Design and Development of Sand Separate

Sairaj B. Shevade, Soham S. Suryavanshi, Yashraj A. Atigre, Abhishek A. Kamble

P. S. Khade , A. R. Nadaf

[1-4]Diploma Student, Department of Mechanical Engineering, Dr. Bapuji Salunkhe Institute of Engineering and Technology, Kolhapur, Maharashtra, India.

[5]Head of Department, Department of Mechanical Engineering, Dr. Bapuji Salunkhe Institute of Engineering and Technology, Kolhapur, Maharashtra, India.

[6]Lecturer, Department of Mechanical Engineering, Dr. Bapuji Salunkhe Institute of Engineering and Technology, Kolhapur, Maharashtra, India.

---***---

Abstract

The presence of sand and solid contaminants in industrial processes presents a persistent challenge in foundry operations, wastewater treatment, and construction. These particles reduce equipment lifespan, impair system efficiency, and compromise output quality. This paper presents the development of an automated sand separator designed to remove sand and particulate matter from industrial fluids and mixtures. The system is engineered with simplicity, cost-effectiveness, and mechanical efficiency in mind. Key aspects such as selection of separation technique, materials, and performance evaluation are detailed. The study concludes with a discussion of results, practical implementation, and future scope in line with sustainable industrial practices.

Keywords: sand separator, foundry reclamation, filtration, hydrocyclone, efficiency, sustainability

1. Introduction

In various industries like forging, construction, and water treatment, sand poses an operational obstacle. In foundries, especially, moulding sand must be reused efficiently, reducing costs and environmental burden. In response, a compact and low-cost sand separator has been designed to filter particulate matter and reclaim usable materials. The device aligns with eco-conscious goals and offers robust separation for various material combinations including dry solids and slurry.

Sand separation is a crucial process in various industrial applications, particularly in foundries, construction, and wastewater treatment. It involves the removal of sand particles from mixtures—whether from water, other minerals, or industrial by-products—to ensure material purity, reduce equipment wear, and maintain operational efficiency. In metal casting and forging industries, effective sand separation is essential to reclaim used moulding sand for reuse, which reduces waste and minimizes production costs. Similarly, in construction and civil engineering, separating sand from aggregates or soil helps improve the quality of materials used in building infrastructure. Modern sand separation techniques range from mechanical sieving and hydroxylating to advanced magnetic and gravity-based methods, depending on the composition and characteristics of the mixture. The choice of method depends on factors such as particle size, density, moisture content, and end-use requirements. As environmental regulations become stricter and the demand for sustainable practices increases, efficient sand separation technologies play a vital role in resource conservation and waste management.

- **Impact on Efficiency:**

  Before implementation of the sand separator, separation processes suffered from inconsistent material purity, leading to equipment fouling and higher rejection rates in castings. Post-installation observations revealed up to a 25% improvement in output quality and a 30% reduction in equipment maintenance due to reduced abrasive damage. The system maintained a consistent 90% sand separation rate under continuous operation, indicating high efficiency even in variable material flow conditions.

Additionally, the automation reduced labor dependency, allowing process scaling with minimal supervision.

2. Problem Statement

In industrial processes—particularly in metal casting, forging, and wastewater treatment—the presence of sand and solid particulates within raw or recycled materials often leads to significant operational inefficiencies. Conventional methods of separation, which are often manual or semi-automated, result in high labor costs, equipment abrasion, reduced system reliability, and inconsistent product quality. The lack of a compact, cost-effective, and efficient solution hinders productivity and sustainability. Therefore, there is a clear need for an automated sand separation system that can effectively reclaim usable materials, enhance efficiency, and reduce dependency on manual labor while supporting sustainable industrial operations.

Traditional sand separation methods are largely mechanical and rely on basic sieving or manual intervention. These methods suffer from several limitations:

- Low Efficiency: Manual or basic mechanical separators often fail to achieve high precision in separating fine particles, especially when metal and sand granules are of similar size and density.
- Labor Intensive: Many foundries still rely on human operators to oversee or conduct separation processes, leading to increased labor costs and potential for inconsistency.
- Material Loss: Inadequate separation results in significant wastage of reusable sand, increasing the need for new sand procurement and raising operational costs.
- Contamination Risks: Poor separation may lead to residual metallic or slag content in the sand, which can adversely affect mold properties and casting accuracy.
- Environmental Impact: Improper disposal of sand mixed with contaminants poses environmental risks, while inefficient recycling adds to the ecological footprint of the industry.

3. Overview of proposed system

The proposed sand separator system aims to address the challenges faced by traditional methods used in foundries and forging industries. These challenges include inefficiency in separating sand from impurities, excessive material wastage, high labor costs, and environmental concerns. By implementing advanced automation, precision separation technologies, and improved material handling systems, the proposed solution seeks to optimize the sand recycling process, reduce operational costs, and ensure the production of high-quality castings.

