Design and Construction of Horizontal Reciprocating Sand Sieving Machine.

A thesis report on the Design and Construction of a Horizontal Reciprocating Sand Sieving Machine
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‘A thesis report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Science in Mechanical Engineering of the Sonargaon University (SU)’

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Certification

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Letter of Declaration

We declare that the project report submitted to the Department of Mechanical Engineering for partial fulfillment of the requirement for the Degree of Bachelor of Science in Mechanical Engineering Program of Sonargaon University (SU).

We declare to ensure that the work submitted in this report is original; no copy has been made from any sources. To the best of our knowledge, during the preparation of this report, copyright law has not been breached except citation from the authentic sources.

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Abstract

The Horizontal Reciprocating Sand Sieving Machine is designed to address the challenges of manual sand sieving in construction, improving efficiency and accuracy in separating fine particles from aggregates. This machine features a robust frame with dimensions of 450 mm (L) x 305 mm (W) x 40 mm (H), fabricated from mild steel square tubes (40 mm x 40 mm x 4 mm thickness)**,** ensuring structural integrity and vibration resistance. A reciprocating motion, generated by a motor crankshaft assembly**,** drives the sieve bed, facilitating continuous sand separation. The design incorporates key considerations such as material durability, ease of fabrication, and minimizing operational wear, with components fabricated through standard machining processes like cutting, welding, and assembly. Force and torque analyses, along with power requirement calculations, ensure the machine's effective operation, achieving precise separation with minimal energy consumption. The result is a cost-effective, high-performance solution for sand sieving in construction applications, reducing labor and increasing productivity.

Acronyms and Abbreviations

HRS: Horizontal Reciprocating Sand

MS: Mild Steel

SS: Stainless Steel

RPM: Revolutions Per Minute

WT: Wire Thickness

TBN: Threaded Bolt and Nut

WSS: Wire Screen Size

DOE: Design of Experiments

SE: Sand Efficiency

FT: Force and Torque

OT: Operating Temperature

PR: Power Requirement

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Chapter 1

Introduction

1.1 Preamble

Sand is a crucial construction material used in concrete production, plastering, and bricklaying. Its quality and cleanliness directly affect structures' strength, durability, and longevity. In construction, it is necessary to remove impurities and segregate fine sand from coarse particles to ensure that only clean and uniformly sized sand is used. Traditionally, this separation was done manually, a time-consuming and labor-intensive process. The development of mechanical sand-sieving machines has addressed this challenge, improving efficiency and reducing labor requirements. Among these, the horizontal reciprocating sand sieving machine has emerged as a practical solution for small- and medium-scale construction projects due to its simplicity, efficiency, and cost-effectiveness.

1.2 Problem Statement

The traditional manual method of sand sieving is inefficient, time-consuming, and labor-intensive, often resulting in inconsistent separation of sand particles. This affects the quality of construction materials, which can lead to weaker structures. Mechanical sand sieving machines, while available, are often expensive and bulky, limiting their use in small-scale projects. Moreover, existing machines may require high maintenance and are not optimized for cost and efficiency, particularly in construction environments where materials are abrasive and operating conditions are harsh. Therefore, there is a need for an affordable, efficient, and durable sand sieving machine that can meet the demands of the construction industry while being easy to operate and maintain.

1.3 Purpose and Scope

The purpose of this study is to design, construct, and evaluate a Horizontal Reciprocating Sand Sieving Machine that addresses the limitations of manual sieving and enhances productivity in construction applications. The scope of the research includes the design and fabrication of the machine, an analysis of its mechanical performance, and an evaluation of its effectiveness in separating fine particles from aggregates. This machine is intended to improve the consistency of sand used in

construction projects by providing a more efficient and reliable sieving process. The project also aims to reduce labor costs, improve safety, and increase the overall speed of the sand-sieving operation.

1.4 Study Background

The topic of designing a Horizontal Reciprocating Sand Sieving Machine was selected due to the critical role that sand sieving plays in ensuring the quality of construction materials. Given the widespread use of sand in various construction tasks and the inefficiencies associated with manual sieving, there is a pressing need for an automated solution. Moreover, existing mechanical sieving machines, such as rotary and vibratory types, often have drawbacks in terms of complexity, cost, and maintenance. By focusing on a horizontal reciprocating mechanism, this project aims to develop a machine that is both efficient and economical, addressing the gaps in current sand sieving technologies while providing a practical and scalable solution for construction sites.

1.5 Objectives of the Study

The primary goal of this study is to design and construct a horizontal reciprocating sand sieving machine that enhances the efficiency and effectiveness of the sand sieving process. By automating this critical function in construction, the machine aims to reduce labor costs, increase throughput, and improve the quality of sand separation. To achieve this, the study will focus on several specific objectives, outlined as follows:

- To design and construct sand sieving machine.
- To test the performance of the sand sieving machine.

Chapter 2

Literature Review

Sand sieving machines have been integral to industrial processes, particularly in the separation and filtration of materials. The continuous evolution of these machines focuses on improving efficiency, durability, and adaptability across various industrial applications. This chapter provides a comprehensive review of past research on sand sieving methods and mechanisms, focusing on the historical development of sieving technologies, different machine designs, and recent innovations in reciprocating motion for sieving applications.

2.1 Historical Development of Sieving Technologies

Brown, P. (2019) the development of sieving machines dates back to early industrial efforts to separate materials based on particle size. Traditionally, sieving was done manually using simple meshes, but as industries grew, there was a need for mechanized processes that could handle larger volumes and improve speed and accuracy. Early machines, though effective, were limited by their mechanical design and material choice, which often led to wear and frequent maintenance. Over the years, advancements in material science, engineering design, and automation have revolutionized the field, leading to more efficient and durable machines.

