Pneumatic free valve actuators

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Introduction

Large cryogenic systems as projected for FCC need a large number of cryogenic and warm valves. Most of these valves are control or metering valves guided by a PLC generated signal. Furthermore also, actuated shut-off valves are needed. Today such valves are driven by pneumatic actuators with electro-pneumatic control. The supply pneumatic system and electric signal cabling increases with the number of valves, is energy intensive, needs space and continuous servicing. In addition, operation and capital costs for such an electro-pneumatic system are quite high.
One can observe new developments in the refrigeration, natural gas and energy industries which use pneumatic free electric driven control and shut-off valves. Based on the positive experiences in these industries, innovative cryogenic and warm valves actuated by an electric stepper motor-based linear actuator were developed. Together with the control module the full functionality including fail open or fail closed positions as well as many further control advantages are available. Using this type of valves allows a highly-simplified installation. These advantages open a potential to reduce operation and capital costs remarkably. Presently available are electric stepper motor-based linear actuator for up to size DN40 depending on the required shut-off pressure. For larger valves and higher shut-off pressure, actuators with their own electro-hydraulic drive control system are available.

Today's electro-pneumatic driven valves

- Control and shut-off valves of a cryogenic plant/system are actuated by pneumatic air
- Many ancillary components: Air compressor, condensers/dryers, pneumatic distribution lines, drop lines, air supply filter control, e-p positioner, 3/2-way solenoid valves etc.
- Needs space, risk leaks, needs continuous servicing
- Operates at very low efficiency of about 6...10%
- Operation and capital costs for an electro-pneumatic valve actuating system are high!

Electric stepper motor-based linear actuator

- Rotary movement of an electric stepper motor turns stepwise a high precision nut and threaded screw gear for a directly converse into a linear action
- High stable dynamic & holding torque, fine resolution, for accurate position control
- Open loop control requires accurate sizing of stepper motor and gear drive considering valve size and service conditions
- Increased applications for high accurate positioning devices (3D printing, medical and laboratory engineering etc.) allows further new applications ==> prices coming down remarkably!
- Electric energy supply and control system is considerably simpler, efficiency of 70% or even higher

Electronic control module

- Does control the power supply to electric stepper motor-based linear actuator in an open-loop
- Includes an adjusted control electronics with the valve specific algorithms (routines to confirm the valve travel calibrations, the speed control profile for spot landing set point w/h overshooting etc.)
- Independent power failure energy supply by super-cap for emergency operation (FC or FO) optional
- Actual control module with an analogue 0...10V signal, developments on direct digital signals are ongoing

Valve design — cryogenic or warm valve

- Requests a similar level of accuracy and quality to make use of the advantages of a high precise electric stepper motor-based linear actuator (orifice bore, flow plug, seat design, travel, zero backlash coupling, seat seal for high tightness and zero calibration, high MTBF and low maintenance etc.)
- Retrofit of existing standard valves is possible

Conclusions and prospects

Cryogenic or warm valves for control or shut-off function, driven by an electric stepper motor-based linear actuator and controlled by programmed electronics shows a high potential of a massive simplification and cost reduction for the instrumentation of a cryogenic system. Such a valve design allows also to combine flow control and flow measuring functions, if pressure and temperature are known.
First valves are already in service in specific applications. Further developments on the electronic control module will allow a full digital control of the valve. Actual available size of the stepper actuators, limiting the valve size up to DN40 depending on service conditions. However, there are further developments for high power actuator based on micro-hydraulic systems. For specific applications, such actuators are already available.
Furthermore, special design of electric stepper actuators allows service in high-vacuum, radiation load and even in space ambient. Thus, further specific valve design for mounting inside the cryogenic vacuum insulation as well as in radiation load surroundings are conceivable variants. For high accurate applications also stepper motor with encoder — for a closed loop valve travel control — may be possible.
Next steps are to gain further operational experiences with cryogenic or warm valves driven by an electric stepper motor-based linear actuator and controlled by programmed electronics.

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