MODELING AND SIMULATION OF A TWIN SCREW COMPRESSOR OPERATION

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Abstract: Screw compressors are part of the rotary volumetric compressor category. By eliminating the crank-connecting rod mechanism present in piston compressors, these machines achieve a balanced operation. Screw compressors exhibit higher isothermal efficiencies and flow coefficients compared to other types of compressors. This category includes a wide variety of designs and functions. The number of these compressor types has increased dramatically in recent years, now representing approximately 80% of volumetric compressors sold today. This type of compressor can operate with various fluids, including gases, dry vapors, or multiphase mixtures, where phase changes occur inside the machine.

A screw compressor can operate dry (without oil injection), with oil injection, or by using other fluids injected during gas compression. Achieving maximum efficiency is not possible by specifying a universal rotor configuration or by imposing certain operating parameters.

Keywords: twin screw compressor, modeling, simulation, flow, rotor

1. OPERATING PRINCIPLE OF SCREW COMPRESSORS

A screw compressor consists of two rotors: one driving and the other driven. These rotors feature a small number of lobes, with each pair forming a helical channel. The lobe configurations can include 2/2, 2/4, 3/3, 4/4, 4/6, 3/5, 5/6, and 5/7, depending on the required flow area. Fewer lobes allow a larger flow area but also increase the pressure differential between lobes.

The gas enters the helical channels, which sequentially communicate with the suction port. When the channels disengage from the suction port, the gas is trapped in

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isolated spaces formed by the helical channels of the rotors and the compressor housing. Subsequently, the lobes of the driving rotor interlock with those of the driven rotor, reducing the volume of the spaces containing the gas. The gas is axially displaced and simultaneously compressed. This continues until the helical channels connect with the discharge port, located at the opposite end of the cylinder. The rotors not only move the gas from the suction to the discharge side but also compress it.

The suction, compression, and discharge occur successively in each channel formed by a pair of conjugate lobes. Consequently, the final pressure in the channel upon connection with the discharge line does not depend on the network backpressure but on the rotor geometry and the discharge port position. Screw compressors are suitable for constant pressure in the discharge pipeline.

While the suction port is typically axial, it can also be radial or a combination of radial and axial. The radial configuration offers a shorter compressor length and thus a shorter sealing line. When the gas is drawn between the rotors and rotated with them, centrifugal force acts against the air's entry. Experiments show that a radial port is advantageous at low rotor speeds, while an axial port yields higher volumetric efficiency at high rotor speeds. A combined port provides a larger flow area for gas entry, reducing the pressure drop. The discharge port size determines the pressure ratio. Like piston compressors, screw compressors operate in four stages: suction, transport, compression, and discharge. Their fully rotary operation, with rotors symmetrically centered, ensures dynamically balanced functioning. Figure 1 illustrates a virtual model of a screw compressor.