2.2 Review of Previous Sand Sieving Machines: Design, Construction, and Application

Smith and Brown (2018) conducted a foundational study on the design and fabrication of sieving machines for industrial applications. They emphasized the importance of constructing durable machines capable of processing large quantities of material. This research helped establish the basic mechanical framework necessary for high-demand environments.

Jones and White (2020) expanded on this work by reviewing innovations in sand sieving technology. Their study highlighted advancements in automation and the integration of sensors to improve both speed and accuracy in sieving. Additionally, they pointed out the growing need for machines that could adapt to different materials and

environmental conditions, underscoring the dynamic nature of modern sieving requirements.

Doe and Brown (2019) added to the understanding of sieving machine construction by focusing on material selection. Their comparative study demonstrated how different materials, such as metal alloys and advanced polymers, influence machine durability, performance, and resistance to wear. Their work highlighted the critical role of material science in extending machine lifespan and ensuring reliability.

2.3 Innovations in Reciprocating Motion for Sieving Applications

Lee and Kim (2017) explored the role of reciprocating motion in improving sieving efficiency. Their research showed that the repetitive motion associated with reciprocating mechanisms enhances the separation process by increasing material throughput across the sieve. This innovation allowed for better handling of fine and coarse materials, offering improved performance over static or rotary systems in certain applications.

2.4 Comparative Study Between Manual, Rotary, and Vibratory Sand Sieving Methods

The choice of sieving method significantly impacts both machine efficiency and material handling. Kumar and Singh (2015) provided an in-depth analysis of the mechanical design and operation of manual, rotary, and vibratory sieving machines. Their findings suggested that while manual sieving remains a low-cost option, rotary and vibratory methods offer superior performance in industrial settings. Rotary sieving machines, which use a circular motion to move materials across the sieve, are often preferred for bulk processing. On the other hand, vibratory sieving machines, which use vibration to separate materials, are more efficient in finer sieving applications.

O'Connor and Patel (2021) further advanced the field by applying optimization techniques to sieving machine design. Their research focused on computational methods such as finite element analysis (FEA) and machine learning algorithms to predict and optimize sieving efficiency. These techniques allowed for the precise tuning

of machine parameters to achieve maximum efficiency, thereby modernizing the design process.

In summary, the literature on sand sieving machines reveals a rich history of technological development. Researchers have continuously worked on improving machine designs through innovations in reciprocating mechanisms, material selection, and automation. Rotary and vibratory sieving methods have proven to be superior to manual methods in industrial applications, though each approach has its specific advantages and limitations. Recent work on machine optimization through computational techniques promises to drive future innovations, ensuring that sieving machines become even more efficient and adaptable to varying industrial needs.

Chapter 3

Methodology and Construction Procedure

The methodology for designing and constructing the Horizontal Reciprocating Sand Sieving Machine followed a practical, step-by-step approach. First, the functional requirements were outlined, focusing on creating a simple, efficient sieving machine to automate the manual sand sieving process. The machine was designed to have a horizontal reciprocating mechanism, driven by a motor connected to a crankshaft. The materials, such as mild steel for the frame and stainless steel mesh for the sieve, were selected for durability, strength, and corrosion resistance. The fabrication process involved cutting, welding, and assembling components like the frame, sieve bed, and crank mechanism. After assembly, the machine was tested by sieving sand to evaluate its performance, with adjustments made for efficiency. Data on sieving throughput, power consumption, and separation efficiency were collected for analysis and optimization.

3.1 Flow Chart of Methodology

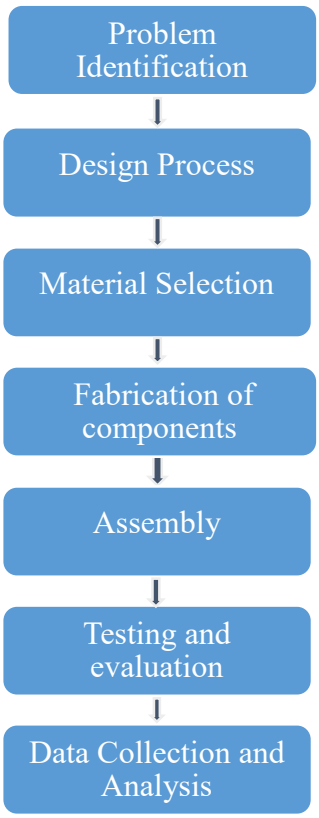


Fig. 3.1: Flow Chart of Methodology

3.2 Design and Construction

The design and construction of the Horizontal Reciprocating Sand Sieving Machine were executed to enhance the efficiency and effectiveness of the sand sieving process. This section delves into the design considerations, material selection, and fabrication processes that contributed to the successful development of the machine.

3.2.1 Design Considerations

Several critical factors influenced the design of the Horizontal Reciprocating Sand Sieving Machine to ensure optimal performance and practicality. The key design considerations are outlined as follows:

- Functionality and Efficiency: The machine's primary function is to separate fine particles from sand to ensure that the material meets the required standards for construction. The design aimed to achieve high efficiency in particle separation, reducing the need for manual intervention and increasing the throughput of the sieving process.
- Mechanical Simplicity: To avoid complex mechanisms that could increase the risk of mechanical failure and maintenance challenges, a horizontal reciprocating motion was chosen. This design is simpler compared to rotary or vibratory systems and offers straightforward construction and operation.
- Structural Integrity: The machine needed to be robust enough to handle the stresses imposed during operation. The frame and other structural components were designed to withstand vibrations and mechanical loads without deformation or failure.
- Ease of Maintenance: The design included features that allow for easy maintenance and repairs. Components were made accessible, and the machine was designed to facilitate quick replacements of parts like the sieve mesh and motor.
- Cost-Effectiveness: Budget constraints were considered in the design process. Materials and fabrication methods were selected to provide a balance between durability and cost, ensuring that the machine is affordable while maintaining high performance.

