TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Mechanical Science and Engineering Bitzer Chair of Refrigeration, Cryogenics and Compressor Technology

Experimental investigations of pneumatically forced-actuated valves

Compression and expansion within one machine

Christian Stöckel (christian.stoeckel@tu-dresden.de) // Christiane Thomas // Ullrich Hesse

Motivation

A newly developed poppet valve used within a reciprocating compressor opens up new possibilities for operating the machine. On the one hand a volume flow control is possible, on the other hand the machine can be used reversible as an expander.

A control pressure is applied to the surface opposite to the poppet´s sealing area, hence a lifting force can be generated by the pressure difference. The control pressure is supplied by the compressor itself either from the suction or the discharge chamber. The pressure level can be switched by use of an electromagnetically actuated slider valve. During regular operation the slider is not actuated and the valve is working self-actuated. Applying a voltage to the slider valve the pressure is switched and the poppet is forced-actuated by the pressure difference.

An experimental investigation of the new valves is mandatory in order to evaluate the calculation models.

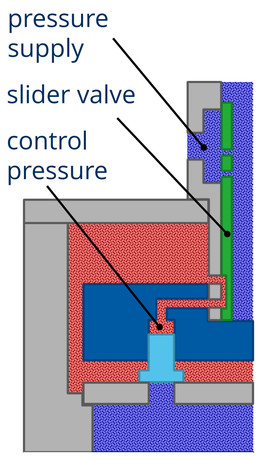

Fig. 1: Valve self-actuated

- low pressure in working chamber
- high pressure in discharge and control chamber

→ valve is closed

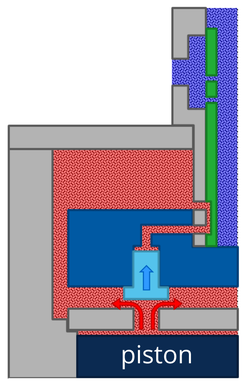

Fig. 2: Valve self-actuated

- piston moves up
- gas is compressed

→ poppet opens self-actuated

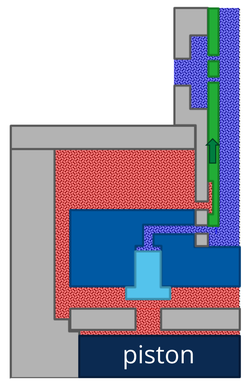

Fig. 3: Valve forced-actuated

- slider is actuated
- low pressure in control chamber

→ pressure difference keeps poppet open

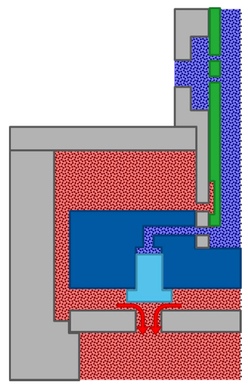

Fig. 4: Valve forced-actuated

- piston moves back
- poppet is forced-actuated open

→ reverse flow is achieved

Valve test rig

A valve test rig was set up to investigate the valve working principle outside the compressor and thus to enable a wide range of operating conditions:

- switching frequency
- actuation duty
- control pressure level

Applied measurement technology:

- piezo-resistive pressure probes
- eddy-current distance sensor
- laser-distance scanner

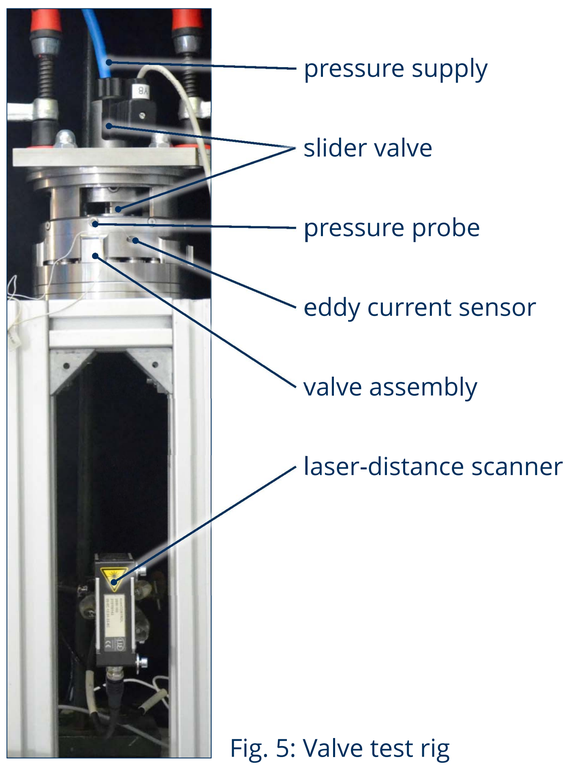

Fig. 5: Valve test rig

Test compressor

A two-stage reciprocating compressor (Atlas Copco) was set up for the investigation of the newly developed valves. Since both stages were equipped with the valves, it was possible to run the first stage as compressor and the second stage as expander simultaneously.

Beside conventional measurement techniques high-speed pressure probes were used to allow a measurement accuracy of the signals up to about 0.1° crank angle.

Fig. 6: Test compressor Atlas Copco AR 1

Results

The experimental data achieved by the valve test rig is in good agreement with the data gained by the simulation. Accordingly, it can be assumed that the valve model with simplified conditions is correct.

The discharge valves were tested inside the compressor and a flow control could be achieved. The comparison between simulation and experimental results show a good consistency, however there is a misalignment during the valve-opening-phase, which is caused by not yet implemented additional valve effects.

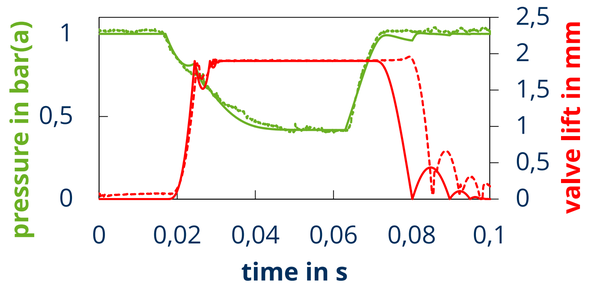

Fig. 7: Comparison between experimental (---) and simulation (—) results of valve test rig

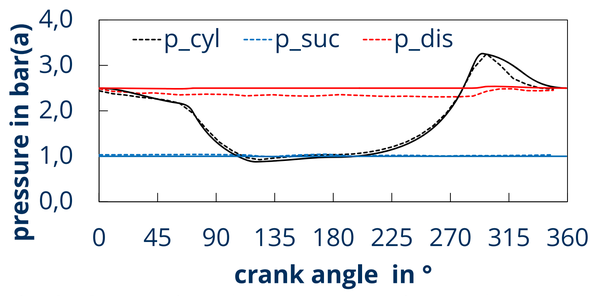

Fig. 8: Comparison between experimental (---) and simulation (—) results of test compressor