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WEAR TEST STAND FOR OILS APPLIED IN REFRIGERATING COMPRESSORS

Key words

Wear testing machine, wear, refrigeration compressor, refrigerant.

Abstract

Lubricating medium in friction pairs of refrigerating compressors is always a mixture of oil and refrigerant. Therefore, the problem of choosing lubricating oil for co-operation with refrigerant applied in the device is essential for the durability of refrigerating compressors.

Valid regulations concerning refrigerants constrain their progressive exchange to the ecological ones. One of the perspective refrigerants considered as a substitute of the generally withdrawn refrigerant R22 is propane R290.

Each substance used as refrigerant behaves in a different way in contact with oil in the operation conditions of refrigerating compressors. This paper discusses the attempt of selecting wear tests parameters of refrigerating compressors' friction pairs lubricated with a mixture of mineral oil and the ecological refrigerant propane R290.

Introduction

In refrigerating systems, the working refrigerant circulates among the individual elements of the circuit. Depending on the pressure and operation temperature values, refrigerant in a refrigerating installation can become liquid, wet steam, or superheated steam (gas). Refrigerant is always in contact with lubricating oil in the refrigerating compressor, and this creates a mixture of concentration mainly determined by pressure and temperature. This situation can have a negative influence on the friction pairs that are in co-operation in the refrigerating compressor resulting in excessive wear of motion elements.

In order to determine the influence of the presence of refrigerant in lubricating oil on the degree of the wear of elements creating friction pairs in the refrigerating compressors, a model test stand with the friction pair type roller--block was designed and built. The paper defines wear tests parameters of refrigerating compressors friction pairs lubricated with the mixture of mineral oil and ecological refrigerant propane R290.

1. Test stand

The occurrence of the mixture of lubricating oil and refrigerant in refrigerating systems is an important service problem. In practice, there are no means to perform tests concerning the phenomenon in real operation conditions of the systems, so there was an attempt made experimentally model the service conditions in the laboratory.

The mixture of lubricating oil with refrigerant and the realization of testing was carried out on a prototype stand for testing wear with the friction pair block-on-ring type being situated in a high-pressure chamber (Fig. 1).

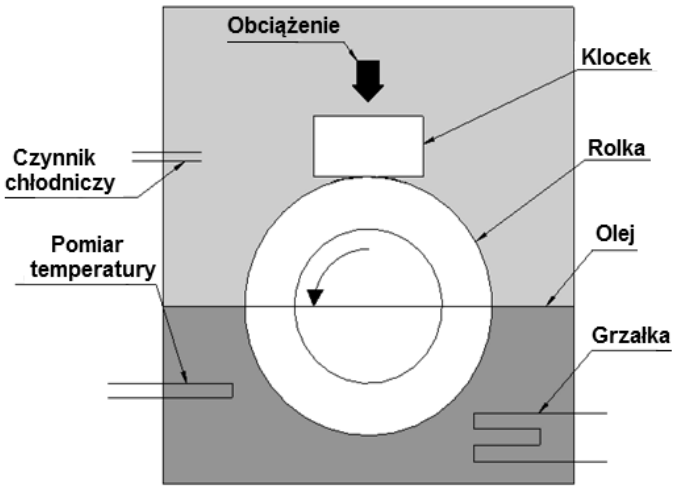

Fig. 1. Scheme of the block-on-ring laboratory wear test

The test stand enables the replication of working conditions of the refrigerating compressors (mixture temperature, refrigerant pressure, friction pair loading, roller rotational speed), including the production of the mixture of lubricating oil with refrigerant, and the friction conditions of the wear process.

The stand's measuring software enables the visualization and registration of the values of friction moment, the rotational speed, the temperature of the mixture, and the refrigerant pressure in the chamber. The roller rotational speed is controlled by the frequency converter. The speed value can be set automatically or manually within 0 to 3000 rpm. The load value is set by the operator of the system with the use of weights, and it can be set within 10 to 150 N with minimum increments of 5N.

