Simulation of the flow in valves to determine flow factors

Graduate

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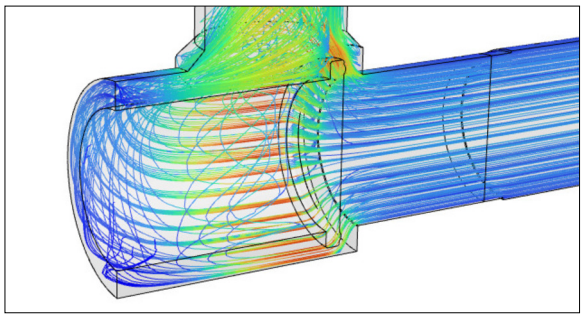
Introduction: VAT Vakuumventile AG is the world leader in the manufacture of high-performance vacuum valves. These are used in various industrial sectors such as semiconductor manufacturing, solar cell production and display fabrication. VAT's product portfolio includes vacuum transfer valves for loading and unloading process chambers as well as control valves and angle valves. These are used for the targeted pumping or venting of process chambers and thus enable precise control of the flowing process gases. A central parameter of the valves is the flow factor, also known as the Kv-value. This defines the volume flow that flows through the valve under a certain temperature and pressure. The Kv-value can thus be regarded as a measure of the flow resistance of the valve and is accordingly of decisive importance for the design and dimensioning of vacuum systems.

The experimental determination of Kv-values is regulated in standards, but is very demanding and time-consuming for compressible media. In particular, the determination of the critical differential pressure ratio, at which a flow limitation occurs, proves to be difficult in practice. Therefore, several relations for the calculation of Kv-values have been published in the literature, which circumvent the determination of the critical differential pressure ratio by suitable assumptions and simplifications. However, these alternative approaches provide different Kv-values.

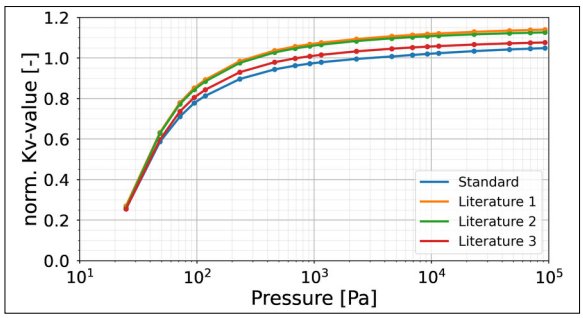
Definition of Task: The aim of this bachelor thesis is to analyse and compare the different approaches for calculating Kv-values. In particular, the assumptions and simplifications underlying each approach will be elaborated and highlighted. Furthermore, a numerical model will be developed, which will serve as a basis for future CFD-simulations of Kv-values. The results which were calculated with the model are to be compared with a specially developed, standardised measurement setup. In the future, the simulation model should enable early fluidic optimisation of the valve design, which will save time and costs.

Result: On the basis of a mathematical derivation, it was possible to identify and highlight the assumptions and simplifications on which the different approaches to calculating Kv-values are based. Furthermore, it was possible to develop a simulation model for calculating the flow in valves. With the help of the simulation model, all characteristic values required for the calculation of the Kv-value can be determined computer-aided. This makes it possible to determine Kv-values in the future with the help of CFD-simulations. The simulation model can also be used to optimise the geometry of the valves in terms of flow technology at an early stage of development.

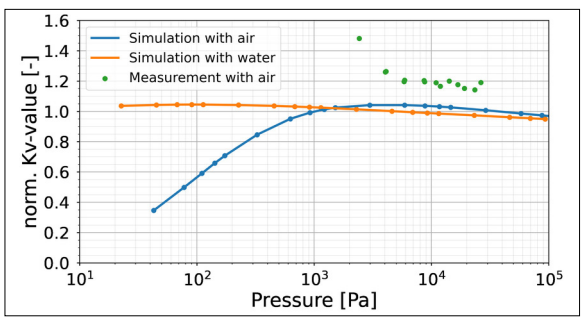
Visualisation of the flow lines of the velocity of air through the simulated valve
Own presentment



Comparison of the normalized Kv-values between the different calculation formulas of the standards and literatures
Own presentment



Comparison of the normalized Kv-values between simulation and measurement
Own presentment



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