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Silo Level Monitoring Using IoT

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Abstract: This study Silo Level Monitoring Using IoT is a real-time industrial monitoring system developed to measure and track the material level inside cement tanks or storage silos. In many industries, silo level checking is still performed manually, which may result in inaccurate measurement, delayed decision-making, overflow, shortage of material, wastage, and poor inventory management. This project overcomes these limitations by using IoT-based sensing and monitoring technology to continuously detect the storage level and display the data on a web-based dashboard.

The proposed system uses relevant hardware components such as an ESP32/NodeMCU microcontroller, ultrasonic sensor for measuring the distance between the sensor and material surface, power supply module, connecting wires, and optional alert components such as a buzzer or LED indicators. The ultrasonic sensor measures the empty space inside the silo, and based on this distance, the system calculates the filled percentage of the tank. The ESP32/NodeMCU processes the sensor data and transmits it to the web application through Wi-Fi connectivity.

The software side of the system is developed using HTML, CSS, and JavaScript for the web dashboard. The dashboard displays real-time tank level, distance value, percentage level, status such as Full, Medium, or Low, graphical analysis, and daily cement level logs. This allows users or industry operators to monitor silo status remotely without physically checking the tank. The system helps avoid overflow, reduces material wastage, improves inventory control, and increases operational efficiency. Overall, the project provides a smart, low-cost, reliable, and efficient solution for industrial silo level monitoring using IoT.

Index Terms - Silo Level Monitoring, IoT, Cement Tank Monitoring, ESP32, NodeMCU, Ultrasonic Sensor, Real-Time Monitoring, Web Dashboard, HTML, CSS, JavaScript, Industrial Automation, Inventory Management, Remote Monitoring

I. INTRODUCTION

Industrial silos are widely used for storing cement, grains, powders, chemicals, minerals, and other bulk materials. In cement plants and construction-related industries, accurate knowledge of silo level is very important because material shortage can stop production, while overfilling can cause wastage, spillage, safety risks, and maintenance issues. Traditional silo monitoring is often done manually or through periodic inspection, which is time-consuming, inaccurate, and dependent on human availability.

The Silo Level Monitoring Using IoT project provides a smart solution for real-time monitoring of material level inside a cement tank or silo. The proposed system uses an ultrasonic sensor to measure the distance between the top-mounted sensor and the surface of stored material. Based on this distance, the system calculates the filled percentage of the silo. A microcontroller such as ESP32 or NodeMCU processes the sensor reading and sends the data to a web dashboard through Wi-Fi connectivity.

The web dashboard is developed using HTML, CSS, and JavaScript. It displays real-time tank level percentage, measured distance, status such as Full, Medium, or Low, graphical visualization, and daily logs. The system helps industries monitor silo conditions remotely, reduce manual checking, avoid overflow, prevent material shortage, and improve inventory management.

Recent IoT level-monitoring studies commonly use ultrasonic or distance sensors with microcontrollers/cloud dashboards for real-time level visibility, wastage reduction, and remote monitoring. Similar approaches have been reported in water tank, cistern, and industrial level-monitoring studies where sensor-based IoT systems improved monitoring accuracy and reduced manual dependency.

II. LITERATURE REVIEW

H. K. H. Singh, H. Kamaludin, I. R. A. Hamid, N. Z. M. Safar, and N. Abdullah published "IoT-Based Water Tank Level Monitoring System Using Ultrasonic Sensor" in AIP Conference Proceedings in 2023. The paper focused on using an ultrasonic sensor to measure water tank level and transfer the data through an IoT platform. The major finding was that ultrasonic-based measurement can provide reliable level detection without direct contact with the stored liquid. Although the paper was based on water tank monitoring, the same sensing principle can be applied to cement silo monitoring because both systems require distance-to-level conversion.

M. A. Wister and co-authors published "Using IoT for Cistern and Water Tank Level Monitoring" in 2024. This study discussed real-time level data collection using IoT sensors and remote data publishing. The finding showed that IoT-based level monitoring helps reduce overflow, supports better resource management, and improves remote supervision. For the proposed silo project, this research supports the idea that real-time level visibility is better than manual inspection.