The stand allows for the measurement of the friction moment within 0 to 2 Nm. The stand operator can determine the test duration and frequency of measurements registration. The stand chamber allows one to control the temperature of the mixture of lubricating oil and refrigerant, thus simplifying the control of the mixture composition.

The test chamber can create conditions close to the vacuum and maximum pressure of refrigerant to 0.8 MPa.

2. Testing procedure

After the right installation of the samples in the handles situated in the chamber and after it is tightly closed, a vacuum of the order of 10–5 MPa is produced inside. Then, lubricated oil is poured into the chamber allowing its level reaching the half-height of the roller diameter (Fig. 1). Figure 2 presents the scheme of the connection of the systems in the refrigerant feeding unit when making the mixture of lubricating oil and refrigerant. During the operation, the cut-off valves 1, 7, and 8 are closed; whereas, the cut-off valves 2–6 remain open. Refrigerant pressure controlled by the pressure regulator is delivered to the test chamber.

Earlier publications of the authors [1–3] allowed for selecting extreme values of such test run parameters as the following:

- load – 120 [N],
- rotational speed – 500 [rpm],
- pressure exerted on oil – 0.75 [MPa],
- test run duration – 1200 [s].

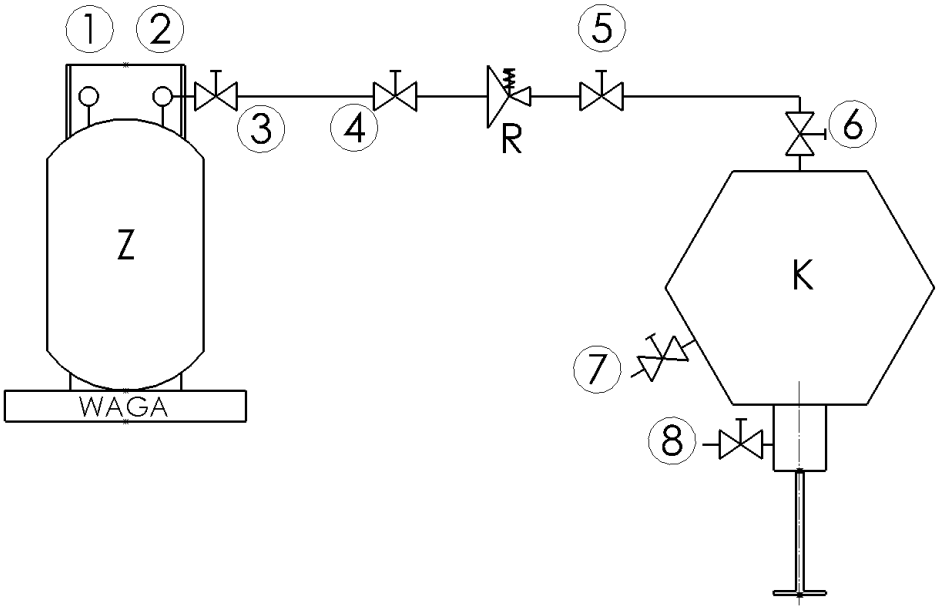

Fig. 2. Scheme of devices setup during refrigerant charging leading to oil/refrigerant mixture: K – high-pressure chamber test, R – refrigerant pressure reducer, Z – refrigerant tank, 1–8 shut-off valves

As the composition of the mixture of lubricating oil with refrigerant depends on the system pressure and temperature, the time of lubricating oil saturation with refrigerant should be determined individually for each refrigerant [4].

The tests were performed with the use of motionless samples in the shape of aluminium block PA6 (AlCu4MgSi (A)) and turning samples in the shape of a roller of grey cast iron GJL-200. Table 1 presents the properties of the used lubricating oil.