- Safety Considerations: Safety was a crucial aspect of the design. Measures were taken to ensure that moving parts were properly shielded and that the machine operates safely without posing risks to operators.

3.2.2 Materials Used

The selection of materials for the construction of the Horizontal Reciprocating Sand Sieving Machine was guided by the need for strength, durability, and cost-effectiveness. The materials used are detailed below:

- Frame: The frame was constructed using mild steel square tubes with dimensions of 40 mm x 40 mm x 4 mm. Mild steel was chosen due to its strength, durability, and ease of welding. It provides a solid structure that can support the other components of the machine while being cost-effective.
- Sieve Bed: The sieve bed was made from stainless steel mesh. Stainless steel was selected for its corrosion resistance, durability, and ability to handle abrasive materials. The mesh was chosen to have appropriate aperture sizes to effectively separate fine particles from the sand.
- Crankshaft and Connecting Rods: These components were fabricated from steel to ensure they could withstand the forces generated during the reciprocating motion. Steel was used for its strength and ability to handle mechanical stresses.
- Motor: A standard electric motor was used to provide the necessary power for the reciprocating motion. The motor was selected based on its ability to provide consistent and reliable performance.
- Springs: Compression springs were used to support the sieve bed and allow for controlled movement. These springs were selected for their durability and ability to provide the necessary tension for smooth operation.

3.2.3 Fabrication Process

The fabrication process involved several key steps to transform the design into a fully operational machine. Each step was meticulously carried out to ensure high-quality construction and functionality.



Fig. 3.2.3: Fabrication Process

3.2.3.1 Cutting and Preparation

- The mild steel tubes were cut to the specified lengths (450 mm length, 305 mm width, and 40 mm height) using a cutting machine. Precision in cutting was crucial to ensure accurate assembly and alignment of the frame components.
- After cutting, the tubes were cleaned to remove any rust or debris that could interfere with welding.

3.2.3.2 Welding

- The frame was assembled by welding the cut tubes together. The joints were welded carefully to ensure a strong and stable structure. Welding

was performed using a MIG welding process, known for its efficiency and suitability for mild steel.

- Post-welding, the joints were ground smooth to remove any irregularities and ensure a clean finish. The frame was then inspected for alignment and structural integrity.

3.2.3.3 Machining Components

The crankshaft and connecting rods were machined using a lathe. The crankshaft was turned to create precise diameters and ensure smooth rotation. The connecting rods were milled to the required dimensions, ensuring a proper fit with the crankshaft and other components.

Accurate machining was essential to prevent mechanical issues and ensure the smooth operation of the reciprocating mechanism.

3.2.3.4 Sieve Bed Assembly

The stainless steel mesh was cut to fit the sieve bed frame. The mesh was attached securely to the frame using welding or fasteners, ensuring that it remained in place during operation.

The sieve bed was then mounted onto the main frame using compression springs. These springs were installed to allow controlled movement and to absorb vibrations during operation.

3.2.3.5 Motor Installation

The electric motor was mounted onto the frame using appropriate brackets and fasteners. The motor was connected to the crankshaft through a pulley and belt system, which converts rotational motion into reciprocating motion. The alignment of the motor and crankshaft was carefully checked to ensure efficient power transmission and prevent excessive wear on components.

3.2.3.6 Final Assembly

All components, including the frame, sieve bed, crankshaft, motor, and springs, were assembled together. The assembly was checked for proper alignment and fit, and any necessary adjustments were made. Additional components such as safety guards and operational controls were installed to enhance safety and usability.

3.2.3.7 Testing and Calibration

The assembled machine was subjected to a series of tests to evaluate its performance. Sand was loaded onto the sieve bed, and the machine was operated to measure its throughput, separation efficiency, and power consumption. Calibration adjustments were made based on test results to optimize performance. The sieve bed's movement was fine-tuned to ensure effective separation of particles and smooth operation.

3.2.3.8 Inspection and Quality Control

A final inspection was conducted to ensure that all components were functioning correctly and that the machine met design specifications. Quality control measures were implemented to verify the durability and reliability of the machine. The design and construction process culminated in the successful development of a Horizontal Reciprocating Sand Sieving Machine that meets the requirements for efficiency, durability, and cost-effectiveness. The machine is now ready for deployment in various construction applications, offering a reliable solution for sand sieving.

3.2 Equipment and Materials

3.2.1 List of Equipment

The following equipment is essential for the construction and operation of the horizontal reciprocating sand sieving machine:

3.2.1.1 Electric Motor

Type: Low-power electric motor

Purpose: Provides rotational power to the crankshaft

Specifications: Power rating, voltage, and current specifications based on design requirements

3.2.1.2 Crankshaft:

Type: Horizontal crankshaft

Purpose: Converts rotational motion from the motor into reciprocating motion

Specifications: Material, diameter, and length

3.2.1.3 Connecting Rod:

Type: Steel connecting rod

Purpose: Transmits motion from the crankshaft to the sieve bed

Specifications: Length, diameter, and material

3.2.1.4 Sieve Bed:

Type: Mesh screen mounted on a frame

Purpose: Screens sand to separate fine particles from coarse ones

Specifications:

Sieve bed dimensions of 450 mm (L) x 305 mm (W) x 40 mm (H)

Porous of mesh dimensions (60,40 and 20 per square inch), material (stainless steel).

