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Refinery at twilight. (Photo: Dreamstime ©Tomas 1111)

Developments in axial valve design

By Paul Root, Director, Goodwin International and Hans Gustorf, Sales Director, Noreva GmbH.

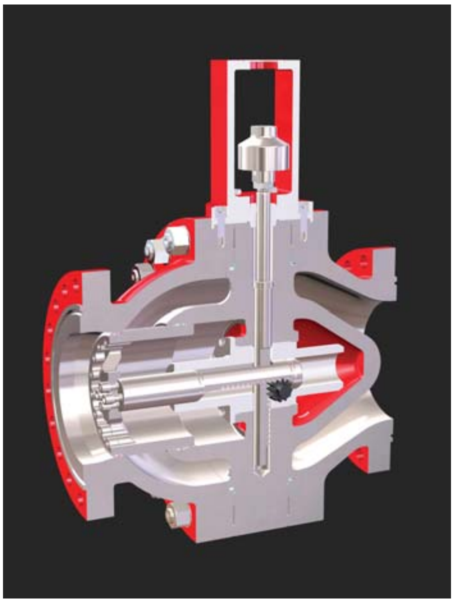
Axial valve design has been used with success over the past twenty years. However, UK based Goodwin International Ltd and German based Noreva GmbH have taken the opportunity to develop this further. This article looks at the past, present and future of axial valve design.

After several years of exceptional growth in global demand for industrial products, particularly in the oil and gas sector, a period of reduced growth has presented a window of opportunity to fast-track the development of new products for the future.
UK based Goodwin International Ltd have developed a range of axial flow valves, suitable for both isolation and control duty and, in conjuction with Noreva GmbH in Germany, a new axial check valve engineered for challenging low flow gas applications. Several worldwide patent applications have been filed for innovative design features associated with each of the new valves.

Axial isolation valves

Axial flow valves have been used for around 50 years within the oil and gas industry. There are several areas where the axial flow valve has an advantage over the more common globe, gate and ball valves including:

- Tight shut off sealing performance & longevity
- Low pressure drop across the valve



Goodwin axial isolation valve

- Low turbulence
- Low actuation forces
- Rapid soft closure
- High reliability & long maintenance intervals

Axial isolation valves are capable of moving from fully open to fully closed within 2 seconds and can maintain very low seat leakage rates, even after many years in service. Positioning the main flow seals out of the flow path when the valve is open is key to ensuring that they remain in good condition, ready to seal on demand.

Rapid valve closure is achieved with low actuation forces, resulting in the use of small actuators. Pressure balancing inside the valve mechanism means that seal and mechanical friction are the significant forces in play. This has the additional benefit of increasing the service life of the valve.

The axial flow principle induces low turbulence on the media passing through the valve. The flow out of the valve regains stable flow conditions much more quickly than a comparable globe valve thereby improving the performance and longevity of downstream equipment and pipework.

Despite the significant functional advantages, the axial flow valve is not simple to manufacture. As such, high level engineering and manufacturing specialists are needed in order to investigate and overcome the technical challenges, especially in addressing historic design limitations. In addition, extensive valve endurance testing is necessary for new design concepts.

3 piece split body

The majority of axial flow valves supplied into the oil and gas industry are constructed using single piece castings for the valve body.

The single piece casting method is technically challenging, resulting in unnecessarily high unit costs, long lead times and in many cases incomplete access for non-destructive examination.

The 3 piece split body design developed by Goodwin addresses all of these weaknesses. With primary and secondary fire safe sealing as standard, it also allows the use of forged material for the manufacture of pressure boundary components, plus the flexibility to construct the valve with dissimilar inlet and outlet connections.

Futhermore, the 3 piece split body permits full access for NDE, giving maximum confidence in pressure boundary integrity.

Figure 1: Typical 45 degree rack mechanism.

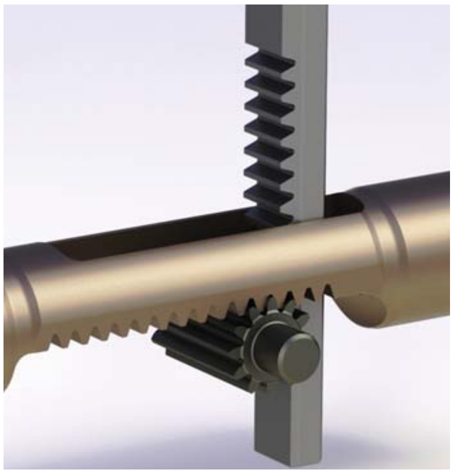


Figure 2: Goodwin rack-pinion-rack mechanism.