Tab. 1. Properties of testing oil

Oil type	**Properties**				
	Kinematic viscosity [mm^2/s]		**Density at 15 ^{o}C [kg/m^3]**	**Flash-point [^{o}C]**	**Pour-point [^{o}C]**
	40 ^{o}C	**100 ^{o}C**			
mineral	32	4,8	889	185	-45

3. Tests results

In order to determine the saturation of lubricating mineral oil (MO) with refrigerant R290 (propane), test runs at different contact times of refrigerant with lubricating oil were made. Figure 3 presents wear values of the sample of the block shape after saturation with refrigerant for 40 minutes, 2 hours, 4 hours, 20 hours, and 30 hours.

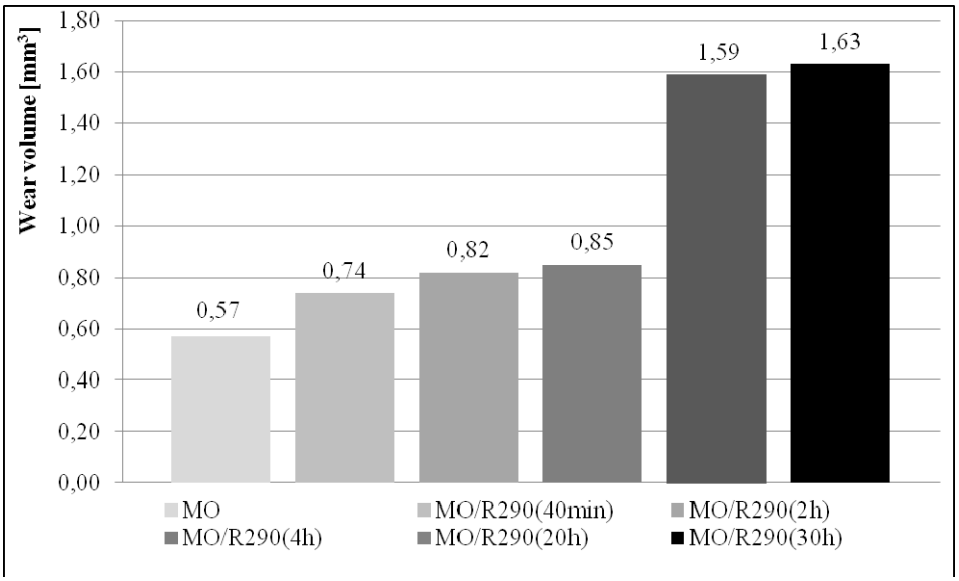

Fig. 3. Determination of the saturation period of oil/refrigerant mixture for mineral oil and refrigerant R290

The wear tests results for different periods of creating the mixture of mineral oil with refrigerant R290 confirm the negative influence of refrigerant on the wear of friction pair's elements. It should be pointed out that the wear value in the case of the mixture creation, respectively, in the periods of 40 minutes, 2 hours and 4 hours were slightly higher than in case of unpolluted lubricated oil. In turn, for the period of creation of 20 hours, the wear increased significantly and reached the value about three times higher than in the case of unpolluted lubricated oil. The increased saturation time did not bring greater changes in the wear value. Based on the presented tests results, the mixture creation period was determined to be 20 hours for the mixture R290/MO. The wear tests results were compared to the test of oil unpolluted with refrigerant.

A series of three test runs was performed for both the unpolluted mineral oil and for its mixture with refrigerant R290, Figure 4 presents the comparison of mean wear values for these tests.

