DESIGN OPTIMIZATION OF A NOVEL ORIFICE CONTROL VALVE FOR TURBOMACHINERY TESTING FACILITIES

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ABSTRACT

In testing facilities for turbomachinery applications, the main component for the regulation of the flow is the control valve. In order to fulfill the flow rate requirements, the performance of the control valve should be highly accurate in a specified flow range. The robustness of the control valve against variations and disturbances, along with the occurrence of cavitation are only some of the major issues to be considered.

A control valve incorporated in any testing facility has to meet certain requirements. Thus, operating aspects, such as the flow rate range and the valve pressure drop, along with control prerequisites, regarding flow stability, repeatability and robustness of the valve, are considered. The purpose of this study is to establish a new approach to optimize the design of a control valve.

Orifice plates, although they are pressure-differential flowmeters, serve as a guideline for the entire study because of the geometrical similarities with the control valve. An initial sensitivity analysis determines the most influential parameters and prioritizes the requirements. With an emphasis on the cross-sectional area and by neglecting its shape, a simplified 2-D model is optimized. Eventually, a CFD model, verified by experiments, is used for the analysis of the effects of geometrical parameters.

The established workflow weighs the requirements according to each application and indicates the method to achieve the desired goals. The simplified 2-D model proves to be sufficient for setting the valve's characteristics, with the optimization further enabling the modification of its properties. Experiments and CFD simulations verify the 2-D model and assist in the fine adjustment of the valve's characteristics. Nevertheless, they seem to be more necessary, mostly, in applications with extreme flowrate and temperature conditions or for the investigation of phenomena such as cavitation.