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FAILURE ANALYSIS OF SCREW COMPRESSOR AND ITS MODIFICATIONS

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Abstract

Screw compressor is one of critical equipment at many industries. Therefore, its reliability and performance shall be maintained. One problem that often arises with screw compressors is the lubrication system. This study investigates the cause of the screw compressor failure and its modification to prevent failure in the future. The failure analysis of the screw compressor was successfully conducted using the fishbone analysis diagram and visual examination. The presence of water in the oil was found due to a change of oil color. The water content analysis showed that 6% of water was found in the oil in the third month. Indeed, the presence of water has a detrimental effect on the screw compressor part, showing that corrosion has occurred in the inner part of the screw compressor element. We found the water source comes from the air due to high humidity. Therefore, modification in the air supply is needed to prevent water contamination in the oil. The air supply modification is done using dry air at the screw compressor outlet, flowing into the breather system. The modification results showed that the oil's water content decreased significantly from 6% to 0.0035%. In addition, the vibration that occurs decreases from 80 dB to 58 dB. This shows the effectiveness of the modification process to extend the life of the tool and maintain the plant's operational continuity.

Keywords: Screw Compressor, fishbone diagram, vibration, water content.

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1. Introduction

A screw Compressor is the main machine that functions to produce compressed air used to drive a production machine that works automatically for 24 hours non-stop and requires the continuous sound of compressed air to ensure the quality and availability of products.

This screw compressor is used to supply the air needed to operate equipment/instrumentation such as drive valves, control valves, and others. In addition, some other compressed air is also flowed to the nitrogen system to produce nitrogen gas and liquid nitrogen needed for dry gas seals, purging equipment during plant start-up and shutdown, adding to the mixed refrigeration system and purging blanketing of equipment during regular operation. Therefore, a screw compressor is important enough to keep the factory operational. However, if there is a failure in the compressor engine, it can interfere with the production machine's performance and even cause the production process to stop. One problem that often arises with screw compressors is the lubrication system.

This study investigates the cause of the screw compressor failure and its modification to prevent failure in the future. In the first step, we analyzed using the fishbone diagram and collected the data to know the cause of failure. Thus, we modified the system to prevent failure and test the performance of the screw compressor after modification.

2. Experimental and Procedures

There are two stages of investigation in this study. First, find the cause of failure in the screw compressor. A fishbone diagram was used to find and narrow the problem in this stage. Moreover, we checked the unit of the screw compressor and analysis thoroughly to see the problem.

After finding the problem, we modified the system to prevent failure in the future. Indeed, the screw compressor performance was measured and compared to the initial condition.

A moisture analyzer (CA-200, Karl Fischer Titrator) was used to analyze the water content in the oil. The vibration of screw compressor before and after modification was monitored using a vibration meter (ZT275-10-50/E, Elektronikon). Borescope (MVIQCSYS3-CO, GE Mentor Visual) was used to inspect the inner condition of the screw compressor.

Fig. 1 shows a diagram of the fishbone in this study. As shown in Fig. 1, 4 possible factors affect the components resulting in a mismatch or damage, such as factors of a machine, human, measurement, environment, and method factors

Fig. 1. Fishbone diagram in this study

3. Results and Discussion

As aforementioned, we conducted the fishbone diagram analysis to narrow the cause of screw compressor failure. Fig. 1 shows the fishbone diagram, which shows 6 parameters that might affect the inability of the screw compressor, i.e., measurement, material, method, environment, man, and machine. According to the fishbone diagram, we can exclude the factor of man and material since the operator is already trained and the oil of the screw compressor follows the specification in the manual book. Therefore, the problem might come from 4 parameters: measurement, method, environment, and machine.

Fig. 2 shows the visual examination of oil in the screw compressor. It is shown that the color of the oil changed to milky. Therefore, it might be contaminated with water. Further investigation was performed to check the water content in the oil, and the results are shown in Fig. 3. The maximum content of water in the oil is 0.5%[1], which is indicated by the dashed line in Fig. 3. In fact, the water content increases 2% every month, which is very high, as shown in Fig. 3. Furthermore, we found the water content as high as 6% in the third month. The lubrication system in a piece of equipment is essential.