L. M. Pires and co-authors published "IoT-Enabled Real-Time Monitoring of Urban Garbage Levels Using Time-of-Flight Sensing Technology" in 2025. The paper used a distance-based sensor with an ESP32-S3 microcontroller and IoT gateway to monitor fill level. The finding showed that distance sensors are useful for measuring fill levels in containers without physical contact. This is relevant to silo monitoring because cement powder should not be touched directly by sensors due to dust, vibration, and material flow.

H. Alamsyah and co-authors published "Monitoring and Detection System of Level and Turbidity in Embankment Water in Real Time Based on IoT" in 2024. The system used an ultrasonic sensor for level measurement and visualized data through an IoT web platform. The main finding was that real-time visualization improves monitoring speed and helps users respond quickly to abnormal level conditions. This supports the web-dashboard concept used in the proposed silo monitoring system.

A 2023 IEEE INDICON paper titled "IoT Smart Water Level Monitoring System" focused on ultrasonic level tracking and real-time monitoring. The study used ultrasonic sensing to measure tank level and transmit readings for monitoring. Its finding showed that IoT-based level monitoring can reduce dependency on manual checking and provide timely information to users. This directly supports the use of a sensor-dashboard model in the silo monitoring project.

M. A. Al-Shareeda and co-authors published "Secure IoT-Based Real-Time Water Level Monitoring System" in 2025. The study used ESP32, ultrasonic sensing, and real-time display/monitoring for level measurement. The finding highlighted the importance of secure and reliable IoT communication for remote level monitoring. This is important for industrial silo systems where wrong or delayed readings can affect material planning and operational decisions.

S. Jayalakshmi published work on an IoT-enabled smart water tank monitoring system with Android application control in 2023. The study showed that mobile or web-based access improves user convenience and allows operators to check level status remotely. The finding is useful for the proposed project because the silo dashboard can be extended into a mobile application or admin monitoring panel in the future.

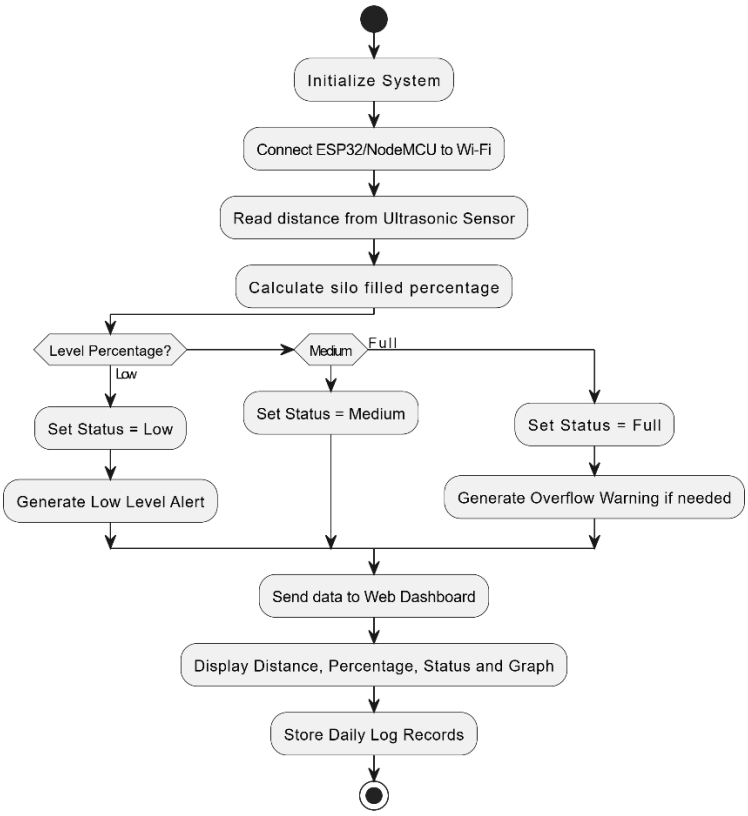
III. METHODOLOGY

The proposed methodology follows a simple sensor-to-dashboard workflow. First, the silo height is defined in the system. An ultrasonic sensor is fixed at the top of the silo to measure the distance between the sensor and the cement surface. The ESP32/NodeMCU reads the distance value and calculates the filled level percentage using the silo height. Based on the percentage, the system classifies the status as Low, Medium, or Full.