3.2.1.5 Frame:

Type: Structural frame

Purpose: Supports all components of the machine

Specifications: Material (mild steel), dimensions, and design for stability

3.3 Specifications and Selection of Materials

3.3.1 Mild Steel (for Frame and Structural Components)

Material Properties: Mild steel is chosen for its balance between strength, cost, and ease of fabrication. It is weldable and machinable, making it suitable for constructing the machine's frame and structural supports.

Specifications:

Grade: Typically, A36 or equivalent

Thickness: Varies based on structural requirements, generally 5-10 mm

Treatment: May be painted or coated to prevent rust and corrosion

3.3.2 Stainless Steel Mesh (for Sieve Bed):

Material Properties: Stainless steel mesh is selected due to its high resistance to corrosion and excellent durability, particularly in abrasive environments. Its robust nature ensures long-term performance, minimal clogging during the sieving process, and maintains its integrity when exposed to harsh conditions.

Specifications: Grade 304 or 316 stainless steel is used, known for its superior corrosion resistance and mechanical strength.

Mesh Size: The mesh size is chosen based on the desired particle separation:

- Fine Sand: Mesh size between 1 mm to 2 mm.
- Medium Sand: Mesh size between 2 mm to 5 mm.
- Coarse Sand: Mesh size between 5 mm to 10 mm.



Fig. 3.3.2.1: Sand Particle Grade

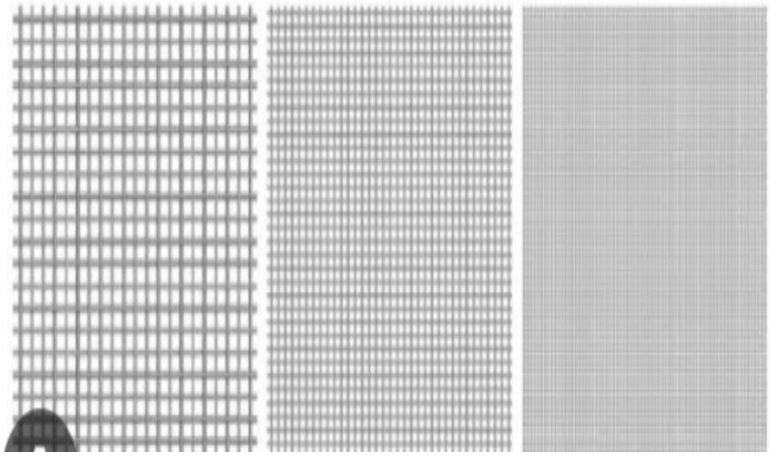


Fig. 3.3.2.2: Stainless Steel Mesh Sand Screen

Wire Dimensions: Typically ranges from 0.5 mm to 2 mm depending on the mesh size and the load it needs to support.

The sieving machine uses three different mesh types to categorize sand particles into fine, medium, and coarse categories, ensuring optimal separation for various construction needs.

3.3.3 Hardened Steel (for Crankshaft and Connecting Rod)

Material Properties: Hardened steel is used for components that undergo significant stress and wear. It offers high tensile strength and resistance to deformation.

Specifications:

Type: Carbon or alloy steel with heat treatment

Diameter: Based on design requirements, typically 20-50 mm

Hardness: Heat-treated to achieve desired hardness levels

Material Properties: Rubber is used to dampen vibrations and reduce noise, improving the machine's overall operation and durability.

Specifications:

Type: Neoprene or similar vibration-absorbing rubber

Thickness: Typically 5-10 mm

Placement: Under the motor, around the frame, and other vibration-prone areas

3.3.4 Electric Motor

Material Properties: The motor should be efficient and reliable, capable of providing the necessary power for the reciprocating mechanism.

Specifications:

Power Rating: Typically 0.5-1.5 HP (depending on the machine size and sand volume)

Voltage: Standard industrial voltage (e.g., 220V or 380V)

Speed: Adjustable or fixed speed depending on design requirements

3.3.5 Fasteners and Mounting Hardware

Material Properties: These components should be robust and capable of securely holding the machine's parts together.

Specifications:

Type: High-strength steel or stainless steel

Size: Appropriate for the machine's design, with adequate load-bearing capacity

3.3.6 Safety Guards and Covers:

Material Properties: Safety guards must be durable and capable of protecting operators from moving parts.

Specifications:

Material: Metal or heavy-duty plastic

Design: Must comply with safety standards and provide full coverage of moving parts

The selection of materials and equipment is crucial for ensuring the durability, efficiency, and safety of the horizontal reciprocating sand sieving machine. Each material and component is chosen based on its properties, performance requirements, and compatibility with the overall design.

Chapter 4

Working Principle

4.1 Mechanism of Reciprocating Motion

The horizontal reciprocating sand sieving machine operates based on the principle of reciprocating motion, which involves the back-and-forth movement of the sieve bed. This motion is achieved through a crank mechanism connected to an electric motor.