Fig. 2. Visual examination of the oil in the screw compressor

The indication of a failure in the lubrication system is a discoloration of the lubricating oil (milky) and the vibration of the screw compressor elements has increased. Several studies have been conducted to describe the impact of lubricants contaminated with water on lubrication performance. This contamination is one of the most common and harmful in lubrication. One approach considers water-polluted oil as a

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homogeneous lubricant with physical factors that vary with water concentration[2–7]. The effects of water contamination can decrease the viscosity and then the lubricant film's thickness, which sometimes causes metal-to-metal contact. Water can also cause the phenomenon of cavitation or lower the electrical resistance leading to electrostatic discharge, which can also be very dangerous[8–10]. The presence of water in the oil indicated that the frequency of preventive maintenance needs to be increased, thus high content of water can be avoided in the oil. However, the origin of water needs to be found and remains the main objective. Therefore, the inspection of the breather system in the screw compressor is important.

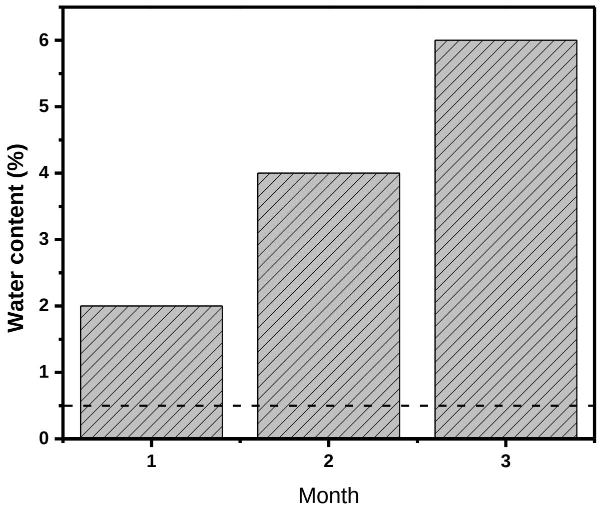
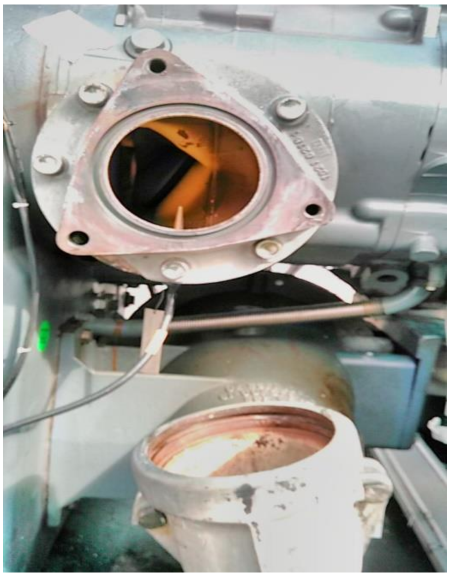


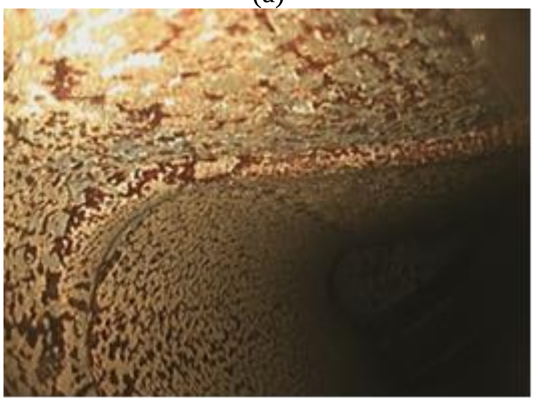
Fig. 3. Water content in the oil as the function of month

Another effort to find the main problem that causing the failure of the screw compressor is an inspection of the screw compressor element. Fig. 4 (a) shows the element of the screw compressor and Fig. 4 (b) the inner condition of the element. Indeed, the condition of an element on the inside is heavily experienced with corrosion. This fact supports the presence of water in the oil. In the normal condition, the corrosion is more likely not to occur due to the surface of the element being covered with oil.