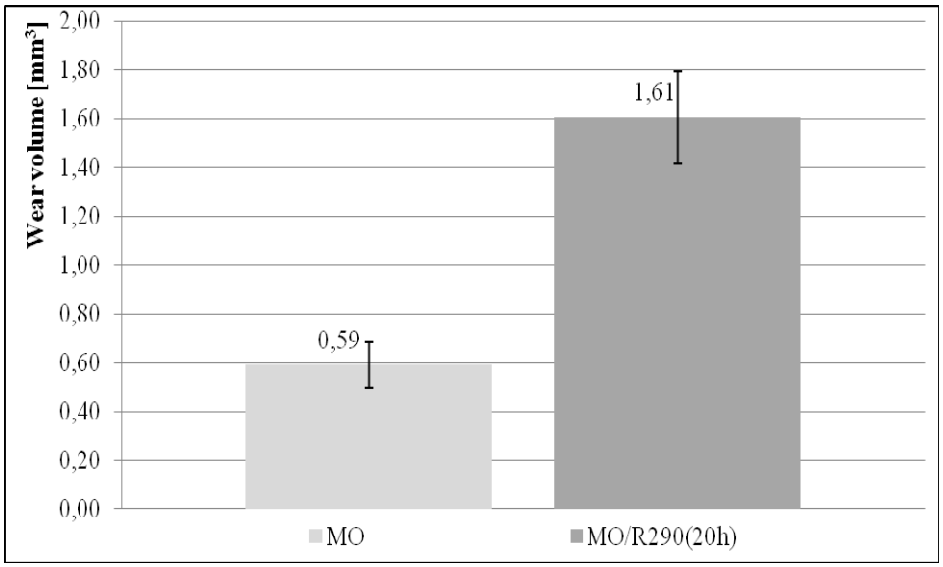

Fig. 4. Wear volume of block-shaped sample after the tests in uncontaminated mineral oil and MO/R290 mixture

Attention should be paid to the fact that the presence of refrigerant in lubricating oil caused the increase in the wear value for the sample in the block shape of about 173%. The result confirms the negative influence of refrigerant on potential wear of elements of refrigerating compressors friction pairs.

Summary

The mixture of lubricating oil and refrigerant occurring in real refrigerating systems is a common phenomenon. It is desirable that a suitable amount of oil circulating in the system should return to the compressor. In turn, the phenomenon negatively influences the behaviour of lubricating oil in the compressor. The amount of refrigerant in the mixture with lubricating oil depends on the pressure and temperature in the system and on the time that the substances are in contact in given conditions.

The article gives the chosen wear parameters of refrigerating compressors friction pairs lubricated with a mixture of mineral oil and ecological refrigerant propane R290. Apart from the parameters determined in the earlier tests by the authors, load and speed, and the mixing time of the lubricating oil and refrigerant was analysed in detail. The results indicated that, for mineral oil and propane, the greatest wear of friction pairs elements occurred after 20 hours of mixture. The results also established that the wear value in case of the mixture increases over 170% in comparison with unpolluted oil.

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Stanowisko do badań zużyciowych olejów stosowanych w sprężarkach chłodniczych

Słowa kluczowe

Stanowisko badawcze, zużycie, sprężarka chłodnicza, czynnik chłodniczy.

Streszczenie

W węzłach tarcia sprężarek chłodniczych medium smarowe zawsze stanowi mieszanina oleju z czynnikiem chłodniczym. Problem doboru oleju smarowego do współpracy z zastosowanym w urządzeniu czynnikiem chłodniczym jest więc kluczowym w kontekście trwałości sprężarek chłodniczych.

Obowiązujące regulacje prawne dotyczące czynników chłodniczych wymuszają ich stopniową wymianę na substancje ekologiczne. Jednym z perspektywicznych czynników chłodniczych rozpatrywanym jako zamiennik powszechnie wycofanego czynnika chłodniczego R22 jest propan R290.

Każda substancja wykorzystywana jako czynnik chłodniczy zachowuje się inaczej w kontakcie z olejem w warunkach pracy sprężarek chłodniczych. W artykule podjęto próbę doboru parametrów badań zużyciowych węzłów tarcia sprężarek chłodniczych smarowanych mieszaniną oleju mineralnego i ekologicznego czynnika chłodniczego w postaci propanu R290.