

RESEARCH ARTICLE

DESIGN AND FABRICATION OF SOYBEAN GRADER MACHINE

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ABSTRACT

Processing soybeans, for planting and business purposes involves sorting them by size, which is a procedure. In Bangladesh, unsorted soybeans are commonly traded in the market. Selling soybeans after grading would be advantageous for growers and buyers both. Soybeans are graded by hand when needed because there are no automatic graders available. This is an expensive, inefficient, and time-consuming procedure. To provide a workable way of grading marketable soybeans by size, the current study was conducted to develop and build a horizontal swing-type grader for village-level activities. The grading unit, outlet tray, AC motor, and hopper are all fixed to a frame that makes up the grader. The grader was built using resources that could be found nearby to maintain cheap prices. The grading unit was constructed with a mild steel angle bar frame, hopper, and output tray made of mild steel sheet in addition to a stainless-steel sieve. A 1 hp single-phase electric motor was employed as the prime mover, and the rpm was decreased using a 16:1 gearing. These were examined on soybean seeds as independent variables to evaluate how they affected the capacity, power consumption, and efficiency of the grading system. After the data were examined, it was determined that the grader's ideal configuration had a delivery rate of 341.71 kg/hr and an inclination of 12°, which resulted in a power consumption of 229.32 W-hr and a system efficiency of 71.38 percent. The device should be improved further to boost effectiveness and economy as well as to make loading and using it easier.

KEYWORDS

Grader, Angle of Repose, Capacity, Power Consumption, Efficiency

1. INTRODUCTION

Various oil crops, including soybean, mustard, sesame, linseed, sunflower, and groundnut, are grown in Bangladesh. Soybean has become an important oilseed crop in Bangladesh due to the increasing demand for poultry feed in recent years. Among oilseeds in Bangladesh, soybeans account for only 10.5 percent of the total oilseed planted area. Mustard dominates with 65%, followed by sesame, groundnuts, and others (sunflower, linseed) at 11.5%, 11.3%, and 1.7%, respectively (FPMU Report, 2021). According to DAE sources in Laximpur, a total of 46,360 hectares have been brought under soybean cultivation. The districts of Noakhali and Laxmipur have successfully eradicated poverty through the practice of soybean planting on sandy river shoals

In Ramgati Upazila soybeans have been cultivated on 18,700 hectares, compared to 15,500 hectares in Kamalnagar. The rest is being cultivated in Raipur, Sadar, and Ramgati upazila. Soybean seeds contain about 42 to 45% proteins and up to 22% edible oil (Mondal et al., 2002). Soybean quality can be improved by grading it based on its size and color. In the seed processing industry, a Soybean grader is used to sort seeds into several classes, such as good seed, low grade, foreign particles (such as wooden sticks or soybean plant leaves), muck, lightweight, broken seed, and undersized seed. The vigor of seedlings is related to the size and protein content of seeds. According to a researcher, large seeds germinated more readily than medium and small seeds and their seedlings fared better in the field when their survival rate was higher (Weimarck,

1975). The usage of high-quality seed is crucial for both market export and the development of a high-quality crop. The food business places great importance on the quality control procedure. Food products are categorized and graded into various grades based on quality. The main factors used to grade soybeans are their size, texture, color, and shape of grain. The machine's settings for many factors, including bulk density, angle of repose, and coefficient of friction, determine how seeds are graded. The current study aims to develop and build a power-driven inclined grading apparatus to grade soybean seed. This makes the machine appropriate for a wide range of seeds while also improving grading quality and processing efficiency. Farmers in Bangladesh would be able to utilize the grader to grade soybeans. It is planned to be utilized in the seed processing industry to grade seed into several classes, including good seed, low grade, foreign particles (wooden sticks, soybean plant leaves), mud, lightweight, broken seed, and undersized seed with reduced grain loss. Therefore, it is high time to introduce a low-cost soybean grading machine. To address this issue, it is critical to use machine technology to complete the work more quickly and correctly. Thus, this project was done to design and manufacture a soybean grading machine.

2. METHODOLOGY

2.1 Material selection criterion

Materials used for designing this soybean grading machine are ASTM 1020 plain sheets (yield stress of 325 MPa, tensile stress of 535 MPa, and 35 %

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elongation). ASTM A36 Mild Steel (yield stress 235 MPa, tensile stress 375–500 MPa, 23 % elongation). The framework is constructed of gray iron, ASTM A48 Class 30 (cast iron), and 304L stainless steel (SS). Strength,

durability, flexibility, weight, corrosion resistance, capacity to cast, weld, or harden, machinability, electrical conductivity, and availability are some of the most essential properties of materials, as shown in Table 1.

| Table 1: Material selection criteria | |
|--------------------------------------|--|
| Materials name | The Reason for Selection |
| Plain sheet (ASTM 1020) | One of the most used plain carbon steels is 1020. It has a nominal carbon content of 0.20% and a manganese content of approximately 0.50 %. |
| Gray Iron ASTM A48 | It offers excellent vibration and sound-dampening characteristics. Gray Iron pulley enables to use the force in any action, not simply the one in which it is to be applied. |
| Mild Steel (ASTM A36) | Mild steel has good ductility and weldability. Impact strength is high. Cost is Low |
| 304L Stainless Steel (SS) | Excellent corrosion resistance. Does not rust |

