International Congress Motor Vehicles & Motors 2012

Kragujevac, October 3rd-5th, 2012

MVM2012-022

Dobrivoje Ninković[1]
Dragan Taranović[2]
Saša Milojević[3]
Radivoje Pešić[4]

MODELLING VALVE DYNAMICS AND FLOW IN RECIPROCATING COMPRESSORS – A SURVEY

ABSTRACT: Thermodynamic performance (delivery rate and power intake) and reliability of reciprocating compressors are largely dependent upon the valves. Since the valves open and close automatically, there is a high degree of coupling between the gas flow through the valve and the sealing element dynamics; a mismatch between the two leads inevitably to degradation of the compressor performance and/or short valve life. The latter is due to excessive impact forces between the sealing element and other parts of the valve assembly. Therefore, matching the valves to the compressor application at hand is a complex task that calls for the use of the corresponding simulation models.
Surveyed in the paper are mathematical models for the prediction of the valve performance, consisting of the submodels describing compressible gas flow through the valves, sealing element dynamics, and the interaction of the latter with the flow. It is concluded that flow models based on the discharge coefficient are intrinsically not able to predict the critical flow regime with sufficient accuracy, requiring thus experimental data that are not always available. It is also suggested that other loss calculation approaches, such as e.g. the stagnation pressure loss model, should be investigated as possible alternatives to the discharge coefficient concept.

KEYWORDS: Valve dynamics, Valve flow, Discharge coefficient, Reciprocating compressor.

INTRODUCTION

Reciprocating compressors are widely employed in 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 3000 bar for the purpose of producing LDPE (low-density polyethylene), very low suction temperatures (of the order of -150ºC) 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.

[1] *Dobrivoje Ninković, PhD, Ruchwiesenstr. 28, 8404 Winterthur, Switzerland, dninkovic@bluewin.ch*
[2] *Dragan Taranović, MSc, University of Kragujevac, Faculty of Engineering, tara@kg.ac.rs*
[3] *Saša Milojević, MSc, University of Kragujevac, Faculty of Engineering, tiv@kg.ac.rs*
[4] *Radivoje Pešić, Prof. University of Kragujevac, Faculty of Engineering, pesicr@kg.ac.rs*