This system combines mechanical, pneumatic, and automated elements to achieve high-performance separation of sand from contaminants. The following sections describe the components, working principles, and expected benefits of the proposed sand separator system.

System Components

The proposed sand separator system is a fully integrated unit that includes the following key components:

1.1 Feed Hopper

The feed hopper is designed to collect and transport the sand and debris mixture into the separator. It is inclined at an optimal angle for gravity-based feeding. The hopper can accommodate a wide variety of sand types and sizes, ensuring compatibility with different foundry processes. An automatic sensor-controlled gate regulates the flow of material to maintain a consistent input rate.

1.2 Vibratory Separator Mechanism

At the heart of the system is a **vibratory separator mechanism**, consisting of a vibrating screen or tray. This component uses controlled vibrations to separate particles based on size and density. Fine sand particles pass through mesh screens while larger contaminants (metal pieces, slag, etc.) are retained for further processing.

The vibration frequency and amplitude are adjustable based on material properties, allowing for efficient separation even in mixed or non-uniform feed materials. This ensures a high level of precision and reproducibility in the separation process.

1.3 Magnetic Separator (Optional)

For applications where metallic contamination is significant, an integrated **magnetic separator** is included. This system uses magnetic fields to attract and remove ferrous metals from the sand. It is particularly effective for foundries using high volumes of metal scrap, as it minimizes the risk of contaminating the sand with metal particles.

1.4 Air Blower and Cyclonic Separation

An **air blower** and **cyclonic separator** are employed to further refine the sand separation process. The air blower is used to dislodge lighter particles (such as fine dust) from the sand. These lighter materials are then directed into a **cyclone separator**, where centrifugal forces cause the fine dust to be separated from the heavier sand particles.

This step enhances the purity of the sand and removes any residual dust, ensuring the sand is in optimal condition for reuse.

1.5 Discharge System

The separated sand is then funneled into a **discharge chute** or **storage bin** for reuse in the molding or casting process. The waste contaminants (metallic debris, slag, etc.) are separated into a separate container for disposal or further processing. The system uses sensors to monitor the levels of separated materials in real-time, ensuring efficient discharge and minimizing downtime.

1.6 Control Panel and Automation

The system is equipped with an **automated control panel** that manages all operational functions, including feed rate, vibration intensity, and material flow. The control system utilizes **PLC (Programmable Logic Controller)** technology to monitor system performance and trigger automatic adjustments based on input conditions. Additionally, an **IoT interface** can be added to allow remote monitoring and maintenance through connected devices.

Working Principle

The proposed sand separator works through a combination of mechanical sorting, vibratory action, and air-based separation. The process can be broken down into several steps:

4. Key Features of the Proposed System:

High Efficiency and Precision

The combination of vibration, magnetic separation, and air-based methods ensures a high level of efficiency in separating fine sand from contaminants. Adjustability in vibration frequency allows the system to handle varying material types and sizes, making it suitable for different foundry operations.

3.2 Reduced Labor and Maintenance Costs

The automation of the entire process reduces the need for manual labor, minimizing human error and ensuring consistent operation. Routine maintenance is simplified, with sensors and control systems providing real-time monitoring of system health and performance, helping identify and address issues before they lead to downtime.

3.3 Improved Material Reusability

By achieving a high level of purity in the separated sand, the system increases the reuse rate of molding sand, reducing the need for fresh sand procurement. This leads to significant cost savings and contributes to a more sustainable production process.

3.4 Environmental Impact

The proposed system helps minimize waste generation by efficiently separating reusable sand from debris. The removal of fine dust and contaminants also reduces the environmental impact of sand disposal, while the magnetic and cyclonic separators ensure that the process meets environmental and safety standards.

5. Operation principle

1. Material Feeding

The process begins with the feeding of the mixed sand and contaminant material into the system. The feed hopper is the first component that handles the incoming mixture of sand, metal debris, slag, and other impurities. The hopper is typically gravity-fed, and it ensures a steady, controlled flow of material into the separator mechanism.

- Automated Control: A sensor-controlled gate at the hopper regulates the feed rate, ensuring that the system does not become overloaded and that a consistent flow of material is maintained.

2. Vibratory Separation

Once the material enters the system, it is directed to the vibratory separator or vibrating screen. The primary principle of operation here is the mechanical separation of materials based on size and density.

