Design, Fabrication and Performance Evaluation of an Okra Seed Extractor for seed production

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Srimaya Mohapatra
Indian Institute of Technology Guwahati

Design, Fabrication and Performance Evaluation of an Okra Seed Extractor for seed production

submitted in partial fulfilment

of the requirements for the award of the

*Degree of B. Tech in **Agricultural Engineering***

by

Bishnu Prasad Patra (203001170010)

Abinash Panda (203001170018)

Subhasmita Pradhan (203001170019)

Srimaya Mohapatra (203001170028)

Under the esteemed guidance of

Dr. Korla Harshavardhan

School of Agriculture and Bio Engineering

Centurion University of Technology & Management,

Paralakhemundi, Odisha, 761211

May 2024

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15/7/24

Dr. Korla Harshavardhan
(Asst. prof, SoABE)
Supervisor

Dr. Sadat Ali
(Dean, SoVET)

15/7/24

Dr. Santosh DT
Head of the Department of
Agricultural Engineering

15/7/24

Dr. Korla Harshavardhan
(Dean, SoABE)

HOD
Agriculture Engineering
Paralakhemundi
CUTM

15/7/24

DEAN
School of Agricultural & Bio-Engineering
CUTM, Paralakhemundi
Dist- Gajapati, Pin-761211

External Examiner

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Abinash panda

Abinash Panda (203001170018)

Subhasmita Pradhan

Subhasmita Pradhan (203001170019)

Bishnu Prasad Patra

Bishnu Prasad Patra (203001170010)

Srimaya Mohapatra

Srimaya Mohapatra (203001170028)

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ABSTRACT

Indian Agriculture has shown remarkable progress over the past five decades. The production of food grains has increased significantly, from 50 million tons in 1947 to 212 million tons in 2003-04. Seed production plays a critical role in the global food supply chain by ensuring the availability of high-quality seeds for planting, thereby supporting crop yield, sustainability, and food security. The seed production industry is crucial for economic growth, employing professionals and utilizing advanced technology for high-quality seeds. However, limited access to technology can hinder innovative solutions. Okra, a widely cultivated annual vegetable, holds significant importance in the tropical and warmer temperate regions across the globe. This nutritious food offers numerous health benefits. Indian farmers face challenges in threshing okra for commercial purposes due to traditional manual methods, labour-intensive tasks, and poor quality. The high cost of multi-mechanical threshers exacerbates these issues. To improve okra production, an affordable and effective okra thresher is needed to address the labour-intensive and time-consuming task.

An improved okra seed extractor with a petrol engine has been developed to take the role of manual threshing and offer a more effective substitute for motorized threshers. The machine was put through performance testing with different speed of threshing cylinder and moisture contents of okra pods. Based on the following parameters: threshing efficiency, throughput capacity, and percentage seed damage, the machine's performance tests were carried out three times with 10,000, 8,000, and 6000 grams of okra pods at threshing cylinder speeds of 200, 240, and 280 rpm each and moisture contents of 12%, 15%, and 18%, respectively. The results of the testing demonstrated that the thresher had the greatest threshing efficiency of 98% with a moisture content of 12.3%, a feed rate of 120 kg/hr, and a threshing cylinder speed of 200 rpm. The highest throughput capacity was found to be 40.18 kg/hr while the threshing cylinder was running at 200 rpm, the feed rate was 120 kg/hr, and the grain moisture percentage was 12.3%. The greatest cleaning effectiveness and grain damage were found to be 93.06% and 4.90%, respectively. This showed that feed rate and moisture content reduced while cylinder speed increased, increasing the efficiency of threshing and cleaning as well as the throughput capacity. The ideal crop-machine parameter combination for thresher performance is thus 12.3% moisture content in okra and 200 rpm threshing cylinder speeds. The equipment works satisfactorily, and small-scale farmers will feel more at ease threshing with it.

CHAPTER - 1

INTRODUCTION

Indian Agriculture has experienced significant progress in the past half-century. The production of food grains has soared from 50 million tons in 1947 to 212 million tons in 2003-04. The country has successfully transformed from facing food shortages and relying on imports to achieving food security and having surplus for exports. The Green Revolution in India has been widely recognized as a triumph, thanks to the joint efforts of farmers, scientists, and the government. The 60s and 70s saw significant agricultural achievements due to high-yielding varieties, fertilizer use, irrigation expansion, extension efforts, and Indian farmers' ingenuity. However, the sector's growth has stagnated, impacting food security and the economy. To ensure national food security, nutritional security, and economic development, a focused approach is needed to increase productivity and production in agriculture. With limited cultivation area, focusing on productivity per unit of cultivated land is crucial.

Cultivated okra [*Abelmoschus esculentus*] is an important annual vegetable commonly grown in the tropics and warmer temperate regions of the world. It is a nutritious food with many health benefits. It is rich in dietary fibre, minerals (Sodium, Calcium, Sodium, Potassium, Zinc, and Iron), vitamins (A, B, and C), antioxidants, and folate. Okra seed is rich in proteins (15–26%), the seed oil is edible (20–40%), and rich in unsaturated fatty acids like the linoleic acid essential for human nutrition. According to Food and Agriculture Organization (FAO) data, the area harvested from okra in India witnessed a CAGR of 0.77% from 2016 to 2021. In 2021, the area harvested from okra was 531 thousand hectares, which is an increase of 2.3% from the 2020 area harvested area of 513 thousand hectares. Thus, the growing area under okra cultivation fuels the demand for high-yielding okra seed varieties. According to the FAO, okra production in 2018 was 6,095 thousand metric tons, and it increased by 2.24% and reached a production volume of 6,371 thousand metric tons in 2020. Hence, okra seeds demand is driven by increasing okra production per year. At the same time, the export demand for okra seeds from India, along with the Indian companies' overseas presence, is adding stimulus to the growth of the market.

Okra production cannot be considered complete without the essential process of threshing. Threshing is the method used to separate the grains from the pods, and it can be carried out either manually or mechanically. Manual threshing is known for being time-consuming, resulting in loss of grains, and\ requiring a lot of physical effort. On the other hand, mechanical threshing, although more costly, ensures the quality of the final products and reduces the physical strain associated with traditional threshing methods. In India, threshing is traditionally done by placing the harvested crop on the ground and beating it with a stick or flail. However, this method, along with using mortar and pestle, is not efficient enough as it leads to low output, potential contamination, long processing times, and a high demand for labour. **Sinha and Pandita**, 2002 threshed Okra cv. Pusa A4 seeds by manual, tractor treading, de-awner (400 rpm) and Pullman thresher (650 rpm) gave 54.05, 53.8, 46.7 and 51.30 per cent seed recovery and germination of 92.6, 88.0, 78.0 and 87.0 per cent respectively. The seedling dry weight and vigour index was also significantly higher in manually threshed seeds. Mechanical damage to seed was higher with tractor treading (Table 3).

Table 1: Effect of threshing methods on seed quality in Okra cv. Pusa A-4

Treatment	Speed (rpm)	Visible cracks	Germination (%)			Dry Weight (g/10 seedlings)
			Normal	Abnorm al	Dead	
Manual threshing	-	54.05	92..6	2.3	5.0	0.2784
De-awner Threshing	400	53.80	88.0	2.7	9.3	0.2781
Tractor Threshing	-	46.70	78.0	4.0	18.0	0.2503
Pull-man Threshing	650	51.30	87.0	3.6	9.3	0.2683
C.D at 5% Level	-	-	3.9	NS	3.8	0.012

Indian farmers are encountering various challenges related to threshing okra, particularly for commercial purposes. The traditional manual methods are inadequate for large-scale operations, resulting in time-consuming processes with minimal efficiency. Women and children are primarily responsible for the labour-intensive task of threshing, leading to significant grain losses and breakage. The poor quality of threshed okra affects its shelf life and viability, ultimately impacting farmers' profits and consumers' well-being. The high cost of multi-mechanical threshers further compounds the challenges faced by rural farmers. To mitigate these issues, it is essential to develop an affordable and effective okra thresher to enhance okra production in the country. The demand for an okra thresher is driven by the labour-intensive and time-consuming manual harvesting process, which presents numerous challenges such as labour intensity, time consumption, physical strain, inefficiency, scale limitations, quality control, and economic viability.

