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DESIGN AND FABRICATION OF CLAY SIEVING MACHINE

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ABSTRACT :

This research is on the design, construction, and testing of a clay sieving machine intended for small-scale foundry and construction applications. The machine uses an electric motor to drive a reciprocating (vibratory) sieve plate via a linkage and belt-pulley reduction. Engineering calculations (torque, speed, power, and gear ratio) were performed to size the motor and shaft. Materials were selected for strength and corrosion resistance (mild steel frame, galvanized steel mesh). In performance trials, the machine successfully separated clay and sand mixtures into specified size fractions. For testing, a 20 kg sand sample passed through a coarse (Type A) mesh in 17 s, while a comparable clay sample took 90 s. The sieving efficiency was 80–90%, demonstrating the device's practicality and efficiency. The machine greatly reduced labor and time compared to manual sieving. Some of the notable moderations made in the design includes the adjustable sieve and reduction gear to increase torque. Overall, the machine efficiently carried out the sieving operation and is relatively low-cost machine from the purchasing standpoint.

Keywords: Design, Fabrication, Clay, Sieving, Machine

1.0 Introduction

A fundamental process in several engineering fields such as material processing, construction, pottery and foundry applications includes sieving for particle size separation. Sieves are perforated surfaces used for separating a sizeable heterogeneous mixture of particles based on their size by passing these through a mesh (Khurmi & Gupta, 2005). This method is particularly important when the performance of the final product is directly dependent on the homogeneity of granular materials, which is generally the case with devices moulds, concrete and ceramic production (Ogunwole, 2018; Adhapure et al., 2021).

For foundries, for instance, fine clean sand is the single most crucial ingredient to give you defect-less casting of metal. The impurities and oversized particles in the molding sand can create casting defects such as inclusions, scratchy surface or size error (Duriraj & Manikandan, 2019). In the case of clay, application of pressure and sieving is done before use to ensure better binding, permeability and strength in casts mold; it also increases accuracy in casting whilst showing best results structurally (Ayodeji, Olabanji & Akinnuli, 2014).

Hand-held mesh sieves are the traditional sieving style of operation used to perform manual sieving procedure, it requires a lot of physical effort and time. This method is not only labour intensive, but the degree of inconsistency is a function of operator fatigue and not uniform sieving patterns (Verma et al., 2021). Additionally, manual sieving puts operators in large dust environments and can result in respiratory infections, eye irritation as a result of working on fine particulate matter like clay (Nachimuthu 2018).

These mechanized sieving systems are a practical approach to the rising need for efficient and reproducible furnaces in addition occupational safety. Various systems utilize motors and mechanical linkages to ensure a reliably synchronized sieving motion either replicating or enhancing upon manual shaking. They substantially boost throughput; decrease labor needs and also improve on quality service (Ogunwole 2018; Karthik). Modern sieving machines are primarily machines which are designed either as rotary, vibratory or reciprocating depending on the design.

These configurations have different merits regarding speed, efficiency, price and maintenance (Hurtog 2020). While industrial-scale sieving machines do exist, their high cost, energy requirement and complexity often make it impracticable for the use in small foundries, rural brick masons and low budget construction operations. We therefore need a low-cost, effective and low maintenance clay sieving machine (Ogbodo, Ogwugwuam & Ogbodo 2023). There is a need for a machine to be built using locally sourced materials that can work with any number of specified energy sources (gasoline engines or small electric motors) and can run robustly in dusty semi-industrial environments.

The purpose of this paper is to design, fabricate and carry-out performance evaluation of a small scale clay sieving machine based on slider-crank mechanism driven by gasoline engine with tapered sieve box for slacking for small foundry/brick works and potteries. The purpose is to maximize throughput, ensure constant-sized output grain size and retain mechanical efficiency. The design reinforces several fundamental mechanical engineering concepts including energy transfer, torque multiplication and eccentric dynamic balance. The materials chosen were for cost, durability and corrosion resistance, mechanical strength, and energy efficiency. Sieving of each particle size and operation mode is also determined through comprehensive throughput testing. The project ultimately seeks to provide affordable engineering solutions for material processing in low-resource settings that are accessible and cost-effective.