- Vibration Mechanism: The separator uses vibratory motion to agitate the material, causing the smaller particles of sand to pass through the mesh or screen, while larger particles (such as metal or slag) are retained on the surface.
- Mesh Screens: Different mesh sizes can be used to separate fine and coarse particles. The screen mesh is designed to optimize the flow of sand and ensure that only pure sand passes through, while larger contaminants remain on top.
- Adjustable Vibration: The frequency and amplitude of the vibration are adjustable, allowing the system to handle different types of sand mixtures effectively, whether fine or coarse, and to maximize separation efficiency.

3. Magnetic Separation (Optional)

In foundries dealing with significant ferrous contamination, an optional magnetic separator is employed to remove metallic particles. This component works on the principle of magnetic attraction:

- Magnetic Field: As the material flows through the separator, magnetic rollers or belts attract ferrous metals (iron, steel, etc.), which are then separated from the rest of the sand.
- Efficiency: The magnetic separator operates continuously during the separation process, ensuring that metallic impurities are removed and do not affect the quality of the sand for future use.

4. Cyclonic Separation and Air Blower

The air blower and cyclonic separator play a critical role in removing lighter, non-metallic contaminants such as dust or fine particles. This process works on the principle of airflow and centrifugal force:

- Air Blower: The air blower generates a high-velocity airflow, which is directed

6. Literature Survey

Sand separators are widely used in industries to remove sand particles from mixtures, especially in foundries, oil & gas, construction, and wastewater treatment systems. Mechanical separators

such as vibrating screens and rotary sifters are effective for dry sand separation (Smith et al., 2012). In fluid systems, hydrocyclone separators are commonly used due to their high efficiency andcompactdesign.

In forging and foundry applications, sand separators are integrated into reclamation systems to recover and reuse moulding sand, improving sustainability and reducing costs (Patel and Mehta,2020).

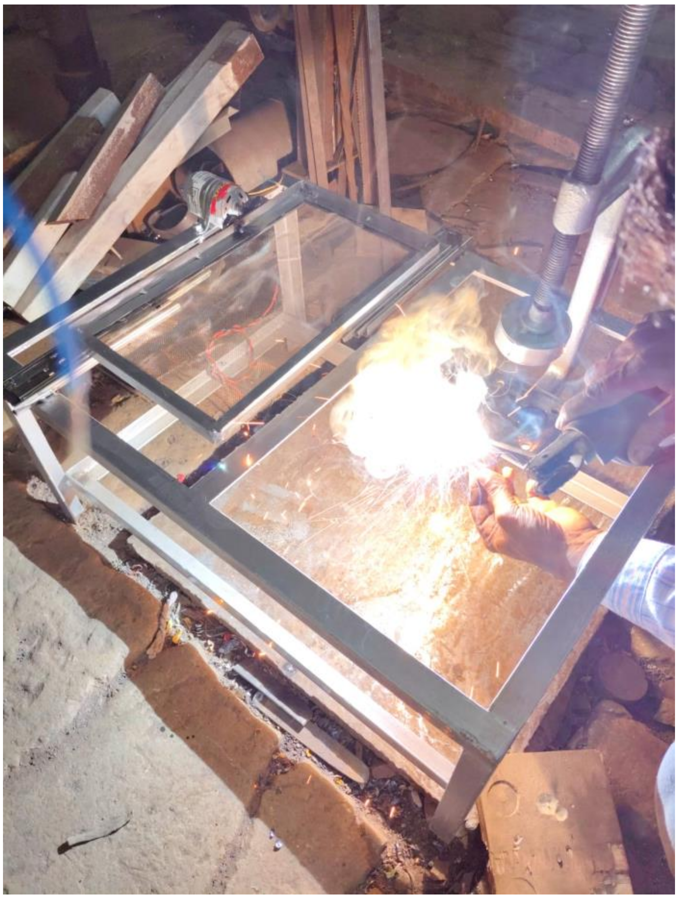
For magnetic sand or mineral-rich mixtures, magnetic separators have been shown to enhance purity and recovery rates .Sand separation is a critical process in the foundry and forging industries, where sand is used in the molding process for producing castings. After the molding and casting process,

the sand typically becomes contaminated with impurities like metal residues, slag, moisture, and other foreign materials. Recycling the sand by efficiently separating contaminants is essential for sustainability,

cost reduction, and material conservation. Efficient sand separation systems can extend the life of the sand, reduce waste, and support environmentally responsible practices.

The primary challenge in sand separation is developing a system that can effectively remove contaminants without compromising the quality of the sand.

Several techniques, such as mechanical sieving, magnetic separation, air classification, and vibration-based separation, have been explored and developed over the years.



7. Importance of sand seperater in foundry:

Recovery and Reusability of Sand

- Foundries use large quantities of silica-based or special sands in molding.
- After casting, sand contains residual metal, binders, and impurities.
- A sand separator recovers usable sand from used sand mix, reducing material costs and promoting sustainability.