After processing, the sensor data is sent to the web dashboard through Wi-Fi or a backend server. The dashboard developed using HTML, CSS, and JavaScript displays the real-time values, graphs, and daily logs. The data can also be stored for future analysis. If the level is too low or too high, the system can generate an alert for the operator.

Working Steps

1. **Requirement Analysis**
   Identify the need for real-time silo level monitoring, required hardware, web dashboard features, and alert conditions.
2. **Hardware Setup**
   Connect the ultrasonic sensor with ESP32/NodeMCU and mount the sensor at the top of the silo.
3. **Sensor Data Collection**
   Measure the distance between the sensor and material surface using ultrasonic waves.
4. **Level Calculation**
   Convert distance into filled percentage using silo height.
5. **Status Classification**
   Classify the tank condition as Low, Medium, or Full.
6. **Data Transmission**
   Send processed data from the microcontroller to the web dashboard/server.
7. **Dashboard Visualization**
   Display real-time level, distance, graphs, and daily logs using HTML, CSS, and JavaScript.
8. **Alert and Log Management**
   Store records and generate warning status when the silo level crosses defined limits.

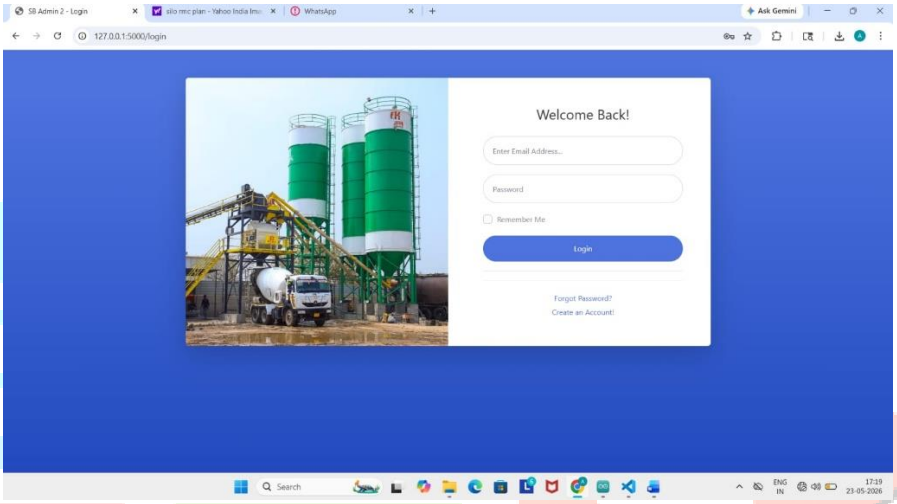


IV. RESULT & DISCUSSION

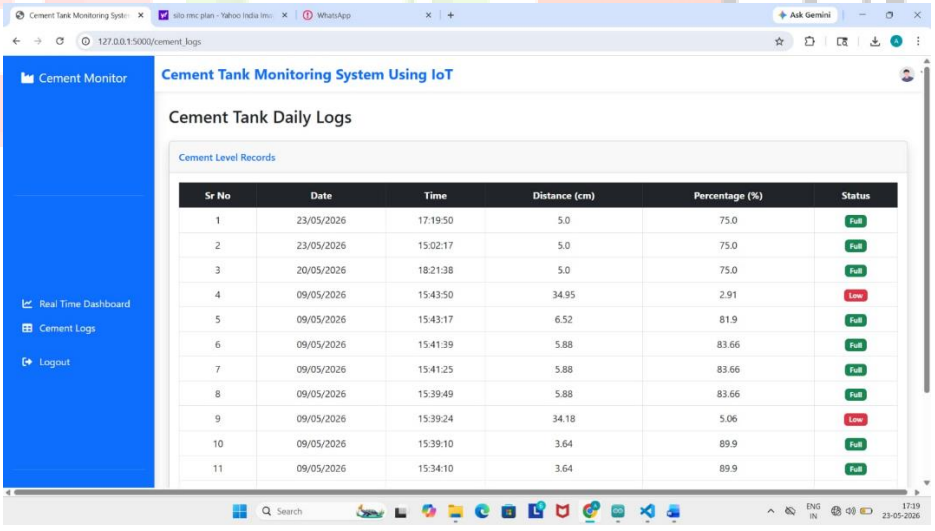
The developed system successfully monitors the material level inside the silo in real time. The ultrasonic sensor measures the distance from the top of the silo to the material surface, and the system converts this reading into a percentage level. The web dashboard displays the current tank level, measured distance, status, graph, and daily logs.

