AUTOMATIC MOBILE OIL DISPENSING WITH MONITORING FOR TRAIN COMPRESSOR

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Abstract

Train compressors require the appropriate oil level to function effectively. Kettles and pitchers are useless, inexact, and dangerous for hand oil replenishment. To solve these problems, this project developed an automated mobile oil delivery system that monitored the oil. The technology avoids spills, dispenses oil accurately, and monitors oil levels and battery efficiency in real-time. All of the above requires a very thoughtful design and development of a self-priming pump, ultrasonic sensors, an electronic battery sensor, an ultrasonic flow meter, and an Arduino Giga display. It was developed and tested locally. The system accurately administered oil and monitored oil levels and the condition of the battery; excellent comments were received from the maintenance experts. This implies that automated oil refilling for railway depots' train compressor oil may enhance efficiency and safety. The potential to work with various train compressors, as well as economic and environmental advantages, deserve further research.

1. Introduction

An essential component keeps trains moving smoothly in the railway system. The train compressor compressed air for the braking system, pneumatic doors, air suspension, and HVAC system. Train compressors are crucial to passenger safety and comfort.

Maintenance workers face everyday challenges with train compressors. Manually restocking the Train Compressor oil is laborious and reduces maintenance efficiency. Overfilling or uncontrolled refills may waste oil and spill it onto the ground, causing unsafe working conditions and increasing maintenance crew injury risk. Making tools for this kind of repair would simplify and boost maintenance experts' efficiency.

Manual oil distribution for train compressors wastes oil, overfills, and takes time. Manual oil transfer using a kettle or plastic container typically leaks, wasting oil. Maintenance workers may be at risk from unethical oil transfer. Oil contamination may also come from improper oil transmission.

Maintaining oil in the train compressor ensures optimal operation of systems. R. Bechayda (2024) notes that maintenance personnel find the kettle used to transfer oil from the bucket to the train compressor problematic. Oil leaks occur when kettles are used.

Oil waste and inefficiency arise from using plastic bottles or kettles to transport oil to train compressors, which is unethical and may cause spillage. Lack of equipment, such as specific oil delivery systems, and human error compound the problem. Leaks from damaged or improvised equipment, such as DIY oil transfer arrangements, exacerbate the problem. This difficulty is exacerbated by inefficient transfer operations, which might include numerous manual steps. These causes provide dangerous floors for workers, significant oil procurement waste, clogged hoses, cutaneous difficulties from touch, and poorly lubricated components that reduce efficiency and wear on critical components.

Automatic Mobile Oil Dispensing System with Monitoring for Train Compressors is the researchers' goal. To prevent illegal oil transfer risks. The automated mobile dispensing device will provide the train compressor with the right amount of oil, store enough oil in the reservoir, and monitor the container's oil level, battery condition, and dispensing history. Train compressor oil management safety, efficiency, and maintenance are the system's goals.

1.1 Literature Review

Review of Related Literature and Studies

Enhancing Efficiency and Safety in Railway Maintenance

Train parts must be serviced in railway operations for safety and efficiency. The pneumatic train system relies on the train compressor, such as suspension, door opening, and deceleration. Replenishing train compressor oil through manual handling is unsafe and risky for maintenance staff.

As argued by Wu et al. (2023), the train compressor is a vital factor in both the safety and efficiency of the train. Compressed air is required for a variety of functions that are not less indispensable, including braking, pneumatic doors, air suspension, heating, ventilation, and air conditioning, as Wang et al. (2022) suggest. The compressor must be reliable and efficient to maintain schedules, keep passengers comfortable, and decrease the chances of accidents (Li et al., 2021). The replenishment process of train compressors' oil, as stated by Liu et al. (2019), is laborious, thus reducing the efficiency of the maintenance personnel. According to Wang et al. (2022), oil might spill or leak due to an overfilled tank and wrongly refilling the tanks. According to Crosera et al. (2018), oil leaks might make a workplace hazard and raise its dangerousness. Approaches that are either more precise or better automated must be studied to enhance the safety and efficiency of train repairs.

