BLADE-TYPE PISTON COMPRESSOR INVESTIGATION OF SEALS

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Abstract

The paper presents the test results of selected seals applied in the blade-type piston compressor designed and realized in Propulsion Department of Institute of Aviation according to Patent No 6822 specification. Principle of operation of the compressor and the construction of test stand utilized to the seals testing were presented in the paper published in the Journal of KONES 2009. The special blade-type piston realizes a pendulous movement in the circular cylinder divided into two bulkheads. Each of bulkheads, fitted out with a set of bidirectional operating valves, creates by sequential opening and closing of them two compression chambers for one blade. Comprehensive tests of different kinds of seals were carried out on a single-compression machine driven by pneumatic actuator. The pressure rise vs. blade movement and drop of pressure when the piston was stayed at top dead centre were measured. The results of leak tightness of other structures of blade-type piston were analyzed as well and are subject to the following paper.

The new design of piston relied on fitting-out of piston with side disc was prepared with intention of eliminating the loss of usable pressure in compression chamber, especially in area of top dead centre. The proposed design eliminated the leaks on the drive shaft and lateral seals, but not on the cylindrical surface of discs

Keywords*: piston machines, piston compressor, seals testing,*

1. Introduction

Prof. Włodzimierz Chomczyk is an author of Patent No 68220 comprising the compressor equipped with new art of piston of rotary-turning motion. The piston in the form of double-sided blade moving in rotary-turning manner inside a circular cylinder realizes two working-cycles (intake and compression) in four chambers simultaneously. The conversion of oscillatory motion to the rotary one has been accomplished by means of 'crank and rocker' mechanism.

The detailed structure of compressor as well as appropriate kinetic, dynamic and strength calculation of design were presented in the paper entitled "Blade piston compressor" at KONES 2009 conference.

The research works carried out on especially designed test bench applied for several variants of seals between the piston and the cylinder and between the shaft and the cylinder, among which following types of seals ought to be mentioned:

a) the labyrinth seal on the blade and the shaft,
b) the labyrinth seal on the blade and contact seal on the shaft,
c) the contact seals on the blade and on the shaft.

The leak tightness as a function of pressure curves variability compared with construction of blade-type piston with side sealing shields was analyzed as well.

The results of research works on different seals are described in the present paper underneath.

2. The researches of seals

The single-compression machine as the test stand provided the motion of the blade in circular cylinder in similar way as in target compressor. As the driving unit of shaft-blade assembly a hydraulic servomotor was used which rotational velocity was controlled by changing of actuator's working pressure. The hydraulic brake system along with the bumpers stopped the motion of servomotor in definite position, determined by the change of connecting rod length and the position of bumpers. The quick-variable pressure versus piston position has been measured in the chamber formed by blade-type piston and boundary baffle. The speed of pressure accretion as well as the speed of its drop can be regarded as a quality measure of different seal variants.