Rack-pinion-rack gear train

The most common mechanism used to operate many axial flow valves is an unconventional sliding rack arrangement. The gear teeth on both the vertical and horizontal rack are cut at 45 degrees, which converts vertical linear motion into horizontal linear motion to open and close the valve (see Figure 2).

There are inherent weaknesses in this legacy design, in that it is highly susceptible to seizing. There are, of course, methods to counteract this, based around increasing the surface hardness of the components. Despite this, long term wear will cause sliding surfaces to degrade, at which point unpredictable galling and seizure are a concern.

The design of axial flow valves that use a rack-pinion-rack mechanism to convert vertical linear motion to horizontal linear motion is engineered to counteract the threat of seizure whilst maintaining high accuracy and reliability (see Figure 2). The principle of rolling gear mechanisms is tried and tested, and widely accepted as a robust and gall resistant solution.

Axial control valves

The axial control valve benefits from the same extensive endurance testing conducted on the isolation valve as the internal mechanisms and sealing systems are the same. By using common principles of construction, the activity needed in order to launch both the isolation & control valves is made more efficient.

The axial flow body is particularly well suited to service as a control valve as minimal pressure losses are induced by the body itself. The advantage of this is that the control valve variant can regulate close to the entire pressure drop across the valve. For globe valves in particular, there are large fixed pressure losses due to the body geometry, which are uncontrollable.

During the design phase, extensive CFD simulation of the valve and valve trim was

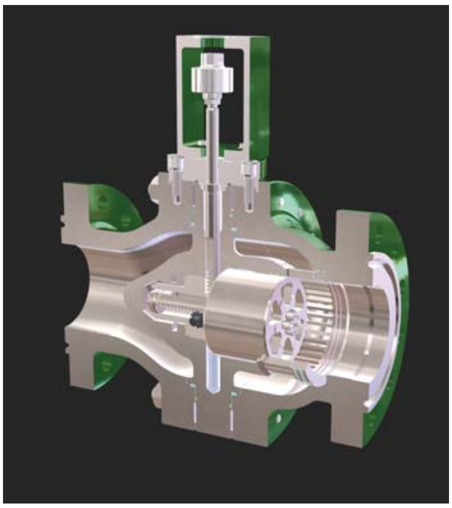


Figure 3. Goodwin axial control valve

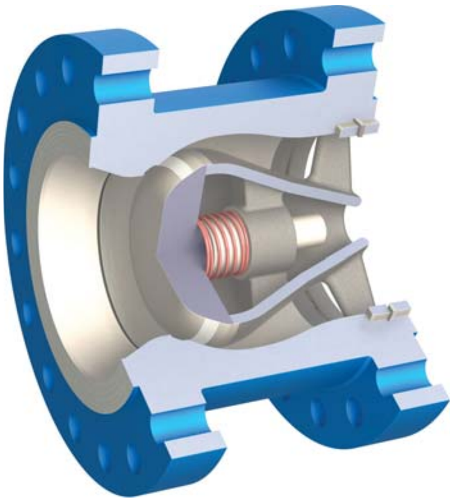


Figure 4. Noreva.Goodwin ZB axial check valve

conducted with different configurations and installation conditions. This serves as a good guide to influence the design, but it has not replaced physical testing of installed valves.

Control valve test rig

Goodwin has designed and manufactured its own in-house control valve test rig in accordance with IEC 60534. Extensive testing is conducted on new valve and trim designs. The reason for conducting this testing is to facilitate accurate sizing of valves, to be able to confidently predict the installed acoustic characteristics and to calibrate the control valve sizing software.

The acoustic performance of control valves is notoriously difficult to predict with accuracy and there is no substitute for detailed, methodical valve testing to be confident in the performance of new products.

Control valve sizing software

Control valves also go through an in-house valve sizing program in accordance with IEC 60534 which has inbuilt selection and design of valve trim components giving accurate and rapid responses backed up by extensive testing.

Axial check valves

Check valves in low flow gas applications – A challenge and its solution

A common problem for the design of compressor stations is that check valves on the discharge side of the compressors need a certain amount of flow to be stable when fully open.