CHAPTER - 2

REVIEW OF LITERATURES

Technology advancements in agriculture, particularly the seed extractor or thresher, have significantly enhanced efficiency and productivity in the sector. The okra seed extractor, for instance, has revolutionized modern agriculture by enabling farmers to obtain high-quality seeds, thereby increasing productivity and profitability in seed production. This chapter aims to provide a comprehensive review of literature on threshers for seed crops in agriculture, highlighting their significance, diversity, advancements, and impacts on farming practices. Various types of seed extractors utilized in agriculture, such as tractor-mounted multi-crop threshers, small-scale okra threshers, and cowpea threshers, are analysed in this literature review. Each type caters to different farming requirements, capacities, and crop varieties, offering unique features, advantages, and limitations. By examining existing research findings, this chapter will shed light on the suitability and effectiveness of each type of thresher in specific agricultural settings.

Kushwaha et al. (2005) developed a prototype extractor for okra seed extraction. Their study aimed to evaluate the effects of different factors on machine performance and seed quality. Three types of extractor drums were utilized: square head bolted, rubberized, and rasp-bar. The square head bolted drum demonstrated the highest extraction efficiency (99.3%), best cleaning efficiency (97.9 to 99.6%), and lowest seed loss (4.7%). Optimal seed quality machine performance was achieved at 12.3% moisture content, 7 mm concave clearance, and 5 m/s cylinder speed.

Ajav et al. (2021) developed a okra thresher and evaluated with three different levels of cylinder concave clearance (10, 20, 30 mm), three levels of seed moisture content (12.5, 14.0. 17.0 per cent), two levels of cylinder speed (4.2 and 4.4 ms-1), and feed rate of 10 kgh-1 of dried okra pods and the performance was found to be a maximum of 97 per cent threshing efficiency and 97.7 per cent cleaning efficiency, a minimum of 3.3 per cent total seed loss and a maximum germination of 85 per cent at 30 mm concave clearance, 4.2 ms-1cylinder speed and 17 per cent moisture content.

A. G. Berlage et al. (1986) designed and constructed a vertical belt thresher and tests were conducted on legume and grass seed crops, individual flower seeds and vegetable seeds. Thresher was designed in such a way that threshing aggressiveness was due to speed difference and/or the contact pressure or spacing between the two belts. In the machine three different types of interchangeable textured belts were used. The effect of changes in belt clearance, speed ratio, and texture were evaluated. All three variables were evaluated in the test of seed coat removal for lentils. The threshing efficiency was reported maximum 70.4 % with medium textured, 10:1 speed ratio, and 3 mm clearance.

Anwar et al. (1991) developed a multi-drum thresher consisting three rasp-bar cylinders, delivery augers, rubber flap elevator, aspirator fan for cleaning and oscillating screen. The machine was powered from tractor PTO and mounted on its three-point linkage for transport. It was reported that the machine had an average intake crop capacity of 1500 kg/h, cleaning efficiency 94 %, grain damage 8.5 % and grain loss 3 %. The thresher was tried for other crops like soybean, sunflower and safflower. The average grain damages reported for these crops were 1.5, 1.1 and 0.5 %, respectively.

Mesquita et al. (1993) conducted research on soybean threshing mechanics without uprooting the plant. They designed a test stand to study the effects of frictional rubbing and impact on soybean plants by replicating the movement of experimental units across a row of soybean plants, achieving threshing efficiencies of 93% and 92%, respectively.

Rizivi et al. (1993) delved into the examination of a sunflower thresher's threshing unit. They evaluated breakage performance across various drum types (peg, rasp-bar, and rubber-strip), drum speeds (400-500-600 rpm), and concave clearances (2.2, 4.4, and 6.3 cm). The findings suggested that the peg type cylinder, with speeds ranging from 400 to 500 rpm and a concave clearance between 2.2 and 3.0 cm, offered the most effective results for sunflower threshing.

Bhutta et al. (1997) analysed the performance of a locally produced sunflower thresher in comparison to a combine harvester. The sunflower thresher had an output capacity of 447 kg/h, with a threshing efficiency of 97.3% and breakage rate of 4.87%. On the contrary, the combine harvester, featuring a threshing drum with 8 rasp bars measuring 104 cm in length and 60 cm in diameter, had an output capacity of 1000 kg/h, with a threshing efficiency of 98.7% and breakage rate of 0.26%, employing the fundamental principle used for cereal threshers.

K. Desta et al. designed a sorghum thresher that can process 188 kg/h based on specific physical properties. The thresher underwent fabrication and evaluation to assess its performance in terms of threshing and cleaning efficiency, visible damage, germination percentage, and sieve loss. Test results suggest that for optimal performance, the thresher should run at a cylinder speed of 400 rev/min, with a cylinder-concave clearance of 7 mm, and a feed rate of 6 kg/min. The power needed to operate the thresher under these conditions was 5 kW, resulting in a maximum output of 162 kg/h.

Glancey et al. (1996) have made a significant breakthrough by developing a stationary threshing machine specifically tailored for green peas and lima beans. This remarkable machine was created by modifying the FMC model 011-LV green pea and lima bean combine. Its primary objective is to facilitate the evaluation of yield in extensive trials of green peas and lima beans, which are cultivated in the challenging climatic conditions characterized by high temperature and humidity in Delaware. Furthermore, this machine will serve two additional purposes: firstly, to conduct an in-depth analysis of the threshing characteristics of peas and lima beans, thereby providing valuable insights into conventional combine threshing methods, and secondly, to evaluate the threshing characteristics of different varieties of peas and lima beans**.**

Magar et al. (2009) have designed a groundnut thresher with a square beater bar drum type, consisting of a feed hopper, threshing unit, cleaning unit, and power transmission unit. In their trials, they evaluated the performance of the developed square beater threshing drum with a 50 mm concave clearance, as well as the existing flat plate beater threshing drums, at three different plant moisture contents: 21.30%, 18.40%, and 16.10% (w.b.) for the SB XI variety of groundnut. The thresher had an average feed rate of 660 kg/hr. At a plant moisture content of 16.10% (w.b.), an average sieve loss of 7.4% was observed. Additionally, the highest blown pod percentage of 4.89 was observed at the same moisture content. The flat plate beater threshing drum caused an average pod damage of 3.12%, which was 36% higher than the average pod breakage of 1.97% caused by the developed square beater bar threshing drum. Furthermore, the developed square beater bar thresher exhibited an average highest threshing efficiency of 97.23%, which was 3% higher than the existing flat plate beater threshing drum at a plant moisture content of 16.10% (w.b.). The average power consumption of the developed square beater bar thresher was 1.54 Kw/hr. By using the developed power operated groundnut thresher, the cost of groundnut threshing was reduced to Rs. 22.71/quintal, resulting in savings of 86.40% in cost and 99.3% in time compared to manual striping.

CHAPTER - 3

MATERIALS AND METHODS

This chapter deals with the materials used and the methodology followed to conduct the research work. The research work was chronologically carried out as per objectives. This research work attempts to develop a smart sprayer. The research work was divided into two objectives. In the first objective development of remote-controlled self-propelled vehicle was designed and developed. Microcontroller, motor driver module, Bluetooth device, DC motor, stepper motor, and wheels of vehicles were selected for this objective. Electric circuit design was also developed for this objective. In the second objective, a spraying unit was developed according to the selected crop. In the second objective pump, nozzle valve, hose, and hose connections were selected. The various methods employed and materials used are presented below under the following subheadings:

3.1 Physical characteristics

3.2 Design consideration

3.3 Fabrication of okra seed extractor

3.4 Sorting unit

3.5 Principle

3.1 Physical characteristics

The dimensions of length, width, thickness, geometry mean diameter and sphericity in Table 1 were recorded as 5.27 mm, 4.67 mm, 3.98 mm, 4.53 mm, and 0.86 mm respectively at a moisture content of 6.10 percent. It is evident that as the moisture content increased, so did the dimensions. For instance, at 8.20 percent moisture content, the mean length, width, thickness, geometry mean diameter, and sphericity was 6.14 mm, 5.38 mm, 4.72 mm, 5.29 mm, and 0.86 mm respectively. Furthermore, at 11.50 percent moisture content, the average length, width, thickness, geometry mean diameter, and sphericity measured 7.29 mm, 6.26 mm, 5.40 mm, 6.15 mm, and 0.85 mm respectively.

