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MODELLING VALVE DYNAMICS AND FLOW IN RECIPROCATING COMPRESSORS

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1. INTRODUCTION

Reciprocating compressors are widely employed in a number of industry and transportation branches, and it can be freely stated that some of the applications would hardly be possible without this type of machinery. The latter refers to such extreme cases as compressing ethylene to pressures upwards of 300 MPa for the purpose of producing LDPE (low-density polyethylene), very low suction temperatures (of the order of -150 ºC) in the field of liquefied gas transport and storage, or for compressing gases contaminated with particles. In commercial vehicles for road transportation, reciprocating compressors are customarily used for obtaining pressurized air for auxiliary purposes, such as braking, gear shifting, etc. Common to almost all reciprocating compressor applications is the fact that the compressor is a rather small component in comparison with the process and/or system that it supplies with gas, but its reliability determines the availability and safety of the entire plant. Therefore, the plant designers and owners require trouble-free operation from their compressors over long periods of time. Indeed, expected service time for a small hermetic compressor in a common household refrigerator is more than 20 years.

Conceptually, a reciprocating compressor stage consists of a cylinder, the volume of which varies periodically due to the motion of a piston that closes one end of the cylinder. The other end of the latter is closed by two valve sets, one each for admitting the gas to be compressed into the machine (suction valve), and for allowing the high pressure gas to be delivered to the process and/or machines utilizing it (discharge valve). One speaks here in terms of valve sets because there are machines (usually large process compressors) which may be equipped with more than one valve pro suction and discharge side, respectively.

From the standpoint of thermodynamic performance, the cylinder must be completely sealed at both ends during the compression process, and the suction and discharge processes are to be realized exclusively through the respective valves, which translates into the zero-leakage requirement for the machine. While the piston can be reliably sealed by means of one or more rings (lubricated or dry-running) that press against the cylinder wall, securing zero-leakage function of the valves is by no means a simple task.

The key feature of compressor valves that simultaneously affects both their sealing performance and reliability is that they, unlike their counterparts in a conceptually similar IC engine, are not actuated. They are held closed by elastic forces internal or external to the sealing element; and they open and close automatically, in accordance with the balance of gas pressure forces and the previously mentioned elastic ones. Under the gas pressure forces one understands both the force due to static pressure difference across a closed valve and the

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