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A WIN FOR FLOW CONTROL

Paul Root, Goodwin International Ltd, UK, outlines a new design concept for axial isolation and control valves to improve flow management in oil and gas applications.

Axial flow valves have been adopted throughout the hydrocarbon industry in critical, high integrity and severe service applications. They are best suited to applications where minimal downstream turbulence, low fixed pressure drop, rapid closure, accuracy of control and reliability are important. Thousands of axial flow valves are installed in upstream, midstream and downstream applications, with an exceptionally good service record.

Despite the challenging market conditions in the hydrocarbon industry, Goodwin International has devoted considerable resources to the development of flow control equipment, in anticipation of a future return to market growth. The company manufactures dual plate and axial check valves, supplying its products to major engineering, procurement and construction (EPC) companies and end users globally. In response to positive market research, a range of advanced axial isolation and control valves have been developed to provide an alternative to existing equipment. These two new product lines form the core of the new Goodwin Flow Control division, with further associated research and development on the horizon.

Innovative technology

A similar design concept is applied to both the isolation valve and the control valve, in that the construction of the body and the actuation mechanism use the same components. Indeed, an essential feature of the design brief was to make the design platform as close as possible between isolation valve and control valve configurations without compromising performance. Throughout the design process, several innovative features were included, which have international patent applications lodged.

Three piece split body

The most common style of axial flow valve currently available to the market incorporates a one piece body design. Necessarily, one piece bodies are manufactured using

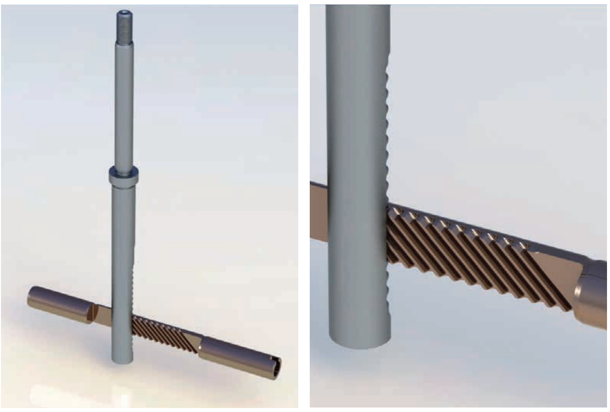

Figure 1. Typical 45˚ rack actuation mechanism.

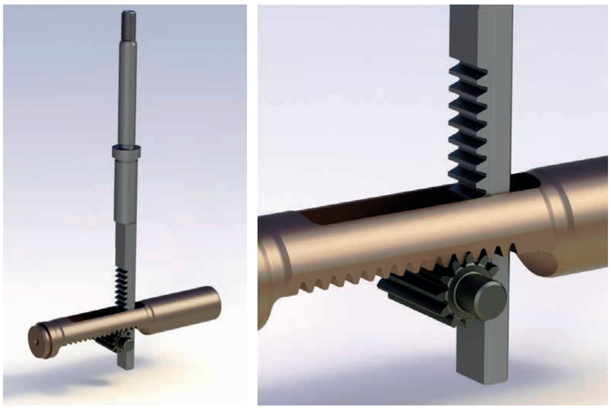

Figure 2. Goodwin rack-pinion-rack actuation mechanism.

castings due to the complex internal geometry, making it inaccessible to conventional machining methods.

The Goodwin designed axial isolation and control valves incorporate a novel three piece split body design, which is widely accepted throughout industry on other valve types. A precision engineered bolted joint connects the three body sections together, with an advanced primary and secondary sealing system to comply with stringent fugitive emissions standards. The joint is assembled under tightly controlled factory conditions in order to ensure peak performance from the sealing arrangement. The streamlined, low turbulence internal flow path, which is synonymous with axial flow valves, is maintained through accurate machining of the joint interfaces. Indeed, if the body were to be sectioned through after assembly, the joint lines would be almost imperceptible to the naked eye.

Manufacturing the valve body in three sections has several advantages over one piece designs:

- The casting method is considerably simplified, thereby reducing manufacturing defect rates and weld repairs. As such, the traditional lead times the market has had to historically accept can be considerably improved.
- The enhanced accessibility that results from splitting the body permits 100% access for non-destructive examination (NDE). Full NDE is not possible on one piece designs, which is a concern regarding confidence in material integrity. Where defects are discovered in single piece bodies that require reparation, through wall welding is often necessary due to the very difficult access.
- The complex internal geometry becomes accessible for conventional machining operations when split into three sections; the entire body can therefore be manufactured from forged materials where required.
- The bolted body joint enhances the stiffness of the valve, preventing excessive distortion under maximum temperature and pressurisation. This allows very close fits to be used on moving parts, enhancing performance, accuracy and reliability.
- The inlet flange, centre section and outlet flange can be constructed according to application specific sizes. This allows a step up or step down in pipe size to be accommodated within the length of the valve, without the need for upstream or downstream transition pieces. Of course, this is particularly useful for compressible media applications with large pressure reductions, and where space saving is a priority.

