Tribological test of compressor used in the refrigeration industry

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Abstract

The article describes the analytical procedures and acceptance criteria for analysis of compressor and components with a focus to tribological aspects. In the introduction, the article deals with tribology as a scientific discipline. Subsequently, the article describes different kinds of wear, which may occur during the operation of compressor at different levels. Subsequently, the article mentions the equipment used in the test. At the end the results of the test are summarized with complete photo-documentation.

Keywords: Tribology, wear, compressor

1. Introduction

The Tribology belongs to scientific department with more than 60 year history in the Slovak republic and still has a place in the field of equipment care. The function of Tribology is guaranteed reliability and safety of operation the machinery and equipment. It deals with the processes of friction, wear and lubrication [1].

Tribology technology affects all phases of the production process, such as development, construction, production technology, operation, maintenance, but also the repair of machinery and equipment. This is applied to all industries, such as automotive, aerial, cosmic, chemical or electro-technical industry. We also encounter the need to analyze tribological tests for refrigeration compressors in an effort to optimize production and material technologies in order to minimize friction and wear losses. [2].

The wear is in technical practice undesirable. It arises for various reasons, such as the interaction of moving surfaces or the action of the media on the surface of the device, respectively. components. The occurrence of wear is classified into several types.

Adhesive wear is the loss of material from one or both surfaces of a friction pair, which may or may not be lubricated. The necessary conditions for this type of wear are direct contact between the two parts (usually due to the breakdown of the lubricating film) and high chemical affinity between the two materials, which allows the formation of metal-metal bonds. Adhesive wear is the most common type of wear on materials and components. It manifests itself as seizure.

Scratch wear or abrasive wear is caused by the friction of two surfaces, one of which may have a rougher surface. This penetrates scratches and scratches. This unwanted the wear can also be caused by sharp edges, fillings, but also dirt between the moving parts of the system. Scratches or nicks are usually straight, continuous and spaced in rows, allowing them to be visually distinguished from other types of wear. In Figure 1. schematically shows adhesive and abrasive wear [3].

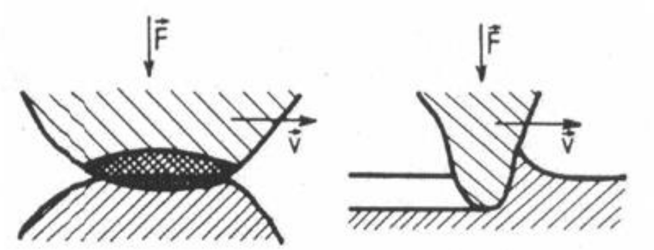

Figure 1. Scheme of Adhesive (a) and Abrasive (b) wear [3]

Polishing is a wear process characterized by uniform consumption of material, which tends to gradually transform the original surface treatment into a light (polished) surface. It usually occurs between surfaces with low adhesion to each other; this property is preferred by surface treatments which, inter alia, produce anti-adhesion behavior, such as cooling and tempering, nitriding, phosphating or steam treatment.

Vibration wear (Figure 2) is defined as abrasive wear of two components due to a combination of micro-movement and high contact pressure; respectively it is a mutual oscillating movement of functional surfaces of the bodies. The occurrence of vibration wear is analyzed by profile measurement of the affected areas and comparison between components that are tested with different durations. The wear should stabilize or decrease over time. [3].

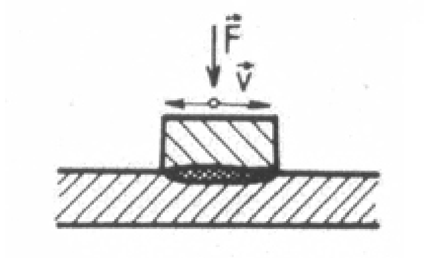

Figure 2. Vibration wear scheme [3]

Pitting is a form of wear that occurs with rolling bearings. During this wear, the surface layers break, move relative to each other and be microscopically welded. Subsequently, the welded layers are torn off and the surface between the inner ring of the bearing and the rolling element is damaged. [3].