Only fully open valves guarantee stable, chatter-free operation. Check valves that operate under partial open conditions are prone to excessive wear and tear.

Non-axial check valves (swing, tilting disk, dual plate etc.) bear the highest risk of chattering under low flow conditions. The preferred solution is installation of axial non-slam nozzle type check valves.

Axial check valves can stand partial open operation much better, but are still recommended to be fully open under all flow conditions.

Historically, there have been two basic designs for axial non-slam check valves, a single piston and a ring disk type.

The single piston design has a solid disk plate, it is centrally guided and is seated using a single spring.

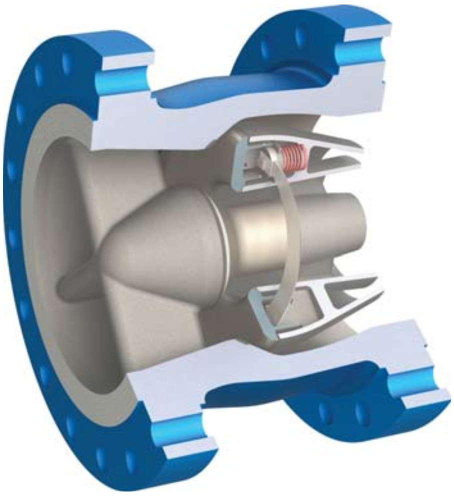


Figure 5. Noreva.Goodwin NB axial check valve

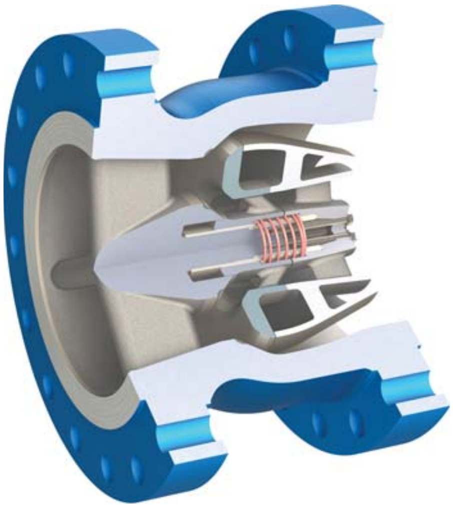


Figure 6. Noreva.Goodwin NZ axial check valve

Valves of this design need a very strong spring to overcome the friction between the guide bush and the disk stem, due to the centre of gravity being at the disk plate and so outside the guiding area.

The ring disk design has a frictionless radial guiding system with multiple springs. Valves of this design also need strong springs to be able to push the disk into the correct seat position. The friction-free radial guides have inherently larger tolerances which mean that the disk may become de-centralised when closing slowly.

In both designs, to guarantee that valves are fully open in low flow conditions, the size of the valves has to be reduced to increase flow, therefore increasing the pressure loss across the valve.

Noreva/Goodwin has combined the best features of both well-established designs to bring a new, globally patented valve design to market.

The NZ non-slam, axial nozzle type check valve, offers a fully balanced ring disk that easily slides on a central guide bush.

The NZ has a lightweight ring disk with the centre of gravity precisely aligned with the bearing area. This eliminates any bending moment, which significantly reduces friction.

The combination of reduced friction and disk weight allows the spring load to be significantly lowered and the valve to remain fully open even at extremely low flow rates.

An adjustable length spacer allows the NZ to be tailored to be fully open under flow conditions in different applications.

The NZ has improved dynamic behaviour as a result of a very short disk stroke and is operationally stable even when experiencing partial flow conditions.

The NZ design is available in manufacturer standard, short or API6D face to face lengths and can be retrofitted to most existing Noreva/Goodwin axial nozzle check valves.

About the authors

P. Root

Paul Root is a Director of Goodwin International and is responsible for the development and introduction of the axial isolation and control valves. Covering all aspects of the development process through to manufacture and sale of the new products, it is a varied and challenging brief. Prior to Goodwin, Paul was employed for 11 years in International Operations & General Management positions at actuator manufacturer Rotork.

H. Gustorf

Hans Gustorf is the Sales Director of Noreva GmbH. Joining the Mannesmann valve division in 1991, Hans has held a number of key positions at the original inventor of the axial nozzle check valve. Being responsible for Project Engineering, Quality Management and Sales, Hans was one of the founders of Noreva in 2001.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