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DESIGN AND DEVELOPMENT OF A COST-EFFECTIVE MULTIPURPOSE SIEVING MACHINE FOR AGRICULTURAL APPLICATIONS

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ABSTRACT

Efficient separation of grains from impurities is a critical process in post-harvest agricultural operations. This paper presents the design and development of a cost-effective multipurpose sieving machine specifically tailored for agricultural applications. The machine employs a motor-driven crank-slider reciprocating mechanism to create controlled vibrations that enable the separation of cereal grains based on size. Designed with affordability, ease of use, and durability in mind, the machine is constructed using mild steel to ensure structural strength and longevity. The sieving system utilizes interchangeable wire mesh screens, allowing it to cater to different grain sizes and applications. Emphasis is placed on ergonomic design, minimal maintenance, and reduction in manual labor, making the machine suitable for use in rural and semi-urban settings. Comparative analysis with existing commercial models highlights the economic and operational benefits of the proposed design. The machine demonstrates promising results in improving grain cleaning efficiency while keeping the overall cost low, thus making it an ideal solution for small and medium-scale farmers.

Keywords: Grain Separation, Crank-Slider Mechanism, Agricultural Machinery, Vibrating Screen.

I. INTRODUCTION

One of the critical stages in agricultural processing is post-harvest handling, which involves cleaning, grading, and preparing produce for storage, consumption, or sale. Among the various post-harvest processes, the separation of grains from impurities such as dust, broken particles, husks, stones, and other foreign matter is essential to ensure the quality, shelf life, and marketability of agricultural produce. Traditionally, grain cleaning and sieving have been carried out manually, which is both time-consuming and labor-intensive. Manual methods often lack consistency, efficiency, and hygiene, especially when large quantities of produce are involved. On the other hand, most of the automated grain sieving machines available in the market are designed for large-scale industrial operations and are expensive, bulky, and complex to operate. This creates a gap in accessibility for small and medium-scale farmers, agricultural cooperatives, and rural entrepreneurs who require affordable, compact, and efficient solutions for grain processing. To bridge this gap, there is a growing need for low-cost, efficient, and user-friendly sieving machines that can cater to the needs of farmers at the grassroots level. The development of such machines not only reduces the physical strain on laborers but also enhances productivity, reduces post-harvest losses, and improves the overall quality of the produce.

This research paper focuses on the design and development of a cost-effective multipurpose sieving machine intended for agricultural applications. The machine employs a motor-driven crank-slider reciprocating mechanism, which provides the required vibration and movement to separate grains based on size. It is specifically designed to handle up to 5 kilograms of grains, making it highly suitable for small-scale operations and household use. The sieving machine is fabricated using mild steel, chosen for its strength, availability, and cost-effectiveness. The machine consists of a frame, a reciprocating tray mechanism, sieve, and a collection tray. The screen or sieve is easily interchangeable, allowing the machine to be used for different types of grains such as wheat, rice, maize, pulses, and more. The motion required for sieving is achieved through a crank connected to a small electric motor, which moves the sieve back and forth in a horizontal or slightly inclined direction, facilitating efficient separation of grains and impurities.

An important aspect of this design is its modularity, portability, and ease of maintenance. These features make the machine ideal for use in rural and semi-urban settings where resources may be limited. Additionally, its compact design and low power consumption make it a sustainable and eco-friendly alternative to traditional grain cleaning methods.

II. LITERATURE REVIEW

Joshi Anil Kumar et al. [1] presented the design and fabrication of a solar-based sand sieving machine. Their work highlights the need for an automated solution to filter sand, which is extensively used in construction, manufacturing, and industrial processes. Furthermore, the solar-powered mechanism not only reduces dependence on conventional fossil fuels but also makes it accessible to a broader demographic, including the elderly and individuals with health issues.

A.K. Nachimuthu et al. [2] proposed a horizontal sieving machine also focusing on solar-powered mechanisms. In addition to the machine's physical design, the study incorporates optimization techniques using the Taguchi method to improve welding parameters for the machine's frame. Their analysis revealed that welding speed significantly affects the tensile strength of joints, contributing to the structural integrity of the sieving system.