Gear train

Most axial flow valves incorporate linear actuation in order to position the obturator. The most widely adopted linear mechanism available to the market makes use of a 45˚, 1:1 sliding rack (Figure 1) to convert actuator vertical linear motion to horizontal linear motion in order to open and close the valve.

As with many sliding gear mechanisms, there are high frictional forces encountered when moving under load. These forces result in a low efficiency rating, thereby increasing the actuation forces required to operate the valve reliably.

There are further inherent weaknesses with this type of mechanism. With enough cycling under load, it will fail due to galling and eventual seizure, particularly in conditions where there is limited or no lubrication. The friction and wear of the gear teeth and sliding bearing areas will result in degradation of these surfaces, eventually abrading away hardened surface treatments.

The Goodwin rack-pinion-rack gear train (Figure 2) solves the issues associated with this type of mechanism, in that it is almost impossible for a galling failure mode to cause the gear train to seize. A rolling motion gear system has high efficiency and, therefore, low frictional losses, reducing the actuation forces necessary to operate the valve. Of course, as the forces required to position the valve become lower, the strain and wear on the actuation mechanism decreases proportionally, increasing longevity. In contrast to the traditional 45˚ sliding rack, where failure/seizure is a catastrophic failure, the rack-pinion-rack has a graceful failure mechanism where an increase in backlash would become evident over a period of several million cycles. This gradual degradation could be easily measured without dismantling the valve.

Axial isolation valve

Due to the streamlined shape and smooth flow path through the valve, there are low fixed pressure losses. The cross-sectional flow area of the company's axial isolation valve (Figure 3) remains above 90% of the inlet capacity at all points throughout the valve.

Reducing pressure losses across the valve has a considerable positive effect on the loading of upstream pumps and compressors. Again, due to the streamlined flow path, flow at the outlet of the valve has low turbulence, which considerably reduces internal erosion of downstream pipework and components.

Axial isolation valves are often fully pressure balanced, meaning that the only significant forces resisting valve operation are seal and mechanical friction between the gear system components. The Goodwin axial isolation valve makes use of 100% pressure balancing in order to permit the selection of much smaller actuators than comparable alternative valve types.

Bi-directional tight shut-off at the valve seat is achieved with advanced, non-elastomeric sealing systems. These are designed to meet the rigorous testing requirements of the standards used within the hydrocarbon industry. The longevity of the main flow seals is enhanced by ensuring that they are positioned out of the flow path when the valve is in the fully open position.

With safety performance the primary consideration, the axial isolation valve has primary and secondary sealing on all leak paths to atmosphere. The sealing arrangements are fire safe, ultra low leak and highly reliable when installed in service.

All of the above features are also included within the control valve product, resulting in a more efficient prototype testing programme.

Axial control valve

The company has also worked on revising some of the engineering and commercial challenges surrounding design, sizing and manufacture of control valve products (Figure 4). The in-house software development team has designed and created a sophisticated sizing program, which allows rapid application specific sizing, valve selection and concurrent trim design of control valves. The calculations used in this process are in line with international standards and predict acoustic, pressure and flow performance.

As all components associated with the control valve trim are designed, manufactured and tested in-house, the company has the ability to experiment, improve and optimise the trim, whilst ensuring that the valve sizing and selection software is synchronised with the latest improvements.

When used in the construction of the control valve, the three piece split body has a further advantage over one piece body designs in that the control valve trim components do not have to be assembled through the outlet of the valve. This means that a larger diameter trim can be used when compared to one piece valves, resulting in larger flow capacity, reduced noise and larger pressure drops being accommodated.

Testing programmes

An extensive in-house type testing programme has been developed in order to verify the performance of the valve design for both control and isolation service. All functionality testing is conducted in-house on company designed and manufactured test rigs, which are constructed in accordance with appropriate international standards. By conducting testing in-house, one can gain a greater understanding of the performance of the valves. Any improvements can be made, installed and tested in considerably shorter timescales.

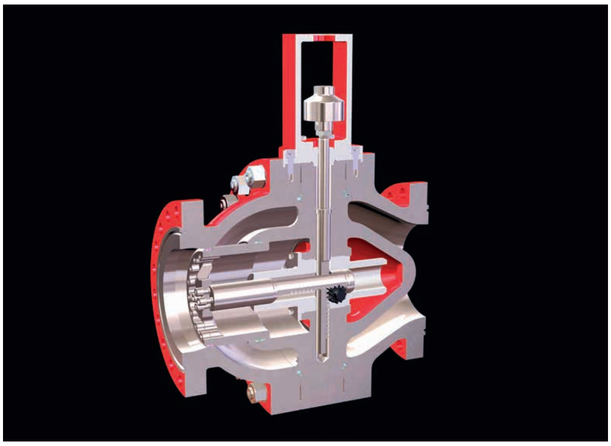

Figure 3. Goodwin axial isolation valve.

