ALAM JOURNAL OF MARITIME STUDIES

ISSN: 2590-4345 e ISSN: 2976-3843 Volume 5 Issue 1 Year 2024

Water Detector for Main Air Compressor Sump Oil

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Abstract - Water contamination in the oil sump has always been a problem with air compressor machines used in marine shipping. It is often too late to detect it through a sight glass which leads to compressors being damaged, especially in Unmanned Machinery Spaces (UMS). The proposed solution is developing a sensor system like Main Engine Water Observation and Information System (WOIS) but using different types of sensors that are more efficient. This paper talks about working principles and components needed for the system and emphasizes its ability to give early warnings as well as trigger alarms and stop the compressor during severe conditions.

Keywords: Compressor, Sensor, Water detector

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1.0 INTRODUCTION

Marine environments and other industrial applications require maintenance of the main air compressor since it is responsible for providing compressed air to power equipment. The performance and longevity of the compressor are greatly affected by the quality of sump oil used as a coolant and lubricant. However, water contamination in sump oil can corrode, reduce efficiency of lubrication, leading to rapid wear of emulsions that can cause compressor failure. This paper describes how a water detector has been designed and implemented to detect water in the main air compressor lube oil offering real-time monitoring with instant alarms for prevention of major faults/damages to optimally keep working.

2.0 LITERATURE REVIEW

2.1 Water Contamination in Sump Oil

Some of the common operational issues faced due to water contamination in sump oil are as follows - Wang et al. (2015) presented the influence of such type and percentage on compressor damage caused by acceleration in oxidation, corrosion, anti-wear disfunction resulting from moisture content over 1 mass % (heat-induced water-in-oil concentrations). In this context, Smith and Davis (2018) demonstrated that water contaminating acidic compounds leads to emulsified oil breaking down the protective oil film resulting in mechanical wear.

2.2 Traditional Detection Methods

In the past, detection of water contamination in oils was generally done through regular oil sampling and laboratory analysis such as Karl Fischer titration and infrared spectroscopy (Jones & Harris 2017). These methods are relatively slower exercise since it lacks monitoring function for real-time detection and hence not so beneficial in case of hypothetical contamination happening suddenly.

2.3 Enhancement on Sensor Technology

The key component of routine monitoring is the ability to monitor motors continuously and in real time during operation, which has been conducted using modern sensor technology developed for sump oil water content analysis. Capacitive Sensors: This type of sensors detect variations in the dielectric property of oil-water mixtures, and they provide, on time, precise feedback (Lee & Kim 2020). These effects effectively detect water contamination through acoustic impedance variations using piezoelectric sensors (Zhang et al. 2019).

2.4 Industry Applications

Water detection systems in industrial compressors integration has been one of the main points for consideration. Real-time monitoring: Nguyen and Patel (2021) noted real time monitoring is used to control the costs of additional maintenance while also avoiding unnecessary downtime. They also stressed the importance of creating sensors that were resilient to extreme industrial environments.

2.5 Emerging Technologies

In the process of detecting water in sump oil, new methods such as fibre-optic sensors or microwave sensing technology are being developed. Fiber optic sensors were proposed by Kumar and Singh because of its high sensitivity, immunity to electromagnetic interference, microwave sensing used the selective absorption properties between water-oil mixture for precise detection contamination (Ramos et 2023).

3.0 PROCEDURAL

This project employs research and case studies to ensure the system functions as intended. Simulations using Proteus and C compiler demonstrate the functionality of water and oil level sensors in triggering alarms and stopping the air compressor.

