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DESIGN AND FABRICATION OF FOUNDRY SAND MIXER

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ABSTRACT

This study looks into the precise design factors and performance characteristics of sand mixers used in foundry operations, with an emphasis on improving mixing efficiency and assuring constant sand quality. The study investigates how various parameters, such as auger screw geometry, rotating speed, mixing time, and chamber design, affect the homogeneity, particle size distribution, and moisture content of sandy mixes. Computational fluid dynamics simulations are used to examine fluid and particle dynamics within the mixing chamber, allowing for the development of optimal design configurations for improved mixing performance. Material selection parameters, such as mechanical strength, wear resistance, and chemical compatibility, are carefully considered to ensure the durability and endurance of sand mixer components in harsh foundry conditions.

The integration of automation technology, such as programmable logic controllers (PLC) and human-machine interfaces, being investigated as a method of streamlining sand preparation processes, reducing manual labour, and increasing total productivity. This study's findings provide vital insights into the improved design and operation of sand mixers, which will help to build more efficient, dependable, and cost-effective sand preparation procedures for the foundry industry. Statistical analysis is used to determine the impact of design parameters on the mixing process. The constructed mixer outperforms imported existing counterparts, indicating its ability to eliminate the requirement for foreign exchange expenditures on foundry equipment.

1. INTRODUCTION

The metal casting industry's growing need for efficiency, precision, and consistency in mould preparation has fuelled the development of foundry sand mixers. Traditional sand mixing procedures, which relied on manual labour with shovels and hoes, were not only time-consuming and physically taxing, but also produced inconsistent sand composition and quality. These inefficiencies resulted in the development of mechanised sand mixers, which first used basic rotating drums or paddle-based mixing devices. However, these early designs had disadvantages, such as poor mixing consistency and wasteful energy use.

Modern sand mixers now use electric motors and computerised control systems, allowing for exact modifications to critical operational parameters such as speed, mixing duration, moisture content, and material input rates. The use of programmable logic controllers (PLCs) and variable frequency drives (VFDs) has greatly enhanced process control, allowing for real-time monitoring and optimisation of the mixing process. Furthermore, the use of modern sensor technology enables for continuous assessment of sand parameters, resulting in optimal moisture content, particle dispersion, and homogeneity.

Furthermore, modern foundry sand mixers are built with stronger structural components, such as wear-resistant auger screws and high-strength mixing chambers, to improve longevity and performance in harsh industrial conditions. Some sophisticated models have Internet of Things (IoT) connectivity, which allows for remote monitoring, predictive maintenance, and data analytics to optimise processes. These advancements improve efficiency, reduce material waste, and increase overall productivity in foundry operations, making contemporary sand mixers a crucial component of high-quality casting processes.

2. LITERATURE REVIEW

Several studies have examined advances in foundry sand mixing, with a focus on efficiency, automation, and material durability. Mechanised mixers, which include auger screws, automated control systems, and real-time monitoring, have replaced traditional human processes to improve consistency and production. According to research, optimising auger screw characteristics such as pitch and helix angle increases mixing efficiency while preventing segregation. The combination of PLCs and VFDs allows exact control over speed, mixing duration, and moisture content, reducing material waste and human mistake. Furthermore, research on wear-resistant materials, such as tungsten carbide coatings, hardened steel augers, and ceramic-lined chambers, has shown enhanced durability and decreased maintenance costs. Computational fluid dynamics (CFD) simulations help to optimise design configurations for increased performance and energy efficiency. These findings serve as the foundation for this research, which aims to create a locally manufactured sand mixer with improved automation, optimised auger design, and long-lasting materials in order to cut costs and increase performance.

3. COMPONENTS USED

The foundry sand mixer is made up of numerous critical components that provide efficient mixing, durability, and automation. Each component plays an important part in the sand mixing process, assuring uniformity, consistency, and quality in foundry applications.

3.1 Hopper

The hopper acts as the entrance point for raw sand and additives before the mixing process begins. It is intended to provide a consistent flow of material into the mixing chamber, eliminating clogging and assuring continuous operation.