Table.2 Average dimensions of seeds with moisture content

Moisture content %	Length mm	Width mm	Thickness mm	Geometric mean diameter	Sphericity
6.10	5.27	4.67	3.98	4.53	0.86
8.20	6.14	5.38	4.72	5.29	0.86
11.50	7.29	6.26	5.40	5.29	0.85

Table 2 presents the findings regarding the average bulk density, true density, porosity, and angle of repose. The results indicate that at a moisture content of 6.10 percent, the bulk density, true density, porosity, and angle of repose were measured as 0.77 g/cm3, 1.30 g/cm3, 40.62, and 26.92°, respectively. As the moisture content increased from 6.10 percent to 11.50 percent, there was a decrease in bulk density, true density, and porosity. Additionally, it was observed that the angle of repose increased from 26.92° to 28.52° as the moisture content increased from 6.10 percent to 11.50 percent.

Table.2 Average of bulk density, true density, porosity and angle of repose with moisture content

Moisture Content, %	BD, g/cm3	TD, g/cm3	Porosity	Angle of Repose, degree (°)
6.10	0.77	1.30	40.62	26.92
8.20	0.74	1.23	39.55	27.52
11.50	0.62	1.01	37.88	28.52

In table 3, the average length, width, and thickness were 3.39, 2.40, and 1.57 mm at the 6.10 percent moisture content respectively. The moisture content increased from 6.10 percent to 11.50 percent with also increased length (5.68 mm), width (4.95 mm), and thickness (4.29 mm). The geometry mean diameter in the range was 2.30 mm to 4.85 mm at the moisture content from 6.10 percent to 11.50 percent. The sphericity was 0.69 to 0.86 mm with the moisture content 6.10 to 11.50 percent.

Table.3 Average dimensions of seeds with moisture content

Moisture Content, %	Length, mm	Width, mm	Thickness, mm	Geometric mean diameter, mm	Sphericity, mm
6.10	3.39	2.40	1.57	2.30	0.69
8.20	5.58	4.53	3.69	4.46	0.80
11.50	5.68	4.95	4.29	4.85	0.86

It shows that in table 4, the bulk density was decreased from 0.645 to 0.569 g/cm3 with the moisture content increased from 6.10 to 11.50 percent. The true density was also decreased with increased moisture content. The porosity was in the range of 41.99 to 37.28 at the same moisture content. The angle of repose was increased from 27.21° to 28.13° at the moisture content 6.10 to 11.50 percent respectively.

Table.4 Average dimension of bulk density, true density, porosity and angle of repose with moisture content

Moisture Content, %	BD, gm/cm3	TD, gm/cm3	Porosity	Angle of Repose, Degree
6.10	0.645	1.112	41.993	27.210
8.20	0.597	1.014	41.104	27.580
11.50	0.569	0.907	37.286	28.130

3.2 Design Considerations

The thresher's material selection was based on design considerations, considering each component's strength, suitability, cost, and reliability. The availability of materials in the local market was also considered without compromising quality, aiming to reduce the overall cost and make the machine affordable. To ensure optimal threshing, the okra's moisture content and the materials' physical parameters to be threshed were considered. Additionally, anthropometric data of end users, such as operation, height, stability, and vibration, were critically considered. Given that the drum shaft would experience various loads, including tension, compression, twisting, and bending, efforts were made to calculate the forces acting on the shaft. A 5.5 horsepower petrol engine was chosen to power the thresher, allowing its usage in villages without electricity and in areas with unreliable power supply from the national grid.

3.3 Fabrication of okra seed extractor

3.3.1 Machine frame:

This is the rigid frame stand made from rectangle hollow pipe which acts as structural foundation upon which other parts are assembled or mounted on. It measures 60 mm x 40 mm with a thickness of 3 mm. The required plates were cut according to the dimensions in the drawing and necessary holes were marked out and drilled at strategic point on the pipe. The main frame was structured out as specified in the detailed drawing and the structure was given a temporary weld for any adjustment in the work process.

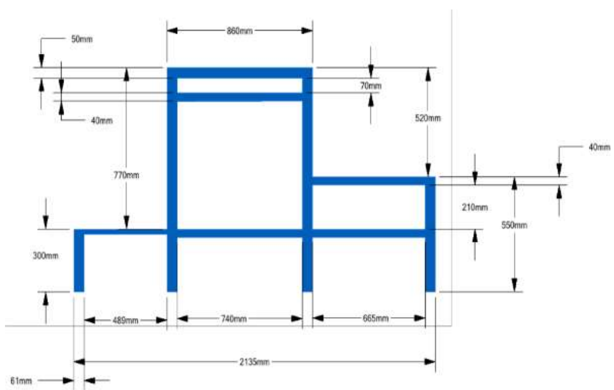

Figure 3.1: Side view of the frame

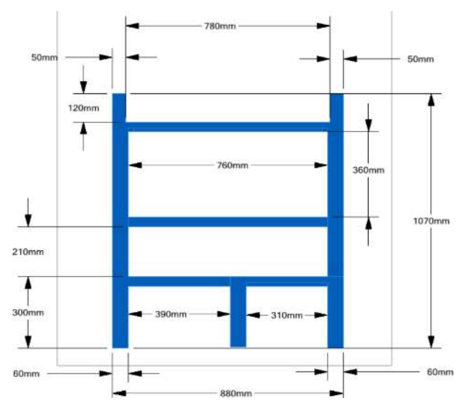

Figure 3.2: Front view of the frame

Plate 3.1: Fabricated frame

3.3.2 Threshing Cylinder:

A square-head bolted drum was created using a mild steel sheet (480mm diameter, 695mm length, and 1.5mm thickness) forming a cylindrical shape with 6mm holes. The drum was fitted with 10mm² section heads, forming 14 and 58 rows. The heads were arranged so the gap between heads and perforation was greater than the width of the okra seed.