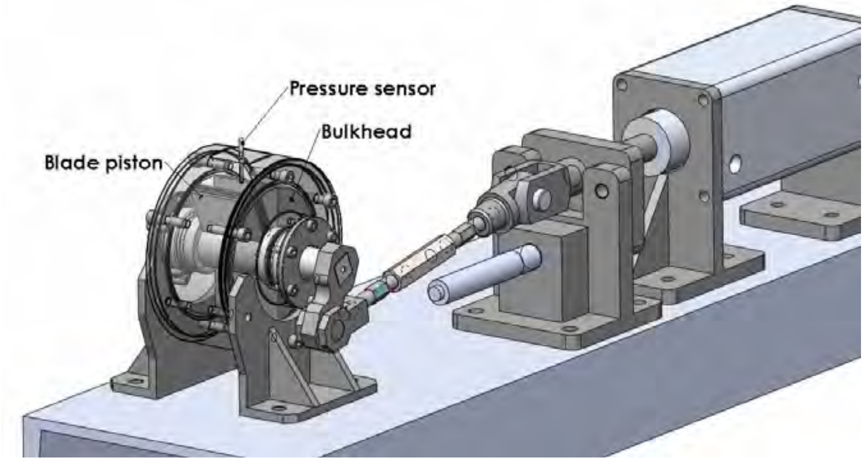

Fig. 1. The 3D-view of seals testing stand

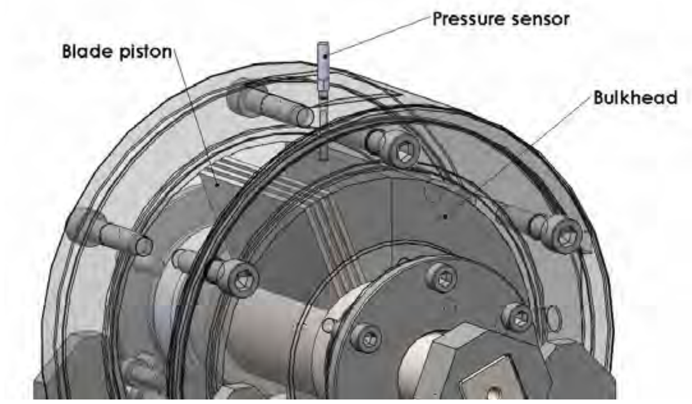

Fig. 2. The 3D-view of localization of pressure sensor

3. The researches using labyrinth seals

The front and lateral surfaces of blade-type piston were equipped with labyrinth seals. The backlash value between piston and cylinder surfaces amounts to 0.05 mm. This manner of sealing was treated as the basic design of compressor's labour-assembly.

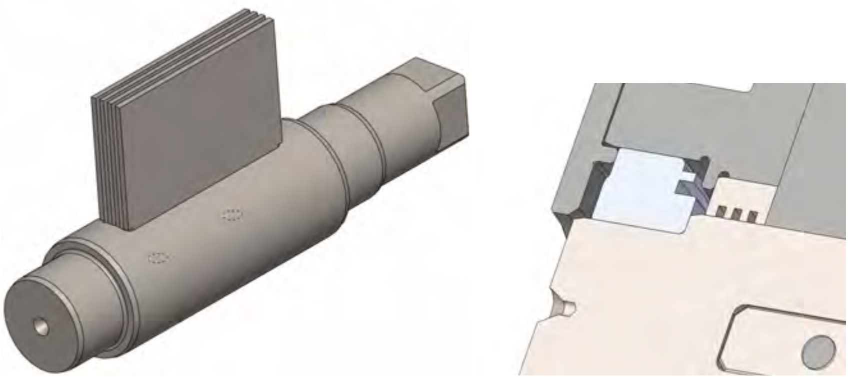

Fig. 3. The 3D-view of labyrinth seals on blade and shaft

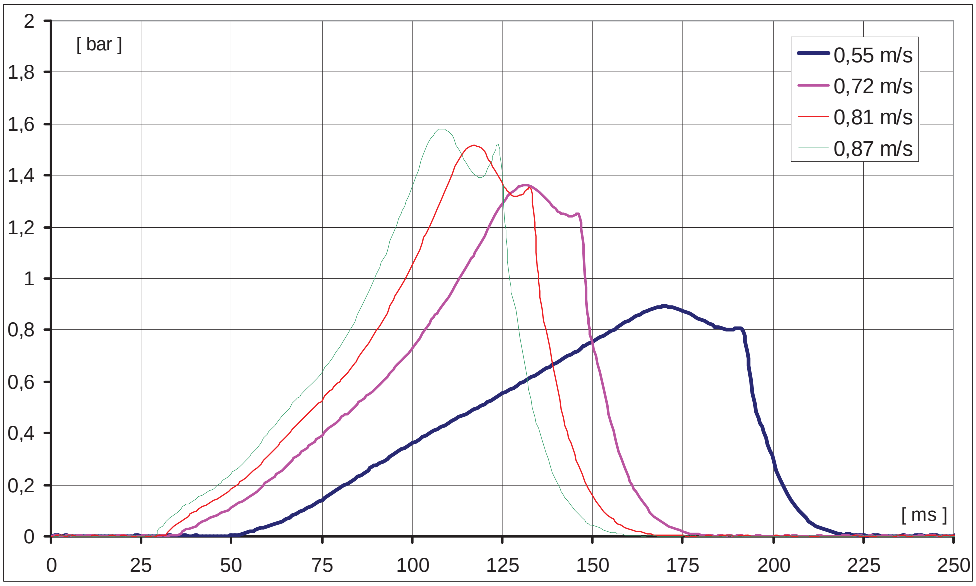

Fig. 4. Comparison of average pressure curves for labyrinth seals on piston (blade); the shaft sealing was labyrinth type as well

4. The researches using labyrinth seals on piston and contact seals on the shaft

In case of this seal variant, the labyrinth seal on the shaft was replaced with the Trelleborg type contact seal shown on the figure below.