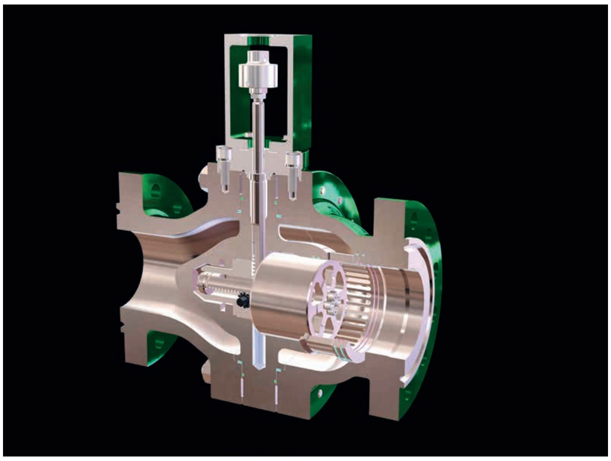

Figure 4. Goodwin axial control valve.

The focus of the axial isolation valve test programme is on endurance. The valve is tested over a high number of cycles whilst subjected to maximum load and closure speed conditions. This is designed to simulate as close to worst case installed service conditions as is feasible in an accelerated laboratory test programme (Figure 5).

Full seat test pressure is applied to the valve on every cycle to ensure that the loading of the mechanism and seals is realistic. Actuation forces and valve seat leakage are both accurately monitored to detect any sign of degradation. The test facility is designed to operate for 24 hours per day, seven days per week in order to accelerate the mechanical ageing of the valve. Cycling, pressure testing and fault detection are all fully automated in a safe, controlled environment.

The aim of the testing is to determine the expected life of mechanical components to ensure that the valve performance is reliable. Prototype valve testing has yielded extremely positive results and has allowed rapid refinement of the valve design in line with testing discoveries.

As the mechanism and sealing technology is common for both the axial isolation valve and the axial control valve, the durability and reliability of both platforms can be assured on the basis of the same testing regime.

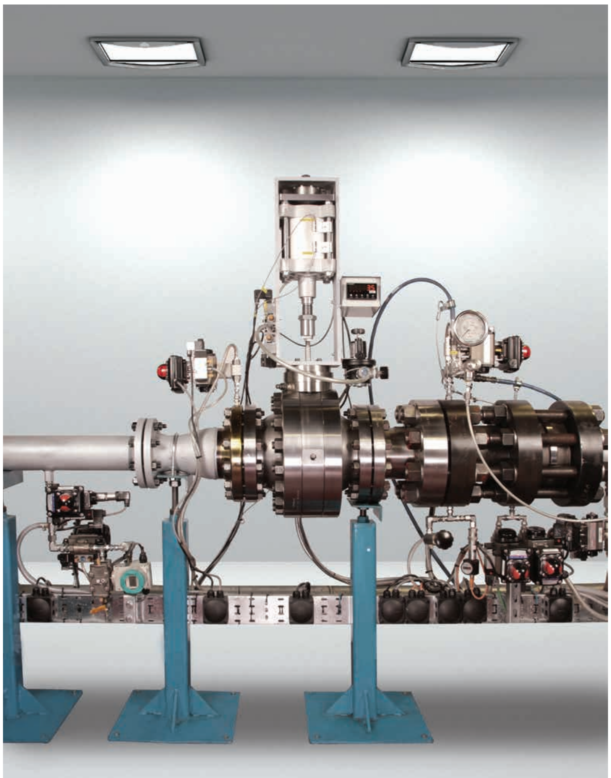

Figure 5. Goodwin axial isolation valve, installed in a hydraulic endurance rig.

The axial control valve test programme is focused on the prediction of performance in service. Optimisation of flow capacity, pressure control and noise for a given set of installed conditions is the key to ensuring that a control valve is correctly selected for the application it is being installed into.

The control valve test facility incorporates a blow down test rig, designed and manufactured by the company in accordance with IEC 60534-2 and IEC 60534-8. This test rig permits efficient and rapid testing of a given valve and trim at incremental pressure ratios.

In order to ensure the highest level of sizing accuracy, the company is conducting extensive in-house testing to validate calculated noise, capacity and pressure let down for various valve and trim configurations. The testing allows valve specific factors used in the standard calculations to be determined more accurately so that the calculations closely represent the true performance of the valves in service.

By conducting extensive testing and capturing detailed performance data, the axial control valve will be accurately sized according to application data supplied, therefore preventing excessive over or under sizing of valves.

Conclusion

Research and development of innovative, optimised flow control products and services is essential to the growth of the global hydrocarbon industry, for upstream, midstream or downstream applications. Companies that maintain full control over the design, manufacture and development process have a key advantage, in terms of product quality, and are in a good position to meet demand for highly reliable, accurate equipment and keep up with future market growth.