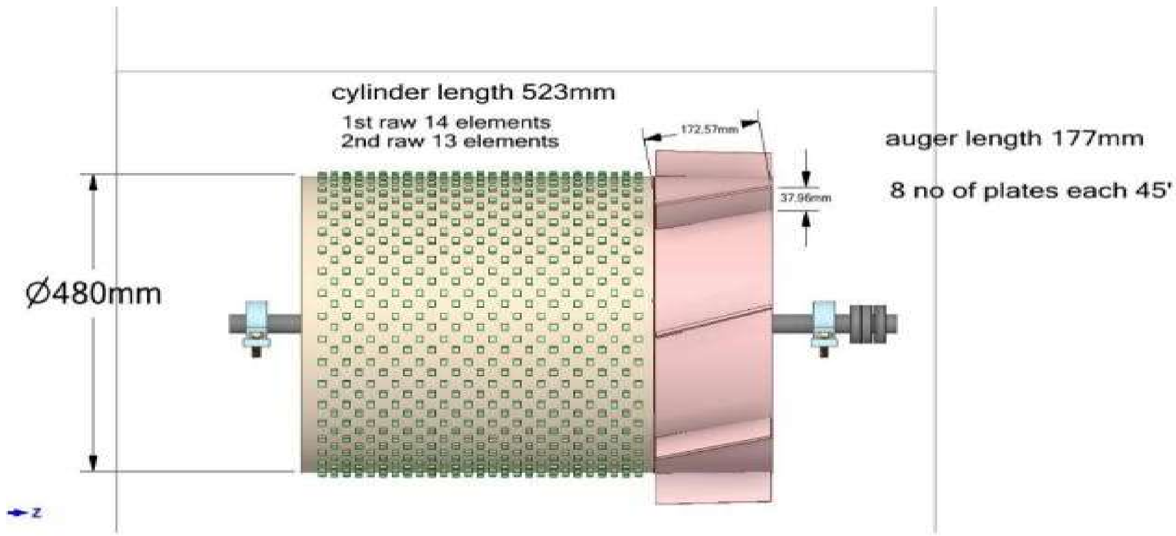

Figure 3.3: Overall Dimension of threshing

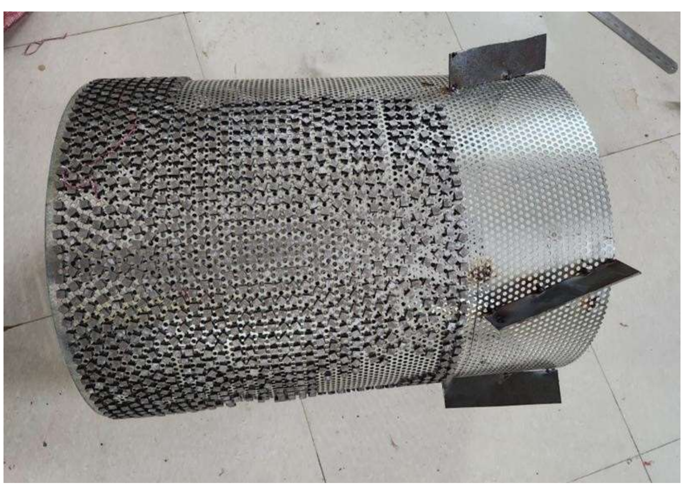

Plate 3.2: Fabricated Threshing Cylinder

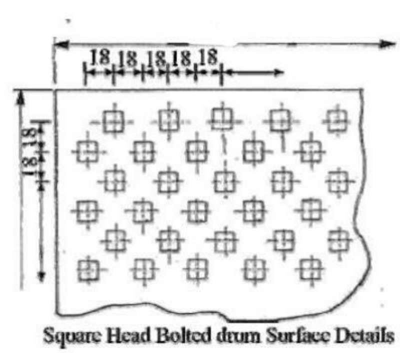

Figure 3.4: spacing of square headed

3.3.3 Concave section: A semicircular concave was created using mild steel flat (size, 35 x 5mm), and a 6mm square bar. The screen was made of 77 longitudinal square bars (size 698mm length x 8mm) and perforated 8mm apart for seed extraction. The concave clearance was adjusted to determine extraction efficiency and seed damage. Three concave clearances (10, 20, 30 mm) were tested using different size spacers.

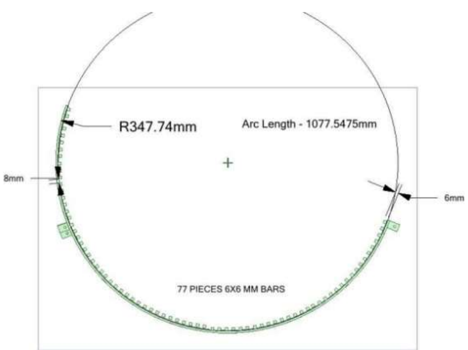

Figure 3.5: Overall dimension of Concave

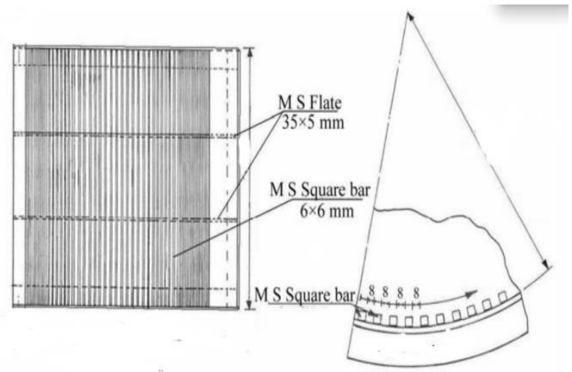

Figure 3.6: Spacing of the square

Plate 3.3: Fabricated Concave

3.3.4 Screen:

There are 2 screens used in okra seed extractor. The screen is made of mild steel sheet with a thickness of 1.5 mm and drilling of 8 mm with 1981 bores and 6 mm _______. It is concave in shape and perforated to allow for the threshed seed and chaff to fall under gravity into the okra outlet where the threshed okras will be finally collected. The screen is located at a distance of 450 mm below the threshing cylinder.

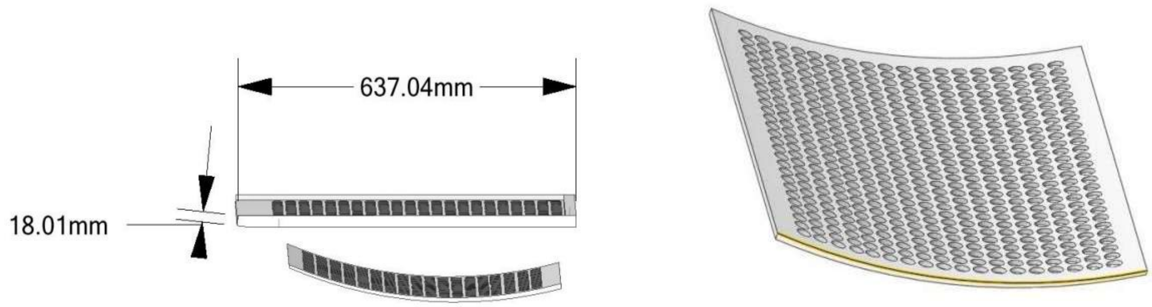

Figure 3.7: Dimension of Perforated sheet

3.2.5 Blower:

It is a straight blade centrifugal fan with six blades of 1.5 mm thick, 680 mm length and 130 mm width. The fan is stationed at the distance of 640 mm below the perforated concave screen to separate okra seeds from the chaff. The exit of the fan is at right angle to the direction of flow of seeds and chaff from the threshing unit.

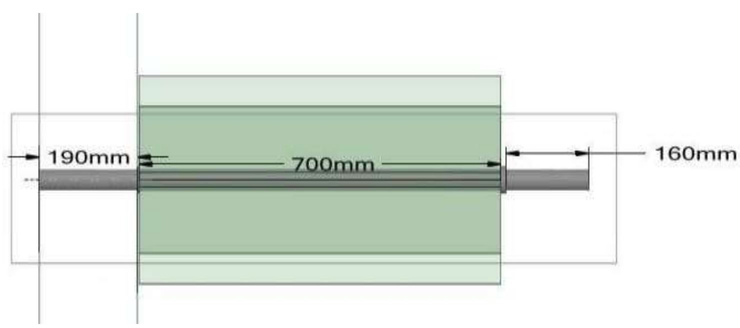

Figure 3.8: 3D model of the Blower

Plate 3.4: Fabricated Blower

3.2.6 Bearing housing:

The bearing housing was made from a thick mild steel pipe, which was properly and carefully matched with the diameter of the required bearing to ensure proper fittings. The bearing housing was bolted to both ends of the frame in other to accommodate the shaft.

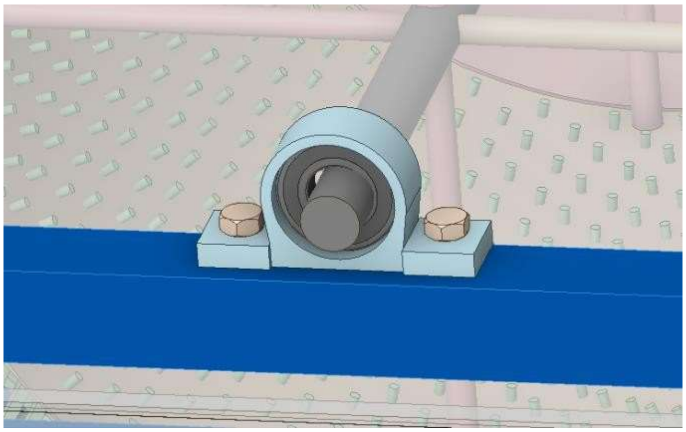

Figure 3.9: Bearing

Plate 3.5: Purchased bearing

3.3.7 The chaff outlet:

This outlet is situated at the right side of the machine. It has a rectangular shape and is directly below the threshing chamber for the chaff to be easily discharged.