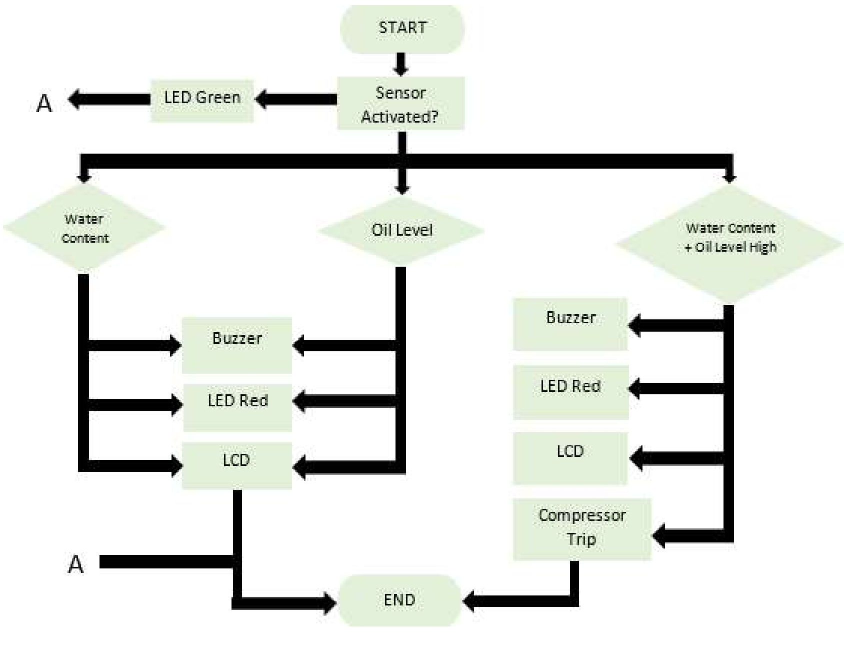

Fig. 1. WOIS system flowchart

Fig. 1 shows the flowchart of the WOIS system. The system operates by detecting water or oil levels exceeding set limits, triggering alarms, and potentially stopping the compressor. In Proteus, components such as MCU PIC16F84A, LEDs, sounder, LCD, toggle switches, and a motor (representing the compressor) simulate the system's functionality.

The simulation works by choosing the condition of the programmed either normal, bypass or off.

During normal operational normal, where no sensor is being triggered, a green indicator LED shall be on, and the display screen shall indicate "NORMAL." But should high water content or a high oil level trigger its sensor, an audible alarm turns on, and a yellow indicator light, along with the respective warning showing as “Water Content High” or “Oil Level High,” appears on the LCD, after which the air compressor continues to run.

In case of the detection of a high-water content and high oil level, it shall sound an audible alarm, a red LED, and indicate in the respective LCDs “Water/Oil Level High” and the air compressor shall then be turned off.

In bypass mode, it will only bypass the sensors to activate an audible alarm and trigger yellow LED. The LCD will display “BYPASS,” while the air compressor continues running normally.

If the system is in off condition, then the program will not work. In this condition, the air compressor will also work normally, no audible alarm or LED will be triggered, and in the LCD, “OFF” shall be displayed. Figure 2 illustrates the Proteus schematic circuit.

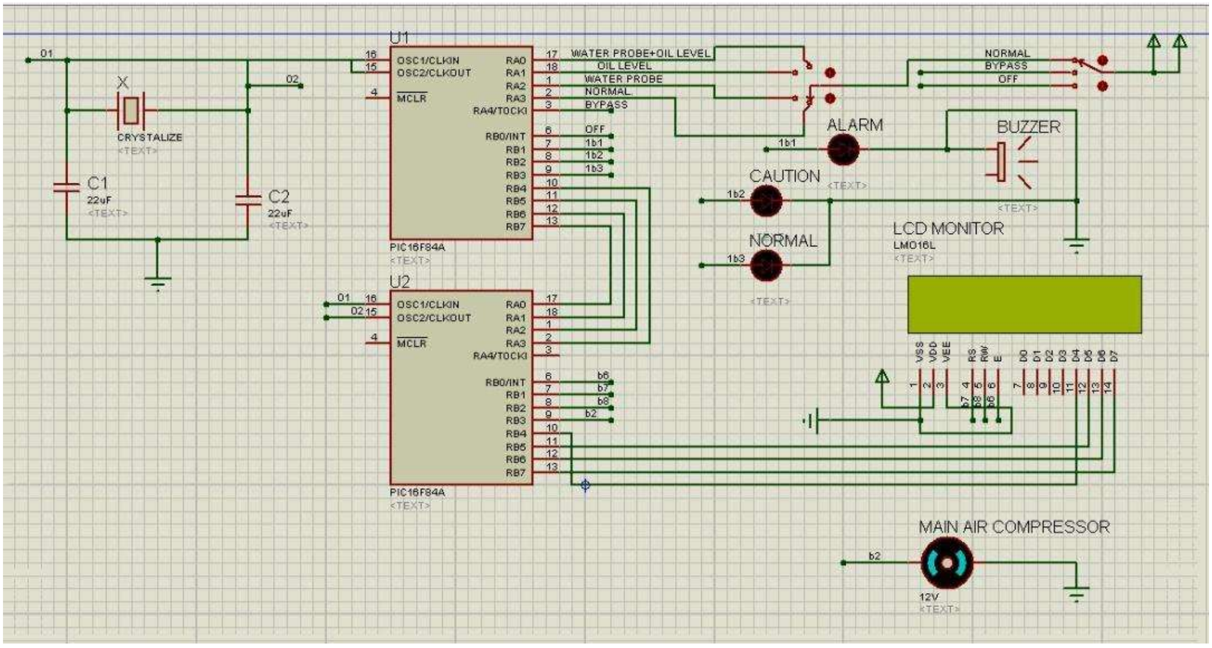

Fig. 2. WOIS Schematic circuit

The Table 1 below, outlines the operation of a Water Operating and Information System, detailing how its components respond to different conditions such as high water content, high oil levels, system status (on or bypass), and combined high water and oil levels. The Water Probe and Oil Probe activate independently when their respective thresholds are exceeded and simultaneously during the combined condition. The Buzzer and Red LED provide warnings in all high-level scenarios, while the Yellow LED remains inactive, indicating it is not used for these conditions. The Green LED signals normal operation, activating only when the system is on and no faults are present. The LCD Display provides real-time information under all conditions except when the system is bypassed. Additionally, the Compressor Trip is triggered only when both water content and oil levels are high, serving as a safety measure to protect the system. This setup ensures comprehensive monitoring, timely alerts, and protective actions to maintain operational safety and efficiency.