The result shows that when the measured distance is low, the silo is considered highly filled because the material surface is near the sensor. When the measured distance is high, the silo level is considered low because the material surface is far from the sensor. This logic helps operators understand the actual storage condition without physically checking the silo.

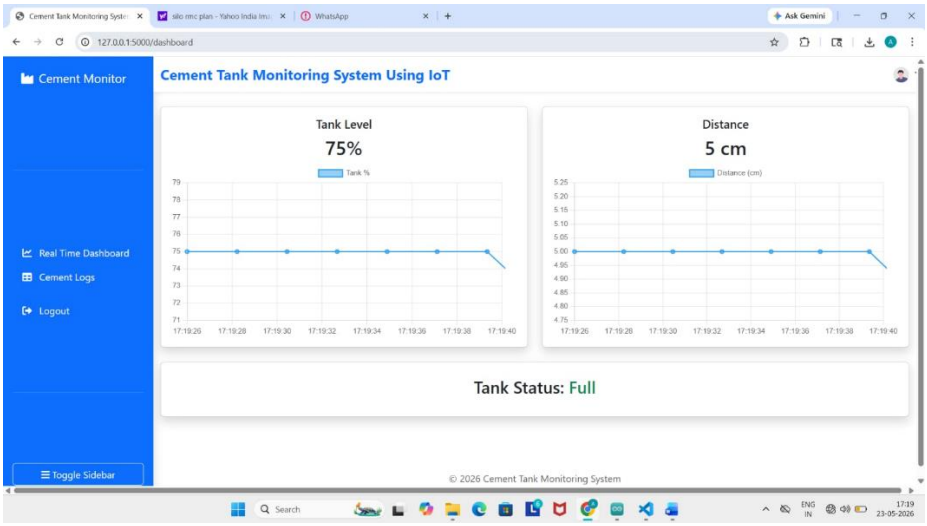
The dashboard improves visibility by showing live values and historical records. It also supports better inventory planning because the operator can identify whether cement stock is sufficient or needs refilling. The system reduces manual effort, avoids overflow, and improves industrial monitoring efficiency.



SC 1 : Home Page



SC 2 : Daily Logs



SC 3 : Cement Logs

Result Table

Sr. No.	Distance Measured	Calculated Level	Status	System Response
1	5 cm	75%	Full	Normal monitoring, silo has sufficient material
2	15 cm	50%	Medium	Material level is moderate
3	30 cm	15%	Low	Refill alert required
4	35 cm	5%	Low	Critical low level warning
5	6 cm	82%	Full	High storage level detected

The table shows sample results generated from the silo level monitoring system. A lower distance value indicates that the material is closer to the sensor, meaning the silo is more filled. A higher distance value indicates that the material level is lower. The system uses this distance value to calculate the percentage and classify the status as Full, Medium, or Low.

Discussion

The proposed system provides a practical and low-cost solution for silo level monitoring. Compared to manual checking, the IoT-based system gives faster and more accurate updates. The graphical dashboard makes the system easier to understand for operators. Daily logs also help in analyzing usage patterns and planning material supply. The system can be further improved by adding GSM alerts, cloud database storage, mobile application support, multiple silo monitoring, and predictive analytics for material consumption forecasting.

V. ACKNOWLEDGMENT

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