Ranjit Sharma et al. [3] developed a fully automated sand sieving system that utilizes a reciprocating motion mechanism. Their machine separates coarse particles from fine sand, which is crucial for high-quality construction work, especially during plastering and concrete preparation. A motorized horizontal shaft connected to a mesh filter enables consistent sand flow and efficient separation, thereby enhancing the quality and uniformity of sand used on construction sites.

Ganjar Kurnia et al. [4] evaluated several conceptual designs for a human-powered sand sieving machine. Their approach employed functional decomposition and morphological matrices to identify the most cost-effective and energy-efficient solution. Using a decision matrix, they concluded that a crank-powered design with chain transmission and centrifuge-based sieving offered the best balance of performance and sustainability. The design emphasized environmental friendliness and low production costs, suitable for small-scale or rural applications.

Mr. Pranit S. Patil et al. [5] introduced a multipurpose sand screening machine capable of simultaneously performing drilling, grinding, and sawing operations. Using a scotch yoke mechanism and bevel gears, their design achieves high productivity while conserving electricity and floor space—factors critical in industrial settings where cost and efficiency are paramount.

Prof. A.D. Dighe et al. [6] extended the sieving concept to petal filtration, demonstrating a vibration-based mechanism to separate contaminants from flower petals. Though different in application, the mechanical principles and filtration methodology align closely with sand sieving systems, showcasing the versatility of vibrational sieving mechanisms.

Santosh R. Pawar et al. [7] introduced a multi-level vibrating screening machine utilizing a cam and follower mechanism. This design supports multiple sieving layers, enhancing performance for industrial applications such as mining and agriculture. By separating materials of various sizes, the system improves sorting efficiency and throughput.

Oladeji Akanni Ogunwole [8] designed and tested a dry sand sieving machine, achieving a theoretical efficiency of 97%. His design incorporated V-belt transmission and allowed for multi-layer mesh configurations to sort different particle sizes. The machine proved to be a robust alternative to traditional manual methods, significantly increasing productivity.

Midthur A. Salman Khan et al. [9] developed an automatic sand sieving machine based on a slider crank mechanism. The study focused on reducing human effort and enhancing operational safety. Though compact, the machine delivered around 70% efficiency under normal conditions and was tailored for ergonomic handling and high production rates.

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III. METHODOLOGY

1.1 Materials

Table 1. Bill of Material

Sr.No	Part Nwme	Material / Specification	Quantity / Weight
1.	Hollow Square Pipe	Mild Steel	15 Kg
2.	DC Motor	12 Volt	1
3.	Sieve	Mild Steel	4 Meter
4.	Bearing	High carbon steel	1
5.	Slider	Mild Steel	1
6.	Battery	12 volts, 7ah	1

1.2 Components

1. Motor

The motor is a 50-watt DC motor with a constant operating speed of 60 rpm. It uses carbon brushes to supply current, functioning as an accumulator motor. The motor's speed can be adjusted by varying the current supplied through these brushes. It is foot-mounted and securely bolted to a motor base plate, which is welded to the base frame of the indexer table.

Figure 1: 50 Watt DC Motor.

2. Grit Frame & Sieve

This is the supporting structure that houses the guides for the grit. It undergoes a vibrating motion, allowing the grits to move back and forth along its surface.Grit refers to a mesh or net with holes smaller than the granules we aim to separate. It is used for screening materials. The grit holds the desired particles while allowing the finer, unwanted powder to fall through to the next layer of grit.A perforated metal sheet is a piece of metal that has been punched, stamped, or fabricated to create a pattern of holes, slots, or decorative shapes. Various metals can be used in this process, including steel, aluminum, stainless steel, copper, and titanium. While perforating enhances the metal's appearance, it also provides functional benefits such as protection, filtration, and noise reduction.

Table 2. Types of Grit Used.

Sr.No	Grit	Size (Hole Dia.in mm)	Type of Sieve	Applications / Type of Grains
1.	Grit No.1	5mm		1. Wheat 2. Maize (Corn) 3. Barley
2.	Grit No.2	4mm		1. Rice 2. Wild Rice 3. Millet
3.	Grate No.3	2mm		1. Chia Seeds 2. Teff 3. Fonio

Figure 2 : Supporting Frame.

