environmental pollution through emissions or inadequate waste management practices.

Addressing all these problems is crucial to improving the overall performance, efficiency, and environmental impact of oil extraction machines.

3. Objectives

3.1. General Objective

The general objective for this project was to design of an automatic jatropha seed oil extraction machine.

3.2. Specific Objectives

To design hopper, nozzle, chamber and oil dropper.
To design screw.
To design frame.
To design pulley.
To select standard material: AC motor, belts, bearing and bolts.

4. Materials and Methods

4.1. Design of Hopper

The hopper, used to carry and direct the Jatropha seeds into the screw press, was designed with specific considerations in mind [10].

Material Selection: The components of the hopper were selected to be made of galvanized steel. This choice was based on factors such as cost, availability, strength, and wear resistance [5].

Function and Feeding: The purpose of hopper is guiding the seeds into the screw press. It relies on gravity for feeding, eliminating the need for additional energy. The hopper is a stationary part mounted onto the vessel [9].

Passage Hole Size: The passage hole of the hopper was designed to be large enough to prevent the seeds from getting stuck or causing blockages. This ensures smooth and uninterrupted seed flow during the extraction process [4].

Vibration Unit: Unlike some conventional screw presses that incorporate a vibration unit to overcome potential choking situations, this design does not include such a unit. The omission of a vibration unit was done to reduce costs while still maintaining efficient operation [7].

The hopper able to supply enough seed to the press machine according to the specifications [3]:

1) Assume that the flow rate of 120kg /hr (2kg/min) because at least 2kg seed are flow into the chamber.
2) The output area (assuming a square cross Section) of the hopper able to flow 2kg of dry Jatropha seed per min. then, Q = 2 kg/min
3) Assuming the seed would act as a fluid when it passes the intake hopper. We would try to get the volume of A3: Final dimension of the hopper is:

θ = 60mm S = 300mm

Li = 300mm Lo = 60mm

Volume of Hopper, V_h

V_1=441800mm^3

V_2=7952400mm^3

V_3=38289mm^3

$V_h=V_1+V_2+V_3$ = 8432489mm^3 = 0.008432489m^3

Hopper Capacity, H_c

The hopper capacity is determined from the equation.

$$H_c= \rho * V \tag{1}$$

Where:

ρ=density of jatropha sample = 750 kg/m^3

V= total volume of hopper

H_c= 400kg/m^3*0.008432489m^3 = 3.37 kg

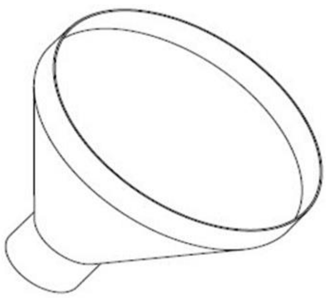

Figure 2. *Hopper.*

4.2. Design of chamber

Selected material for the chamber is steel since less cost and high strength. Determination of Volume of chamber for Jatropha seed pressing [14].

Therefore, the mass of jatropha seeds that the chamber can accommodate can be explained in mathematical terms [13]:

M = ρ_a × Inner volume of chamber for Jatropha seed pressing.

M = 400 kg/m^3*304267.9*10^{-9}m^3

M = 31.56 g

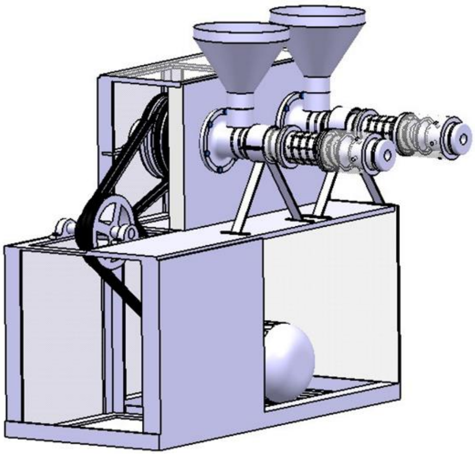

Figure 3. *Assemble drawing.*

5. Results and Discussion

After identifying the weaknesses in the initial design, software tools such as CATIA and AutoCAD were utilized to make modifications and address the identified issues. These modifications included increasing the thickness of certain parts and changing the material types for different components, ultimately resulting in an optimized design.

The proposed design and concepts were developed based on the specific problem at hand and the requirements and specifications provided by the customer. The objective was to meet the increasing demand for fuel in a rapidly growing market. By applying problem-solving strategies and leveraging creative innovations, we aimed to design a solution that would best fulfill our intended goals.