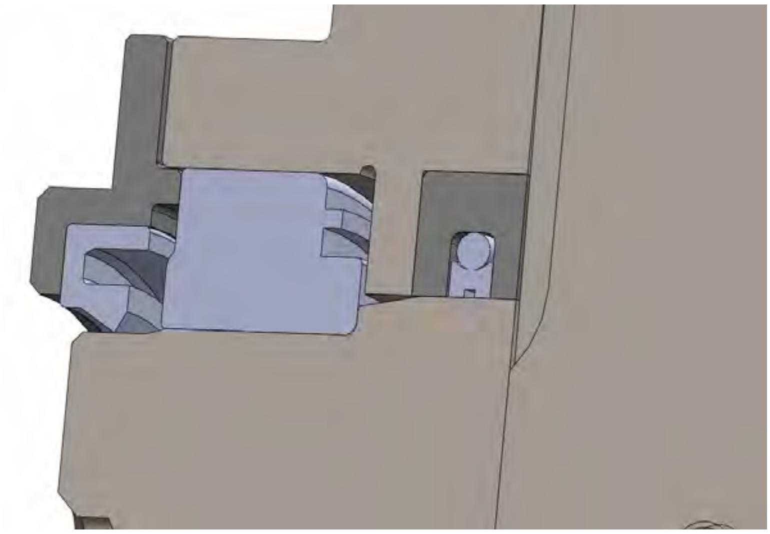

Fig. 5. The Trelleborg type seal on the shaft

The change of manner of shaft sealing caused about 30% increase of maximum working pressure across working cycle of compressor.

5. The researches of contact seals on piston and contact seals on the shaft

Unsatisfactory tightness between the blade and the cylinder resulted in applying of another type of seal – contact seals in form of brass pads located in furrows made on side surfaces of blade. They filled simply the gaps of labyrinth seals.

Such exchange of piston sealing caused about 50% increase of maximum working pressure across working cycle of compressor.

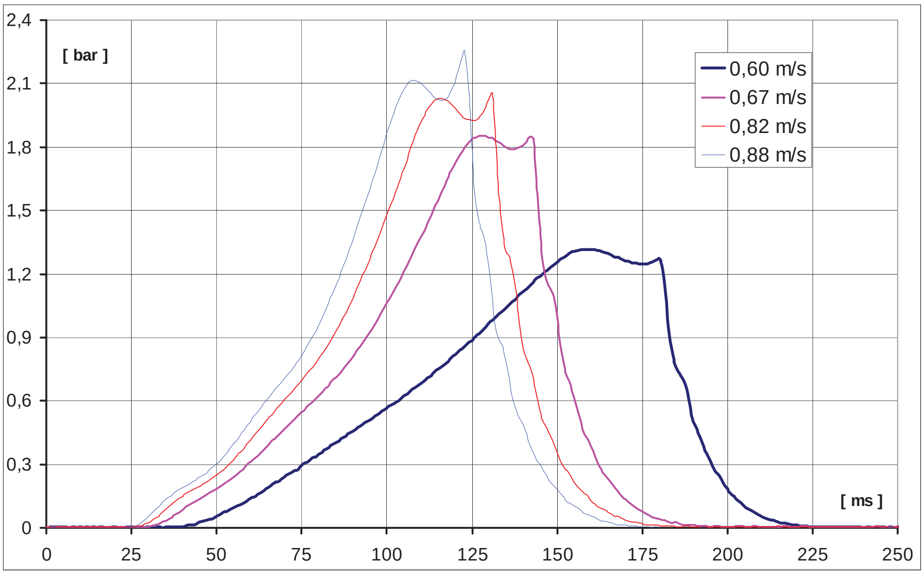

Fig. 6. Comparison of average pressure curves for labyrinth seals on piston (blade); the shaft seal was Trelleborg type

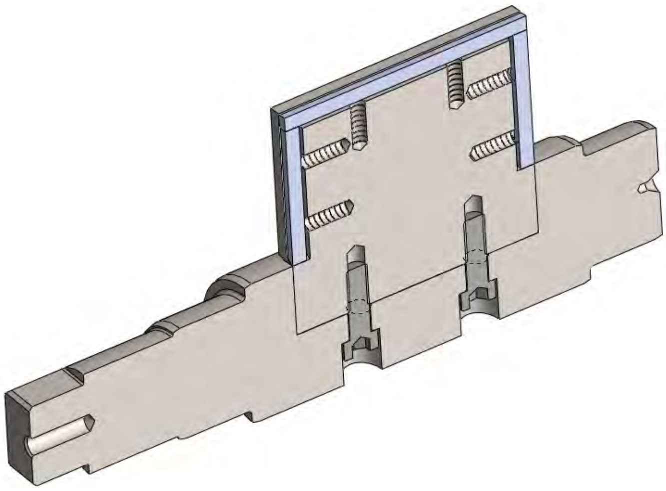

Fig. 7. The 3D-view of contact seals on blade.