2.2 Design consideration

The soybean grader machine was designed using CAD engineering tools SolidWorks 2020 Premium). By design, the machine prototype was built in the Farm Power and Machinery (FPM) department's research workshop at Bangladesh Agricultural University, Mymensingh, Bangladesh. A laboratory test was conducted in the FPM divisional workshop. The following considerations were addressed when developing the machine:

- Easy to operate and maintain.
- The machine was made with locally accessible materials and can dispense seeds of different sizes.
- Ensure seed homogeneity after grading.
- Prevent spilled seed on the sieve using aerodynamics, falling rate, and seed meter height.
- Improved hopper capacity
- Reduced seed damage when sifting and ensure the stability of the machine.

Before constructing the CAD model, it was crucial to consider several components necessary for the design, such as sieve opening size, power required for machine operation, and frame design. The overall width of the machine for hopper storage, the weight of the equipment for easy portability during operation on and off the farm, and the overall height of the machine for ease of operation by a rural farmer are the main design considerations for the entire machine. The material that will be utilized needs to be inexpensive, readily accessible to farmers, robust for the longevity of the machine, and resistant to rust or, if not, paintable. For the machine to operate effectively, its five primary components must be precisely designed and constructed. These include a unit for power transmission, grading, regulating, feeding, and collecting seeds.

2.2.1 Feeding unit

This is where the seed is loaded through the seed meter. This component's design/orientation should prevent any seeds from escaping during sowing. The hopper will be mounted to the machine framework.

2.2.2 Controlling unit

The feeding controlling unit is important as machine performance depends on the feeding rate. The seed hopper opening can be controlled with a nut and bolt system so that vibration cannot affect the opening of the seed hopper.

2.2.3 Grading unit

An oscillating sieve with a swing along the width direction will be used to screen the size of the soybean seed. It consisted of three oscillating sieves with different hole sizes. A guard will be installed on each sieve to prevent the stuck soybean seed during oscillation. The soybean after screening size will be transferred to outlets for each grade.

2.2.4 Determination of angle of repose of soybean seed

The experiment's sieve slopes were chosen with the requirement that angle α be less than or equal to angle φ (Fouda, 2009). The tangent to an angle is the trigonometric ratio of the adjacent and opposing sides of a right triangle containing that angle. The inclination of repose (Φ) was

computed using equation (1) (Gurjar et al., 2017).

$$\Phi = \left(\frac{2h}{d} \right) \quad (1)$$

Where α is the sieve's inclination with the horizontal, and φ is the contact angle among the mixture of seeds and chaff with the sieve surface. As per the condition stated above, the entire material on the sieve would not slide when the sieve was at rest (stationary), i.e., when the velocity of the sieve equaled zero at the end of the strokes.

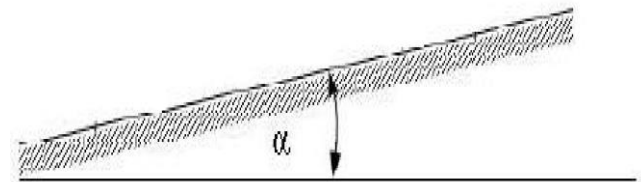


Figure 1: The inclination of the sieve with the horizontal.

According to researcher, the mean value φ (angle of internal resistance) of the grain on mild steel is 20° (Figure 1) (Gebreselassie, 2012). Hence, 8°, 12°, and 15.5° sieve slopes were selected to investigate their effects on the separation and cleaning of the grain and chaff.

2.2.5 Collecting unit

This was arranged based on the required grade of soybean and space between the sieves available above the compartment and there are three outlets in three directions for easy collection of soybean seeds.

2.2.6 Power transmission unit

A power transmission frame was fabricated using an M.S. angle and fitted at the bottom of the mainframe. The power transmission unit was divided into two parts, (a) sprockets-chain arrangement and (b) speed reduction unit.

2.3 Design calculation

2.3.1 Determination of swing power of grading unit.

The swing power of the grader machine according to (Nachimuthu, 2016).

$$Work = Force \times Distance \quad (2)$$

$$Power, P = Force \times Velocity \quad (3)$$

$$Acceleration = m \times w \times r \times \left(\sin \sin \theta + \sin \sin \frac{2e}{n} \right) \quad (4)$$

$$Force = Mass \times Acceleration \quad (5)$$

2.3.2 Determination of average chain velocity (V)

The average chain velocity is given by Sharma *et al.* (2019)

$$\text{Velocity, } V = N \times p \times \text{RPM} \quad (6)$$

Where, V = chain speed, m/min; N = number of teeth on the sprocket; P = chain pitch, m and

RPM = revolutions of sprocket per min.

