Sand Level Measurement System for Enhanced Sandpot Management

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Abstract. The "Sand Level Measurement System for Enhanced Sandpot Management" addresses a critical gap in traditional sand level monitoring methods prevalent in industrial processes, such as the use of dipsticks or rods, leading to operational setbacks and increased maintenance costs. This research introduces an innovative solution by integrating advanced sensor technologies, bundled with microcontroller systems and IoT connectivity. The methodology involves developing and implementing the sand level measurement system, followed by rigorous testing to verify its effectiveness. The empirical results demonstrate the system's precision and accuracy, offering real-time data on sand levels, thereby enhancing sandpot management. This advancement contributes to industrial efficiency, reduces maintenance costs, and provides a technologically sophisticated solution for industries relying on abrasive processes like sandblasting.

Keywords: Sand Level Measurement, Sandpot Management, Industrial Efficiency

1 Introduction

Sandblasting is a well-established and highly effective method employed across various industries for combating corrosion and revitalizing surfaces[1]. At its core, the successful execution of sandblasting hinges on the meticulous management of sandpots, the containers responsible for housing the abrasive material and delivering it to the blasting nozzle. Maintaining an optimal and well-monitored sand level within these pots is paramount to achieving consistent and high-quality blasting results[1, 2].

However, sandpot management, particularly in industrial settings, presents formidable challenges, chiefly concerning the accurate measurement and real-time monitoring of sand levels within these containers. Traditional approaches, such as assessing sand levels by utilizing a dipstick or rod, often prove inadequate, resulting in operational setbacks, increased maintenance expenditures, and diminished equipment longevity.

Recognizing the pressing need for a comprehensive solution, this study endeavors to introduce an innovative approach that addresses these challenges head-on. This journal introduces an

ICAE 2023, November 07, Batam, Indonesia

DOI 10.4108/eai.7-11-2023.2342941

advanced "Sand Level Measurement System" aimed to revolutionize sandblasting operations. Deviating from traditional methodologies, the system integrates high-end sensor technologies, microcontroller units, and Internet of Things (IoT) connectivity for precise, real-time monitoring of sand levels within sand pots. The novelty of this journal's approach lies in the calibration of advanced sensor technology, ensuring accuracy in measuring sand levels. The microcontroller unit orchestrates seamless communication, processing, and analysis of the acquired data, enhancing sand pot management. By doing so, it not only optimizes sandblasting operations but also empowers organizations with the means to proactively manage maintenance and reduce operational costs[3].

2 Architectural System Description

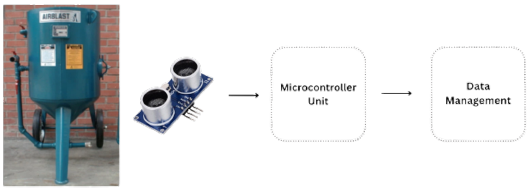

Fig. 1. Simplified end to end diagram of the system

Figure 1 provides an in-depth representation of the streamlined architecture used to measure sand levels, leveraging advanced sensor technologies as a robust method for real-time sand level monitoring. This intricately designed system is arranged around a key component, the microcontroller, which is meticulously configured and interconnected to support seamless sand level monitoring operations [5].

At its core, the microcontroller serves as the nerve center, coordinating the various elements of the system to ensure accuracy and reliability [5]. This central unit plays a central role in coordinating the entire sand level monitoring process.

The system's effectiveness depends on data collection from sand level sensors, a series of sophisticated devices meticulously calibrated to provide accurate and precise readings [3] of sand levels in the sand storage unit. These advanced sensors are capable of collecting real-time data, providing a foundation for further operations.

The data collected by the microcontroller represents the first stage of a complex data processing process. This data is not simply raw but serves as the basis for a series of complex data processing operations. These operations are designed to transform raw sensor readings into meaningful, insightful, and actionable interpretations.

In essence, this architectural design highlights a commitment to harnessing technological advances to achieve unprecedented levels of detail and accuracy in sand level monitoring. By combining advanced sensors, a precisely calibrated instrument cluster and a sophisticated data processing ecosystem, this system represents a paradigm shift in sand level monitoring, promising efficiency and Excellent reliability in industrial installations and operations.