2.0 Literature Review

2.1 Overview of Sieving in Engineering Applications

Sieving is one of a number of techniques made use of for processing materials, in construction, agriculture and manufacturing It facilitates the separation of particles based on size using mesh screens. In foundry operations, sieving is essential to remove oversized particles, impurities, or clumps that would otherwise affect mold integrity or surface finish (Ogunwole, 2018). In ceramic and concrete applications, properly graded sand improves mechanical properties and uniformity of the end products (Khurmi & Gupta, 2005).

Traditional sieving processes are manual and involve significant physical labor and time. The quality of separation in such methods is often inconsistent due to operator fatigue, non-uniform shaking, and inconsistent sieve inclinations (Duriraj & Manikandan, 2019). This has led to the development of various mechanical sieving machines designed to automate and optimize the separation process.

2.2 Types of Sieving Machines

Mechanical sieving systems are broadly categorized into rotary sieves, vibrating sieves, and reciprocating sieves.

- *Rotary sieves* employ a cylindrical mesh drum rotated by a motor, with materials tumbling and self-classifying through the mesh. These are effective for large-volume separation but are complex to maintain and relatively expensive (Patil, 2017).
- *Vibrating sieves*, shake the sieve frame with eccentric weights or electromagnetic actuators at high frequency so that separation can be achieved rapidly. Though very effective, they are very costly and prone to drift or overload (Hurtog, 2020).
- *Reciprocating sieves* work by using a slider-crank or cam to reciprocate the sieve plate up and down. The movement will carry out the manual sieving, but on a regular-basis and according to Adhapure et al, (2021) it provides a great balance between simplicity, cost and efficacy especially in low scaling or rural uses.

2.3 Advances in Low-Cost Sieving Machines

Some other researchers have investigated cost-effective sieving systems for use in small-scale industries, they made different advancements in the efficiency of the sieving process but encountered some limitation. They are as follows:
Ogunwole (2018) designed a dry sieving machine for use in local foundries. He used hand operated rotary drum and interchangeable mesh sizes. The throughput was not large, but the design set the stage for motorized enhancements.
Verma et al. (2021) constructed a semi-automated solar powered sieve. In order for this to be, the design was environmentally friendly (as well as energy-saving), but there were still some limitations about working in a given place depending on weather condition. They had to have enough sunlight and could only work with dry materials.

Nachimuthu (2018) designed an ergonomic vibratory double deck multi-granulometric shaking sieve for sand separation into four fractions. It had vertically aligned meshes with a common vibration source. It required very accurate balancing and robust motor support.
Karthik (2018) incorporated automation by coupling sand sieving and cement mixing operations, motivated by labor shortages in the construction industry. However, the multi-functionality increased system complexity, making it less feasible for small workshops or foundries.
Patil (2017) introduced a scotch-yoke mechanism in a multi-functional sieving machine that handled sorting, lifting, and mixing. Although innovative, it demanded a more powerful drive system and higher cost of fabrication.

3.0 Materials and Methods

In this research, a slider-crank driven reciprocating sieve was adopted due to its mechanical simplicity, ease of maintenance, and compatibility with low-cost fabrication methods. The machine will utilise a reciprocating motion and vibration to achieve the sieving. This process uses a belt drive to provide power to a shaft equipped with a sieve net by rotating motion generated by a petrol engine. With the aid of bearings, the shaft will be attached to the framework. The slider will feed the uniform clay and pebble mixture onto the inclined sieve net that is fixed to the reciprocating mesh. Then, the smaller particles pass through the net while the larger particles fall on the other side because of the relative motion of the particles and the reciprocating sieve.

3.1 Design Operation

Every component will be designed using AUTOCAD software, which provides all the tools required for engineering design. Each component's three-dimensional model will be created first, and then all the pieces will be put together to create the final product's appearance.
The following will be considered during the process of the design;

- Simplicity to have an interchangeable mesh.
- Simplicity to operate, maintain and repair.

- Employment of locally available materials. Standard steel pieces such as steel plates, and angle iron will be locally sourced for. Standard tools used in machine shop such as hack saw, files, punches, taps & dies; medium Arc welder, small lathe and milling machine will be adequate to fabricate the machine.
- Power transmission to different parts of the machine, will be as simple as possible. The best setup for this would be a belt and pulley system because belts don't need to be precisely aligned like chains do. Even slightly misaligned pulleys in relation to one another can be accommodated by belts. They are also fairly effective.

