INVESTIGATION OF BLADE PISTON COMPRESSOR

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Abstract

The paper presents the results of scientific research of the blade-type piston compressor which were conducted on the test rig built especially for this purpose. The construction concept of the compressor, design calculation of its main elements and tests of contact- and contactless sealing types were discussed in papers published at subsequent KONES-symposia 2009 and 2010. The results shown in present document are focused on studies of compressor having the piston equipped with labyrinth or contact seals. When testing on test bench, the intake air flow to the compressor as well as temperature and pressure of air compressed in the tank of 0.1 m3 were measured. Quick-changing pressure in the compression chamber and air temperature at the compressor's outlet were recorded and analyzed, also.

The research was carried out for contact-type seals made of various materials which do not require lubrication and for contactless-type seals (labyrinth). In the course of studies the proper backlash between the piston and the cylinder wall was matched to ensure trouble-free operation of installation. The results of compressor power demand were presented in this article, too.

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***Keywords**: mechanics, compressor, seals*

1. Introduction

The blade-form piston of compressor performs the rotary-oscillating motion in cylinder equipped with two bulkheads, in which automatic pressure valves and pressure channels carrying away compressed air are located. During one revolution of the drive shaft the blade-type piston through a crank system performs two full swings realizing in four working-chambers alternately the intake and compression cycles. Inlet valves are mounted on the side covers of the compressor cylinder.

2. The compressor test stand

Test stand was built to allow investigation of compressor exploitative and functional properties. The rotational speed of electric motor which drives a compressor is controlled by means of inverter. Four inlet conduits to the compressor are connected to the equalizing tank in order to damping pulsation of medium. The orifice placed between the compressor inlet and the tank allows measurement of intake air quantity. There are two methods applied to calculate outlet air flow rate: the first of them is based on measurements of pressure and temperature of medium in the tank and the second one relies upon measuring of regulated air bleeding from the tank using rotameter so as to maintain constant pressure in the tank.

3. Researches of compressor equipped with contact seals

The study was carried out for seals made of PTFE, PET and graphite. Each of the sealing elements was pressed onto the surface of the cylinder and the surface of the side covers by means of two springs in order to ensure contact during the entire period of operation. The reduction of components dimensions due to the wear was taking into consideration as well. The kind of material used had an impact on the durability of the seal. The shortest life period was observed in case of seals made of PTFE and the largest - of the graphite. However seals made of PTFE and PET lost their sealing properties after several minutes of work as a result of thermal distortion in spite of not exceeding the allowable working temperature for plastic materials (190°C).

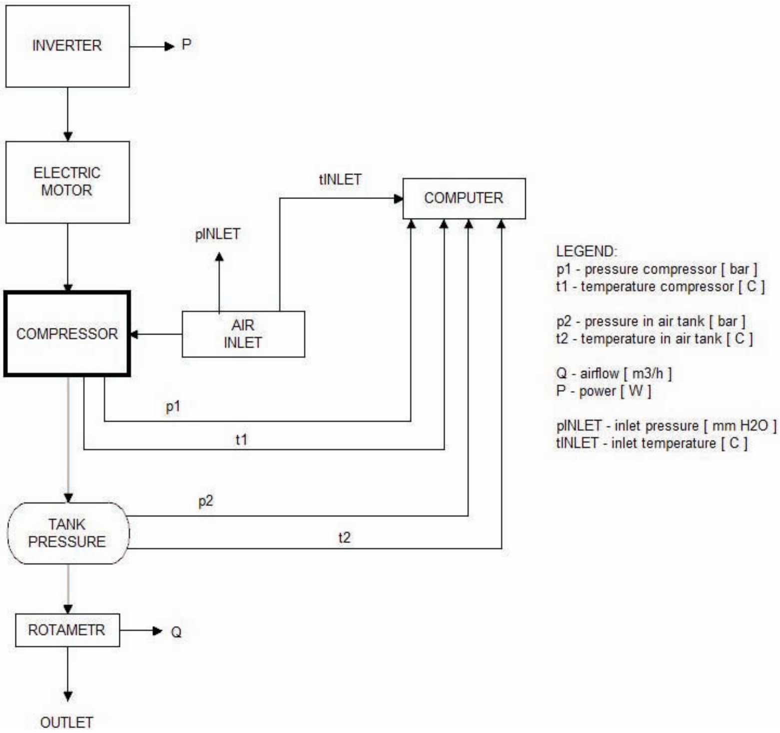

Fig.1. Block diagram of measuring system and test stand built for compressor testing