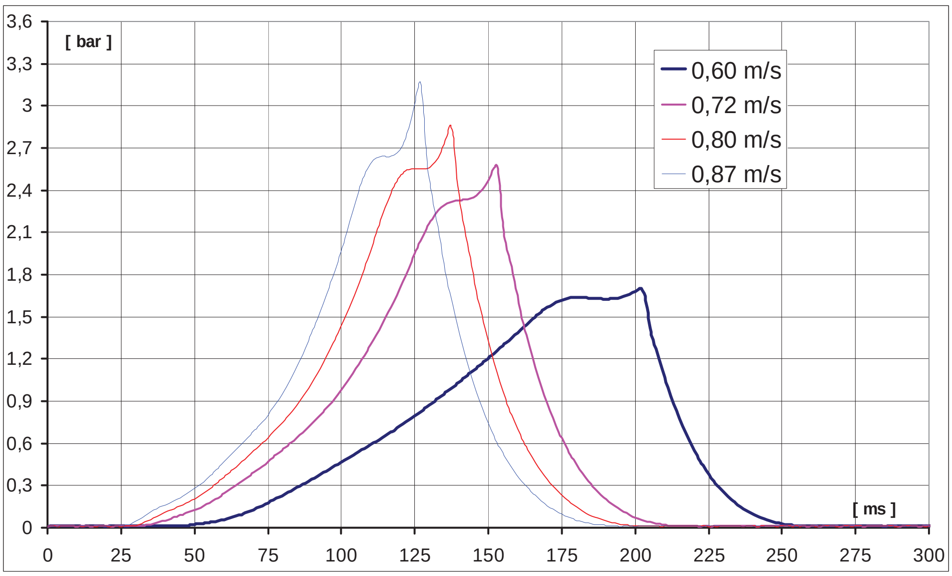

Fig. 8. Comparison of averaging pressure curves for contact seals on piston (blade); the shaft sealing was Trelleborg type

6. The researches using blade-type piston with side disc and contact seals on the shaft

The new construction of piston relied on fitting-out of piston with side disc was prepared with intention of eliminating the loss of usable pressure in compression chamber, especially in area of top dead centre. The proposed design eliminated the leaks on the drive shaft and lateral seals, but not on the cylindrical surface of discs.

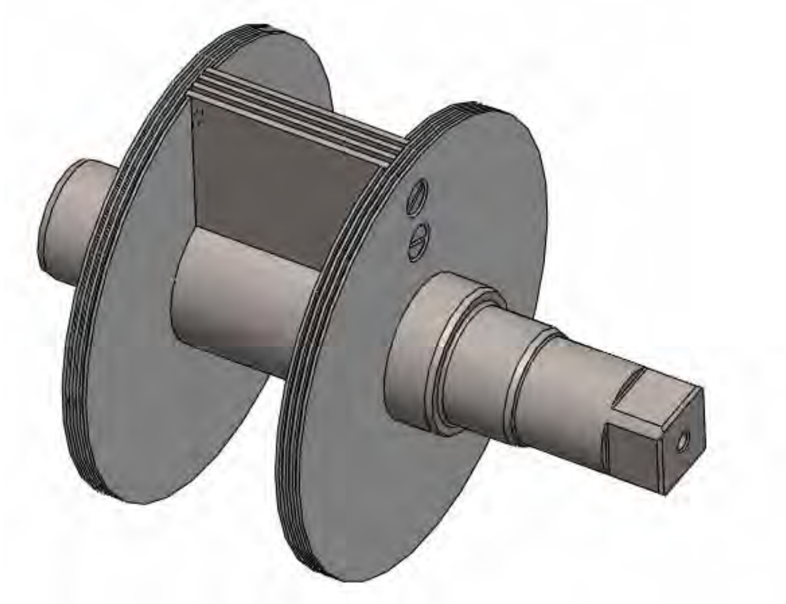

Fig. 9. The 3D-view of blade with side discs (with labyrinth seals on cylindrical surface)