3. Battery

Sr. No	Parameters	Specifications of Battery
1.	Type	Lead Acid Rechargeable Battery
2.	Voltage	12V
3.	Current	1.3 Amp
4.	Capacity	7.0 AH

4. Slider Crank Mechanism

A crank slider mechanism is a mechanical linkage that converts rotary motion into linear motion. It consists of three main components: a crank, a slider, and a connecting rod that links the crank and slider. It helps to vibrate the sliding mechanism with to & fro reciprocating motion.

Figure 3 : Slider Crank Mechanism.

5. Bearing

Bearings are mechanical components that reduce friction and enable smooth motion between moving parts. They consist of a rotating inner ring, an outer ring, and rolling elements such as balls or rollers. By allowing parts to rotate or slide with minimal resistance, bearings increase efficiency, reduce wear and tear, and support heavy loads.SKF 6207/C3 Deep Groove Ball Bearing. This bearing has an inner diameter of 35 mm, a width of 17 mm, and an outer diameter of 72 mm.

Figure 4 : Slider Crank Mechanism

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IV. DESIGN CALCULATION, MODELING AND ASSEMBLY

4.1 Design Calculations

1. Load Force Calculation

Assume the 5 kg is moved horizontally (no incline).

$F = m \times g$

$F = 5 \times 9.81$

F=49.05 N

2. Torque Requirement

We need to calculate how much torque is needed to drive the crank against the load.

$T = F \times r$

Where, T = torque (Nm), F = force (N), r = crank radius (m)

Crank radius r =0.05 m

$T = 49.05 \times 0.05$

T=2.45 Nm

3. Power Requirement Check

Now check if the motor can supply this torque at the given speed:

$$P = \frac{2\pi NT}{60}$$

Where: P = power in watts, N = speed in RPM (50), T = torque (Nm)

$$P = \frac{2\pi \times 50 \times 2.45}{60}$$

P = 12.83 W

So the motor power required is ~13 W is well within our 60 W motor capacity

4. Crank Length and Stroke Length

If stroke (slider travel) needed is, say, 100 mm (0.1 m), the crank radius should be:

r=Stroke2=0.12=0.05 m

5. Structural Design

Frame and linkage must support at least 5 kg plus dynamic loads.

Use mild steel.

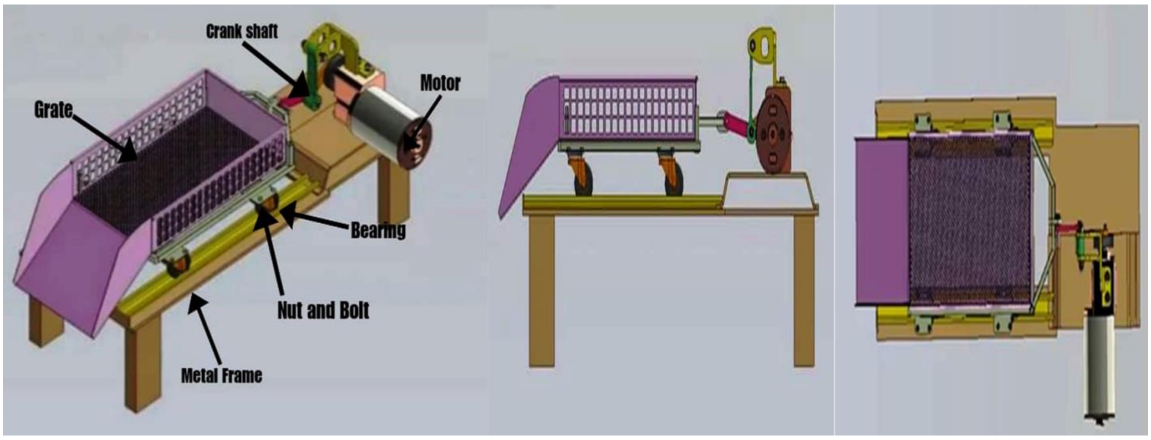

Figure 5 : CAD Model (Different Views)

4.2 Assembly and Installation

1. Base Frame Setup

- Place the base frame on a leveled surface.
- Ensure the frame is rigid and vibration-resistant.

- Weld or bolt the motor mounting plate securely to the frame.

2. Motor Installation

- Place the DC motor on the motor base plate (foot-mounted type).
- Align the motor shaft properly with the crank mechanism.
- Secure the motor using bolts and lock washers.
- Connect carbon brush terminals carefully to the power supply for proper current flow.