From the works of Liu et al. (2019) and Gong (2021), this might help the automated oil distribution system in train compressors mitigate all these difficulties and help the maintenance be smoother. The system will, therefore, prevent oil spillage, provide a precise measurement of the oil required, and keep track of the remaining and used oils, according to the findings of Zhang et al. in 2020 and Wang in 2022. According to Al-Mulali et al. (2016) and Jiao et al. (2017), this automation may help increase safety, efficiency, reduction of waste, and predictive maintenance. Railway firms may also increase their operational dependability while reducing downtime by implementing automated train maintenance, according to Yang et al. (2021). In addition, this allows them to allocate resources correctly.

Challenges of Manual Oil Refilling

When oil is topped up manually using kettles, plastic bottles, or pitchers, chances of oil loss, faulty topping up, and contamination arise (Crosera et al., 2018; Liu, 2019). It's not only ineffective but dangerous as well. Spilling and overflows resulting from hand pouring contribute to wastage of oil and damage to the environment (Chen et al., 2021). These simple mechanisms cause an inability to know the quantities that are held within this barrel, which can subsequently result in damage to these compressors due to being filled either under or over capacities (Wang et al., 2022). Thirdly, through having open barrels, oils exposed to dust and particles depreciate the quality and extendability of the lifetime in a compressor (Li et al., 2021).

According to Crossera et al. (2018), transfers may lead to spillages, which will have the effect of resource depletion and making the working place unsafe due to high chances of slips, trips, and falls. Injuries caused by accidents might lead to absenteeism. This will negatively impact the production and morale at work. According to Al-Najjar and Alsyouf (2020) and Qi et al. (2023), automated or controlled oil dispensing systems can eliminate these risks, thus improving worker safety and increasing the likelihood of sustainable maintenance. According to Wu et al. (2023), these systems are capable of ensuring accurate oil distribution, reducing the probability of spills, and minimizing pollution, thus improving the efficiency and reliability of trains.

Existing Technologies and Their Limitations

According to He et al. (2022), the mobile oil dispenser, though portable, most of the time does not have much storage capacity. According to Crosera et al. (2018), hoisting such large oil tanks onto a trolley is a trying and probably dangerous task. This does not only make the "automated" process prone to risk but makes maintenance staff prone to ergonomic experiences. It is known that mobile dispensers lack sufficient storage space, often requiring to be resupplied multiple times because of this, which sometimes can disrupt workflow and efficiency (Liu et al., 2019).

Because of the available limited space, bulk storage oil dispensing systems would not function well at railway depots (Wang et al., 2022). This is due of the enormous storage capacity of these systems. Existing maintenance facilities may not be able to accommodate these systems since they demand a significant amount of floor space. According to Qi et al. (2023), the size and complexity of these technologies may make them less adaptable and more difficult to include into train maintenance processes.

There is a need for nonconventional oil dispensing methods that can overcome the above limitations. The system should be able to combine the portability of mobile dispensers with the storage capacity of bulk systems, all while maintaining its small size and adaptability for use in railway detention centers. According to Al-Najjar and Alsyouf's 2020 research and Wu et al.'s 2023 research, modular designs, adaptive storage, and digital monitoring and control systems may increase oil use and maintenance rates.

Components and Considerations for the Proposed System

The proposed automated mobile oil distribution system has many components, all selected for the purpose and efficiency. The self-priming pump transfers oil from the reservoir to the train compressor with no human priming. This eliminates airlocks and reduces the chances of any airlocks in the line (Li et al., 2021). Ultrasonic sensors are very accurate when measuring fluid levels. Oil levels in the tank will be measured accurately to allow correct dispensing and minimize waste (Wang et al., 2022). An electronic battery sensor would monitor the health of the battery continuously, giving real-time charge levels and status to ensure reliable operation and prevent downtime (Al-Najjar & Alsyouf, 2020).