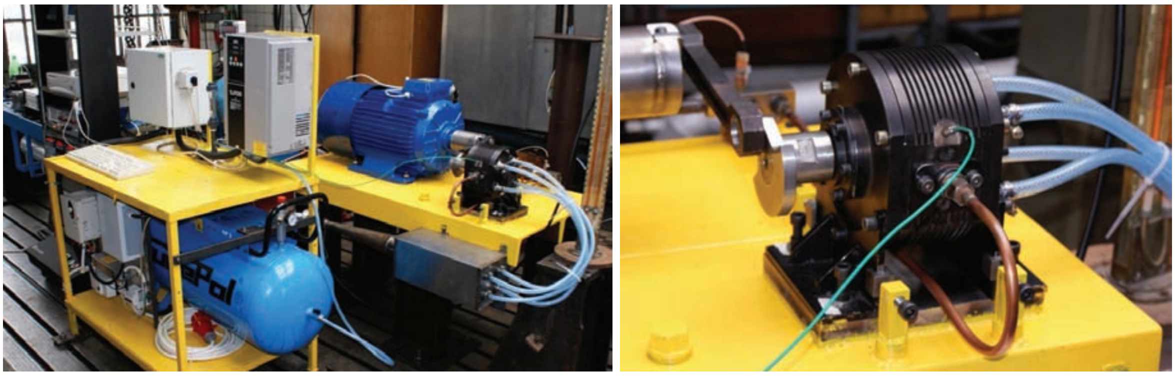

Fig. 2. The view of compressor testing stand

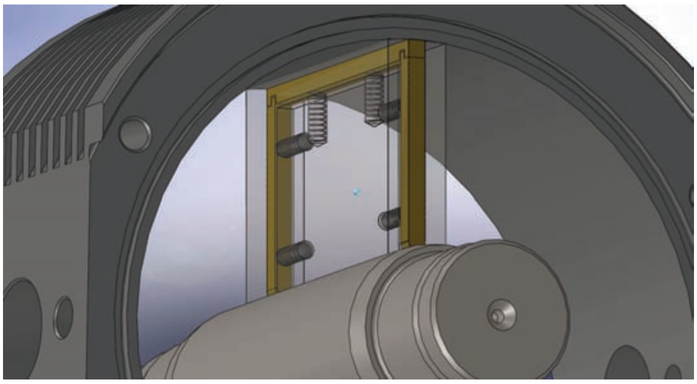

Fig. 3. The 3D-view of localization of contact seals

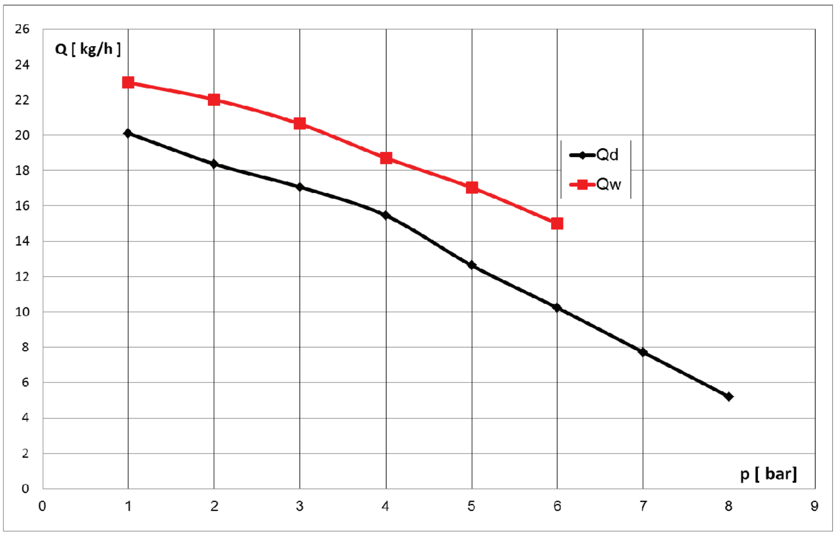

Fig. 4. Inlet (Qd) and outlet (Qw) air flow for engine speed = 970 rpm (PET seal)