3 System Design

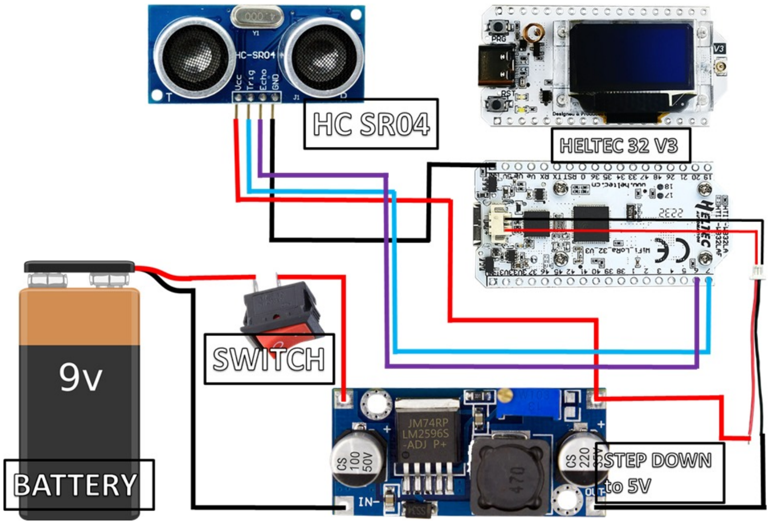

Fig. 2. Sand Level Monitoring System electrical design

Figure 2 presents the electrical design of the Sand Level Measurement System that fosters the monitoring system. At the core of the system is a microcontroller unit, acting as the central processing hub for data acquisition, sensor control, and the Internet of Things communication [8]. Heltec ESP32 V3 is strategically chosen for its compatibility with the advanced sensor technologies and Internet of Things communication protocols employed in the sand level monitoring system.

The electrical design places a strong emphasis on using a battery as the Sand Level Measurement System's main power source in order to ensure portability and independence. The system may function without the use of external power sources thanks to this design decision [9], which is in line with its Internet of Things nature. Additionally, a stepdown mechanism is used to control the battery's output voltage [9] and make sure it is compatible with the system's electrical needs.

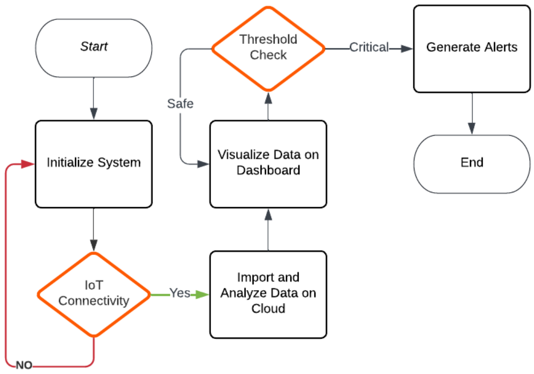

Fig. 3 Sand Level Monitoring System Flowchart

Figure 3 outlines the flowchart process of the "Sand Level Measurement System for Enhanced Sandpot Management" with IoT connectivity. The system begins by initialization, activating the advanced ultrasonic sensors and starts reading the data. Next crucial step involves checking the system's connectivity to the Internet, ensuring reliable data transmission. Once connectivity is confirmed and running, the system engages in IoT communication, transmitting the collected sensor data to a cloud platform, namingly Thinger.io. Next, the collected data is visualized in a monitoring dashboard with user-friendly graphical user interfaces.The data is then undergoes analysis, where algorithms interpret it, and a threshold check determines if the sand level is within acceptable limits. If the level is critical, the system generates alerts, triggering necessary actions.

4 Data Management

For effective and safe data management in this study, the Sand Level Measurement System makes use of the powerful Thinger.io IoT platform. Thinger.io offers a fluid user interface for collecting, storing, and visualizing [10] sand level data from the sophisticated sensor technologies included into the sand pot.

The data management process is initiated when the microcontroller unit acquires real-time data regarding sand levels. The Thinger.io cloud platform receives this data after being safely delivered via Internet of Things connectivity [10]. The integrity and accessibility of the sand level data are guaranteed by Thinger.io, which serves as a central repository. The platform adheres to industry standards for data security and uses encryption algorithms to ensure the confidentiality of sensitive information. Figure 3 presents the user interface of the Thinger.io that orchestrates the Sand Level Measurement System.

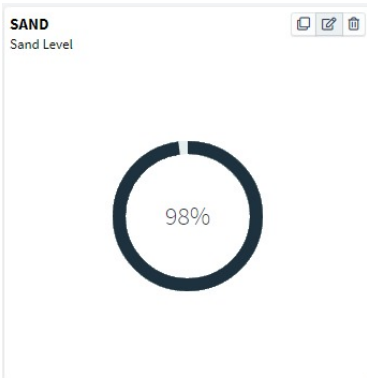

Fig. 4 Sand Level Monitoring System Thinger.io interface

The sand levels are represented using a dynamic progress bar with a percentage scale. This simple graphical interface was made possible with Thinger.io, enabling operators and maintenance staff to quickly understand sand levels. Decision-makers can foresee maintenance requirements and optimize sandblasting operations thanks to Thinger.io's data processing capabilities [11], which also enable the development of historical patterns and predictive analytics.

5 Possible Industrial Use

This research shows great promise in revolutionizing foundry operations. Foundries are industrial facilities where metal casting takes place [2], and effective sand management is essential for successful operations. The proposed system may find invaluable applications in this context.

5.1 Resource Optimization and Productivity Enhancement

Sand is a significant resource in foundries, and its efficient use is essential for cost control [1]. The system prevents overfilling and depletion of sand pots, leading to optimized resource utilization. Of which, resources are an integral part of industries as it contributes to the performance of the select industry [3]. Without excellent management of the sand as resources of the foundries, problems might occur internally for the foundries such as profit loss, system malfunction and damage to the sand pot. Thus, by this system, all the said problems will be eliminated or at least suppressed.