An ultrasonic flow meter will increase accuracy and oil consumption monitoring. This non-invasive method estimates oil flow, enabling dispensing history monitoring, leak detection, and maintenance plan improvements (Wu et al., 2023). System mobility and stability rely on heavy-duty caster wheels, which make it easy to move around the railway depot and ensure safe operation on different surfaces (He et al., 2022). Ultrasonic sensors trigger an automatic shut-off nozzle to prevent overfilling and leaking, thereby increasing safety and the environment (Chen et al., 2021). For daily use, a reinforced rubber hose will convey oil safely and resist degradation.

The system will have a reservoir of oil that stores enough oil to dispense, maximizing capacity and usability for train station applications. The system will be wireless and more efficient with its use of a lithium-ion battery, which has higher energy density and lifespan compared to other batteries. An Arduino Giga display will be the primary means through which the system controls and monitors itself. It will display oil levels, condition of the battery, and flow rate in real-time on this user-friendly interface, helping operators adjust their oil dispensing so it is both accurate and time-efficient (Qi et al., 2023).

The components of this assembly have been chosen carefully for their specific tasks and the potential synergy they hold, for the purpose of developing a strong, efficient, and user-friendly automated oil distribution system that would enhance railway depot maintenance.

The selection of parts and the integration of the system for the construction of this automatic mobile oil distribution system, in addition to safety, require paramount attention. The system shall have to be thoroughly tested to ensure reliability and efficiency in solving the problems of the manual replenishment of oil at railway depots.

The proposed solution is the implementation of monitoring an automated mobile oil supply system. In it, oil levels and battery state will be stored and monitored, and a dispensing history will be recorded, with oil supplied in an appropriate quantity to the train compressor.

1.2 Objective of the Study

The main objective of this study is to develop automatic mobile oil dispensing with monitoring for train compressors. Specifically, the study aims to:

1. Design an automatic mobile oil dispensing with monitoring for train compressors with the following features:
    - 1.1 Chassis to protect the component of the prototype
    - 1.2 Battery to power the self-priming pump
    - 1.3 Self-priming pump to dispense the oil
    - 1.4 Ultrasonic sensor to accurately and efficiently measure the level of oil in a tank
    - 1.5 Arduino Giga display for monitoring the oil level and controlling the oil dispensing
    - 1.6 Heavy-duty caster wheel to carry the heavy load
    - 1.7 Electronic Battery Sensor to monitor and assess the health of the battery, ensuring safe and efficient operation within various electronic devices and systems.
    - 1.8 Ultrasonic Flow Meter to measure the flow of the oil.
2. Fabricate and assemble the prototype to specifications using locally available materials.
3. Test and improve the prototype with regards to its functionality, safety, and durability.
4. Evaluate the prototype's performance using the standard TUP evaluation instrument.

2. Research Methods

The research methodology employed in this study encompasses a comprehensive approach that includes project design, development, operation, testing, and evaluation.

Project Design

The design of the Automatic Mobile Oil Dispensing with Monitoring for Train Compressor is centered on preventive maintenance. The project aims to address the problem of oil spillage and enhance the monitoring of oil levels in train compressors. The system is designed to not only save oil but also improve worker efficiency by providing a systematic approach to oil dispensing and monitoring. This research project is expected to significantly impact the railway industry by modifying the current oil dispensing system used in the country. The design's scope includes improvements to the dispensing process, as well as the evolution of proper oil monitoring and logging history storage.

The project design, as depicted in Figure 1, showcases an isometric view of the tool cart. The cart features a frame with wheels for mobility, and a monitoring unit equipped with an LCD screen for tracking oil level, battery life, and dispensing activity. The system is operated by an Arduino Giga and an LCD touchscreen, responsible for controlling the machine and its components.

Figure 2 provides an exploded view of the tool cart, utilizing labeled blocks to represent individual or multiple items and concepts. Lines connect these blocks to illustrate their relationships within the system.

Monitoring Section
The monitoring section of the Automatic Mobile Oil Dispensing with Monitoring for Train Compressor prototype includes an Arduino Giga display. This display presents the log history, battery percentage, oil level, and controls for oil dispensing. Its primary function is to manage the automatic dispensing of oil.