2.3.3 Determination of speed ratio of chain

The relation between the number of teeth and revolutions between two sprockets is given by (Sharma *et al.*, 2019).

$$\text{RPM}_1/\text{RPM}_2 = N_2/N_1 \quad (7)$$

Where, N₁= No. of tooth on the smaller sprocket; N₂= No. of tooth on the larger sprocket

2.3.4 Determination of chain load or force (Fc)

The average chain load is given by Sharma *et al.* (2019)

$$FC = F + F_c + F_f \quad (8)$$

Where, F_c = Total chain load, N; F = Load due to power transmission, N; F_c = Centrifugal load on-chain, N; F_f = Frictional load, N

Also,

$$F = \text{Power}(kW) \times \frac{1000}{V}, N \quad (9)$$

2.3.5 Determination of horsepower transmitted by chains

The equation of Power (HP) transmitted by the chain is given by (Sharma *et al.*, 2019).

$$HP = P_t \times V/75 \quad (10)$$

Where, HP= Horsepower transmitted; V = Chain Speed, m/s; P_t = Chain pull (tension side), kgf

Also,

$$HP = 500 \times Sf_1 \times f.o.s \quad (11)$$

Where, Q= Maximum breaking load, kg; V Chain speed, m/s; S_{f1} = Chain service factor; f.o.s

= factor of safety

2.3.6 Determination of chain length

The chain link formula (length of the chain) is given by (Sharma *et al.*, 2019)

$$L_p = 2C_p + (N_1 + N_2)/2 + \{(N_2 - N_1)/2\pi\}^2/C_p \quad (12)$$

Where, L_p = Chain link in pitches; C_p= Center to center distance between sprocket and pitches; N₁ = Number of tooth of smaller sprocket; N₂ = Number of tooth of larger sprocket

2.3.7 Determination hopper size

The Seed hopper volume is given by (Sharma *et al.*, 2019)

$$V'_b = 1.1 V_s \quad (13)$$

Where, V'_b = Total seed hopper volume, cm³; V_s = Estimated seed Volume, cm³

Also,

$$V_s = W_s/\rho_s \quad (14)$$

In the equation,

W_s = represents the mass of seeds in the hopper (g) and ρ_s= represents the seed's bulk density (g/cm³).

Putting, V_s = W_s/ρ_s in equation (14) we get,

$$V'_b = 1.1 W_s/\rho_s$$

2.4 Mechanical drawing of the soybean grader

Engineering drawings offer all the details regarding a component's design features. This will be tremendously helpful for engineers in correctly understanding the components. Drawing generates a suitable design on paper with precise dimensions. Figure 2 shows the isometric view of the machine.

