Predicting and preventing failures in compressors

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ABSTRACT

The purpose of this project is to accurately predict the failure of compressors using a life cycle analysis of the device. The ability to give advanced notice to the remaining life time of these devices can maximize the operation and provide necessary warnings leading to a system's breakdown. With this information precautions can be taken to maintain a systems operation before failure can occur and eliminate the risk of damage to secondary components.

Under normal circumstances, the flow of heat travels from an area of higher temperature to one of lower temperature with the potential to provide work (used in power plants for the production of useable energy). In a standard refrigeration cycle the system is reversed, relying on the transfer of heat from one area to another area by providing the work necessary for the movement of thermal energy. The compressor is the device responsible for providing the work in the refrigeration system.

INTRODUCTION

For the purpose of this report, the primary focus of the life cycle analysis will be on the changes to the performance of compressors during its operational life. Throughout the standard operation of a compressor it experiences higher than ambient temperatures due to the mechanical friction, electrical consumption of power, and heat of compressing the refrigerant into the condenser portion of the system. These stresses contribute to the changes in the electrical and mechanical properties of the device, many of which are measurable characteristics to technicians and those maintaining these systems.

Although proper working conditions is ideal, this is not always the case. Harsher, more corrosive environments and defects in related components are unavoidable in the majority of situations. This often leads to other parts compensating for these short-comings and shorter lives for the overall system. Tests that show a significant reduction in the predicted life span of the compressor can potentially identify these imperfections leading to its correction. When a compressor or refrigeration system needs to be removed, it is usually due to a catastrophic failure or because of indications signaling a failure in the future. For this reason, predicting failure is a highly desirable capability to technicians and inspectors attempting to determine the compressors life span.

In a refrigeration cycle used by an A/C unit, the compression of the refrigerant requires mechanical work to be done by the compressor. This leads to high stresses on the mechanical components of this device and like any mechanical device it suffers from wear due to the stresses of its operation. Another factor is many compressors do not exist within an optimum environment for operation. For example, damaged or failed components external to a compressor such as cooling fans are needed to remove waste heat from this thermodynamic cycle. Without these factors, more severe stresses can ensue and cause irreparable damage to the compressor. For the purpose of analyzing the various mechanical problems, it will help to have some ideas regarding occurrences that can cause damage to the mechanical components. One of which is the

incomplete transition of the refrigerant to a superheated vapor. When this occurs there is a risk of liquid refrigerant returning to the compressor. The inability of liquids to be compressed and the significant differences in flow characteristics leads stresses strong enough to deform or fracture the inner workings of the compressors. Just like any mechanical device with moving parts, lubrication is needed to reduce friction and wear at the points of contact. The majority of the oil for a compressor is usually kept inside the compressor near its moving parts; however this is not always the case. With the mechanical parts in direct contact with the refrigerant, the oil is also in direct contact with the refrigerant. Excess refrigerant dissolving into the oil while in its off periods can cause it to carry a significant amount of oil when it is turned back on as the refrigerant attempts to dissolve back out from the rapid change in pressures and aggravation. Sometimes the operation of a compressors operation can be harmed simply by to little refrigerant overall in the system. In this case, the compressor simply does not have enough refrigerant to maintain the pressure of a proper operating cycle, with no ability to compensate.

In a compressor, similar in operation to electric motors, the electrical properties can change in such a way that there is a measurable difference in these qualities from the manufacturer's construction to the current device. Due to the difficulty of evaluating the mechanical conditions of a compressor and the impracticality of cutting one open unless it is believed that it is already compromised, this portion of the study will be highly relevant for those wishing to assess a compressors condition under immediate and noninvasive circumstances. The primary method in evaluating the electrical properties for failure prediction and prevention will be in establishing the criteria for standard operation. Evaluating the conditions under proper operation will then lead to quantifying the electrical properties of operation outside of these criteria, as well as for pre- and post- failed compressors. It is also useful to review the most common electrical problems and failures seen in compressors. Loss of power on one leg of a compressor, although not enough to prevent it from partial operation, can have serious consequences. Since it does not have enough power for efficient operation, the majority of power drawn is wasted as excessive heat. The most common result of this is a triggering of the thermo-relay in the compressor, shutting the system off. Once the compressor cools-off, it continues operation with the same result leading to short-cycling of the system. If this is not addressed, the compressor will be incapable of maintaining the system and experience advanced deterioration due to the extremes of these stresses. Grounding of a compressor is the result of a break in the enamel of the windings inside the compressor, leading to a short between the two. Similarly, internal shorts across the power legs of the compressor have the same effect. A common result when this occurs is excessive current drawn by the compressor, causing a blown fuse or tripped breaker. There are a few components built into the compressor to protect it from damage. When thermo-relays are mentioned, it is with regards to the small relays inside compressors designed to disconnect the power when a compressor experiences high temperatures inside its case. Since high temperatures inside the compressor's case are seen when there are damaged parts or excessive heating from extreme inefficiency outside of normal operation, it is designed to reduce further damage by shutting off. Breakers and fuse both serve the same purpose of limiting the amount of current to given to a device. When this limit is exceeded (a sign of a damaged electrical device) these components will disengage power.

Although most of this report has focused on compressor and failures of their operation, there are a number of other characteristics that require consideration when discussing reasons for failed compressors. For example, low or high charging of a system (the amount of refrigerant inside an A/C unit) can lead to unnecessary stresses on the compressor. Impurities and contamination on the inside of the tubing (flux from brazing the tubes together) can lead to internal wear of the compressor or clogging of valves. During the operation of any system, it is important to note that the any change to one side of the system will inevitably affect something in the other side. Likewise, the performing life of a compressor relies heavily on the functionality of each component on the system.

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