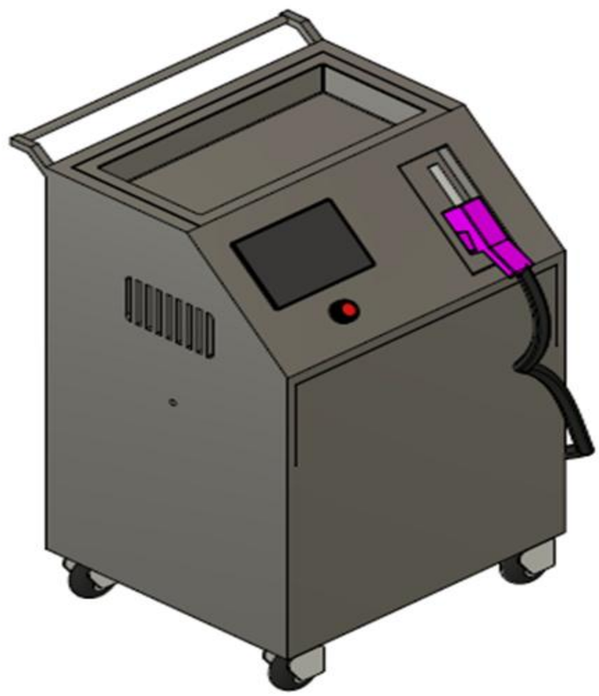

Fig 1. Isometric View of the Automatic Mobile Oil Dispensing System

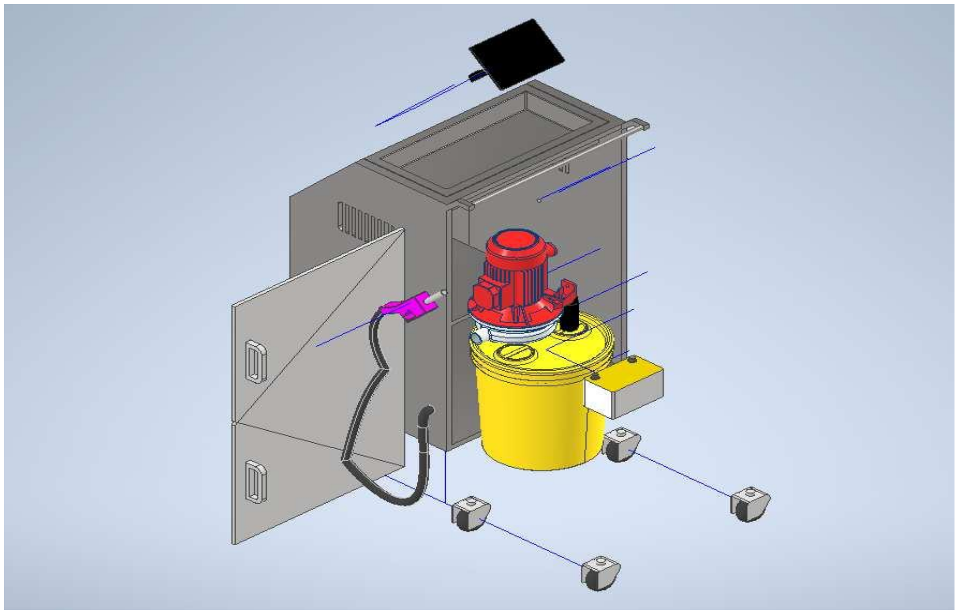

Fig 2. Exploded View of the Automatic Mobile Oil Dispensing System

Figure 3 illustrates the complete flow of the system using a flow chart. The process begins with powering the power supply, which activates the sensors and initiates the pump operation. The pump draws oil from the reservoir through a hose, which then transmits the oil to the automatic shut-off nozzle and finally to the train compressor. The LCD screen displays the amount of dispensed oil, battery level percentage, and the logging history of oil.