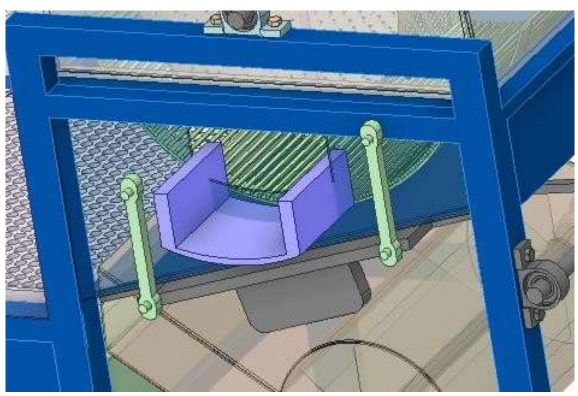

Figure 3.10: Chaff outlet

3.3.8 Okra outlet:

The beans outlet is situated on the left side of the machine. It was fixed at an angle of 45^0 to allow easy discharge of the shelled beans.

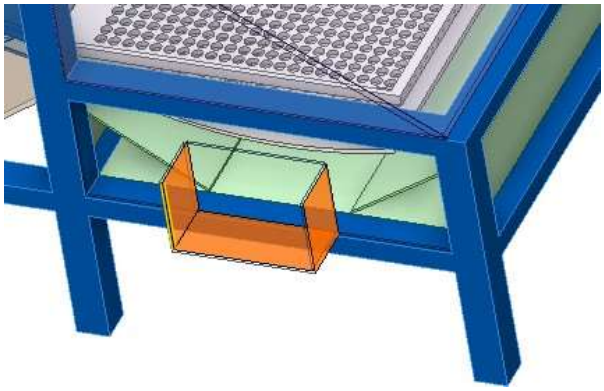

Figure 3.11: Okra Outlet

3.3.9 Collector:

The fabrication process of the collector was similar to that of the screen; except that the collector has no perforation on it. The collector was fitted at an inclined angle of 45^0 with an outlet, which enables the threshed okra seeds to roll down at 40^0 towards the collection outlet to avoid any leftover grains remaining on the surface of the collector.

Figure 3.12: Storage

Plate 3.6: Fabricated storage unit

3.3.10 Hopper and Housing:

This is the feeding unit of the machine. It is made up of a mild steel sheet of 3 mm thickness. It was cut and bent with a cutting and bending machine to form a trapezoidal shape of the hopper and then welded at the edges. The hopper has an upper length and width of 480 mm x 215 mm and a lower length and width of 520 mm x 215 mm respectively with a height of 300 mm.

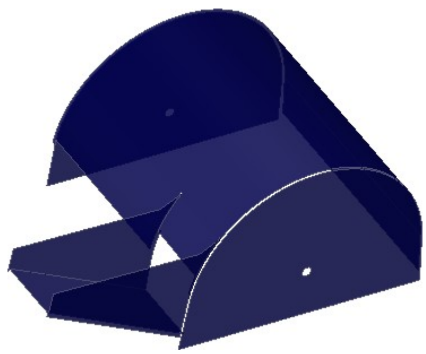

Figure 3.13: Hopper and housing

3.3.11 Power Transmission:

Honda Iron Gx160 5.5Hp General Purpose Engine having 2500 rpm was used to drive cylinder, blower and oscillating sieve assembly using V-belt-pulley arrangement. The engine is mounted on a base frame. A driving pulley of 50 mm diameter was mounted on the engine shaft. Using three different driven pulleys of diameter 375, 320 and 275 mm the cylinder speed was varied. To obtain requisite rpm for blower and oscillating sieve the size of driven pulleys were selected (135 and 390 mm). The cylinder extractor, blower and oscillating sieve were run by a common V-belt. As the distance between the motor and the cylinder was quite large, an idler pulley was provided for causing necessary belt tension.

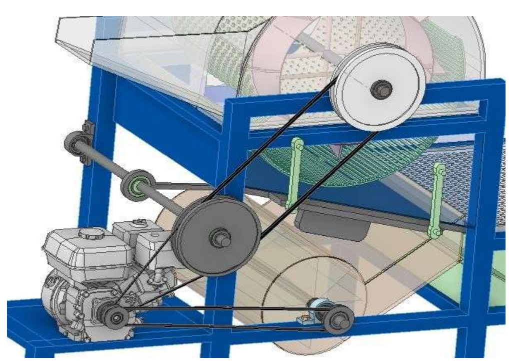

Figure 3.14: Power transmission of the

3.4 Sorting Mechanism:

3.4.1 Microcontroller and hardware unit

The microcontroller acts like a human brain for sensing, interpretation, and action. Similarly, in present study a microcontroller takes information, interprets the information, and sends signal to actuator for open or close the gates for separation of good and bad seeds.

3.4.1.1 Raspberry Pi

The Raspberry Pi is a versatile single-board computer developed by the Raspberry Pi Foundation. It consists of a Broadcom system-on-chip (SoC) with an ARM-based CPU, RAM, GPU, USB ports, HDMI output, audio output, Ethernet port, and GPIO (General Purpose Input/Output) pins. While it's commonly referred to as a "microcontroller" due to its compact size, it's more accurately described as a microcomputer. Raspberry Pi runs various operating systems, including Raspbian (a Debian-based Linux distribution), Ubuntu, and Windows 10 IoT Core. It's widely used in education to teach programming, electronics, and computer science. Moreover, it's popular among hobbyists, makers, and professionals for DIY projects like home automation, media centres, gaming consoles, network services, IoT devices, coding experiments, and scientific research. Its affordability, versatility, and active community support make it an invaluable tool for learning, creativity, and innovation in a wide range of fields and applications.

Plate 3.7: Raspberry Pi

3.4.1.2 HP Webcam W300

The HP Webcam W300 can be used as a camera input device for object detection systems, especially in scenarios where real-time image capture is required. The resolution of the webcam is typically expressed in megapixels (MP) or as the dimensions of the image (e.g., 1920 x 1080 pixels for Full HD). The webcam frame rates include 30 fps and 60 fps. The HP webcams

W300 connect to computers or other devices via USB ports. Some may also support wireless connectivity options such as Wi-Fi or Bluetooth. It comes with various mounting options, such as clips, stands, or tripod mounts, for securing the webcam to different surfaces or devices. It is designed to be compatible with a range of operating systems, including Windows, macOS, and Linux.

Plate 3.8: HP Webcam W300

3.4.1.3 Servo motor

A servo motor can be used to control a sorting mechanism in seed sorting systems. By mounting the servo motor to the sorting mechanism, it can actuate gates or chutes to divert good and bad seeds along separate paths. Integrated with sensors or image processing, the servo motor moves based on predetermined criteria, ensuring precise separation. Programming determines when to open or close the sorting mechanism, directing seeds accordingly. Feedback mechanisms verify successful separation. Through testing, calibration, and maintenance, the servo motor facilitates accurate and efficient sorting, enhancing the automation of seed processing while maintaining quality control.

Plate 3.9: Servo motor

3.4.1.4 Display

An HDMI display in a sorting mechanism provides real-time visual feedback on seed sorting. It showcases live video or images of seeds passing through, aiding operators in monitoring the process. The display instantly presents sorting results, distinguishing between "good" and "bad" seeds based on preset criteria. Serving as a user interface, it allows operators to adjust parameters and configure sorting settings. Additionally, the HDMI display showcases diagnostic information like motor speed and sensor readings, facilitating quick identification of issues. This integration enhances efficiency, quality control, and ease of operation in seed sorting processes.

Plate 3.10: HDMI Display

3.4.2 Working principle:

The sorting mechanism involves several components working together to separate good seeds from bad seeds using a camera module. Here is how each component contributes to the process:

1. Hopper: The hopper serves as a reservoir for the seeds. Seeds are loaded into the hopper, which holds them until they are fed onto the sorting path.

2. Metering Device: The metering device controls the flow of seeds from the hopper onto the sorting path. It ensures that seeds are fed onto the path in a controlled manner, one by one, to facilitate accurate sorting. We are using cell fed type metering device with 10mm cell.

3. Sorting Path: The sorting path is a conveyor or chute system that carries the seeds from the metering device to the sorting area. Seeds move along this path in a single file, making it easier for the camera module to inspect each seed individually.

4. Camera Module: The camera module is positioned above the sorting path to capture images of the seeds as they pass beneath it. It uses imaging technology and software algorithms to analyse the seeds based on predefined criteria, such as size, shape, colour, texture, or defects.