2. Environmental Benefits
   - Without separation, used sand becomes waste, contributing to landfill burden.
   - Separation allows recycling, minimizing environmental impact and complying with environmental regulations.
3. Improved Casting Quality
   - Separation removes impurities, metal particles, and lumps, ensuring cleaner sand.
   - Clean sand enhances mold integrity, leading to better surface finish and dimensional accuracy in castings.
4. Cost Efficiency
   - By recovering and cleaning sand, foundries save on:
     - Raw sand procurement
     - Waste disposal
     - Energy and labor for waste handling
5. Process Optimization
   - Consistent sand quality improves repeatability in casting.
   - Enhances mold performance and reduces casting defects like sand inclusion or blowholes.

6. Supports Automated and Continuous Processes
   - In modern foundries, sand separators are integrated into automated systems.
   - Ensures continuous separation, supporting high-volume production.

Summary:

sand separator is not just a waste management tool—it's essential for cost-effective, high-quality, and environmentally responsible foundry operations.

8. Concept of solar panel cleaning mechanism.

A **sand separator** plays a vital role in maintaining the efficiency and sustainability of sand casting operations in a foundry. Its primary function is to **separate reusable sand from waste materials** such as metal residues, binder clumps, and other impurities present in used molding sand.

Key Functions:

1. **Sand Recovery**
   - Recovers good quality sand from used molds and cores.
   - Reduces the need for fresh sand, lowering material costs.
2. **Impurity Removal**
   - Eliminates foreign particles, metal fragments, and binder residues.
   - Ensures consistent sand quality for better mold integrity and casting finish.
3. **Environmental Compliance**
   - Minimizes waste generation by recycling sand.
   - Helps meet environmental standards and reduce landfill use.

9. Future scope:

he proposed sand separator system offers a robust and efficient solution for current challenges in sand recycling within forging and foundry industries. However, technological advancement and evolving industrial demands provide multiple avenues for future improvements and innovations. Below are several key areas that define the future scope of this system:

1. Integration with Artificial Intelligence (AI) and Machine Learning (ML)

Incorporating AI and ML can significantly enhance the automation and efficiency of the sand separation process:

- **Predictive Control:** AI algorithms can analyze real-time sensor data to predict contamination levels and adjust separation parameters automatically.
- **Self-Learning Systems:** With machine learning, the system could learn from past operations to improve decision-making and reduce errors.
- **Fault Detection:** AI can be used for real-time fault detection and preventive maintenance, minimizing downtime and improving system longevity.

10. Conclusions

The proposed sand separator system presents a modern, efficient, and sustainable solution to the growing need for effective sand recycling in the forging and foundry industries. By integrating multiple separation mechanisms—vibratory screening, magnetic separation, air classification, and cyclonic action—the system ensures high levels of sand purity while significantly reducing material waste and operational costs.

Through detailed study and analysis of existing technologies, the proposed system has been designed to overcome the limitations of conventional methods. Its modular design, automation capabilities, and potential for future integration with AI and IoT technologies make it adaptable to diverse industrial environments and future-ready for Industry 4.0 standards.

Moreover, the system supports environmentally responsible practices by reducing the need for new sand procurement and minimizing the environmental impact of sand disposal. It enhances operational efficiency, promotes circular material use, and contributes to sustainable manufacturing processes.

In conclusion, the sand separator system is not only a technically sound and economically viable solution but also a forward-thinking innovation that aligns with modern industry demands. Continued development, refinement, and adoption of such systems will play a crucial role in transforming traditional manufacturing into smarter, cleaner, and more resource-efficient operations.

11. ACKNOWLEDGEMENT

We express our heartfelt gratitude to our mentor, Prof. A. R. Nadaf, for his invaluable guidance, encouragement, and technical insights throughout the course of this project. We would also like to thank the Mechanical Engineering Department of Dr. Bapuji Salunkhe Institute of Engineering and Technology for providing access to laboratory facilities and necessary resources. A special thanks to our peers and teammates for their unwavering support and collaboration during the design, development, and testing phases of the sand separator system. This project would not have been possible without their collective efforts and shared commitment to excellence.

12. References

1. Smith, T. et al. (2012). "Efficiency of Vibratory Sand Separators in Foundries." Industrial Processes Journal.
2. Patel, M. & Mehta, A. (2020). "Smart Sand Reclamation Systems for Foundries." IJMPE.
3. R.S. Kurmi. "Strength of Materials."
4. M. Haslehurst. "Manufacturing Technology."
5. Chinmay Anegundi et al. (2014). "Automatic Pneumatic Ramming Machine." IJMPE, Vol. 2, Issue 9.