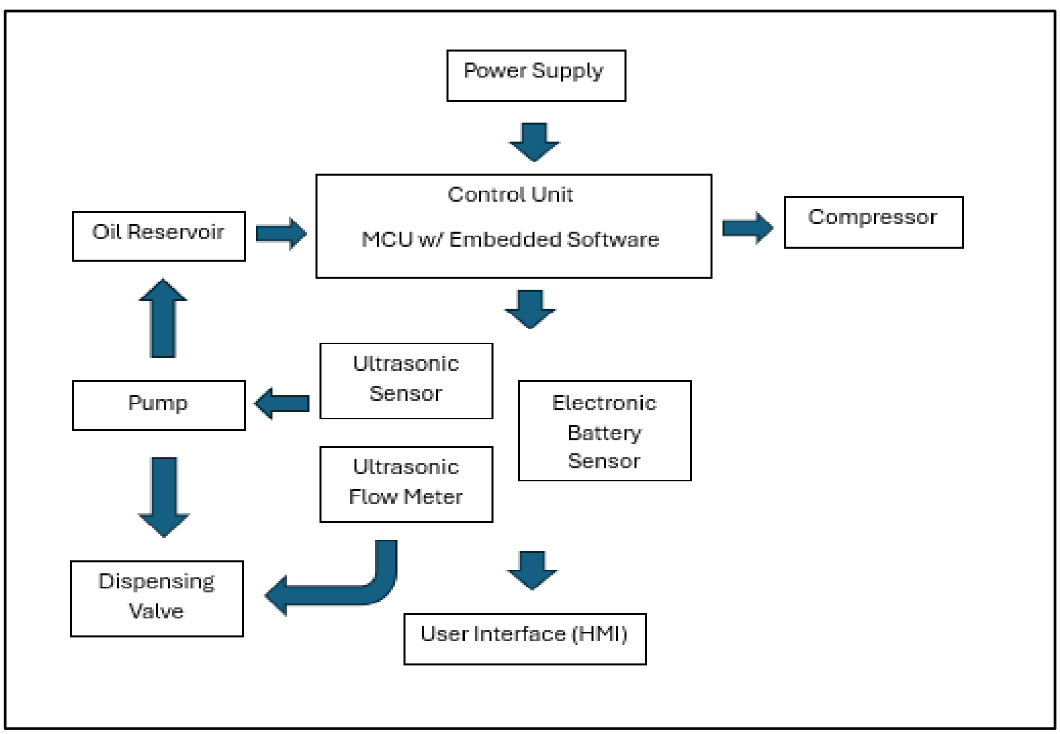

Fig 3. Flow Chart of the Automatic Mobile Oil Dispensing System

Project Development
The development process involves three main sections:

1. **Frame Section**: Constructing a sturdy frame with heavy-duty caster wheels to support the system's components and ensure mobility.
2. **Control Section**: Implementing an Arduino Giga and an Arduino Giga display to control the system's operations and provide a user-friendly interface for monitoring and interaction.
3. **Monitoring Section**: Integrating sensors (ultrasonic, electronic battery sensor, ultrasonic flow meter) to monitor oil levels, battery health, and oil flow, enhancing accuracy and safety.

Fabrication and Assembly
The fabrication process involves using locally available materials to construct the chassis, assemble the components, and ensure the system's structural integrity. The assembly process includes:

1. Constructing the cart frame according to the design specifications.
2. Mounting the oil reservoir securely onto the cart.
3. Installing the self-priming pump and battery, ensuring proper attachment.
4. Integrating the monitoring system components (sensors, Arduino Giga, display).
5. Connecting the electrical wiring system for power supply and sensor operation.
6. Attaching the hose to the pump, container, and nozzle securely.
7. Testing the functionality of all components and the overall system.
8. Conducting a final inspection to ensure all connections are secure and components are in place.
9. Documenting the assembly process for future reference and maintenance.

Operation and Testing Procedure
Operation

1. Check oil levels in the reservoir.
2. Power up the machine and input settings.
3. Connect hoses and nozzles to the train compressor.
4. Start dispensing and monitor the flow.
5. Disconnect hoses and power down after dispensing.
6. Document dispensed oil quantity.