5. Image Processing Software: The camera module is connected to image processing software that interprets the images captured by the camera. The software analyses each seed and determines whether it meets the criteria for being classified as a good seed or a bad seed.

6. Sorting Mechanism: Based on the analysis conducted by the image processing software, the sorting mechanism separates the seeds into different categories. Good seeds may be directed down one path for further processing or packaging, while bad seeds may be diverted down another path for disposal or further inspection.

7. Actuators or Diverters: Actuators or diverters are used to physically separate the seeds based on the sorting results. These mechanisms may include pneumatic air jets, mechanical arms, or conveyor belt diverters that redirect the seeds to different output paths.

8. Feedback System: A feedback system provides information to the sorting mechanism about the classification of each seed. This allows the system to continuously adjust its sorting parameters based on real-time data, improving the accuracy and efficiency of the sorting process.

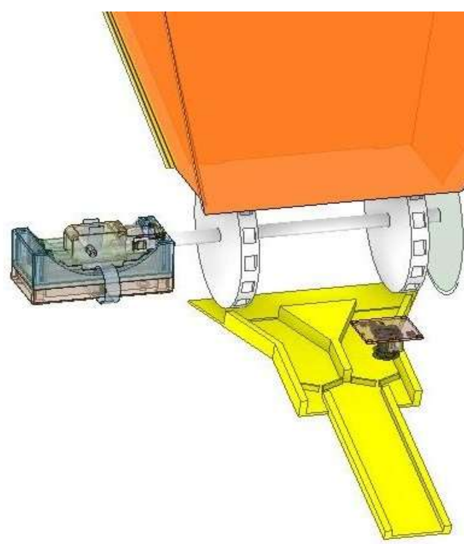

Figure 3.15: Sorting mechanism

3.4.3 Software Methodology:

It describes the workflow for training a YOLOv8 object detection model to sort okra seeds into good and bad categories using RoboFlow and Google Collab, and then deploying the trained model on a Raspberry Pi. Here is a breakdown of the steps involved:

- **Image Collection:** Capture images of okra seeds using an HP Webcam W300 camera.
- **Annotation:** Use RoboFlow software to annotate the images, labelling them as "good" or "bad" seeds.
- **Dataset Creation:** RoboFlow software automatically creates a dataset of annotated okra seed images.
- **Data Preparation:** Upload the created dataset to Google Drive and extract it to Google Collab, a cloud-based Python development environment.
- **Model Training:** Train a YOLOv8 object detection model on the annotated dataset using Google Collab's GPU resources. This involves feeding the annotated images into the YOLOv8 model and adjusting model parameters to improve performance.
- **Model Evaluation:** Evaluate the trained model's performance on a separate validation dataset to assess its accuracy and effectiveness in detecting good and bad okra seeds.
- **Model Deployment:** Once satisfied with the model's performance, upload the trained dataset to the Raspberry Pi, enabling it to perform real-time object detection on new images captured by the camera.
- **Real-time Sorting:** Use the deployed model on the Raspberry Pi to sort okra seeds as they pass through the object detection system. The model identifies whether each seed is "good" or "bad" based on its appearance.

By following this workflow, we have automated the sorting of okra seeds using machine learning and computer vision techniques, improving efficiency and accuracy compared to manual sorting methods.

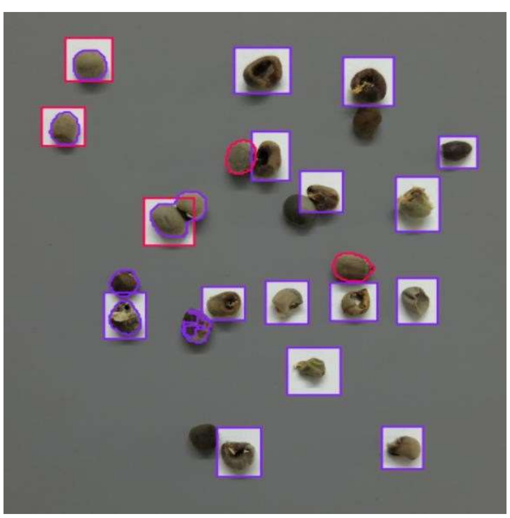

Plate 3.11: Annotating of collected

Plate 3.12: Training of Dataset using

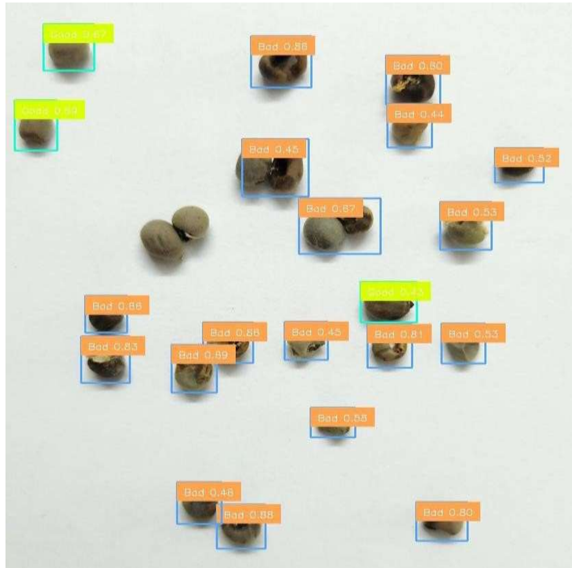

Plate 3.13: Result of the model in RoboFlow

3.5 Principle of Operation of the Machine

The unthreshed okra dried to a desired moisture content of a known quantity are to be fed into the threshing unit of the machine through the hopper after starting the prime mover (petrol engine) that drives the machine and the blower. The petrol engine transmits power to the shaft assembly for rotation. As the mechanism of the threshing drum rotate, it sets up a reaction in the threshing unit, the okra seeds are forced out of their pods due to inner locking movement of the square bolt on the threshing drum and the housing of the machine. This is due to the rubbing action that is set up between the bolts and the okra that come into close contact in the threshing unit. After this reaction in the threshing unit has taken place, the threshed seeds together with the chaffs fall on the surface of the screen under before the blower incorporated in the machine blows the chaff from the okra seeds. The seeds then fall to seed outlet whereas chaffs fall to chaff outlet for collection. After that the separation of good and bad quality seed done. A hopper, metering device, sorting route, camera module, image processing software, sorting mechanism, actuators or diverters, and feedback system are all part of the seed sorting mechanism. The metering system regulates the flow of seeds, and the hopper acts as a reservoir for them. Seeds are transported from the metering equipment to the sorting area via a Chute system called the sorting route. The camera module takes pictures of seeds and uses preset criteria to analyse them. After that, the program examines the photos to see if the seeds satisfy the requirements for categorization. In accordance with sorting outcomes, actuators, or diverters physically separate seeds. Real-time data is provided by a feedback mechanism to increase the sorting process's precision and effectiveness.

CHAPTER - 4

THEORETICAL CONSIDERATIONS

4.1 General introduction

This chapter describes about the calculation and theoretical aspects considered for developing the smart sprayer for crops. Calculations are conducted based on agronomical data and the desired outcome from smart sprayers. Precalculated calculations are extremely important in the selection of parts, materials, and components.

4.2 Design Calculations

i. Diameter of the threshing drum

The diameter of threshing cylinder was determined to know the capacity of the threshing drum. A standard formula for calculating the volume of cylinder was used and is given as follow:

$v = \frac{\pi d^2}{4}$ x L...(1)

$d = \sqrt{\frac{4v}{\pi l}}$ ……………………………………………….(2)

Where V = volume of the drum, mm^2 , d = diameter of the cylinder, mm, L = length of the cylinder, mm.

ii. Weight of threshing drum

The weight of the threshing drum was determined in order to know the amount of load being exerted on the shaft by the threshing drum. The weight of the threshing drum is expressed as:

W = Mg ....(3)

M= ρv .... (4)

Where W = weight of threshing drum, N, M = mass of threshing drum, kg, g = acceleration due to gravity, m/ s^2 , ρ = density of the drum, kg/ m^3, v = volume of the cylinder, m^3 .

iii. Maximum bending moment on both vertical and horizontal loading

Maximum bending moment on both vertical and horizontal loading was obtained using the equation as given by.