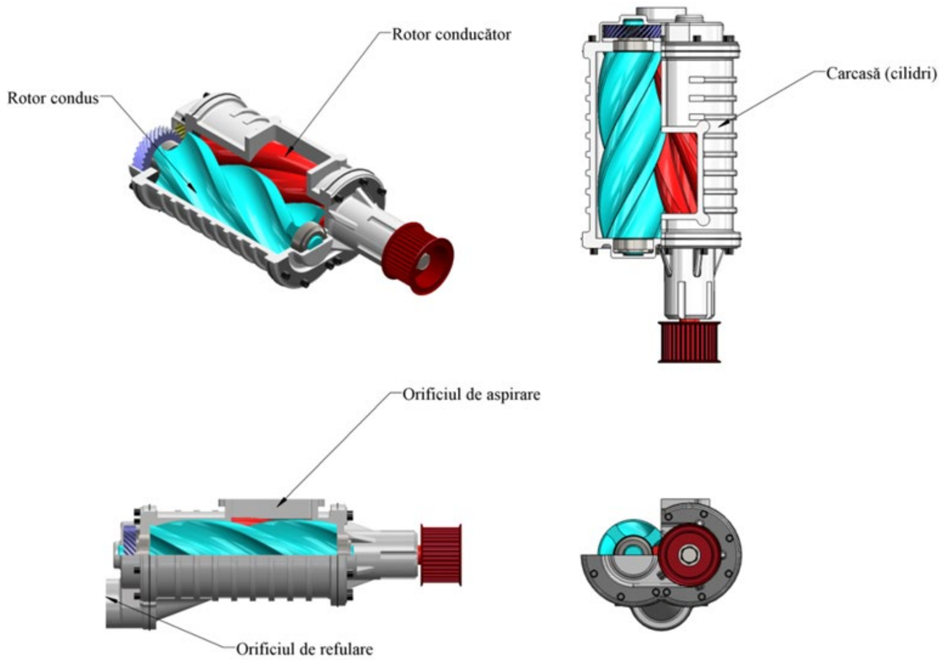

Fig. 1. Virtual model of a screw compressor

The virtual model of the screw compressor, shown in Figure 2, illustrates a 4/4 lobe configuration. Figure 3 represents the main overall dimensions of the compressor rotors.

