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A method for determining valve coefficient and resistance coefficient for predicting gas flowrate

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ABSTRACT

A method is introduced to determine the valve flow coefficient and resistance coefficient with the experiment of air discharging from a reservoir, and with the least squares method to fit the cumulative molar quantities discharged. The test valve is an angle-seat valve (Type 2632, Bürkert) with different apertures. At pressure difference of about 6 bar, the choked flow occurs when the valve aperture over 60%. Both the valve coefficient and resistance coefficient model can exactly predict the flowrate for the non-choked flow, while there are larger deviations for the choked flow. The modified equation for the choked flow can improve the prediction. In the resistance coefficient model, the value of resistance coefficient and the discharged cumulative molar quantities obtained with both the compressible and incompressible assumption are very close. The compressibility of air is negligible within the experimental pressure difference of about 6 bar. The additivity of the resistance coefficient makes the model more convenient to use.

1. Introduction

Valves and connectors are widely used in a piping system. In many cases, we require the knowledge of the quantitative flow characteristics through them in process controls, equipment designs or experiments. An example is pressure swing adsorption (PSA) process. In a PSA process, every component of a gas mixture can be selectively adsorbed and then separated in a series of operation steps of pressurization, adsorption, pressure equalization, depressurization and purge. These steps are performed by valves on or off, and their behaviors and operating results will be related to the flow characteristics of the pipelines. On the other hand, we can design suitable flow characteristics to optimize the operating results [1]. However, the flow characteristics are usually not provided by the manufacturer of valves or connectors, and are also conditioned by the circumstances. And so we need a precise and simple method to measure them in case of their significance.

International Electrotechnical Commission (IEC) provides a method for measuring the valve flow coefficient for compressible and incompressible fluids [2]. The valve flow coefficient can be calculated by measuring upstream and downstream pressures and the corresponding flowrate with steady state experiments, yet it is time and resource consuming to carry out such experiments.

Fu and Ger [3] presented a method for determining the valve flow coefficients of a ball valve and two diaphragm valves. In their work, the experiments of compressed air discharging from a reservoir through the test valves are carried out. The time-dependent pressures at both sides of the test valves are measured which are used to calculate the transient flowrate. Some assumptions are introduced in their data treatments. The valve flow coefficients are obtained by letting the pressure differential ratio x trend to zero. Adiabatic process is hypothesized in their model. This may not be true for compressed air discharging from a reservoir.

In our present work, compressed air discharging from a reservoir is carried out, and the time-dependent temperatures and pressures of the air in the reservoir are measured to calculate the cumulative molar quantities discharged. The valve flow coefficients C_v and resistance coefficients ξ of an angle-seat valve at different apertures (ap) are calculated without the adiabatic hypothesis. These two coefficients are compared to analyze which one is better to predict the fluid flow characteristics.

2. Experiment

Fig. 1 shows the experimental apparatus. The volume of reservoir 1 is 0.2063 m^3. Valve 2 is the test valve (angle-seat valve 2632, Bürkert, Germany) which aperture can be continuously adjusted. Valve 3 (angle-seat valve 2000, Bürkert, Germany) is installed at the exit of the connecting pipe (ID 25 mm) to serve as a quick-opening valve. The temperatures and the pressures of

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