Table 1. The truth table of Water Operating and Information System

Component	Water Content High	Oil Level High	System On	System Bypass	Water Content + Oil Level High
Water Probe	1	0	1	0	1
Oil Probe	0	1	1	0	1
Buzzer	1	1	0	0	1
LED Red	1	1	0	0	1
LED Yellow	0	0	0	0	0
LED Green	0	0	1	0	0
LCD	1	1	1	0	1
Compressor Trip	0	0	0	0	1

4.0 RESULTS

The incorporation of MCU PIC16F84A is the fail-safe operation, input safety checks, emergency shutdowns, and feedback testing. Safety and easy maintenance are a bonus by the manual override toggle switch. The real-time data is displayed on the LCD screen resulting to alarms for efficient operations. The dual sensor integration makes sure that the data collected by the two sensors are cross checked hence eliminating cases of failure of one sensor while at the same time improving the quality of collected data.

5.0 CONCLUSION

The presence of moisture in the sump oil is one of the leading causes of poor performance and/or shorter working life of air compressors. Existing methods are slow and do not have the reactivity feature. Features in sensor technology: capacitive and piezoelectric sensors which are inexpensive, quick, real-time control and action. To achieve higher levels of accuracy and reliability future technologies such as fiber-optics and microwave technologies have been sighted for use in detection instruments.

The advanced water detector system for main air compressor sump oil is highly useful since it helps to eliminate expensive maintenance, the prevention of time wastage through unplanned for compressor loss, all while getting to prolong the lifespan of a valuable and costly machine. Such observation ensures that responses to water contamination are timely, hence, the best performance is achieved.

In conclusion, advanced water detection provides a significant development and integration in compressor maintenance. Further areas for research and innovation in this area are critical to improving the functionality of such systems for more robust assurance of more resilient and efficient industrial operations. Adopting such technology will significantly go a long way to safeguard the performance and reliability of air compressors for operation effectiveness in different industrial applications.

REFERENCES

Dai, F. a. z (1994). A Theory of Hydrodynamic Lubrication Involving the Mixture of Two Fluids. 61(3): 634–641.

José, M., Canejo, J., & Godinho, M. (An Overview. Materials 2023, 16, 2503). Oil/Water Mixtures and Emulsions Separation Methods. 28.

Kimura, Y. a. (1987). Film Thickness at Elastohydrodynamic Conjunctions Lubricated with Oil-In-Water Emulsions. 85-90.

Kimura, Y. a. (1989). Lubricating Properties of Oil-In-Water Emulsions. 524-532.

Kurre, S. K. (2016). A review of biofuel generated contamination, engine oil degradation and engine wear. 8(2), 273–280.

Ramos, D., Sadtler, V., Marchal, P., Lemaitre, C., Niepceron, F., Benyahia, L., & Roques-Carmes, T. (Nanomaterials 2023, 13, 371). Particles' Organization in Direct Oil-in-Water and Reverse Water-in-Oil Pickering Emulsions. *Particles' Organization in Direct Oil-in-Water and Reverse Water-in-Oil Pickering Emulsions*, 22.

Roelands, C. J. (1966). Correlational Aspects Of The Viscosity-Temperature-Pressure Relationship Of Lubricating Oils.

Sadeghi, F. a. (1990). Thermal Elastohydrodynamic Lubrication of Rolling/Sliding Contacts. 189-195.

Sampio, R. a. (1997). On the Viscosities of Liquid Mixtures. *Journal of Applied Mathematics and Physics (ZAMP)*, 607–614.

Wang, X., Zhang, Q., Yang, L., Li, T., & Yang, a. Y. (AIP Advances 14, 035117 (2024)). Study on condensation of oily particles under the influence of water vapor phase transition.

Wilson, W. R. (1993). A Dynamic Concentration Model for Lubrication with Oil-In-Water Emulsions. 207-212.

Wilson, W. R. (1994). A Mixed Flow Model for Lubrication with Emulsions. 543-551.

Yan, S. a. (1997). Lubrication with Emulsion II. The Viscosity Coefficients of Emulsions. 238-243.

Yan, S. a. (1997). Lubrication with Emulsion: First Report, the Extended Reynolds Equation. 230–237.

Zhu, D. B. (1994). Elastohydrodynamic Lubrication with O/W Emulsions. 310–320.