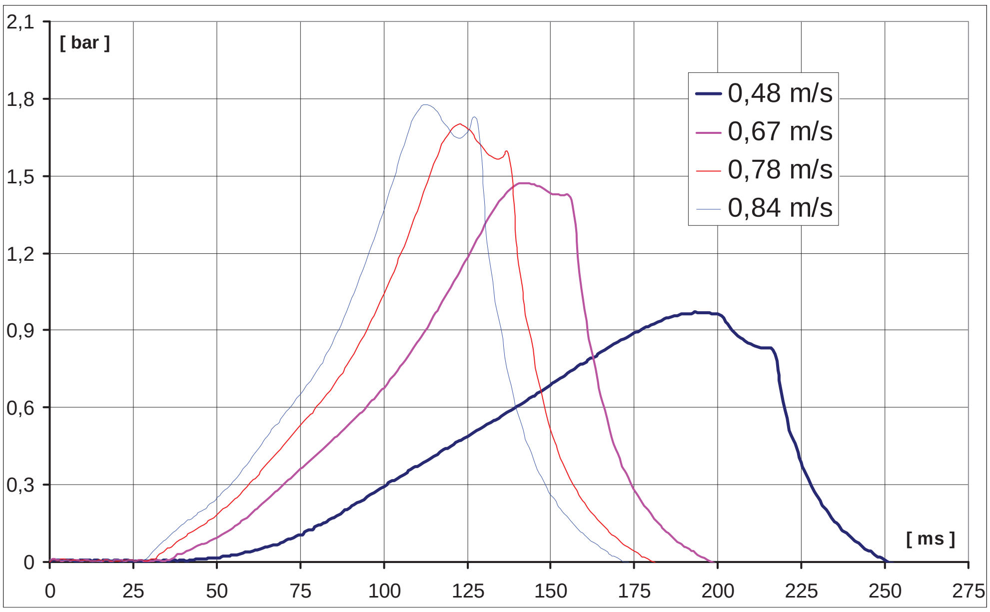

Fig. 10. Comparison of average pressure curves for blade with side discs; the shaft seal was Trelleborg type

7. Comparison of results of carried out tests

The figure below showing the pressure curves achieved for all tested types of seals by the highest possible on test bench piston velocity are to be consider as a measure of dynamic seal quality. The ratio of maximum pressure of the best variant (contact seals for piston and Trelleborg one for shaft) to the worst variant of seals (labyrinth seals for both piston and shaft) reaches almost 2.

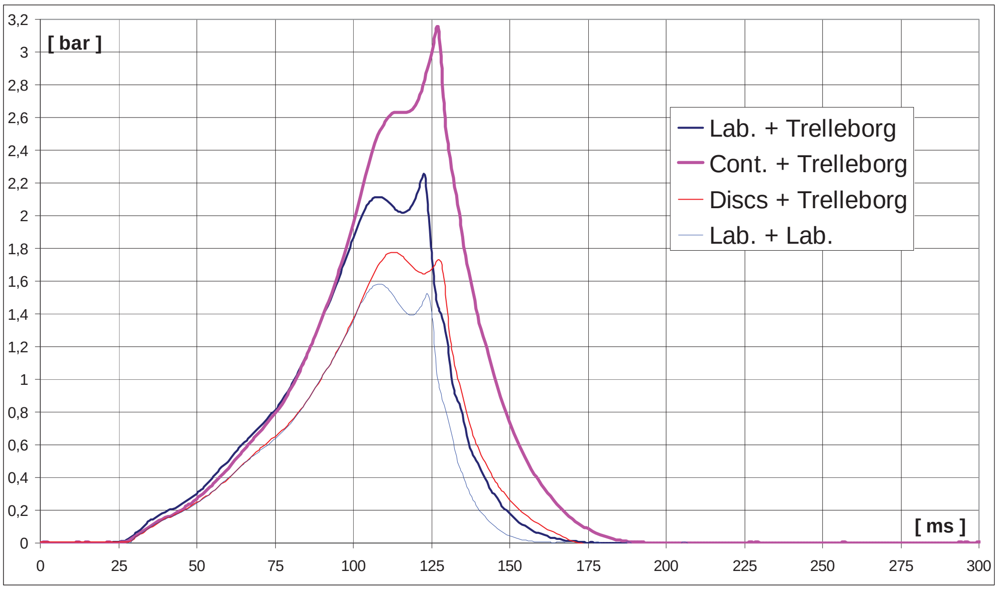

Fig. 11. Comparison of average pressure curves for different seals for max. velocity of piston c.a. 0.9 m/s

8. Summary

1. The highest compression pressure showed the contact seals;
2. Application of labyrinth seal on the piston (blade) resulted with reduction of compression pressure in the order of 30%;
3. Applying of blade-type piston fitted out with side discs to improve the tightness of compression chambers did not yield satisfactory results. The main reason of this was relatively heavy leakage through the labyrinth seals on cylindrical surface of discs;
4. For further study the Trelleborg type seals on the shaft and labyrinth and contact seals of different options for piston were recommended.

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