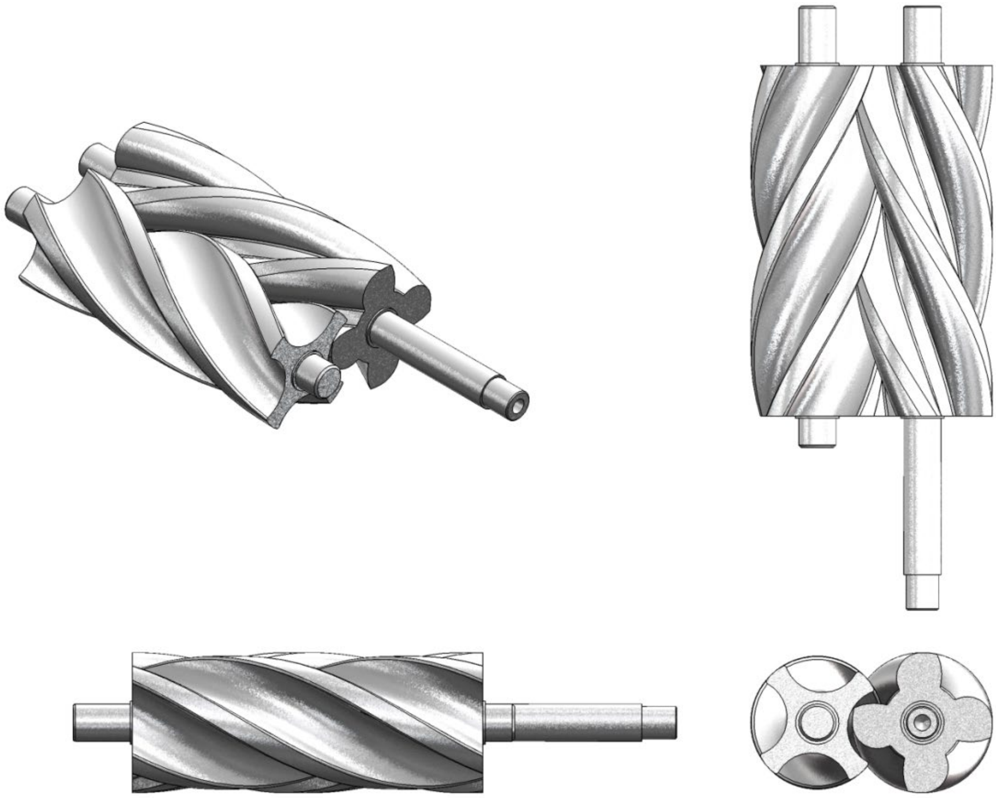

Fig. 2. Lobe configuration

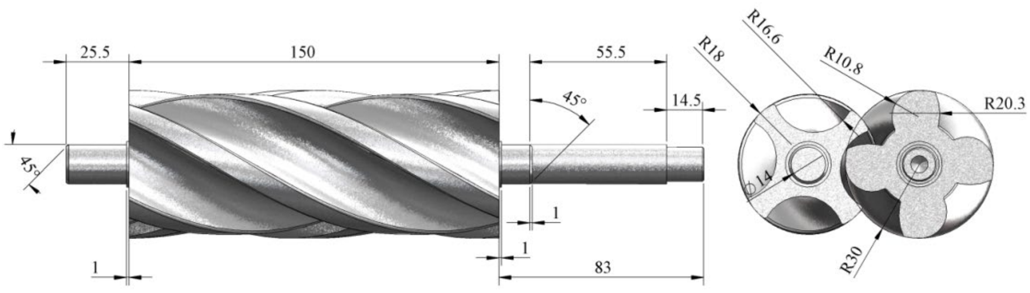

Fig. 3. Main overall dimensions of the compressor rotors

2. SIMULATION OF THE SCREW COMPRESSOR'S OPERATION

Using the cycloidal fan assembly described in the previous section, an internal fluid flow study `(Flow simulation)` was conducted. A key element in this study is the definition of the rotating volumes `(Rotating region)` which are constructed as components of the compressor assembly (Figure 4). After generating the rotating volume as a part, the pump assembly is prepared for the internal fluid flow study. This simulation was performed using the SOLIDWORKS application.

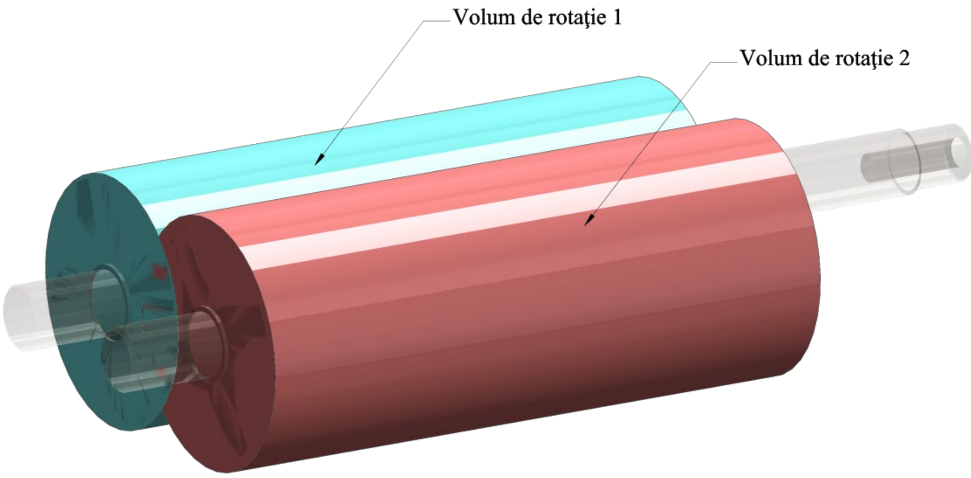

Fig. 4. Definition of rotating volumes

Since the chosen type of analysis is internal, sealing the inlets and outlets is important. This is the accomplished using the Create Lids option, as shown in Figure 5.

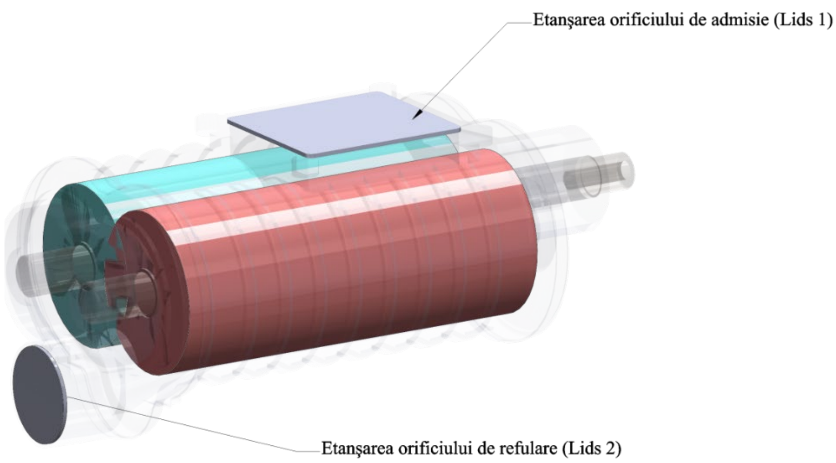

Fig. 5. Sealing the inlets and outlets

3. RESULTS

Figures 6 and 7, shows the pressure in frontal plane respectively in the horizontal plane.

