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Experimental Verification of the Unloaded Control Valve

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Abstract: Findings are presented from the tests of unloaded control valve mounted on the steam piping with experimental turbine. The forces applied on the spindle are recorded and compared to design calculation. The forces are evaluated from the pressures on a servo drive piston or they are measured directly using force transducers. The real operational characteristics are compared with characteristics developed for constant inlet pressure.

Introduction

One of the unloaded valve tests was carried out on the model built into the inlet piping of experimental steam turbine. In the model version operation is controlled by the turbine which requires certain relation between the pressure ratio on the valve and the lift of the cone, i.e. the flow area and thus evens the required mass flow. In the real life conditions the valve operation is driven by consumption body, which is in this case the turbine. The turbine operation corresponds with operational characteristics of the valve. When drafting the designs for turbine and corresponding regulation bodies, constant inlet pressure and steam temperature is expected. But it is impossible to rule out variation in parameters. In the real valve implementation additional forces occur that are connected with the sealed system. The aim of the experiment on the steam version of the control valve is to compare the real result with the prediction of forces applied on the cone and the spindle obtained from experiments with a model version of the valve measured in the air tunnel.

Measuring on the valve model in steam piping

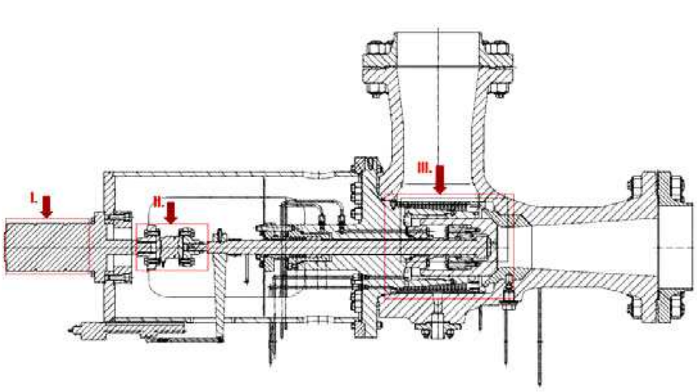

Fig. 1: Control valve for steam operation

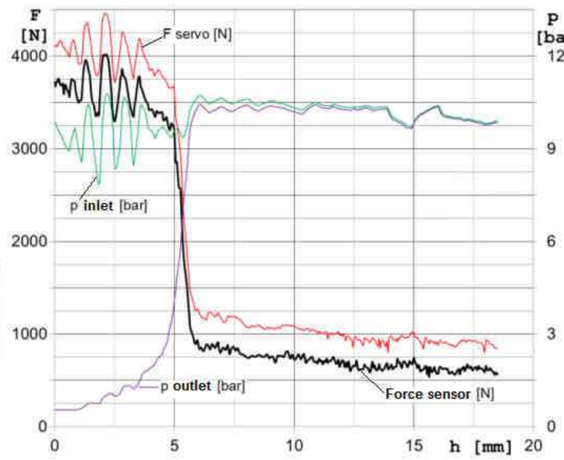

Fig. 2: Forces applied on the valve spindle

Valve arrangement for operation with experimental steam turbine is shown in Fig. 1. The force on the spindle can be determined from the pressures applied on both sides of the servo drive piston and also using the built-in force transducer, see Fig. 2. Operational characteristics are considered for two turbines of different output, where the valve of the same size would be used. Both courses are marked in the diagram of the mass flow valve characteristics in Fig. 3. In the unloaded valve it is advisable for the stabilizing force which keeps the big cone on the spindle to be sufficiently large in all regimes and to operate always in one direction. Force characteristics for the stabilizing force of the cone and two turbine operational characteristics are for the model version processed in Fig. 4. In the diagram the area of the cone lower loading for a limited area of shear cone lift h / D_h. D_h is the throat diameter of the diffuser under the cone. The smaller the pressure ratio $\varepsilon = p_d / p_0$ defined by outlet pressure p_d and inlet pressure p_0, the bigger the stabilizing force F_{ST}. S_S represents the seal area of the cone. In engineering practices it is necessary for various construction implementations of valves to estimate the forces operating on the valve parts and decide on a required dimensioning of the servo drive.

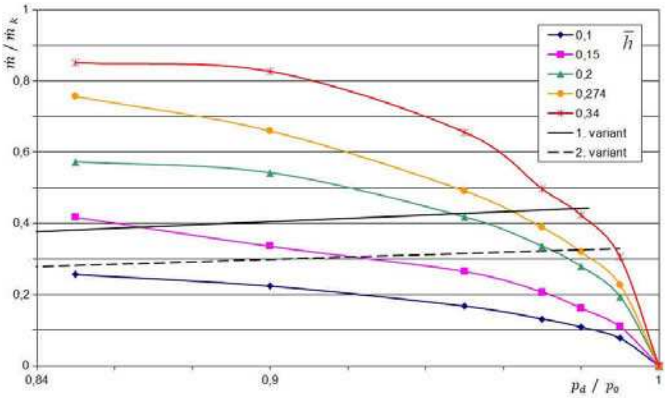

Fig. 3: Mass flow characteristic of the valve

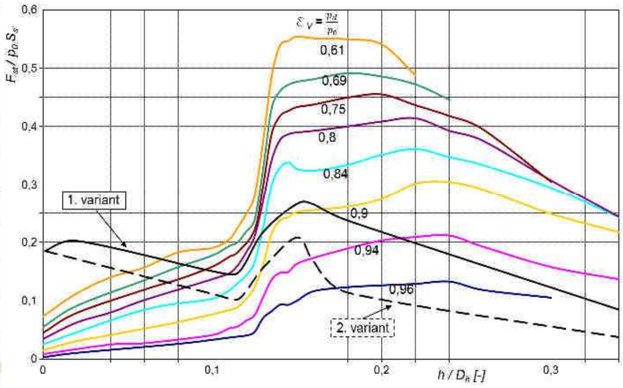

Fig. 4: Force characteristic of the valve

Summary

Experiments on the steam version of unloaded valve confirmed lowering of force needed to tear the big cone from the valve seat up to 1/3 of the original force.

Regarding various limitations occurring while building the valve into the existing steam piping with experimental turbine, it was not possible to test the valve in expected operational states of the turbine. It was necessary to recalculate all the forces from the measured data for designed parameters.

The experiments showed that the friction forces in the servo drive are about 300 N. A similar value is calculated for the valve friction forces. For the unloaded valve operation the predicted and measured forces are in agreement. In the loaded valve operation the measured value is smaller than the predicted one. It can be even negative. The stabilizing force applied on the big cone can be in the whole range positive and it is bigger than the predicted value.

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