The following pictures show the deformation of the sealing elements after 30 minutes of work. Graphite seals met best of their entire role and assured the desired durability of assembly. However, no studies on air purity were conducted despite the observed abrasion phenomenon of graphite during operation of the compressor.

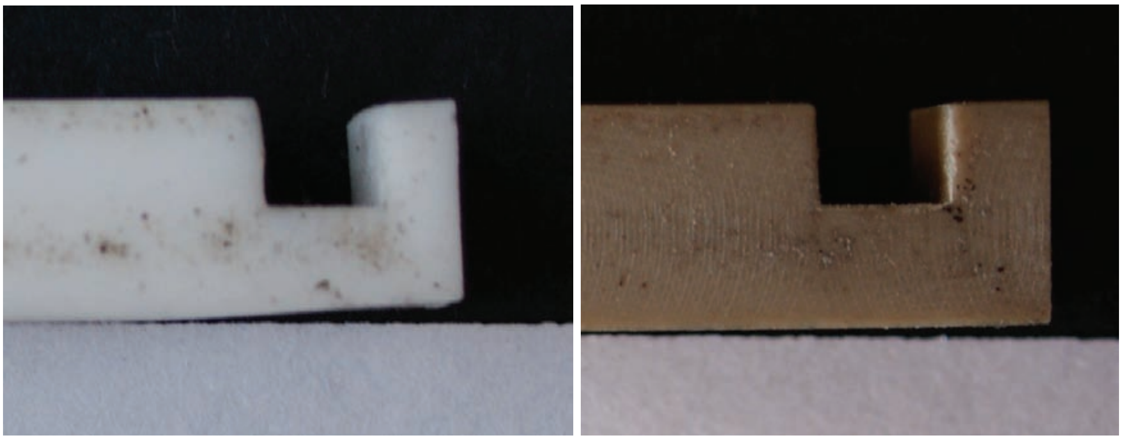

Fig. 5. Deformation of 0.65 mm PTFE seal (left) and 0.35 mm PTE seal (right)

Stuff	Nominal dimension [mm]	After tests dimension [mm]	Rectilinear deformation [mm]
PTFE	7.06	6.61	0.65
PTE	6.69	6.55	0.35

4. Researches of compressor with labyrinth seals

The work was carried out for different values of radial and axial clearance between the blade-type piston and the compressor cylinder. Some of clearance combinations led to seizing of compressor and/or piston, both on the cylindrical part and side surface of piston. Increasing of clearance allowed for obtaining of higher final compression pressure but at the cost of higher leakage and lower compressor efficiency.