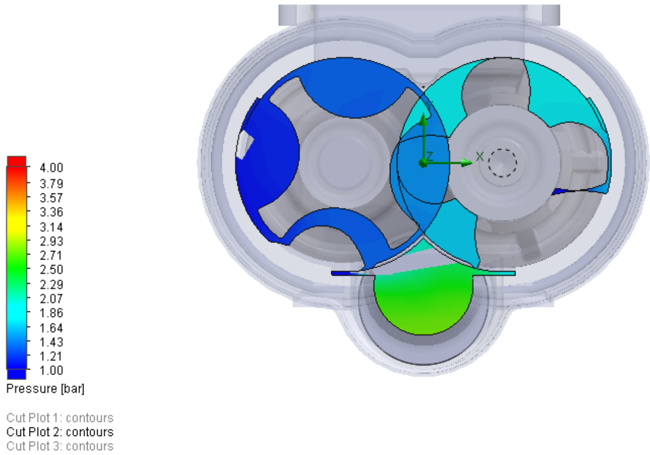

Fig.6. Pressure variation in the frontal plane

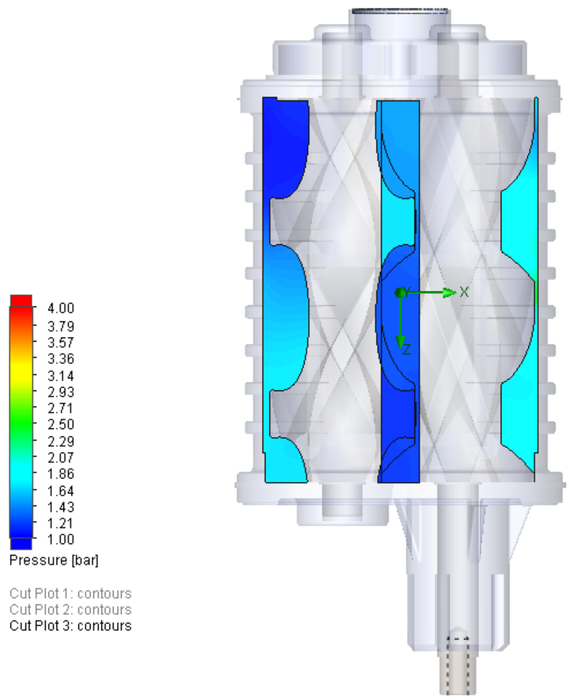

Fig. 7. Pressure variation in the horizontal plane

Fig. 8 illustrates the variation in air velocity within the screw compressor.

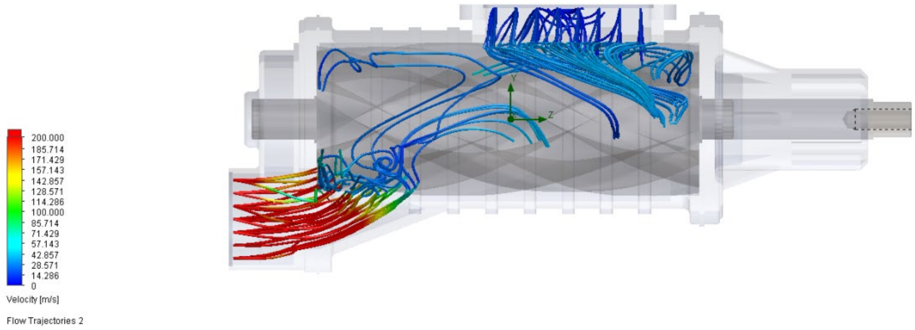

Fig. 8. Air velocity variation in the compressor

CONCLUSIONS

The study highlights the importance of using modern modeling and simulation tools in engineering, applied to the operational study of screw compressors. The adopted virtual model enabled the determination of air pressure and velocity variations within such a compressor. The results obtained and the experience gained in this field allow for the implementation of this approach for other screw compressor configurations.

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