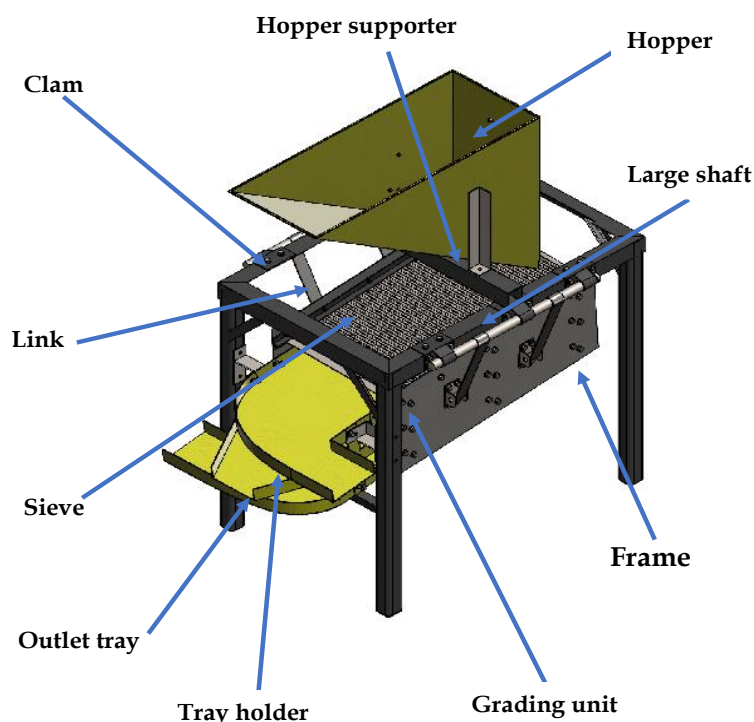


Figure 2: Isometric view of soybean grader machine

2.4.1 The design of the major sections

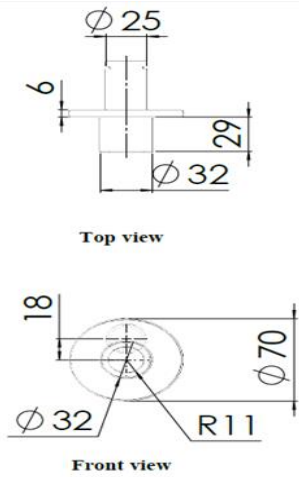


Figure 3: Orthographic sketching of the cam

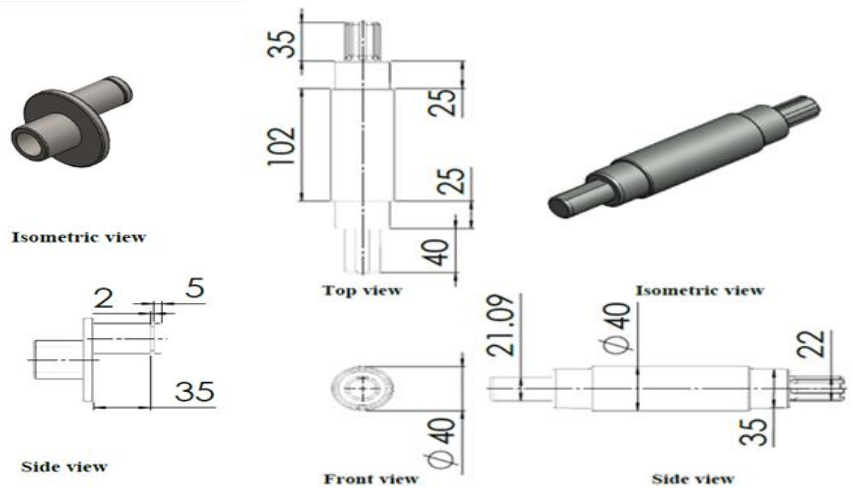


Figure 4: Orthographic view of camshaft

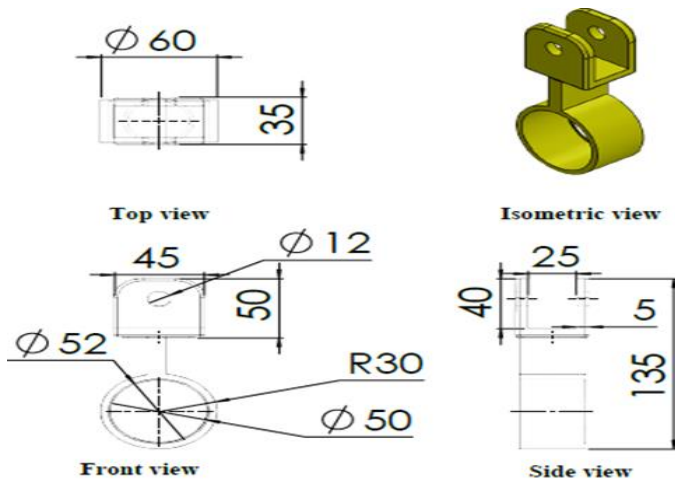


Figure 5: Orthographic view of connecting shaft

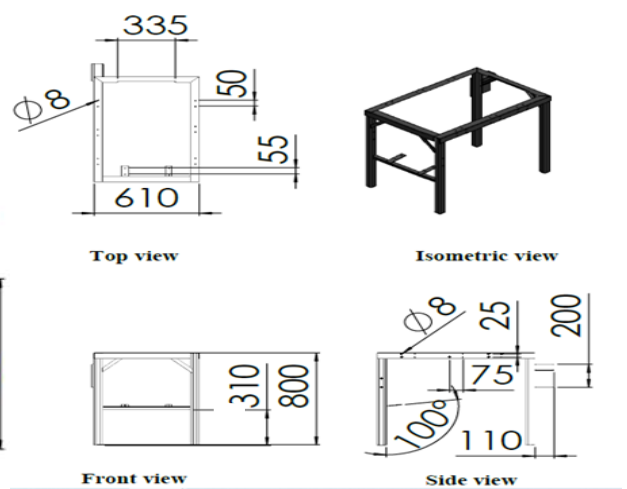


Figure 6: Machine Frame

2.4.2 Welded structure and rotary parts load analysis

A static structural analysis determines the displacements, stresses, strains, and forces caused by loads with little inertia and damping in structures or components. Design engineers consider Von Mises's stress to be safe. An engineer can use this information to declare that his design will fail if the maximum value of Von Mises stress induced in the material is greater than the material's strength. Some analysis of important machine parts was

performed using the CAD software SolidWorks 2020.

Machine frame: Static load analysis with 800 N force and 12 N-m torque was used to determine stress, strain displacement, and factor of safety

Camshaft: The shaft's stress, stress displacement, and factor for safety were determined using static load analysis at 92.175 N-m torque