$M_b = \sqrt{(M_{DV})^2 + (M_{CH})^2}$ ....(5)

Where M_b = Maximum bending moment on both vertical and horizontal loading, Nm, M_{DV} = Bending movement on vertical loading, M_{CH} = Bending movement on horizontal loading.

iv. Torque exerted on the driven pulley

The torque required to transmit the belt was determined using the equation provided by ;

$T = (T_1 - T_2) R$.................................(6)

Where T = Torque supplied to the driven pulley, Nm, T_1 = Tension in the tight side of the pulley, N, T_2 = Tension in the slack side of the pulley, N, R = Radius of the driven pulley, mm.

v. Diameter of the shaft

The equation of a shaft having little or no axial loading was used to compute the diameter according to as shown in Equation .

$d = \frac{16}{\pi s_a} \sqrt{((k_b M_b)^2 + (k_t M_t)^2)}\,\frac{1}{3}$ ……………………..(7)

Where, d = diameter of the shaft, mm, M_b = bending moment, Nm, K_b = combined shock and fatigue factor applied to bending moment, K_t = combined shock and fatigue factor applied to torsional moment, S_a = allowable stress, N/m^2 . For rotating shaft where load is suddenly applied (minor shock), stated that K_b and K_t range between 1.5 to 2.0 and 1.0 to 1.5 respectively.

vi. Second polar moment of the area of the shaft

The second polar movement of the area of the shaft was calculated using the expression according to

$\tau = \frac{\pi d^4}{32}$ …………………………………….(8)

J = second polar movement of the area of the shaft, mm^4 , Ds = diameter of the shaft, mm

vii. Torsional shear stress on shaft

Torsional shear stress on shaft is given by

$$\tau = \frac{Tr}{J} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where τ = Torsional shear stress, N/m2 , J = second polar movement of the area of the shaft, mm4 , ds = Diameter of the driven shaft, mm.

viii. Torsional rigidity

The amount of twist permissible is given by

$$\theta = \frac{TL}{CJ} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(10)$$

Where, L = Length of shaft, mm, θ = Angle of twist in radians, T = Torque or twisting moment on shaft, N/m, C = Modulus of rigidity, N/mm^2 , J = Second moment of area of the section about its polar axis or polar moment of inertia.

ix. Strain energy in the shaft

The strain in the shaft due to torsion as shown in the equation (11) is given by

$E_s = \frac{1}{2} T\theta$.....................................(11)

Where E_s = Strain energy in joules, T = Torsion on the shaft, Nm, θ = Radian deformation (angle of twist)

x. Belt and pulley drive mechanism

The thresher requires two pulleys for operation: one pulley will be attached to the petrol engine (driver) and the second pulley will be attached to the shaft (driven) carrying the okra threshing compartment and beaters. The intended ratio of the speed driven pulley to that of the driver is 2:3. The relationship shown in equation (12) below was used to determine the transmitted speed as provided by :

$N_1D_1 = N_2D_2$..(12)

Where N_1=rpm of the petrol engine, D_1=Diameter of petrol engine (driver) pulley, mm, N_2=rpm of the driven pulley, D_2=Diameter of driven pulley, mm.

xi. Angular speed of the driven shaft

The angular speed of the driven shaft was calculated using the following equation as provided by

$W_2 = \frac{2\pi N_2}{60}$…………………(13)

Where W_2 = Angular speed of the driven shaft, rad/s, N_2 = rpm of the driven pulley

xii. Velocity of the belt

The velocity of the belt was calculated using the expression according to as:

$V = \frac{\pi D_1 N_1}{60}$ …..…………(14)

Where V = Velocity of the belt, m/s, D_1 = Diameter of the driver pulley, mm, N_1= Speed of the motor, rpm.

xiii. Power requirement to drive the machine

The maximum power transmitted by the belt is given by:

$P = (T_1 - T_2) V$ ....(15)

Where: P = Power transmitted by belt to drive the machine, kw, T_1 = Tension in the tight side of the belt, N, T_2 = Tension in the slack side of the belt, N, V = Velocity of the belt in m/s.

xiv. Pulley Centre Distance

The centre distance was determined using the expression established by as:

$c = \frac{D_2 + D_1}{2} + D_1$ ……………………(16)

Where: C = Centre distance between the threshing drum shaft pulley and the motor pulley, mm. D_1 = Diameter of the petrol engine pulley in mm, D_2 = Diameter of the driven pulley in mm.

xv. Length of belt required for power transmission.

$l_b = \frac{\pi}{2}(D_1 + D_2) + \frac{(D_2 - D_1)2}{4C} + 2C$ .... (17)

Where: L_b = Length of the belt in mm, D_1 = Diameter of the petrol engine pulley in mm, D_2 = Diameter of the driven pulley in mm, C = Centre distance between the threshing drum shaft pulley and the motor pulley, mm.

xvi. Angle of contact between pulleys and the belt.

The contact angle α1 and α2 for small and large pulley respectively may be calculated as given by :

For the driver,

$a_1 = 180 + 2 \propto$ ……………………(18)

$where, a = sin^{-1} \left(\frac{D \ -D}{2C} \right) = 180 + 2(sin \quad \frac{D_2+D_1}{2C}$

For the driven

$a_2 = 180 + 2 \propto$ ……………………(19)

xvii. Size of belt required for power transmission

According to British Standard (B.S. 1440:1979) the V-belts are made in seven types i.e. A, B, C,D,E,Y and Z. Selection A, B, C, D, and E are designed for heavier industrial requirements whereas the Y and Z sections are for single belt drives on domestic and lightly loaded equipment. Hence, standard V-belt with the following nominal cross-section in accordance with B.S. 1440:1979 will be adequate. Cross-section Area, Y, Nominal top width = 6.5mm Nominal height, T = 4mm.

xviii. Centrifugal tension in the belt

The tension on both sides of the belt could be obtained from the following expressions given by:

$\frac{T_1 - T_C}{T_{2-T_C}} = e^{\mu\theta}$ ……………….(20)

Where: T_c = Centrifugal tension which tends to cause the belt to leave the pulley and reduces the power that may be transmitted.

xix. Belt tension

The tension on the belt was determined using the following relation:

$2.3 log \frac{T_1}{T_2} = \mu\theta$ …………………………….(21)

Where T= Tension on the belt, T_1 = Tension on the tight sight, N, T_2 = Tension on the slack side, N, θ = Angle of wrap.