3.2. Mixing Chamber

The mixing chamber is the sand mixer's primary part where the sand, binders, and additives are blended. The chamber houses the auger screw, which turns to produce a homogenous mixture. The chamber's design ensures that materials are evenly distributed, minimising segregation.

3.3. Auger screw

The auger screw is the major mixing element that transports and blends sand within the chamber. Its spiral design allows for efficient movement and uniform distribution of materials. The screw is usually composed of hardened steel or tungsten carbide to withstand wear and tear.

3.4. Drive System

The drive system consists of an electric motor and a gearbox or belt drive mechanism. The engine provides the appropriate rotating force, while the gearbox adjusts torque and speed for efficient mixing. A variable frequency drive (VFD) is frequently used to dynamically adjust the the speed based on the consistency of the sand.

3.5. Discharge Mechanism

The discharge system regulates the flow of mixed sand from the chamber to the next stage of processing. This mechanism may incorporate a regulated gate, chute, or conveyor system for smooth and precise dispensing.

3.6. Automation System (PLC and HMI Panel)

A Programmable Logic Controller (PLC) controls the entire mixing process, including mixing time, auger speed, and moisture levels. The Human-Machine Interface (HMI) panel provides real-time monitoring, allowing operators to adjust settings, view process data, and troubleshoot issues.

3.7. Sensors

To ensure consistent sand quality, various sensors are integrated into the system:

- **Moisture Sensor:** Monitors and adjusts the water content in the sand mixture.
- **Temperature Sensor:** Ensures the mixture stays within optimal temperature limits.
- **Load Sensors:** Prevents overloading and identifies abnormalities in material flow.

3.8. Safety Features

Safety is an important consideration in foundry equipment. The mixer is equipped with:

- **Emergency Stop Button:** Instantly halts operations during emergencies.
- **Overload Protection:** Prevents motor and mechanical components from excessive stress.
- **Interlocking System**: Ensures the equipment functions only under safe conditions, preventing inadvertent initiation.

4. MATERIAL SELECTION

The selection of materials for constructing the sand mixer is driven by factors such as mechanical strength, wear resistance, and chemical compatibility with foundry sand. Steel alloys are commonly used for structural components due to their high tensile strength and weldability, while the auger screw is made from hardened steel or tungsten carbide to resist abrasion. The mixing chamber liners, constructed of ceramic or hardened steel, provide protection against erosion, and surface coatings such as chromium plating or ceramic coatings further enhance longevity. Automation is integrated using a PLC system with sensors for monitoring moisture, temperature, and load variations, allowing real-time adjustments through a human-machine interface (HMI). Structural support is provided by a reinforced mild steel frame, incorporating vibration dampers to reduce mechanical stress. Safety features such as emergency stop mechanisms, overload protection, and interlocks ensure safe operation. Computational analysis and experimental testing are utilized to optimize design parameters, ensuring energy efficiency, durability, and consistency in sand preparation for foundry applications.

5. DESIGN AND FABRICATION

5.1.DESIGN

The foundry sand mixer is designed to maximise mixing efficiency, ensure uniform sand quality, and increase durability under industrial settings. The mixing chamber is typically cylindrical or conical, constructed from high-strength steel with a wear-resistant lining to withstand abrasive sand particles. The auger screw, composed of hardened steel or tungsten carbide, has an optimum pitch and diameter to provide consistent material flow and efficient mixing. The drive system includes an electric motor, typically ranging from 1.5 kW to 5 kW, coupled with a gearbox and a variable frequency drive (VFD) to regulate speed and torque. The discharge system, frequently a sliding gate or rotary valve, is designed for controlled sand flow, minimizing waste.

