NPD in gate and globe valves: the balanced stem

Most industries are characterized by rapid new product development, for example regarding product quality. It is interesting to see whether the valve industry has done the same, taking the wedge gate and globe valve (see Figures 1 and 2) as examples. Recently, Téchne and yours truly designed a balanced stem construction that leads to a considerable improvement in operation.

By Ingolf Holmslet

Wedge gate valves are generally used to completely shut off fluid flow or, in the fully open position, provide full flow in a pipeline. Thus it is used either in the fully closed or fully open positions. A (wedge) gate valve consists of a valve body, seat and disc, a spindle, gland, and a wheel for operating the valve. The seat and the gate together perform the function of shutting off the flow of fluid.

A globe valve is primarily designed to stop, start and regulate flow. It is comprised of a movable disk-type element and a stationary ring seat in a generally spherical body. The seat of a globe valve is in the middle of and parallel to the pipe, and the opening in the seat is closed off with a disk or plug. Globe valves can be structured to handle flow in either direction.

Spindle seals

Both valve types are regularly used in various industry sectors and have been in operation in various subtypes for decades. The question is: has there been any development regarding these valves over the last 30 years?

There has been a development on the spindle seals, giving us the cup and cone construction and the low-density, re-enforced braided packings. However, there haven't been any innovations on the valves themself.

Admittedly, limits have been set on leakage rates (fugitive emissions) on new valves, so the emissions have been reduced in the last 30 years, but that is due to higher quality on the packings and not the valves.

The valves have the same spindles that rotate and move up and down in the stuffing box during operation. This movement causes wear with subsequent increased spindle leakage, and globe and gate valves take credit for more than 60 per cent of all spindle leaks.

150 years

The outside screw and yoke construction result in significant friction in the threads as the system pressure pushes the spindle up into the threads. In most cases, high-pressure valves have major operational problems due to this (valve) design. As an example, a relatively small high-pressure valve with a 10 mm spindle will have a frictional force against the spindle threads corresponding to 468 kg at 600 bar system pressure.

Outside screw and yoke is a construction that has been used on wedge gate valves (fig. 1) and globe valves (fig. 2) for the last 150 years, and it is now high time to develop a better construction.

A year ago, a company challenged me to develop a better solution for the above problem. Said company had significant problems with 2" valves on large HPU´s with operational pressure of 680 bar. It was impossible to operate the valves without a cheater bar added with a large

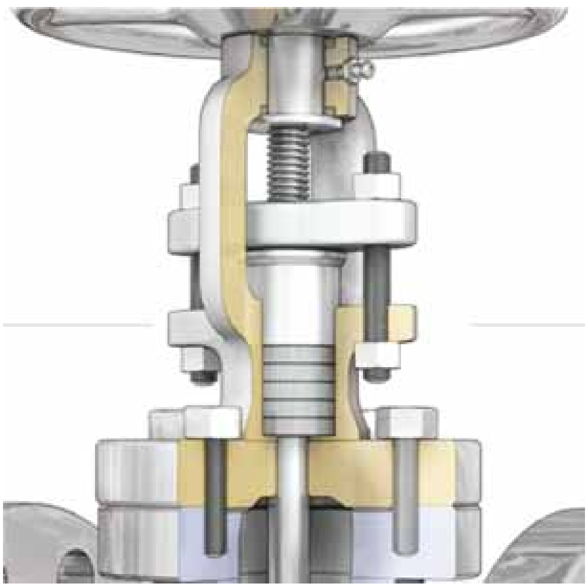

Fig. 1

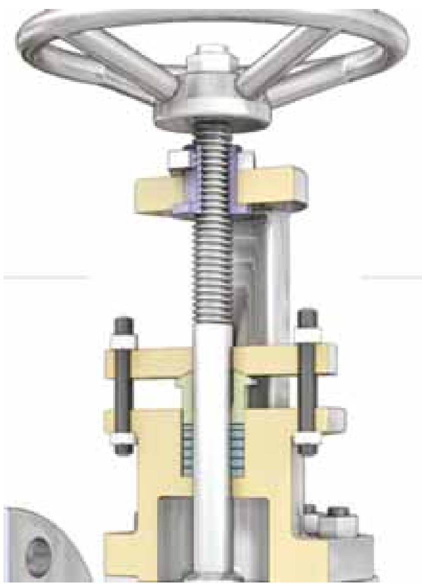

Fig. 2

force. The spindle diameter of these valves was about 25 mm, which gives a force area of 5 cm^2. If you multiply this by 680 bar you get a force from the system pressure of 3.4 tons acting on the threads.