CHAPTER - 5

RESULT AND DISCUSSIONS

5.1 3D Design of Okra Seed Extractor

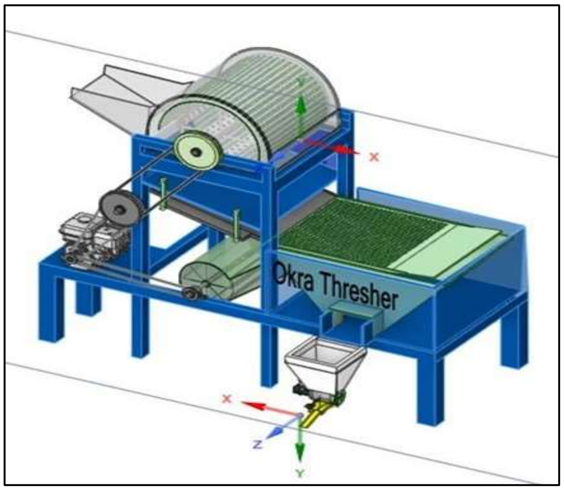

Figure 5.1: Iso View of Okra seed Extractor

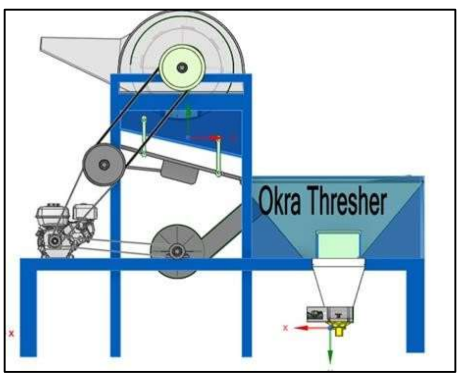

Figure 5.2: Front View of Okra seed

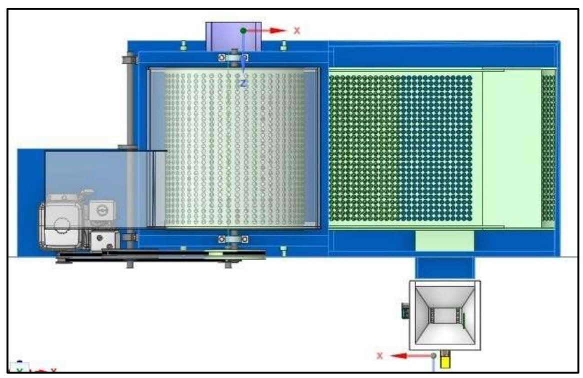

Figure 5.3: Front View of Okra seed

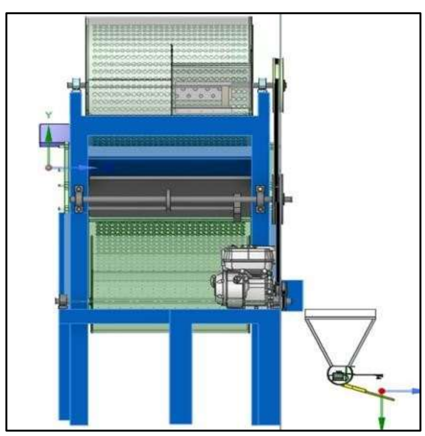

Figure 5.4: Side View of Okra seed Extractor

5.2 COST ESTIMATION OF PROJECT

Table 5.1: Cost estimation of Okra Seed Extractor

SL No	Product Name	Material	Specification	UMO	Quantity	Unit Price	Amount
1	Rectangular Pipe	MS	40 x 60 x 3 mm	Feet	80	118	9440
2	Sheet/ Plate	MS	3ft x 2.5ft x 5mm	Sheet	1	2950	2950
3	Sheet/ Plate	MS	3ft x 2ft x 3mm	Sheet	1	1700	1700
4	Flat Bar	MS	25 mm x 3 mm	Feet	20	18	360
5	Square Rod	MS	8 mm	Feet	80	14	1120
6	Sheet/ Plate	MS	4 x 8 x 3mm	Sheet	3	5450	16350
7	Round Rod	MS	25 mm Dia	Feet	20	1980	1980
8	Round Pipe	MS	25 x 25 x 3 mm	Feet	20	1450	1450
9	Square nut & Bolt	MS	10 x 40 x 6 mm	Nos	1300	19	24544
10	Perforated Sheet	MS	8 ft x 4 ft	Feet	1	4100	4100
11	Pulley	MS	5 x 1B	Inch	1	500	500
12	Pulley	MS	12 x 2B	Inch	1	1900	1900
13	Pulley	MS	16 x 1B	Inch	1	1400	1400
14	Pulley	MS	16 x 2B	Inch	1	2500	2500
					Transport Charges		6000
						Total	**76294**

Cost Estimation in project management is the process of forecasting the cost and other resource needed to complete a project within a defined scope. Cost estimation accounts for each element required for the project and calculate a total amount that determined a projects target.

5.3 FABRICATION WORK

The completion of the fabrication phase of our Okra Seed Extractor marks a significant milestone in our project, showcasing the potential for innovation in agricultural machinery. Our focus has been on creating a machine that addresses the specific needs of okra seed extraction, an area currently underserved by existing technologies. We have successfully fabricated several critical components of the Okra Seed Extractor. The frame, constructed with durable materials, provides a robust and stable structure for the entire machine. This ensures that the extractor can withstand the rigors of continuous operation, essential for both small and large-scale agricultural applications. The blower mechanism, another vital component, has been effectively integrated into the system. This mechanism is designed to facilitate the separation of seeds from the pods, ensuring a cleaner extraction process. By using a controlled airflow, the blower helps to remove lighter debris, enhancing the purity of the collected seeds.

Our innovative sieve system, which includes a reciprocating mechanism with two sieves, has been completed and tested. This system allows for efficient filtration, ensuring that only seeds pass through while larger pod fragments and other unwanted materials are separated out. The reciprocating action ensures thorough processing, contributing to the overall effectiveness of the machine. The cylindrical drum, integral to the feeding mechanism, has been fabricated and installed. It ensures a consistent and even distribution of okra pods into the system, optimizing the machine's throughput and efficiency. Additionally, the storage tank for collecting the extracted seeds has been completed. This tank is designed to hold a substantial volume of seeds, providing a temporary storage solution before further processing.

Despite these significant achievements, some critical components remain to be integrated. The power transmission system, driven by a 5HP Honda motor, is yet to be completed. This motor will provide the necessary power to drive all mechanical components, ensuring the machine operates smoothly and efficiently. Another key aspect pending is the implementation of the image processing system for sorting seeds. This system will use advanced imaging techniques to differentiate between good and bad seeds, enhancing the quality control process. Although this component is currently conceptual and not yet fabricated, it represents a forward-looking approach to improving seed sorting and ensuring only high-quality seeds are collected.

In summary, while the fabrication of the primary mechanical components of the Okra Seed Extractor has been successfully completed, the integration of the power transmission system and the image processing technology remains. Once these elements are finalized, the extractor will be fully operational, offering a comprehensive and innovative solution for okra seed extraction.

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Plate 5.1: Fabrication Work

CHAPTER - 6

CONCLUSION

The development of our innovative okra seed extractor represents a significant advancement in agricultural technology, addressing a crucial gap in the market. This project, characterized by its unique design and functionality, promises to enhance efficiency and productivity in okra seed extraction processes.

The fabrication of the okra seed extractor has been successfully completed, incorporating several key mechanisms to ensure optimal performance. The feeder mechanism, designed with a capacity of 120 kg per hour, ensures a steady and consistent flow of okra pods into the system. This high input capacity is pivotal for large-scale operations, minimizing downtime and maximizing throughput.

Central to the extraction process is the threshing drum, which operates at an optimal speed of 1200 RPM, driven by a 15-inch pulley attached to a 5 HP Honda engine. This drum is designed to effectively separate the seeds from the pods without causing damage, ensuring high-quality seed output.

Complementing the threshing mechanism is the blower system, which is crucial for cleaning and removing unwanted debris. The blower operates at a speed of 1800 RPM, facilitated by a 5-inch pulley, ensuring efficient separation of seeds from chaff and other impurities.

The reciprocating sieve mechanism, featuring two sieves, is driven by a 12-inch pulley attached to the same 5 HP engine, achieving a reciprocating speed of 250 cycles per minute. This mechanism further refines the separation process, ensuring that only the seeds are collected in the storage tank.

The seed storage tank, with a capacity of 120 kg, is designed to hold the extracted seeds until they are ready for the next phase of processing. Although the image processing system for sorting good and bad seeds is currently conceptual, it represents a future enhancement that could significantly improve the quality control process.

In conclusion, our okra seed extractor is a groundbreaking innovation with the potential to revolutionize seed extraction in the agricultural sector. Its robust design, high capacity, and efficient mechanisms make it a valuable tool for farmers and agribusinesses, paving the way for more streamlined and productive operations.

CHAPTER - 7

SCOPE FOR FUTURE WORK

The future work on developing an Okra thresher with a 40 kg per hour output and low cost compared to existing machines can be broadly categorized into several key areas. Design optimization is essential to enhance efficiency, durability, and portability, making the machine more user-friendly and robust. Cost reduction strategies, such as the use of locally sourced materials and streamlined manufacturing processes, are crucial to maintaining affordability without compromising quality. Energy efficiency can be improved through the development of more efficient motors and the integration of renewable energy sources. Incorporating automation and IoT technologies can provide advanced features such as remote monitoring and diagnostics. Additionally, field testing and user feedback will inform iterative improvements, ensuring the machine meets the practical needs of its users. Sustainable practices, including the use of eco-friendly materials and effective waste management systems, should be prioritized to minimize environmental impact. Finally, providing user training and technical support, along with establishing partnerships with agricultural organizations and seeking government subsidies, can facilitate widespread adoption and enhance the machine's impact on agricultural productivity.

CHAPTER - 7

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