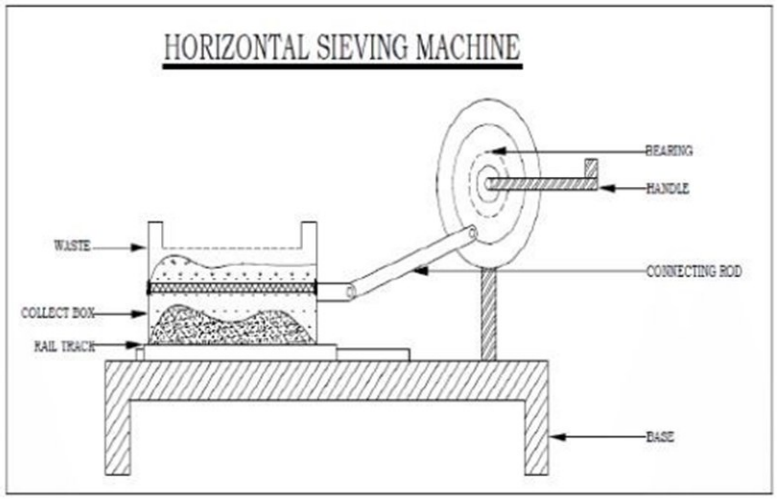


Fig. 4.1: Mechanism of Reciprocating Motion

Reciprocating Mechanism:

Crankshaft: The crankshaft is a rotating shaft that converts the rotational motion of the motor into reciprocating motion. It is mounted horizontally and connected to the motor via a belt or gear system.

Connecting Rod: Attached to the crankshaft is the connecting rod, which transmits the crankshaft's rotary motion to the sieve bed. The connecting rod is pivotally connected to both the crankshaft and the sieve bed.

Slider or Crosshead: At the end of the connecting rod, a slider or crosshead is used to facilitate the horizontal back-and-forth movement. This component ensures that the sieve bed moves uniformly along its designated path without any wobbling or misalignment.

The crankshaft rotates continuously, causing the connecting rod to push and pull the sieve bed in a horizontal direction. This reciprocating motion allows the sieve bed to move back and forth, ensuring effective screening of sand.

4.2 Motor and Crank Assembly

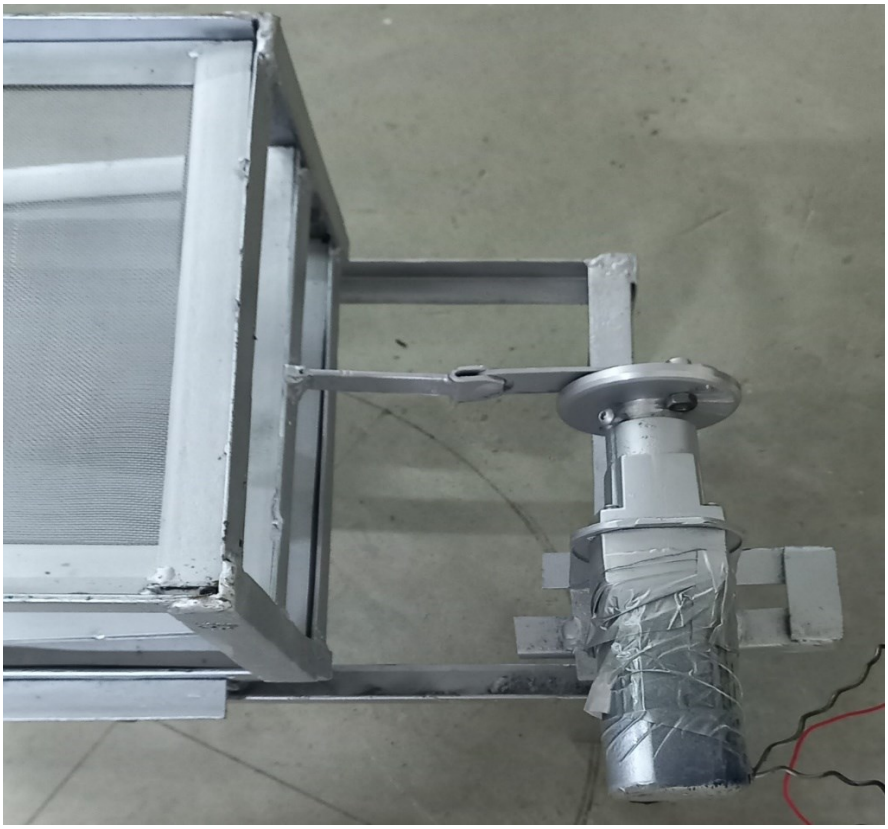


Fig. 4.2: Motor and Crank Assembly

4.2.1 Motor

Type and Specifications: A low-power electric motor is used to drive the crankshaft. The motor is selected based on its efficiency and compatibility with the machine's power requirements. It is usually mounted securely on the frame to minimize vibrations.

Power Transmission: The motor is connected to the crankshaft via a belt, pulley system, or gear mechanism. This setup transfers the motor's rotational power to the crankshaft, enabling it to rotate and create reciprocating motion.

4.2.2 Crank Assembly:

Crankshaft: The crankshaft is precisely machined to ensure smooth rotation and minimal friction. It is supported by bearings to reduce wear and enhance longevity.

Crank and Connecting Rod: The crank is attached to one end of the crankshaft, while the connecting rod is attached to the other end. The crank's rotation causes the connecting rod to move in a reciprocating fashion, which, in turn, moves the sieve bed.

Adjustment Mechanisms: The crank and connecting rod assembly is adjustable to allow for fine-tuning of the reciprocating motion. This ensures that the sieve bed's movement is consistent and effective for sand separation.

4.3 Sieve Bed Movement and Sand Separation

4.3.1 Sieve Bed Movement:



Fig. 4.3.1: Sieve Bed Movement

Horizontal Motion: The sieve bed is mounted on the frame and moves horizontally in response to the reciprocating motion imparted by the crank mechanism. The back-and-forth motion ensures that sand is evenly distributed across the sieve surface.