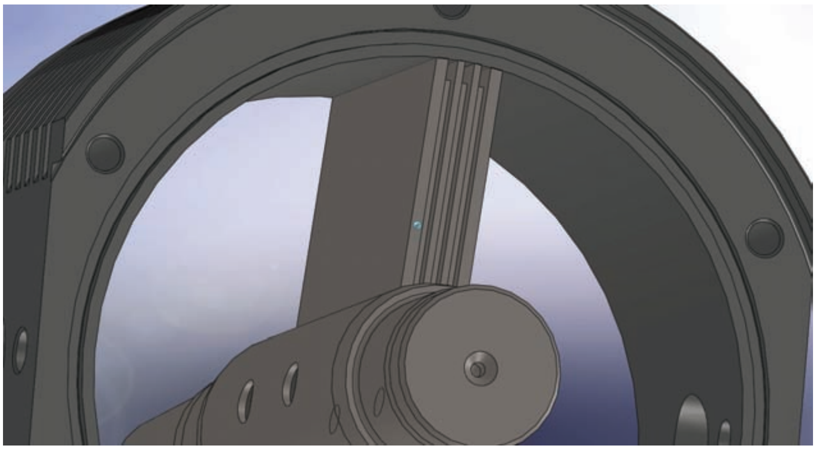

Fig. 6. The 3D-view of localization of labyrinth seals

As a result of subsequent studies axial and radial clearances of 0.15 mm (per side) were estimated. For above-cited values of clearance the final compression pressure of 5.5 bars was obtained, during trouble-free operation.

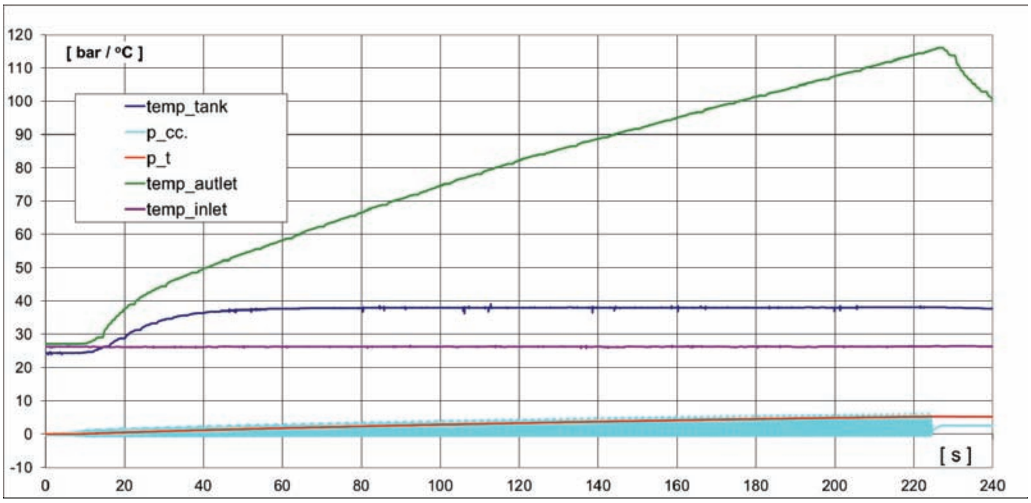

Fig. 7. Variation of pressure and temperature during compressor operation in 0 to 5 bar output pressure range (Temp_tank – air temperature in tank, p_cc - air pressure in compression chamber, p_t – air pressure in tank, temp_outlet – air temperature at compressor outlet, temp_inlet – air temperature at compressor inlet)

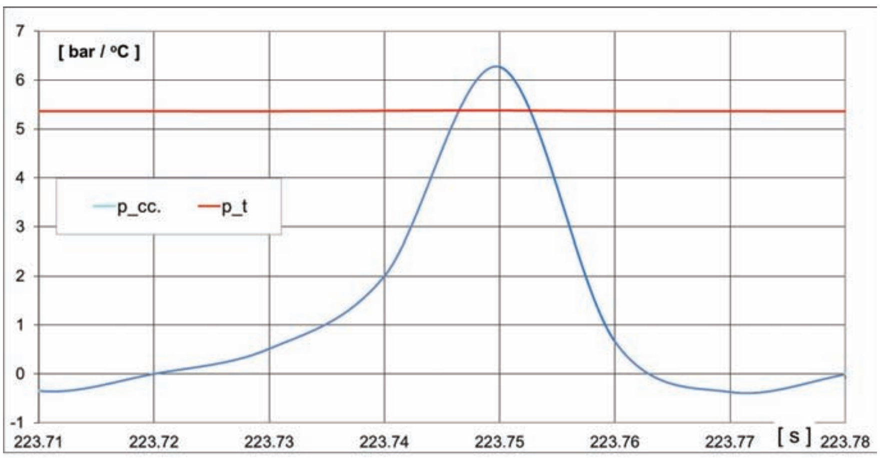

Fig. 8. Air pressure curve in compression chamber at tank pressure of 5,3 bar (zoomed fragment of graph showed

on Fig. 4)