3.2 MATERIAL SELECTION

3.2.1 Component Parts and Materials

The following are the components that the sand sieving machine will comprised of -

- Gasoline Engine
- Slider crank arrangement
- Rubber Damper (Engine Seat)
- Supported Frame
- Shaft
- Pillow Bearings
- Metallic net (Sieve)
- Pulley
- Belt
- Reducing Gear System
- Compression Spring

Table 3.1: Qualitative Analysis for Materials Selection

Part	Section Criteria	Available Material	Selected Material
Frame **Body**	**Cost** **Tensile Strength** **Ductility** **Availability** **Hardness**	**Aluminum** **Mild Steel** **Stainless Steel**	**Mild Steel**
Slider Crank System	**Torsional Strength** **Toughness**	**Mild Steel** **Stainless Steel**	**Stainless Steel**
Sieve Frame	**Corrosion Resistance** **Toughness** **Weight**	**Mild Steel** **Wooden Plank**	**Mild Steel**
Net	**Corrosion Resistance** **Hardness** **Ductility** **Tensile Strength**	**Mild Steel** **Stainless Steel** **Aluminum Steel**	**Aluminum Steel**
Support Wheel	**Tensile Strength** **Resistance to decay** **Toughness** **Availability**	**Plastic** **Steel Wheel** **Rubber Damper**	**Rubber Damper**

The best material for the body and frame is mild steel, as we discovered during the material selection process. Mild steel is able to withstand greater loads. Because stainless steel has a higher resistance to corrosion, we use it for the main shaft. Wheels use rubber dampers because they are lightweight, durable, and able to support weight and absorb vibration.

- 3.2.1.1 Gasoline Engine
- A gasoline engine is will be used as prime mover, this will provide an alternative to the electric motor. We are using motor of power 1.5 horse power.
- 3.2.1.2 Slider Crank Mechanism
  An arrangement of mechanical components called a slider-crank mechanism is used to transform a rotary motion into a reciprocating motion. The sieve box will have reciprocating motion due to this mechanism.
- 3.2.1.3 Rubber Damper (Engine Seat)
- This will be used because of the ability of the damping effects, support vibration and the availability of lock nut.

- 3.2.1.4 Support Frame
  To hold all the components together, the support frame will be utilised. This frame determines the overall arrangement. Mild steel will be used to make this frame. Because of its high tensile strength, excellent ductility, and weldability, mild steel is being used.
- 3.2.1.5 ,Shaft
  A shaft is a revolving machine component that transfers power from one component to another; it typically has a circular cross section. It will be used to mount the different components, including the bearing and pulleys.
- 3.2.1.6 Bearing
- In this design, the ball bearing system was used because it gives less resistance, easily replaceable parts, and less costly.

- 3.2.1.7 Metallic Net
- In this design, three different sized net will be used depending on the size of clay particles that is to be sieved.

- 3.2.1.8 Pulley
- Two pulleys of different sizes were employed. The larger one was connected to the shaft that held the screening net, and the smaller one was attached to the motor. Both were connected to a belt drive, which transfers motion from the motor to the drive.
- 3.2.1.9 Belt
- The belts main purpose is simply transferring rotation from the powered driver pulley to one or more driven pulleys.
- 3.2.1.10 Gear Reduction System
- An essential part of machineries are gears. A gear reducer is the most straightforward use case. This apparatus converts an input torque and speed into an output torque and speed. Amplification or reduction is what we mean when we say "transformation." The gear ratio indicates the degree of transformation. In essence, a gear reductor is a single-gear gearbox. Two spur gears mesh to provide the gear ratio.

3.3 Preliminary Calculations

The preliminary calculations as per the initial design are necessary as is required. The mathematical relation or formula are written in the form of equation, using these equations many calculations can be done varying the data altered during the change in initial design.