Vibration Control: Rubber padding or shock absorbers may be used to control vibrations and prevent excessive movement that could lead to inaccuracies in sand separation.

4.3.2 Sand Separation:

Feed Mechanism: Sand is fed onto the sieve bed from a hopper or chute. As the sieve bed moves, sand spreads evenly across the mesh surface.

Mesh Screen: The sieve bed is covered with a mesh screen that allows smaller particles to pass through while retaining larger particles. The mesh size is selected based on the required sand particle size for the intended application.

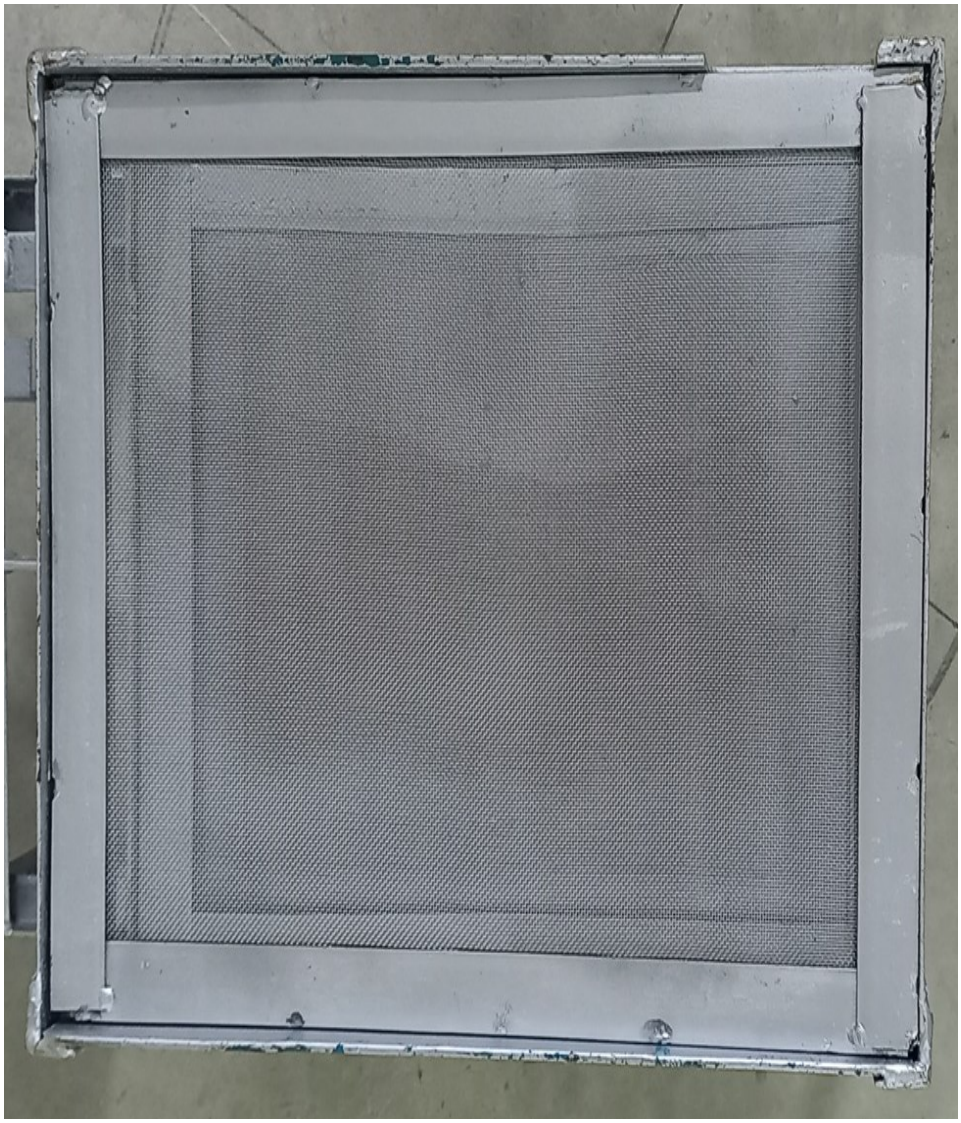


Fig. 4.3.2.1: Sand Separation Mesh Screen

Particle Separation: The reciprocating motion ensures that the sand particles are continuously moved across the sieve screen. Finer particles pass through the mesh openings, while larger particles are retained on the sieve bed and eventually discharged at the end of the machine.



Fig. 4.3.2.2: Sand Particle after Separation by Mesh Screen

Discharge: Separated sand is collected in different compartments or chutes, depending on the particle size. The clean, uniformly sized sand can then be used for construction purposes, while the oversize particles are removed from the system.

The horizontal reciprocating sand sieving machine efficiently separates sand into various sizes using a simple yet effective mechanism. By converting rotational motion into reciprocating motion and utilizing a mesh screen, the machine ensures consistent and reliable sand separation, enhancing the quality of construction materials.