The knowledge and expertise in mechanical design, including both manual and software-based design and analysis systems, proved invaluable during the development of the project. This proficiency allowed us to navigate the design process effectively and efficiently.

Throughout the design coverage, numerous results were obtained. These results encompassed various aspects such as improved performance, enhanced functionality, and increased feasibility. The iterative nature of the design process allowed for continuous refinement and optimization, leading to a final design that addressed the identified weaknesses and met the desired objectives.

Table 1. *Description of the machine operation.*

No.	Requirement	Description
1	Production rate	easy loading/charging of the seed and fast starting of the system enables to reduce warm-up time and preparation time which leads to increased production rate by reducing production.
2	Labour	One-man operation with the simple control panel is possible.
3	Cooling rate	The cooling system is already installed in the motor so it is not hazardous to the system. And also needs no extra cost to control it.
4	Compression Pressure	Simple horizontal compression screw is used to provide the compression pressure needed to press oil out of the seeds.
5	Maintenance	Maintenance is easy due to the fact that the components that are used are very simple and also there only few of the parts that can easily maintained by non-professional personnel to provide preventive maintenance.
6	Safe standard	Machine operation is able to follow the safety standard; as this machine concept is compact and all moving part are inside the machine working area

High production rate

The machine is designed to produce Jatropha seed oil at a significantly high production rate, thanks to its innovative design and effective utilization techniques. This capability allows the machine owner to meet the ever-growing demand for green fuel, tapping into a market with vast potential. By efficiently extracting oil from Jatropha seeds, the machine not only contributes to sustainable energy solutions but also positions its owner to take advantage of the increasing interest in eco-friendly fuel alternatives.

Minimum 120Kg/hr.

For the machine to achieve the desired outcomes, it is essential that it possesses the capabilities outlined above. These capabilities form the foundation for all calculations and assumptions made during the design process. Our estimates are based on both personal experiences and findings from relevant research. Enhancing the machine's delivery capacity is a crucial factor that can significantly boost productivity. By increasing this capacity, we can substantially accelerate the overall production rate.

One-man operation

The machine operation must be handled by a single worker only (one-man operation).

Simple operation process

Machine is operated by a simple ON/OFF button only and no complicated processing is required for the production.

Equipped with cooling system

The cooling system which is installed in the electric motor itself doesn’t require extra task there by simplifying the operation process.

6. Conclusion and Recommendation

6.1. Conclusion

Reflecting on this project, we are pleased to report that all objectives have been successfully met. The designed product aims to help users maximize biodiesel production while minimizing costs. Currently, there are no locally produced products that offer a simple and effective technique for extracting oil from Jatropha seeds. We believe that our project has the potential to meet the domestic demand for biodiesel and conserve foreign currency by reducing reliance on imported fuels.

A primary objective of the Jatropha seed oil extraction machine design was to enhance biodiesel productivity compared to the current production trends observed in the country. This necessitated a thorough understanding of existing technologies and practices, allowing us to identify areas for improvement. The design we developed not only reflects our main goal of increasing biodiesel yield but also integrates specific component objectives to ensure efficiency and effectiveness.

By focusing on local production capabilities, we aim to empower users with an accessible solution that addresses both economic and environmental challenges. Through our innovative design, we aspire to contribute to the growth of the biodiesel industry, ultimately supporting sustainable energy practices and fostering economic independence.

6.2. Recommendation

In the future, this machine can be upgraded to an automated version in solar and AI, enhancing its operational efficiency and user-friendliness while minimizing the need for human intervention during the extraction process. Implementing a conveyor system could be a valuable addition, facilitating an uninterrupted flow of seeds and allowing the machine to operate at its optimal capacity.

The biodiesel extraction machine is a crucial piece of equipment, especially considering the significant biodiesel potential within the country. By harnessing this potential, the project could play a transformative role in mitigating climate change, generating income, and creating job opportunities. If successfully implemented, this initiative could lead to substantial economic and environmental benefits in the future.

Abbreviations

AC	Alternative Current
CAD	Computer Aided Design
CO	Carbon Mono Oxide

Author Contributions

Abera Ayza Anebo: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Eniyew Eskezia: Methodology, Supervision

Mezgebe Teklu: Methodology, Supervision

Mohammed Madole: Supervision

Teferi Teka: Methodology, Supervision

Debritu Debebe: Supervision

Conflicts of Interest

The authors declare no conflicts of interest. All authors have reviewed and approved the final manuscript. This submission is original work and is not under consideration for publication elsewhere.

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