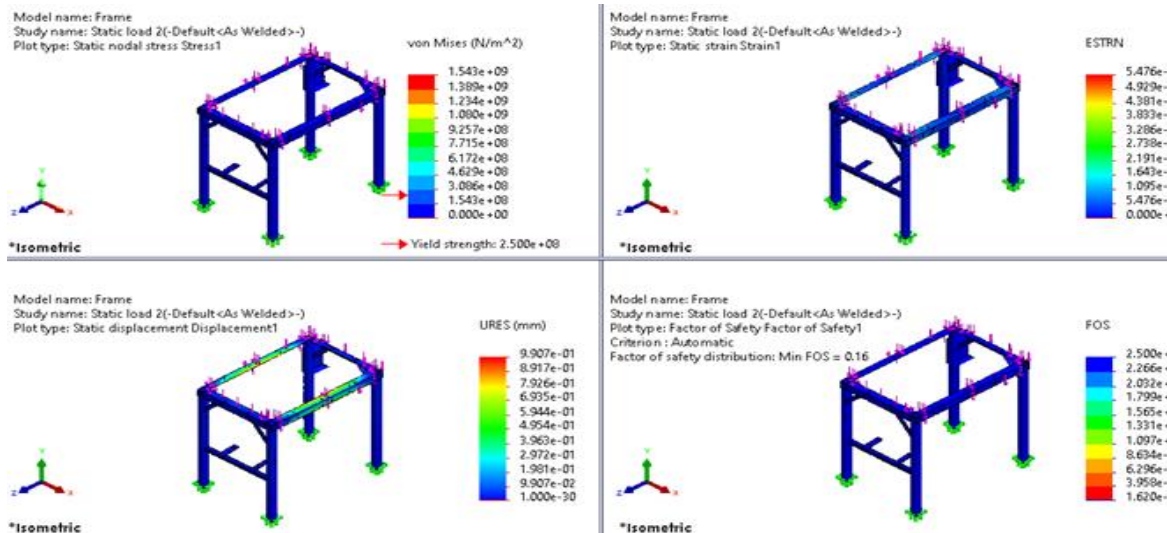


Figure 7: Frame load analysis for 800 N and 92.175 N.m

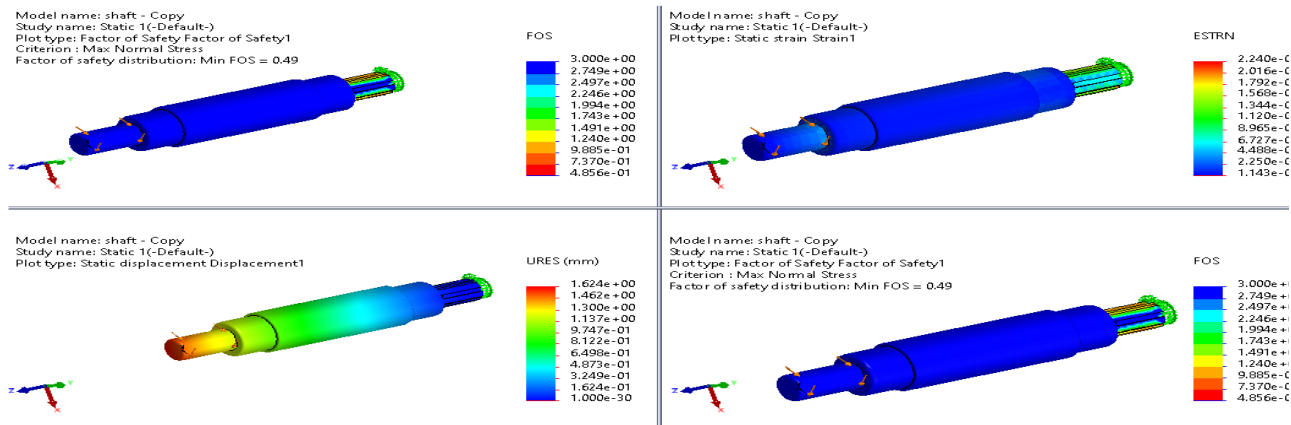


Figure 8: Torque analysis of Camshaft for 92.175 N·m

Cam: The cam's stress, strain displacement, and factor of safety were determined using astatic load analysis with a torque of 92.175 N·m