Furthermore, optimal utilization of the sand as the resources in the foundries could lead to an enhancement of productivity [4]. The system made sure the usage of sand could be monitored, thus administer the resources available with careful projection. Accordingly, the system will be able to constitute a productivity enhancement to support the longevity and production of the foundries.

5.2 Compliance and Reporting

In today's industrial landscape, environmental regulations are becoming increasingly strict [6], industries mainly require adopting sustainable practice. Foundries, being significant consumers of resources like sand, are no exception to this trend. In this context, the system acts as a pivotal role in helping foundries align with these rigorous environmental regulations [6].

At its core, the system operates as an eco-conscious guardian for foundries, promoting sustainability in sand management. Through its precise monitoring, the system orchestrates optimal sand usage, thus eliminating waste production [4] – a pivotal parameter in staying well within the strict environmental compliance standards. By preventing both overfilling, which can potentially lead to environmental hazards, and depletion, which disrupts production schedules, the system ensures a harmonious balance in sand pot management [6].

The true essence of the system lies in its ability to simplify the complex task of adhering to environmental regulations. By providing real-time data and precise control, the system empowers foundries to operate efficiently while upholding environmental responsibility [12]. In an age where environmental consciousness is paramount, the SLMS emerges as an indispensable ally, harmonizing operational efficiency within the foundry industry.

6 System Reliability

Ensuring the robustness and reliability of the system is one of, if not the most essential part in the context of sand pot management within foundries. Reliability in this system extends beyond mere functionality but also it encompasses the capacity to operate seamlessly under the harsh and dynamic conditions commonly encountered in industrial settings [7].

Table 1. Sensor data acquisition and comparison towards real measurement

No	Absolute Measurement (cm)	Sensor Measurement (cm)	Percentage Error Calculation (%)
1	3	2.8	6.90
2	5	4.1	19.78
3	8	7.4	7.79
4	11	10.1	8.53
5	14	13.2	5.88
6	17	15.5	9.23
7	20	18.4	8.33
8	23	22.3	3.09
9	25	26.4	5.45
10	27	26.1	3.39
11	29	28.5	1.74
12	32	30.4	5.13
13	34	33.7	0.89
		PE%	**5.79**

In the pursuit of assessing the reliability of the system in monitoring sand levels within sand pots, comprehensive comparative analysis was conducted. Table 1 provides a detailed account of the sensor's performance concerning actual measurements obtained from an industry-standard measurement instrument [7]. The establishment of this performance metric is vital in substantiating the system's accuracy and its potential utility in practical foundry and/or industrial applications.

To calculate the degree of agreement between the sensor-based measurements and the real instrument readings, the Percentage of Error formula was employed. The formula, expressed as:

$$PE\% = \frac{(\text{sensor readings} - \text{actual measurement})}{0.5 * (\text{sensor readings} + \text{actual measurement})} * 100\%$$

With a Percentage Error of only 5.79%, it is safely affirmed that the system's reliability extends to a scale of 94.21%. This stellar performance underscores the robustness of the system in accurately acquiring the data of sand levels within sand pots.

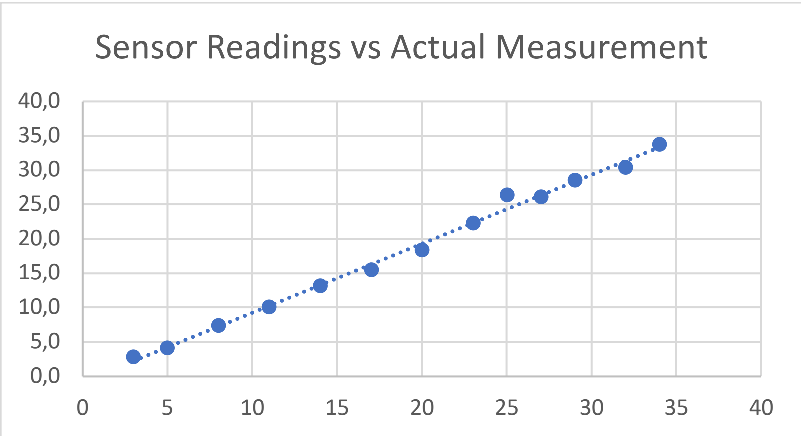

Fig. 5 Sensor readings vs actual measurement line chart

By virtue of the line chart presented on Figure 2, we could see the almost straight line that represents that the sensor readings and the actual measurement wasn’t far off comparison. This close correlation constitutes the sensor's reliability, making it a robust and dependable tool for sand level measurement. The minimal deviation observed in the data assures that the sensor consistently provides reliable information.

7 Conclusion

This journal has set forth research that utilizes the advanced sensor technologies to establish and build a sand level measurement system that helps support the industrial and foundries application, thus leads to enhanced productivity and compliance towards environmental standards. With accurate and precise readings, shown in the experiments conducted, introduces a sand level management system that is substantial towards the success of select industry.

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