Testing

1. Accuracy of Dispensing Test: Verify the accuracy of the dispensed oil quantity compared to the system's recorded data.
2. Power Consumption Test: Determine the battery's capacity and usage time by monitoring its discharge voltage over time.

Evaluation
The evaluation will be conducted by maintenance workers at the LRT Line 2 Depot in Pasig City. They will assess the system's performance based on criteria such as aesthetics, durability, economy, functionality, marketability, safety, and workability. A Likert scale will be used to quantify their feedback, and the overall acceptability of the system will be determined based on the grand mean of the evaluation scores.

3. Results and Discussion
The reason for doing this research study was that the replenishment of oil for the train compressors required improvement to enhance the efficiency and safety involved in this process. The normal procedures done were by means of a manual approach with the use of kettles, plastic bottles, or pitchers. This caused various problems, such as the oil was lost, the amount replenished was inaccurate, the oil got contaminated, and hazards in the workplace.

The primary focus of the study was on developing an automated mobile oil distribution system which could monitor its operational capabilities as well. Furthermore, the design of the technology was done for the optimization of the replenishment method of oil in overcoming the limitations associated with human procedures. The system included a self-priming pump, ultrasonic sensors, an electronic battery sensor, an ultrasonic flow meter, heavy-duty caster wheels, an automatic shut-off nozzle, a reinforced rubber hose, an oil reservoir, a lithium-ion battery, and an Arduino Giga display. These were the basic components that made up the system. In order to evaluate the system's functionality, it was subjected to exhaustive testing.

Through the Accuracy of Dispensing Test, the system proved that it is able to dispense the precise amount of oil, thereby ensuring accuracy and preventing waste. Through the Power Consumption Test, which measured the capacity of the battery as well as its length of usage, very important data was obtained for planning and maintenance purposes. Those responsible for the maintenance at the LRT Line 2 Depot in Pasig City conducted an assessment of the system. They graded the overall acceptability of the system based on their rating, which is founded on a number of variables that encompass beauty, durability, economy, usefulness, marketability, safety, and workability characteristics.

Due to the results obtained, the evaluators revealed a high level of satisfaction, which points out the system's capability to enhance the maintenance processes that are in use within the railway industry. This paper adds new information relevant to the existing literature on automated maintenance systems in the railway sector. This fits into the overall trend of intelligent maintenance solutions for increasing the effectiveness, reliability, and safety of a system. This research concludes that automated systems are likely to significantly enhance the process of railway maintenance, both in terms of improving operations and minimizing risks. The results of our study indicate that the use of automated technology might significantly enhance train maintenance. We are able to guarantee the smooth operation of trains and ensure that passengers arrive at their destinations in a comfortable manner and as scheduled by implementing streamlined procedures and protecting duties. The main focus is on the use of technology to promote increased ease of use and productivity for all individuals.

4. Conclusions

An automated mobile oil distribution system with train compressor monitoring was the goal of this project. The technology reduces oil waste, inaccurate refills, contamination, and occupational hazards associated with manual oil replenishing. Research findings confirm the system's successful design, meeting study aims. Thorough testing and maintenance input appraised the system's performance. Findings show that the system can accurately distribute oil, monitor oil levels and battery quality, and offer an easy interface for operators. This study has several railway implications. It shows how automated technology may improve maintenance efficiency, accuracy, and safety. The system's mobility and monitoring make it suitable for railway depots compared to automated oil transfer systems.

The study has various shortcomings. The system was designed and assessed in a specific context, therefore its applicability to other railway maintenance operations or industries may need more investigation. The study focused on the system's technology, but future research may examine its economic and environmental benefits. Considering research findings and limits, several proposals may be made. Future research may evaluate the system's applicability to various train compressors and oil reservoirs. Cost-benefit analysis and life cycle assessment may assess the system's economic and environmental benefits. Remote monitoring and data recording might be added to the system's design.

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