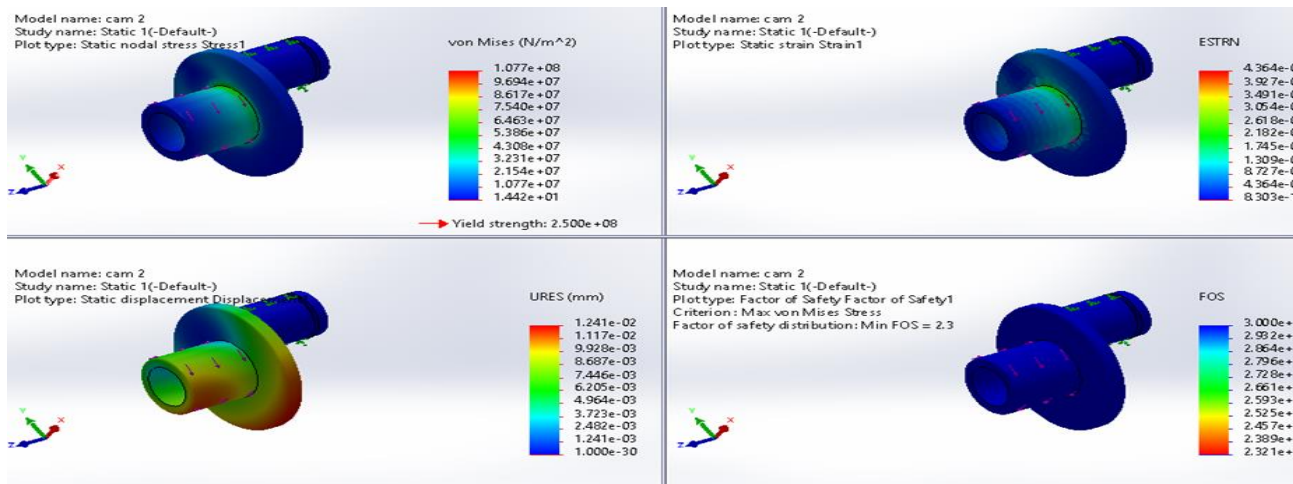


Figure 9: Cam load analysis for 120 N·m

2.5 Performance Test

2.5.1 Design of experiments

The testing strategy for the grading machine's performance test included three distinct storage delivery rates and three distinct sieve angles.

2.5.2 Machine Parameters

The evaluation involved the use of two machine parameters. The hopper's delivery rate was 340.9, 341.71, and 235.73 kg/hr, while the grading unit's inclination was 80, 120, and 15.50 degrees. These machine settings had an impact on the machine's performance during the examination. Machine performance is measured by the grading system efficiency (GSE) in percent and the capacity (C) in kg/hr.

2.5.3 Capacity

The amount of time needed to grade the specified number of tubers was taken into account when determining the grader's capacity. For every trial in this investigation, 8 kg of seeds were employed. According to Eq. 2 (Valentin et al., 2016), the capacity is represented in kg/hr. Where t is the time in hours and W is the amount of seed in kilograms. The unit of expression for capacity is kg/hr. Where t is the time in hours and W is the amount of seed in kilograms.

$$C = \frac{W}{t} \text{ Kg/hr} \tag{15}$$

2.5.4 Electricity consumption

To calculate the electricity usage of the electrical motor, one needs three figures: the wattage of the appliance, the average number of hours used, and the price paid per kilowatt-hour (kWh) of electricity;

$$P=V*I*PF \tag{16}$$

Where, P= power consumed; V= Wattage of appliance; I=Amps consumed; PF= Power factor (considering 0.8) (Cohen, 1983)

2.5.5 Evaluation procedures

Soybean seeds were put into the hopper as they were prepared, while the grading machine swung across the width. During the grading operation, seeds larger than 5.5 mm were retained on the sieve and collected via the outlet, while seeds larger than 4 mm were retained on the second sieve and collected through another outlet. The operation duration was monitored using a timer. Retained seeds on the first sieve and second sieve were graded separately three times to find ungraded seeds during the grading operation. This was done to assess the rating of efficiency of each region, as illustrated in equations 17 and 18 (Valentin et al., 2016).

$$eff_L = \frac{\text{Weight of correctly graded large seed}}{\text{Total weight of medium seed in the sample}} \tag{17}$$

$$eff_M = \frac{\text{Weight of correctly graded medium seed}}{\text{Total weight of medium seed in the sample}} \tag{18}$$

2.5.6 Grading System Efficiency (GSE)

The grading system efficiency was calculated by multiplying the efficiency of big and medium regions, as given in Eq. 19 (Valentin et al., 2016). Where effm is the efficiency, in decimal, of the grader's medium class in classifying medium seeds, and effl is the efficiency of large seeds.

$$GSE = eff_m \times eff_l \times 100 \tag{19}$$

3. RESULTS AND DISCUSSION

This chapter describes the results obtained from the experimental

procedures designed in the methodology section. The results expressed here are based on a relationship between the size of the soybean, and the performance study conducted using the developed machine in respect of grading efficiency. The findings are thoroughly explained in the sections that follow, with special attention to the "fabrication of the grader machine" section. Generally speaking, a grading unit and a power transmission unit make up a federation. The functioning principle additionally demonstrates the noteworthy outcome of the fabricated soybean grader as well as the real operation of the machine as specified.

3.1 Fabrication of the Machine

3.1.1 Machine structure and Feeding unit

Machine frame made with 2" angle bar and jointed with each other by electric arc welding. The hopper is the part where the seed is fed into the sieve. The adjustable delivery unit is based on nuts and bolts and is placed on the machine frame using 10mm nuts and bolts.

3.1.2 Grading unit

A 730mm × 285mm rectangular box for oscillating sieves is made with ASTM A36 material. Two plates are joined with an angle bar along the width direction and 1" angle welded with a rectangular plate for holding the sieves. The soybean after the screening will be transferred to outlets for each grade.

3.1.3 Power transmission unit

A power transmission frame was fabricated using MS angle and fitted at the bottom of the mainframe. Facing and turning operations were carried out on a lathe machine for UCP 207 bearing both sides of the camshaft.

Cam is the main part of the machine which converts rotary motion to reciprocating motion counter cot on the camshaft with an 8 mm nut and bolt and a connecting rod made of MS material with a 6205-bearing housing at one end and a 12 mm drill for the connection unit at the other.