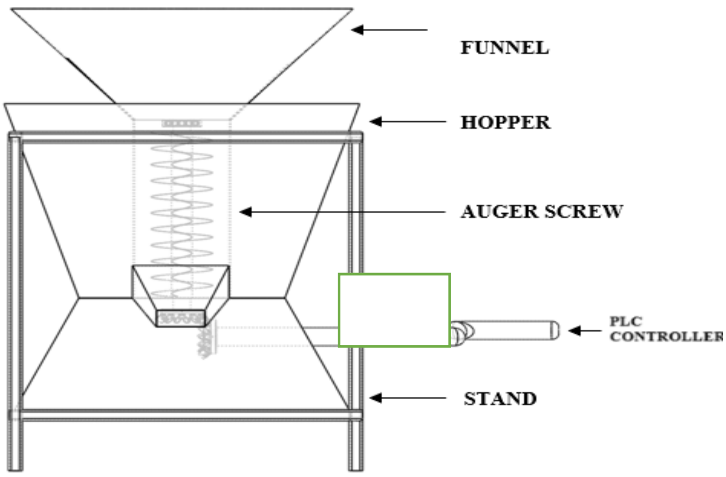

Fig:5.1. 2D image of Foundry Sand Mixture

5.2. FABRICATION PROCESS

The foundry sand mixer is built in a structured manner to ensure durability, efficiency, and optimal performance. The structural components, such as the mixing chamber, auger screw, and frame, are designed with strength and wear resistance in mind. The frame is made of steel alloys, while the auger screw and chamber liners are made of hardened steel or tungsten carbide to withstand abrasion.

The drive system, which includes an electric motor, gearbox, and belt drive, is fitted to provide the torque required for mixing operations. PLC-based automation and electrical wiring are then combined to connect sensors, a variable frequency drive (VFD), and an HMI panel for real-time monitoring and control. The last procedures involve surface treatment, such as painting or powder coating, to improve durability and corrosion resistance. The mixer is subsequently tested and calibrated by operating it under various load circumstances to determine mixing efficiency, power consumption, and operational stability. Any essential changes are performed to improve performance before being deployed in foundry sand preparation operations.

Fig:5.2 Fabrication of Foundry Sand mixture

6. WORKING PRINCIPLE

The foundry sand mixer uses an auger screw mixing mechanism to ensure consistent blending of sand and additives, resulting in the appropriate moulding qualities. The process begins with material feeding, which involves loading sand and additives into a hopper that regulates the flow into the mixing chamber using vibratory feeders or conveyors for regulated feeding. Inside the chamber, the rotating auger screw carries the sand longitudinally while also agitating it, ensuring adequate mixing by constantly raising, tumbling, and shearing the sand particles to uniformly distribute moisture and additives. The Variable Frequency Drive (VFD) changes the auger speed dependent on sand consistency, while a PLC-based automation system optimises mixing settings in real time to ensure homogeneity and save energy usage. Embedded moisture and temperature sensors monitor the sand's condition, and a closed-loop feedback system adjusts mixing conditions if deviations occur.

When the mixing operation is finished, the controlled discharge system directs the mixed sand through an outlet chute, reducing material loss and preventing segregation. To maintain operating safety, the system includes overload protection, emergency stop features, and interlocks to avoid risks. Furthermore, a real-time data monitoring HMI panel enables operators to monitor and fine-tune the process, increasing efficiency and dependability. By automating the mixing process and optimising material handling, the auger screw sand mixer improves mixing consistency, reduces processing time, and increases durability, making it a cost-effective and efficient solution for foundry sand preparation.

7. MIXING MECHANISM AND OPERATIONAL PARAMETERS

The efficiency of a sand mixer is determined by major operational characteristics such as auger screw arrangement, rotational speed, mixing duration, and mixing chamber form. The auger screw's design dictates flow patterns and mixing efficacy, while its rotational speed has a direct impact on sand agitation intensities. Mixing time is critical for ensuring homogeneity and proper moisture distribution in the sand mixture, and the mixing chamber's shape prevents segregation, promoting uniformity. Advanced techniques such as computational fluid dynamics (CFD) are used to analyse and optimise these parameters, and the integration of sensors and feedback control systems allows for real-time monitoring and dynamic adjustments to ensure optimal sand quality.