3. Crank and Slider Assembly

- Attach the crank arm to the motor shaft using a suitable shaft coupling or key & set screw system.
- Fix the connecting rod between the crank and the slider with pins or bearings.
- Ensure free rotation at joints to reduce friction and wear.

4. Slider & Guide System

- Mount the slider onto linear guides (rails or grooves) fitted on the grit frame.
- Ensure smooth to-and-fro motion by testing manually.
- Apply grease/lubricant on sliding parts.

5. Grit Frame and Screen Installation

- Install the grit frame on the slider.
- Place the perforated metal sheets (grits) in layers, depending on granule separation size.
- Fix them securely with clamps or fasteners.
- Align so that unwanted powder falls through the holes properly.

6. Electrical Connections

- Connect the motor's terminals to a DC power source or controller that regulates current.
- Check brush contact and tightness.
- Use proper fusing and insulation for safety.

7. Testing and Alignment

- Run the motor at low speed to observe the slider motion.
- Check for:
- Smooth oscillating motion.
- No jerks or misalignment.
- Correct separation on grits.

8. Final Checks

- Tighten all bolts and nuts.
- Inspect for unusual noises or vibrations.
- Verify safety guards (if any) are in place.
- Ensure the motor doesn't overheat under load.

ADVANTAGES AND DISADVANTAGES

Advantages

- **Compact Design:** Occupies minimal space with an integrated frame and motor mount.
- **Efficient Separation:** Multi-layer grit frames enhance separation accuracy.
- **Low Power Consumption:** 60W DC motor provides sufficient power at low energy usage.
- **Simple Mechanism:** The slider-crank setup is easy to maintain and operate.
- **Modular Setup:** Easily upgradeable for more grit layers or automation.

Disadvantages

- **Manual Feeding:** Requires manual input of granules unless automated.

- **Fixed Speed:** Although variable speed is possible, in this setup it is fixed at 50 RPM.
- **Limited Load Capacity:** Designed for a maximum of 5 kg; cannot handle bulk materials.
- **Brush Maintenance:** DC motor with brushes may require periodic maintenance or replacement.

V. RESULT

A multipurpose sieving machine is designed to separate materials into different sizes or grades. It successfully demonstrated the ability to separate granules based on size using vibratory motion and perforated grit frames. The motor-driven system operated with consistent rotary motion, effectively translating into the required linear oscillation for grit separation. Noise and vibrations were within acceptable limits due to proper mounting and damping. The result of using such a machine is the classification and separation of materials based on particle size, with different-sized fractions being collected in separate containers or bins.

Key results from using the machine include

- Efficient Separation: Accurately divides materials into desired particle sizes.
- Increased Productivity: Automates the sieving process, leading to faster processing.
- Reduced Labor Cost: Minimizes manual effort involved in sorting materials.
- Consistency: Ensures uniformity in the separated materials, enhancing the quality of the end product.
- Versatility: Can handle a wide range of Grains.

VI. CONCLUSION

- This project focused on the development and evaluation of a material separation machine, analyzing its performance under different motor speeds, screen sizes, and operational durations. The results demonstrated that increasing these parameters significantly enhanced the separation efficiency. The project emphasized the importance of precise fabrication, quality materials, and effective problem-solving throughout the design and manufacturing process.
- The hands-on experience gained during assembly and testing was instrumental in understanding practical engineering challenges. Future enhancements will target cost reduction, improved usability, and sustainable operation. By optimizing energy consumption and using locally fabricated components, the machine aims to support both environmental goals and industrial growth.
- Ultimately, this project lays the foundation for a reliable and efficient separation system that can improve productivity and profitability in various industries. Ongoing innovation and development will ensure the machine remains effective and adaptable to future needs, contributing to long-term industrial sustainability and advancement.

VII. FUTURE SCOPE

- **Automation:** Integration of automatic feeders and discharge systems.
- **Speed Control:** Incorporation of PWM-based motor controller for dynamic speed adjustment.
- **Sensor Integration:** Use of load and position sensors for precision feedback and control.
- **Material Handling Upgrade:** Enhance frame strength and motor power for higher load capacities.
- **Dust Control:** Addition of dust collection system for cleaner operation.

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