3.2 Working principle

The horizontal swing grader machine is simple to assemble and operate. Parts used in this machine include hoppers, cam and connecting mechanisms, bearings, sieve boxes, and collecting outlets. A cam and connection mechanism are used in horizontal to and for grader machines. The frame includes collection points. A sieve box can be used to store the sieve when the machine starts, the motor transmits power to the chain and sprocket, causing the sieving box to move left and right to perform the sieving process. A horizontal soybean grader is a machine designed to separate particles at various stages based on sieve size. Small sieves, like those used to sift flour, have extremely fine holes. Depending on the type of particles to be separated, use sieves with different types of holes. Sieves are also employed in the separation of stones from sand. A metal plate or plate, or other similar devices, with regularly spaced openings of uniform size, is attached to a suitable frame or holder for use in size separation. The numbers are used to indicate screen size and are typically the approximate number of openings per inch.

3.3 Specifications of the soybean grader

The following are the parts of the researched and tested fabricated soybean grader machine: receiving tray, grading unit, hopper, and power transmission system. The final characteristics of the gadget after fabrication are displayed in Table 11.

Table 2: Specifications of the soybean grader.

| Item | Specification |
|--|---|
| A. Capacity | 341.71 kg/hr. |
| B. Grading Efficiency, % | 71.38 %, |
| C. Main structure. Dimensions include: | |
| Length | 1276, mm |
| Width | 770, mm |
| Height | 1300, mm |
| D. Assembly for grading units | |
| Length | 700 mm |
| Width | 415 mm |
| E. Optimum sieve angle | 12° |
| F. Type of feeding mechanism | Hopper-type manual feeding |
| G. Prime mover | 220 V, a single-phase (1 hp), capacitor-type electric motor |
| H. Gearbox | 16:1 |
| I. Transmission system | |
| Sprocket | |
| Chain | Pitch 19.6 mm, single-acting |
| J. Power consumption | 229.32 W-hr. |

3.4 Performance Evaluation of the grader.

Several characteristics taken into consideration in the study were measured to establish the grader's overall performance

Table 3: Interaction between the grading unit's inclination angle and feeding rate

| Sieve angle (degree) | Capacity (kg/hr.) | Avr. capacity, (kg/hr.) | Standard deviation (SD) for capacity | Efficiency GSE (%) | Avr. efficiency, GSE (%) | Standard deviation (SD) for efficiency |
|----------------------|-------------------|-------------------------|--------------------------------------|--------------------|--------------------------|--|
| 8° | 309.7 | 337.93 | 29.88 | 80.1 | 73.98 | 6.95 |
| 8° | 334.88 | | | 75.42 | | |
| 8° | 369.23 | | | 66.42 | | |
| 10° | 298.6 | 290.5 | 9.13 | 72.38 | 72.86 | 2.53 |
| 10° | 280.6 | | | 75.6 | | |
| 10° | 292.3 | | | 70.6 | | |
| 12° | 310.4 | 341.71 | 30.48 | 75.3 | 71.38 | 10.70 |
| 12° | 343.43 | | | 74.76 | | |
| 12° | 371.3 | | | 59.3 | | |
| 14° | 340.2 | 340.2 | 33.89 | 59.8 | 63.7 | 7.28 |
| 14° | 338.2 | | | 62.5 | | |
| 14° | 342.2 | | | 68.8 | | |
| 16° | 310.1 | 340.96 | 30.12 | 60.12 | 51.68 | 9.89 |
| 16° | 342.4 | | | 51.8 | | |
| 16° | 370.4 | | | 43.13 | | |

The grader's grading capacity and grading system efficiency (GSE) were calculated and examined about the grading unit's inclination angle and feeding rate. The findings of the device's performance evaluation are summarized in Table 3, which is how the performance is affected by the feeding rate and inclination angle combined. The grader's maximum capacity at a 16-degree inclination angle was found to be 370.4 kg/hr, as Table 3 illustrates. However, the grading efficiency at that same period was a pitiful 43.13 percent.

In contrast, the smallest capacity (309.7 kg/hr) was achieved at an 8-degree inclination angle, where the grading efficiency was highest (80.1%). Table 4 indicates that there are variances in capacity and angle of slope along with variations in grading capacity and efficiency. The results of the single-factor ANOVA calculation are summarized in Table 4, along with the capacity's average and variance values for each of the five types of sieve angles.

Table 4: Summary of single-factor ANOVA analysis

| Groups | Count | Sum | Average | Variance |
|---------|-------|---------|----------|----------|
| For 8° | 3 | 1013.81 | 337.9367 | 892.9626 |
| For 10° | 3 | 871.5 | 290.5 | 83.43 |
| For 12° | 3 | 1025.13 | 341.71 | 929.4213 |
| For 14° | 3 | 1020.6 | 340.2 | 4 |
| For 16° | 3 | 1022.9 | 340.9667 | 910.5633 |

In this manuscript, the ANOVA analysis has been done for the capacity of the sieve angle of the soybean grading machine. Table 5 shows significant differences in three trials for each case with p-value. The p-value for this

test is set at 0.1. Since P-value < 0.1 (0.09), so there is a difference between each group of angles. A probability value (P-value) by this we can arrive at a statement that the null hypothesis is accepted or rejected.