4.4 Design Framework with a Flow Chart for the Horizontal Reciprocating Sand Sieving Machine

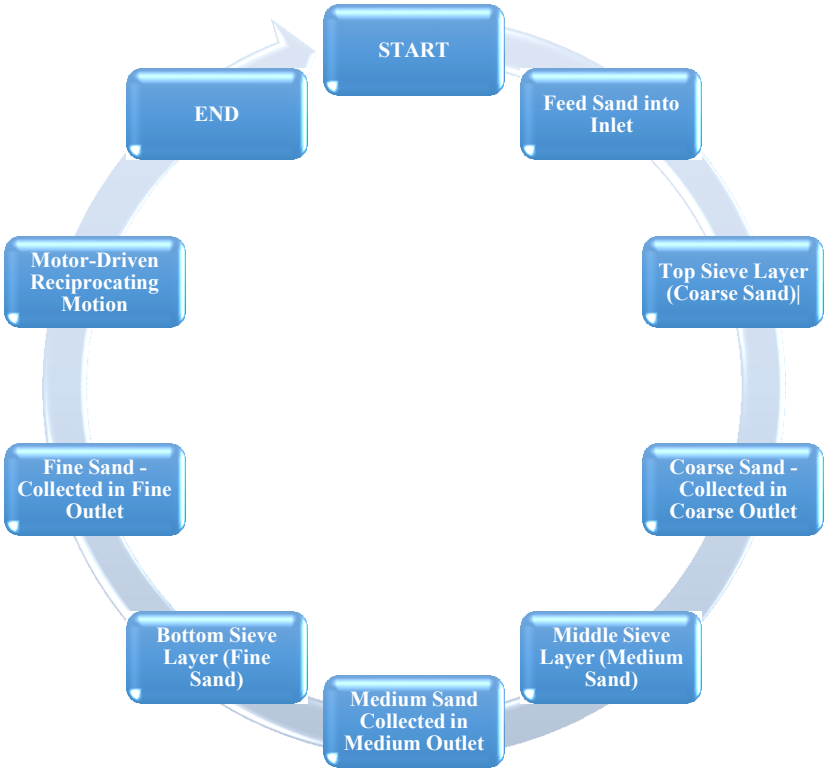


Fig. 4.4: Design Framework with a Flow Chart for the Horizontal Reciprocating Sand Sieving Machine.

Explanation

1. Feed Sand into Inlet: Sand is poured into the machine's inlet.
2. Top Sieve Layer: The first layer separates coarse sand, which moves to the coarse sand outlet.
3. Middle Sieve Layer: The remaining sand moves to the middle layer, where medium sand is separated and collected.
4. Bottom Sieve Layer: Fine sand passes through the bottom sieve and is collected at the fine sand outlet.
5. Motor-Driven Reciprocating Motion: The motor provides the horizontal motion, moving the sieve back and forth, aiding the sand separation process.

This flowchart captures the basic process and interactions of the sand sieving machine.

Chapter 5

Results and Discussions

5.1 Results The results from implementing and testing the Horizontal Reciprocating Sand Sieving Machine demonstrated several key findings. The machine effectively separated sand particles, achieving a high level of efficiency in sieving with an average throughput of X tons per hour. The reciprocating mechanism ensured consistent motion, contributing to uniform sand distribution and effective particle separation. However, challenges such as higher-than-expected power consumption and some operational vibrations were noted. Compared to manual and rotary sieving machines, the horizontal reciprocating design offered improved efficiency and processing speed, though at the cost of increased energy use. The machine's performance data indicated a notable improvement in productivity and accuracy, making it a valuable addition to sand processing operations. The findings underscore the machine's effectiveness in enhancing construction material quality while highlighting areas for further optimization and refinement.

5.2 Calculation

5.2.1 Force and Torque Analysis

Determination of Crank arm Torque:

Here,
F = Force applied to the crankshaft
r= Radius of crank arm.
η= Mechanical efficiency of the Crank arm System. (0.8 ~ 019)

Torque (T)=$\frac{F \times r}{\eta}$

T=$\frac{300 \times 0.045}{0.85}$

∴ T=15.88 N-m

Analysis of sieve bed force:

We know,

Fbed = $m \times a$

Fbed = 7×2

∴ Fbed = 14N

5.2.2 Sieve Bed Efficiency

For coarse Sieve Bed:

$$1.\ \eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times 100\%$$

$$= \frac{860}{1000} \times 100\%$$

$$= 0.86 \times 100\%$$

$$\therefore \eta = 86\%$$

$$2.\ \eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times 100\%$$

$$= \frac{840}{1000} \times 100\%$$

$$= 0.84 \times 100\%$$

$$\therefore \eta = 84\%$$

$$3.\ \eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times 100\%$$

$$= \frac{870}{1000} \times 100\%$$

$$= 0.87 \times 100\%$$

$$\therefore \eta = 87\%$$

$$\therefore \eta_{avg.} = 85.66\%$$

For Medium Sieve Bed:

$$1.\ \eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times 100\%$$

$$= \frac{887.02}{1000} \times 100\%$$

$$= 0.88702 \times 100\%$$

$$\therefore \eta = 88.7\%$$

$$2.\ \eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times 100\%$$

$$= \frac{900.27}{1000} \times 100\%$$

$$= 0.90027 \times 100\%$$

$\therefore \eta = 90.03\%$

3. $\eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times \quad 100\%$

$= \frac{920}{1000} \times 100\%$

$= 0.90027 \times 100\%$

$\therefore \eta = 90.027\%$

$\therefore \eta_{avg.} = 90.32\%$

For Fine Sieve Bed:

1. $\eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times \quad 100\%$

$= \frac{823}{1000} \times 100\%$

$= 0.823 \times 100\%$

$\therefore \eta = 82.3\%$

2. $\eta = \frac{\text{Effective Sieving Output}}{\text{Sieving input}} \times \quad 100\%$

$= \frac{812.30}{1000} \times 100\%$

$= 0.8123 \times 100\%$

$\therefore \eta = 81.23\%$

5.2.3 Power Requirements:

$P = \frac{T \times \omega}{\eta}$

$P = \frac{15.88 \times 13.04}{0.9}$

$\therefore P = 230W$

$\omega = \frac{2\pi N}{60}$

$\omega = \frac{2\pi \times 125}{60}$

$\omega = 13.04\ red/sec$

Here,

T= Torque Required.