Severity levels are divided into mild, moderate and severe, see Table 1.

Table 1. Codification of results, respectively the level of severity of wear

Occurrence	Type of occurrence	Severity levels
Wear	Adhesion	Medium Moderate Hard
	Scratch	
	Polishing	
	Friction	
	Pitting	

2. Tribological test

Equipment required for the tribological test:

- Prepare lighting
- Magnifying glass,
- Photo camera,
- Stereoscopes,
- Meter of torque meter,
- Air gap gauges.

The compressor that has been tested belongs to the latest generation with Full Motion Inverter technology (variable speed) for ice cream refrigerators with extremely high built-in energy efficiency. Provides better food preservation, low noise and a wide range of voltages. It is compact, benefits when deploying applications with limited interior space, and is designed to use R600a natural refrigerant (isobutane). This solution sets accurate and consistent temperatures to protect treated products, such as medical devices (Figure 3).

Figure 3. Compressor tested

Duration of the test: 5 months

Note: Temperature - approx 45 °C

In some cases, a power failure

Voltage start (min. 130 V)

The tested compressor was connected to an artificial circuit in conditions simulating a normal environment. It was exposed to the load as in normal operation. At the end of the test, the compressor was removed from the system and then gradually disassembled and visually examined.

3. Test evaluation

The evaluation of tribological tests is summarized in Table 2. The wear of the individual components is evaluated numerically, where 1 represents no or negligible wear of the surface of the component, 2 determines slight surface damage and 3 serious and unacceptable damage to the component. The compressor is suitable for use if all its evaluated components are marked with the number 1. When rated with the number by 2, it is advisable to examine the compressor in more depth and determine the cause of wear and its consequences. If the wear is stable and does not deteriorate further, the compressor is suitable for further use. When evaluating component number 3, it is necessary to examine the source and extent of wear as well as the manufacturing process and ensure remediation. The compressor is not suitable for further use until the source of wear has been removed.

Table 2 Evaluation of components according to the internal standard:

Component	**Evaluation**
Crancase, Bearing for crankshaft	1
Cylinder	1
Piston	1
Conrod big eye	1
Conrod small eye	1
Piston pin	1
Crankshaft, short leg	1

Crankshaft, bearing for crankcase	1
Crankshaft, long leg	1
Gasket	1
Valve plate	1
Suction valve	1
Discharge valve	1
Overall assessment	1

1 - No or negligible wear
2 - Superficial or slight damage
3 - Serious and unacceptable damage

Review
Final rating
= <3 ...... Positive
> 3… .... Negative

4. Conclusions

The analysis was performed according to internal standards, where the bearing surfaces were examined and evaluated. Compressor bearings have new properties, but they do not wear out. Chemical analysis of the oil volume confirmed good results. The compressor is suitable for further use. In figure 4. to 19. The compressor components under investigation are shown.

