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CALCULATION OF LEAKS IN THE WORKING PART OF A SCREW COMPRESSOR

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Abstract

The article considers a mathematical model and a method for calculating the flow of a compressible medium through slots in the working part of an oil-filled screw compressor, taking into account the mobility of their walls. The analysis of various types of slots, carried out by the authors of the work, showed that in most of the slots of the screw compressor, there is an oncoming movement of the walls and the working substance, and the walls on the contact line and on the discharge side have a passing movement. Due to the fact that when the velocity vectors coincide, the leakage increases, it becomes necessary to take them into account, which was done in the proposed mathematical model. Thanks to the proposed method for calculating leakages, the accuracy of calculating the feed rate of a screw oil-filled compressor increases. The adequacy of the proposed methodology is confirmed by experimental data by comparing the feed rate calculated based on the proposed methodology with the feed rate obtained during testing of the experimental compressor.

Keywords: feed rate VKM, leakage of the working substance, classification of gaps.

Introduction

The helical screw compressor is a positive displacement compressor, the working cavity of which is enclosed by the housing bores, housing end plates, and the helical surfaces of the male and female rotors. As the rotors rotate, the volume of the working cavity varies from zero to its maximum and from its maximum to zero periodically in a manner determined uniquely by the geometry of the compressor. As a consequence of this periodic variation, the compressor completes its suction, compression and discharge processes. Due to the geometry of the mating parts and the need for clearances between them, the compressor has several leakage paths as follows: across the contact line between the male and female rotors, across the rotor tips and end sealing lines, and through the cusp blowholes and the compression start blow hole. The summation of the leakages through all these paths has a large influence on the performance of the compressor.

Leaks through the end seals (seals) of the rotor shaft, in the form of leakage of the working substance or suction of atmospheric air, are called external. Leaks of the working substance through the gaps between the parts in the working space of the VKM from the discharge side to the suction side are called internal leaks and have a significant impact on the working process. Moreover, the leakage of the working substance at the moment of suction is called leakage and affects mainly the feed rate, and to a lesser extent, the effective efficiency and engine power. Leaks occur from the pressurized cavities in the suction cavity, as well as in the cavities connected at that moment to the suction chamber. Filling the suction cavity with the working substance of leaks leads to a decrease in the volume of the newly incoming (absorbed) working substance. The temperature of the steam of the working substance of leaks is higher than the temperature of the newly sucked steam, which leads to an increase in temperature and a decrease in the density of the gas mixture in the suction cavity. Accordingly, the vapor mass of the newly sucked working substance decreases.

In classical gas dynamics, the flow of a perfect gas is considered, for which the Claiperon equation $P=\rho RT$ (2) is used as the thermal equation of state, and the dependence $i=c_pT$ (3) is used as the caloric equation of state, and the specific heat at constant pressure is assumed to be unchanged. The medium compressible by VKM differs in its thermodynamic properties from perfect gases. Therefore, it is of interest to consider the flows of real gases with specific equations of state through slots in the VKM.

An analysis of various types of slots showed that in most of the slots of the VKM, there is an oncoming movement of the walls and the working substance, and the walls on the contact line and from the discharge end have a passing movement. Due to the fact that when the velocity vectors coincide, the leakage increases, it becomes necessary to take them into account, which was done in the proposed mathematical model. When the rotors of the screw oil-filled compressor rotate, the parameters of the slots and the velocity vectors of the mutual movement of the surfaces of their generatrices change. Thus, the movement of a compressible working substance through such gaps should be considered non-stationary.

The main thing to remember when determining the performance of a screw compressor is the fact that performance is always determined not in cubes of already compressed air, but in cubes of air reduced to compressor suction conditions.

In other words - we are talking about the compressor performance at a pressure of 7 bar 10 m3 / min - and we mean that by supplying compressed air with an overpressure of 7 bar to the pipeline, the compressor returns air from the pipeline with an atmospheric pressure of 10 m^3 to the atmosphere in one minute.

Or even simpler - the compressor sucks in 10 m^3 per minute from the atmosphere, although this statement is not entirely true, since in the process of compression, part of the air still goes into "losses".

It is for this reason that modern standards require compressor manufacturers to indicate the capacity value on the compressor outlet valve, normalized to suction conditions.

What are these conditions? Normal conditions (FAD in European version) are +20°C 1 bar atmospheric pressure and 0% relative humidity. There are also Normal conditions, the difference is that the performance is reduced to a temperature of 0°C. With seeming insignificance, normal cubes differ significantly from conditions at 20°C.

When determining the required volume of compressed air for a new production, the design department must carefully summarize the consumption characteristics of individual technological lines, take into account the coefficient of simultaneity of work, determine the "reserve" factor, add possible leaks.

After that, you can get an approximate estimated value of the need. Of course, the accuracy of such a calculation directly depends on the experience and qualifications of the specialist performing the calculation. However, with simple systems, the calculation can be performed independently.

To do this, you need to collect all the passport values of compressed air consumption. The standard margin is 18%. The design value of non-production leaks is 10%.

Coefficients of simultaneous operation of pneumatic devices can, of course, differ significantly, but rarely exceed 80%. So, FAD = (Amount of expenses) * 1.18 * 1.1 * 0.8.

If it is required to determine the flow rate based on the filling rate of the pneumatic cylinders, then, as a first approximation, you can use the simple equation P1*V1/T1 = P2*V2/T2

Where P1 is atmospheric pressure in bar.
V1 is the desired reduced volume in liters
T1 - ambient temperature in Kelvin (20°C + 273°C)
P2 is the absolute operating pressure in bar (1+7).
V2 - the volume of the pneumatic cylinder in liters
T2 - compressed air temperature in Kelvin (35°C + 273°C)

When replacing an existing fleet of compressors, the task at first glance appears to be simpler. As a rule, the production already has compressed air consumption statistics, on the basis of which economic parameters are calculated.

However, starting from these figures would mean completely eliminating the positive impact of a possible upgrade of the system. It would be best to conduct a preliminary audit of the system.

Based on the results of such an audit, one can see non-production leaks, determine the actual amount of air consumed, and identify a consumption schedule. Based on such detailed information, it is possible to design a new or upgrade an old pneumatic line with great accuracy and select equipment.

Having on hand schedules of changes in costs and pressure by department, it is always possible to accurately calculate which of the supply systems is most beneficial for the enterprise.

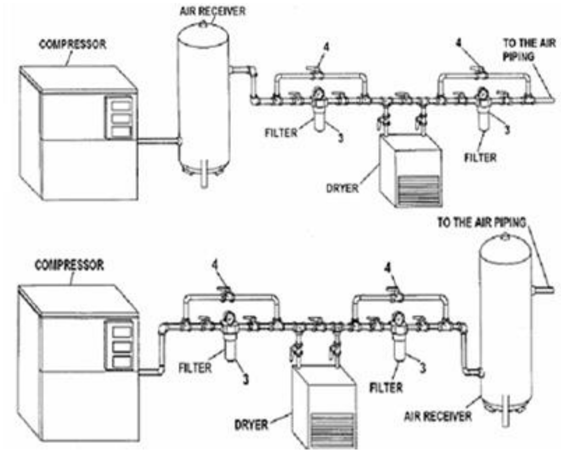

Figure 1. Scheme of installing a compressor on a compressed air consumer line

The main thing to remember when determining performance is that performance is always determined not in cubes of already compressed air, but in cubes of air reduced to compressor suction conditions.

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