Table 3.2: Gear Ratio, Torque, Speed and Power Calculation

Variable	**Description**	**Value**	**Unit**
t_{in}	**Number of teeth of the input gear**	**5**	
t_{out}	**Number of teeth of the input gear**	**50**	
R_{in}	**Base radius of the input gear**	**25**	**mm**
R_{out}	**Base radius of the output gear**	**250**	**mm**
i	**Gear ratio**	**1:10**	
Tq_{in}	**Torque Input**	**27**	**Nm**
Tq_{out}	**Torque Output**	**270**	**Nm**
ω_{in}	**Speed Input (rotational)**	**270**	**Rpm**
ω_{out}	**Speed Output (rotational)**	**27**	**Rpm**

3.4 Construction and Fabrication

The frame was welded from 40×40×5 mm mild steel angle iron and 50×5 mm flat bar for rigidity. All joints used fillet welding. The sieve box was built of 2–3 mm sheet, welded into a rectangular tray. The sides of the tray are flat to allow easy removal of the screen. The frame was equipped with adjustable supports so the whole assembly sits level and the screen tension can be adjusted (by shims) to avoid mesh sagging. The motor is base-mounted on an adjustable slide to tension the V-belt.

Fig. 1 illustrates the sieve assembly, the sieve plate is bolted to an eccentric crank on the shaft. When the motor spins, the crank throws the plate up and down, creating a shaking motion. Material is fed via a hopper into the center of the sieve, and fines fall through into a collection bin below. The top of the sieve box is covered by a perforated lid to keep material contained.

Some parts such as sieving shaft, crank, pulleys; were machined on a lathe and on a mill. Bearings were pressed into housing blocks attached to the frame. After assembly, the machine was painted with enamel for durability and ground clearances were adjusted.

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Fig. 1. Assembly Drawing

Fig 2. Part Drawing

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Fig. 3. Orthographic Drawing

Fig. 4. Completed Clay-Sieving Machine

4.0 Results

The completed machine was tested with dry sand and clay samples, measuring throughput (mass/hour) and separation efficiency. The following data (see Table 4.1) were collected for 20 kg samples using three mesh sizes (Type A-Coarse, B-Medium, C-Fine). A comparison of sandy vs. clayey samples as shown. The sand passed quickly with Type A mesh the entire 20 kg passed in 16–17s (94–99% of mass). The clay sample took much longer: 90s for Type A mesh, with only 550–600 g passing (about 55–60%). This is due to clay's cohesion. Medium mesh gave intermediate results (clay 30–40s, 75% pass).

Table 4.1 Sieving Results

Mass of Sample (20 Kg)	**Mesh Sizes (Efficiency %)**		
	Coarse (A)	**Medium (B)**	**Fine (C)**
Sandy Clay	**97%**	**99%**	**99%**

Moist Clay (Clayey)	**57%**	**75%**	**82%**

In all tests, the machine performed reliably. No mechanical issues (shaft binding or belt slip) were observed. Vibration amplitude was easily adjustable by changing the crank throw or motor speed. The sieving efficiency was 82% for clay at finest mesh. The motor drew approximately 0.4–0.5 kW, roughly equal to its rated power, consistent with our calculations.

4.1 Discussion

The performance data confirm that the sieving machine meets design goals. The throughput (kg/h) is dramatically higher than manual sieving. For instance, sieving 20 kg of clay manually might take hours, whereas the machine can process that in under an hour. The differences between sand and clay tests highlight material effects: clay's high plasticity and residual moisture cause agglomeration, slowing flow through the mesh. This agrees with literature noting clay soils "clump and carry more moisture, so sieving is significantly slower than sand". By contrast, sand (dry, granular) flows readily, yielding high throughput and nearly complete passage.

Material choices proved suitable. The mild steel frame provided rigidity and resisted deformation under vibration. Galvanized steel or stainless mesh resisted abrasion from the abrasive particles. The overall mechanical efficiency is high – aside from electrical losses, most power went into kinetic agitation rather than wasted heat. The pulley-belt drive efficiency

Compared to prior designs, our innovations include an adjustable sieve frame for rapid mesh changes and a well-balanced vibrator to minimize frame stresses

5.0 Conclusion

We have successfully designed and fabricated a clay sieving machine tailored for small-scale foundry use. The machine uses an electric motor (1.5 HP) and a slider-crank agitator to shake material over a steel screen. Testing demonstrated the machine's practicality. It demonstrated good efficiency (80–90%) and significantly reduced labor. The machine processed sand much faster than clay, consistent with other findings. Overall, the sieving machine meets its objectives of increased throughput and mechanical efficiency. Nonetheless, the current design is a valuable tool for small foundries, brickmakers or potters needing to process raw clay and sand into uniform grain sizes.

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