Table 5: The Significant difference between the capacity of the sieve angle

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---------------------|----------|----|----------|----------|----------|----------|
| Between Groups | 5952.983 | 4 | 1488.246 | 2.638381 | 0.097255 | 2.605336 |
| Within Groups | 5640.755 | 10 | 564.0755 | | | |
| Total | 11593.74 | 14 | | | | |

3.5 Fabrication cost

Table 6 indicates the cost of fabricating a soybean grader machine, which includes the main frame, outlet tray, hopper, motor, gearbox, and labor

costs. The total cost of the developed soybean grading machine was determined by the materials employed in its construction, as well as its workmanship.

Table 6: Materials for fabrication of components and total cost.

| Materials | Components used for | Amount (USD) |
|---------------------------|-------------------------------------|------------------|
| ASTM 1020 | Outlet tray | \$ 45.68 |
| Gray Iron ASTM A48 | Main Frame | \$ 63.95 |
| Mild steel | For assembly construction | \$ 36.54 |
| 304L Stainless Steel (SS) | Hopper construction | \$ 54.81 |
| Single phase 1 hp motor | Power source | \$ 41.11 |
| Gearbox | Power transmission | \$ 73.08 |
| Angle iron (3 nos) | Framework | \$ 36.54 |
| Workmanship | For the construction of the machine | \$ 73.08 |
| Total cost | | \$ 424.79 |

3.6 Grading System Capacity (GSE)

Figure 10 shows a comparison of mean values, operating the machine at an average capacity of 337.93 kg/hr (Table 3) with an 8-degree inclination and resulting in a grading system efficiency of 73.98% was the optimum combination. Operating at a 16-degree slant resulted in the lowest grading system capacity and efficiency (51.68%). As the grading unit's capacity/feeding rate and inclination grew, the grading system's efficiency gradually declined. This was caused by the soybean seeds going through the grading unit first because the grading unit's capacity and inclination were raised. The effectiveness of the grading mechanism was lowered as a result of some of the tiny soybean seeds moving into the output. The maximum standard deviation (SD) of efficiency (GSE) is observed at a 12° inclination angle (10.70), indicating a significant variation in the values obtained from each test result as well as between the values obtained from each angle. Furthermore, the 10° inclination angle has the lowest SD (2.53)

of all the inclination angles due to the lowest GSE difference.

Fig.10 shows that the highest average grading capacity is 341.71 kg/hr. was achieved when the machine was operated at a 12-degree inclination with a maximum feeding rate of 371.3 kg/hr and an efficiency of 71.38 %. The lowest grading capacity was found when the grader was operated at an angle of 8-degree inclination with a capacity of 309.7 kg/hr with 80.1 % efficiency. The results show that grading capacity gradually increased with increasing the inclination of the grading unit and decreased with decreasing the inclination. This is because the soybean seeds move first through the grading unit increasing the inclination of the grading unit. For this reason, the greater amount of soybean was graded with less time hence the capacity was increased. For the grading operation, it will therefore be important to select a suitable combination based on use and grading efficiency requirement.

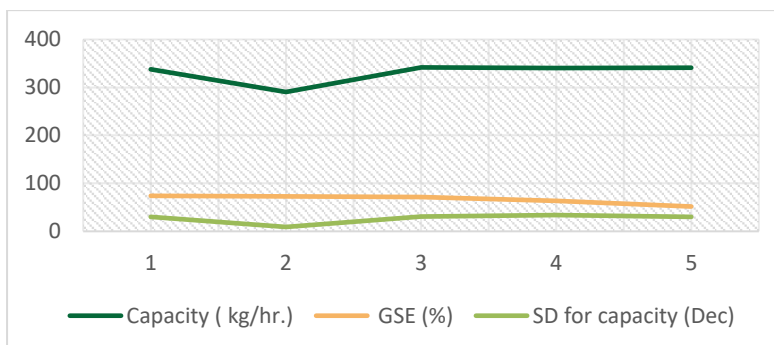


Figure 10. Effect of feeding rate and inclination on grading system efficiency

4. CONCLUSION

An electric motor-operated grader machine was designed and fabricated to grade different sizes of soybeans. As a grading unit, the device employs cam and connecting mechanism swing principles. MS support and SS sieve were used to construct the grading unit. There were two portions to the grading unit. Using a drill, 4 mm perforations were produced in the second part to separate medium-sized seeds and 5.5 mm openings in the first section to separate large-size seeds. A gearbox (16:1) was utilized to lower the rpm of a one-horsepower, single-phase electric motor used as the prime mover. The grading unit received power transfer from the prime mover via chains and sprockets. The manufactured grader's effectiveness was assessed on soybean seeds. The efficiency, capacity, and power consumption of the grading system were all measured. A 12-degree inclination was found to be the machine's ideal operating parameter, resulting in a system efficiency of 74.76 percent, a capacity of 343.43 kg/hr, and a power consumption of 229.32 W-hr. The original cost of the grader was USD 425

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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