One of the possible water sources is from the environment since the air has high humidity. However, the breather system can discharge the condensed water through an auto-drain mechanism. However, the presence of water in the oil indicated that the auto drain mechanism was not working correctly. Therefore, the breather system's low performance might come from the water itself. Oil mixed with water causes inadequate lubrication of compressor components such as bearings and causes damage to fretting or wear on the inner race bearing[11–13]. One indication of low lubrication in the screw compressor is the vibration. The vibration in the high pressure of the screw compressor was 80 dB, whereas the threshold was < 77 dB. Therefore, measured and systematic steps are needed to prevent oil contamination of the screw compressor[14].



(a)



(b)

Fig. 4. (a) screw compressor element and (b) condition in the inner of the element.

The supply of air obtained from the breather system for the screw compressor will greatly affect this system's performance. Wet environmental air makes it difficult to supply the breather system because it will cause condensation. However, the air at the screw compressor outlets is known to have very low humidity. Therefore, we modified the air intake in the breather system using the air from the outlet of the screw compressor. After modification, the water content in the oil was measured every month, as shown in Fig. 5. As aforementioned previously, the maximum water content in the oil is 0.5%. In the first month, the water content decreased significantly after modification of inlet air in the screw compressor, i.e., 0.01775%, which is lower than 25 times than 0.5%, as shown in Fig. 5. In the second and third months, the water content in the oil was relatively stable at 0.0035-0.0038%.

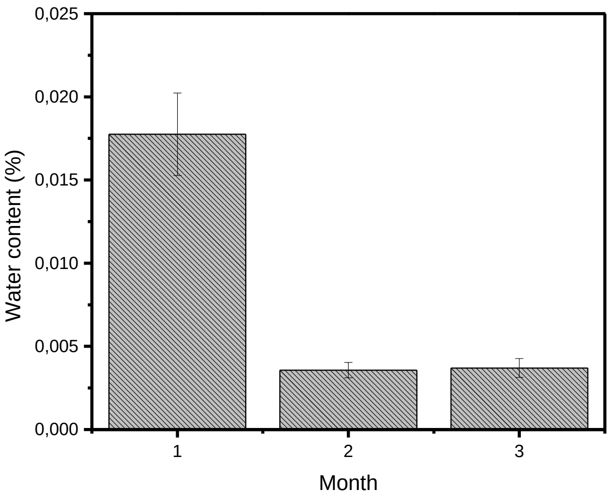


Fig. 5. Water content in the oil after modification of screw compressor

This shows that the modifications have succeeded in maintaining contamination in the lubrication system compared to the screw compressor before modifying it. Another thing that indicates the improved performance of the screw compressor is the significantly reduced vibration of the high-pressure part of the screw compressor, which is 58 dB.

4. Conclusions

The failure analysis of the screw compressor was successfully conducted using the fishbone analysis diagram and visual examination. The presence of water in the oil was found due to a change of oil color. The water content analysis showed that 6% of water was found in the oil in the third month. Indeed, the presence of water has a detrimental effect on the screw compressor part, showing that corrosion has occurred in the inner part of the screw compressor element. We found the water source comes from the air due to high humidity. Therefore, modification in the air supply is needed to prevent water contamination in the oil. The air supply modification is done using dry air at the screw compressor outlet, flowing into the breather system. The modification results showed that the oil's water content decreased significantly from 6% to 0.0035%. In addition, the vibration that occurs decreases from 80 dB to 58 dB. This shows the effectiveness of the modification process to extend the life of the tool and maintain the plant's operational continuity.

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