Photographic documentation

Figure 4. Crancase, Bearing for crankshaft

Figure 5. Crancase, bearing for long leg of crankshaft

Figure 6. Crankshaft, short leg

Figure 7. Crankshaft, bearing for crankcase

Figure 8. Crankshaft, long leg

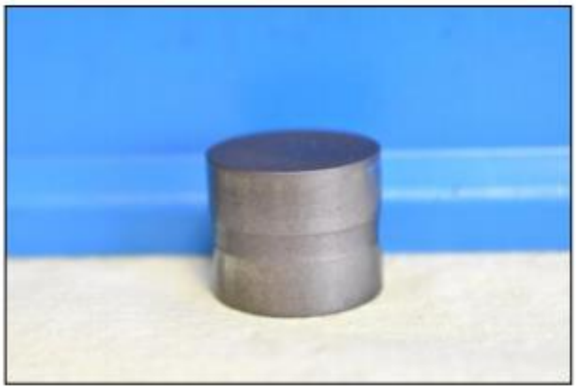

Figure 9. Piston

Figure 10. Piston pin

Figure 11. Conrod small eye

Figure 12. Conrod big eye

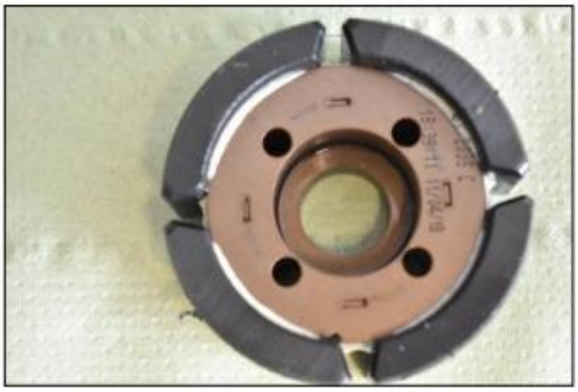

Figure 13. Rotor

Figure 14. Valve plate, suction valve, discharge valve

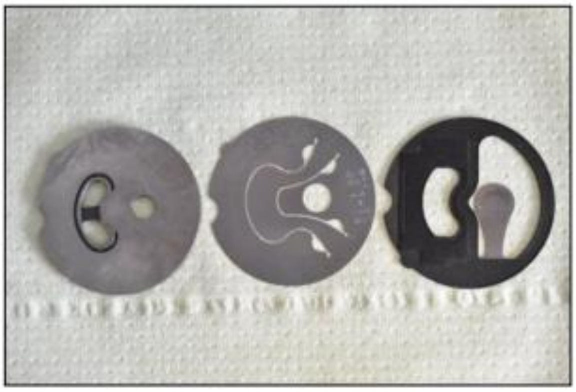

Figure 15. Valve plate, suction valve, discharge valve + gasket

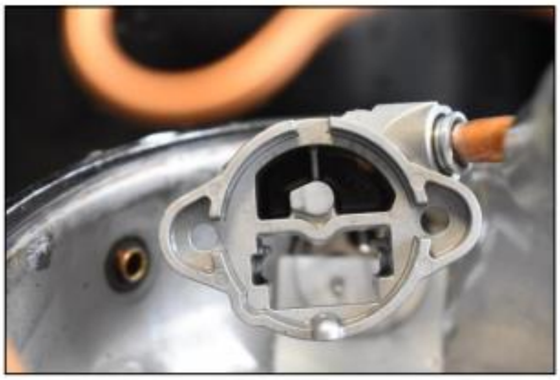

Figure 16. Aluminium cylinder head

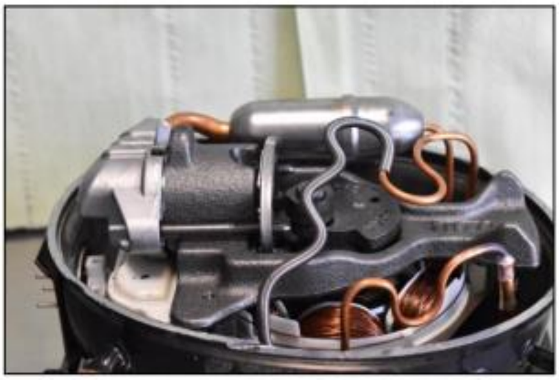

Figure 17. View of body kit compressor

Figure 18. Stator + springs

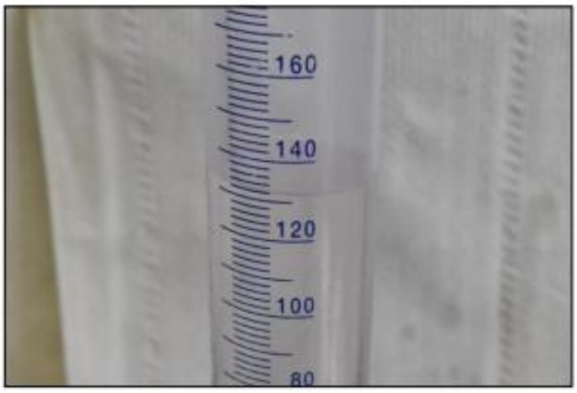

Figure 19. Volume of oil

5. Acknowledgement

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