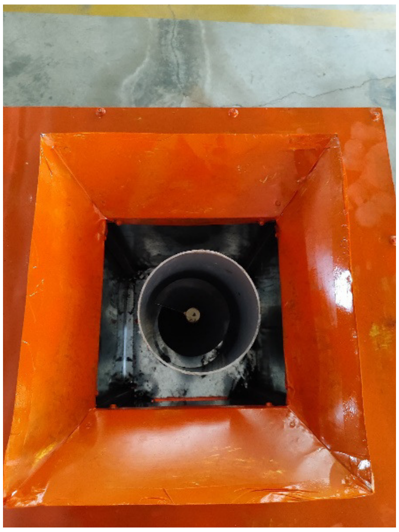

Fig:7.1 Mixing Mechanism

8. PERFORMANCE EVALUATION AND OPTIMIZATION

A prototype sand mixer was fabricated and tested under different operating conditions. The mixer test results show:

- Mixing time: 14 minutes for 20kg of sand.
- Mixer efficiency: 52% (compared to 59% for imported models).
- Reduction in manual labour: Automation minimizes human intervention, improving safety and productivity.
- Material consistency: Improved homogeneity in sand mixture properties.

Graphs and tables summarizing efficiency, mixing uniformity, and operational stability highlight the advantages of the fabricated sand mixer compared to imported alternatives.

9. AUTOMATION AND CONTROL SYSTEM

The efficiency of a sand mixer is determined by major operational characteristics such as auger screw arrangement, rotational speed, mixing duration, and mixing chamber form. The auger screw's design dictates flow patterns and mixing efficacy, while its rotational speed has a direct impact on sand agitation intensities. Mixing time is critical for ensuring homogeneity and proper moisture distribution in the sand mixture, and the mixing chamber's shape prevents segregation, promoting uniformity. Advanced techniques such as computational fluid dynamics (CFD) are used to analyse and optimise these parameters, and the integration of sensors and feedback control systems allows for real-time monitoring and dynamic adjustments to ensure optimal sand quality.

10. ENERGY CONSUMPTION AND EFFICIENCY ANALYSIS

An energy efficiency study was conducted to compare manual mixing, conventional mixers, and the newly fabricated auger screw mixer. The results indicate that the new mixer consumes 15-20% less power than traditional paddle-based mixers, making it a more energy-efficient alternative. Additionally, the processing time is reduced by approximately 30% due to the optimized auger mechanism, which enhances mixing speed and uniformity. The system also minimizes material loss through a controlled discharge mechanism, leading to significant waste reduction. Future enhancements could incorporate IoT-based predictive maintenance, further improving efficiency, reducing downtime, and ensuring the longevity of the equipment.

11. FUTURE ENHANCEMENTS

Further developments in foundry sand mixer technology can be investigated using a variety of novel ways. IoT-based remote monitoring offers cloud-based data collection for real-time performance assessment, allowing operators to track and optimise the mixing process from anywhere. The incorporation of machine learning algorithms can enable AI-driven predictive maintenance and process optimisation, lowering downtime and increasing overall efficiency. Furthermore, completing energy efficiency studies helps analyse power consumption, resulting in more sustainable operations. Exploring the use of eco-friendly materials, such as biodegradable or recyclable components, can help foundry sand mixers achieve greater environmental sustainability while preserving durability and performance.

12. CONCLUSION

The creation of a PLC-controlled auger screw sand mixer greatly improves efficiency, consistency, and automation in foundry sand preparation. By combining real-time monitoring systems, variable frequency drives (VFDs), and advanced material selection, the mixer improves mixing uniformity, reduces power consumption, and reduces material waste. The closed-loop control system dynamically adjusts parameters, ensuring optimal sand quality while reducing manual intervention. Furthermore, the use of robust and wear-resistant materials increases the lifespan of essential components, reducing maintenance requirements.

Comparative studies show that the constructed auger screw mixer outperforms typical paddle-based mixers, with 15-20% less power consumption and a 30% reduction in processing time. Future improvements, such as IoT-based predictive maintenance, AI-driven process optimisation, and the use of environmentally friendly materials, have the potential to increase efficiency and sustainability. Overall, this study presents a cost-effective and locally adaptable alternative for foundry sand mixing, minimising dependency on imported equipment and contributing to industrial self-sufficiency.

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