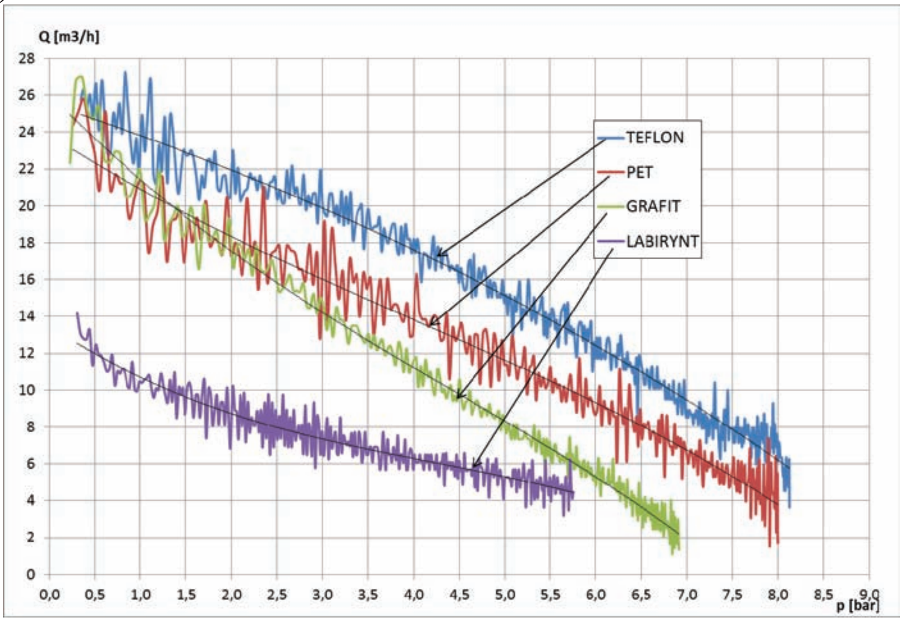

Fig. 9. Comparison of compression rate of blade-type piston compressor for different seal versions

The Fig. 10 shows the compressor power requirement vs. compression pressure for drive shaft speed of 970 1/min. Power values were read out at the display of inverter used to operate the propulsion motor.

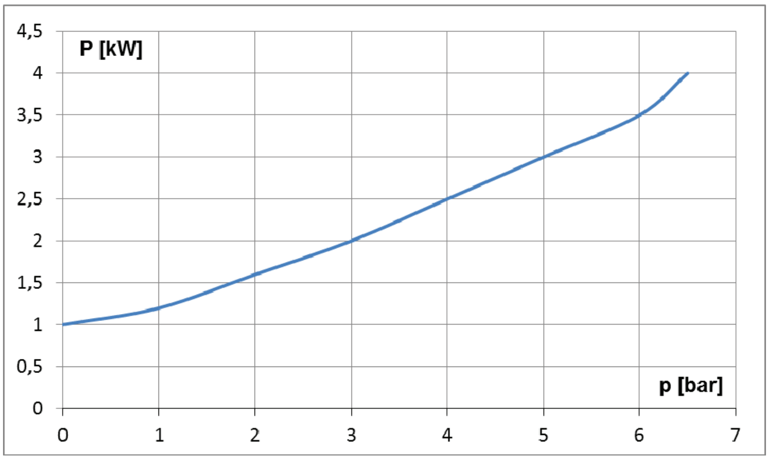

Fig. 10. Compressor power requirement

5. Summary

The researches on compressor indicate that the piston fitted out with labyrinth seal limits the range of working compression pressure to 4–4.5 bar (0.4–0.45 MPa). Thermal expansion of compressor elements at higher pressure forces application of wider clearances between piston and cylinder. In consequence of this the reduction of the compressor efficiency was observed. On the other hand applying of graphite seal extends working range of compressor up to 8 bar (0.8 MPa).

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