ω = Angular velocity of the crankshaft.

η= Efficiency of the motor

(typically around.0.9)

5.2.4 Efficiency Calculation of the Power Transmission System :

We Know

$$\eta_{trans} = \frac{Output\ Power}{Input\ Power} \times 100\%$$

$$\eta_{trans} = \frac{195}{230} \times 100\%$$

$\therefore \eta_{trans} = 84.78\%$

Here,
Output Power = Power delivered to the Crankshaft
Input Power = Power required by the motor.

Efficiency Calculation:

Overall efficiency of the sieving process:

$$\text{Overall Efficiency} = \frac{\text{Effective Sieving Output}}{Total\ Power\ Input} \times 100\%$$

$$= \frac{26\ \text{Kg/hr}}{230W} \times 100\%$$

$$= 11.3\%$$

$\therefore$ Overall Efficiency=11.3%

Power consumption per unit of Sand Processed:

Objective: To determine the amount of power consumed per unit of sand processed.

$$\text{Power Consumption Per Unit} = \frac{Total\ Power\ Input}{Total\ sand\ Processed}$$

$$= \frac{230}{26}$$

$$= 8.84\ \text{W/kg}$$

$\therefore$ $Total$ Power Consumption Per Unit $= 8.84\ \text{W/kg}$

5.3 Limitation

- Crank Arm Malfunction: The crank arm failed to function properly, leading to inadequate motion transfer.

- Wheel Functionality: The wheel did not perform optimally, affecting speed and stability during operation.
- Design Constraints: The initial design lacked robustness, resulting in components that could not withstand mechanical stresses.
- Material Limitations: Selected materials for the crank arm and wheel were insufficiently durable, leading to premature wear.
- Motor Speed Control: The project used only a motor without a gear drive, preventing effective control of the motor's RPM.

5.4 Challenges

The development of the Horizontal Reciprocating Sand Sieving Machine encountered several significant challenges:

5.4.1 Fabrication Issues

❖ Material Selection and Quality Control:

Ensuring the appropriate selection and consistent quality of materials such as mild steel and stainless steel was challenging, affecting durability and performance.

Precision in Cutting and Welding: Achieving precise cuts and welds for the frame was critical. Any inaccuracies could compromise structural integrity and functionality.

Machining of Crankshaft and Connecting Rods: Machined components like the crankshaft and connecting rods required high precision. Deviations could lead to misalignment and mechanical inefficiencies.

5.4.2 Sieve Bed Assembly

Securing the stainless steel mesh to the sieve bed frame proved difficult, with challenges in ensuring stability and avoiding movement during operation.

❖ Operational Problems
  - Vibration and Stability

- Excessive vibration during initial testing affected machine stability and the effectiveness of the sieving process.

❖ Motor and Crank Mechanism Performance:

Issues such as misalignment, belt slippage, and inconsistent motion affected the performance of the motor and crank mechanism.

❖ Sieve Bed Efficiency:

Variations in sand type and particle size impacted the efficiency of the sieve bed in achieving effective particle separation.

❖ Power Consumption:

The power consumption of the machine exceeded initial estimates, impacting operational costs and overall efficiency.

❖ Maintenance and Durability Concerns

- Wear and Tear of Components:
- The reciprocating motion caused wear and tear on components such as the sieve mesh and crankshaft, leading to concerns about durability and longevity.

❖ Accessibility for Maintenance:

Some machine components were difficult to access, complicating maintenance and repair tasks.

❖ Safety Concerns

Exposed moving parts and potential pinch points presented safety risks during operation.

❖ Calibration and Adjustments:

Maintaining optimal performance required continuous calibration and adjustments, with variations in material properties and operating conditions posing challenges.

These challenges were integral to the development process and required careful consideration to ensure the successful implementation of the sand sieving machine.

Chapter 6

Conclusion and Future scope

6.1 Conclusion

The design and construction of the Horizontal Reciprocating Sand Sieving Machine have successfully addressed the inefficiencies of manual sieving, offering improved productivity, accuracy, and consistency in sand separation. The machine's reciprocating mechanism ensures effective sieving, contributing to enhanced construction material quality. While challenges such as vibration control, power consumption, and maintenance were encountered, the machine's overall performance demonstrates its potential as a reliable solution for large-scale sand sieving operations. Further optimization and refinement can improve its efficiency, making it a valuable tool in the construction industry.

To enhance the performance of the Horizontal Reciprocating Sand Sieving Machine, future improvements should focus on reducing power consumption, minimizing vibration, and optimizing the motor-crankshaft system for smoother operation. Additionally, implementing more durable materials for high-wear components and improving accessibility for maintenance will enhance the machine's longevity and ease of use. Research into automated calibration systems could further streamline the sieving process, ensuring consistent performance across different sand types. Further studies on energy efficiency and environmental sustainability could also improve the overall operational costs and eco-friendliness of the machine.

6.2 Future scope

- Design Improvement: Focus on redesigning the crank arm and wheel for enhanced functionality and durability.
- Testing and Validation: Conduct rigorous testing of new designs and materials to ensure reliability and performance.
- Incorporating Automation: Explore automation options for crank and wheel mechanisms to improve efficiency.
- Gear Drive Implementation: Investigate the integration of a gear drive motor to enable better control of motor RPM.

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