Considerations

Due to this force there are several aspects that need to be taken into consideration:

1. The frictional force in the threads/ drive nut against the spindle which makes it very heavy to operate
2. Wear in the threads with the risk of galling, and thus damaging the valve
3. Wear in the stuffing box seal due to large spindle movement with subsequent spindle leakage
4. If the valve is closed with too much force, you risk bending the stem and then again galling and damaging the sealing area
5. The use of compressible spindle packings risk over-tightening and incorrect compression of the packings with the result of high degree of wear and a leaky stem seal
6. Skewed compression on the press gland and compression ring endangers operational contact between the spindle and the bonnet bushing, which easily leads to tearing / galling and subsequent a non-operational valve with spindle leakage
7. In the production of cheap(er) valves, the tolerances are not always in accordance with the guidelines for spindle seals, see the example in fig. 3

Blow out

Examples of technical guidelines for the compressible spindle seal are illustrated in fig. 3, (source unknown). The spindle is the yellow part, the compression ring the dark green and the bonnet is the light green part. Because the spindle is a moving part with a dynamic seal, the surface finish is recommended to be Ra 0.5 µm. The bonnet part of the seal is static and is recommended to be Ra 2 µm. The static seal is coarse, and the dynamic seal is fine, this to reduce the wear and create a good seal.
To ensure that the compression ring will hold the stem packing in place and seal the stem, it must be centered in the middle towards the bonnet part. The distance between the compression ring and the bonnet must be as small as possible if the compression ring is to hold the spindle packing in place when operating the valve under high pressure. This prevents the packing from blowing out when opening the valve.

Several near-misses

The distance between the ID on the compression ring and the OD on the spindle should be in accordance with fig. 3 where this distance is recommended to be max 0.03 mm x S (S = thickness of the packing). If we set the thickness of the packing to 8 mm, the distance between the spindle and the compression ring/ bonnet should not exceed 0.24 mm on each side. These are the technical recommendations on a high-pressure rising spindle, and unfortunately I have seldom seen that the valves are in accordance with this recommendation.
What can happen if you don't follow the technical recommendations? Looking at fig. 4 it shows a graphite spindle seal which blew out at about 400 bar gas, which led to full mustering in the lifeboats in anticipation of getting the situation under control. Fig. 5


Fig. 4


Fig. 5

was an almost similar situation for another company. Here it was about 300 bar gas that blew out the graphite packing. Most all installations on the Norwegian shelf have encountered events as illustrated in fig. 4 and 5. Fortunately, so far it has not had fatal consequences.

Major leak

If you don't do a good enough job assembling and compressing the spindle gaskets, there is a risk that the spindle will be forced at an angle in the compression ring. This forces the spindle on one side in contact with the bonnet and on the other side giving a double tolerance.
Now there is a risk that the situation as illustrated in fig. 6 can occur. Here the spindle has been in contact with the bonnet during operation, both the spindle and the inside of the bonnet have been destroyed and the seal surface torn to pieces with a subse-

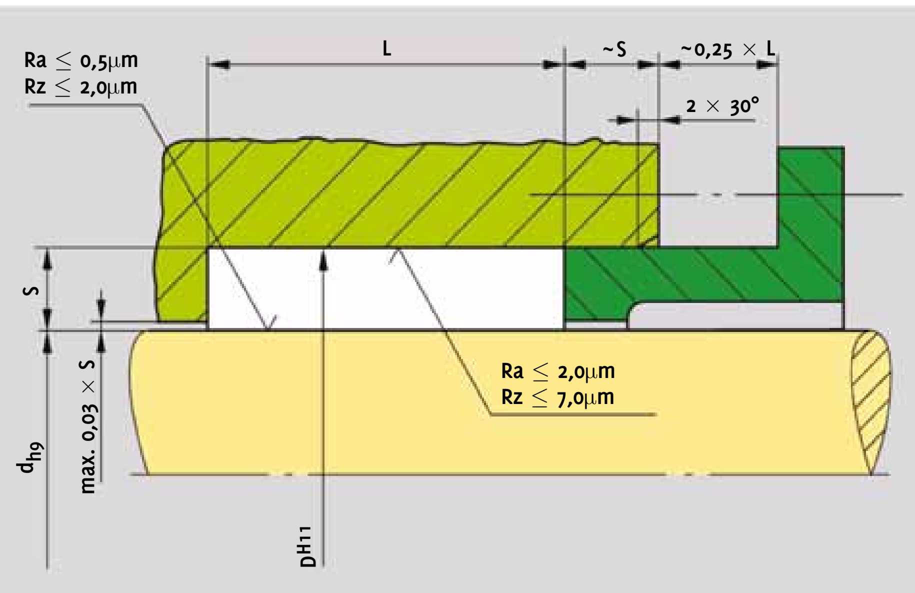

Fig. 3


Fig. 6

quent spindle leak. This led to a major leak and replacement of the valve.
Back to the earlier mentioned challenge I received on the HPU high-pressure gate valve. Together with the Italian valve manufacturer and machine company Téchne, we designed a new balanced stem that can be used on gate and globe valves. The graphs in fig. 7 illustrate how this new construction dramatically reduces the operational friction of the valve.

Benefit of new construction

The stems OD on both valves are 10 mm. The blue is a standard rising stem. And the red is the new balanced stem construction. As the balanced valve is a non-raising stem, the only movement in the stem seals is rotation supported by bearing. There is no up and down movement of the stem.
As illustrated in fig. 7, the torque at 100 bar is around 50 per cent of the standard stem. But looking at 700 bar, the balanced stem operational torque is only 17 per cent of the torque on the standard construction. When the system pressure increases, the torque difference increases too, thereby increasing the benefit of the new stem construction.
It was not possible to operate the standard stem at a higher system pressure then 700 bar, but the balanced stem had only 5,5 Nm torque at 1000 bar system pressure which equals the torque at 220 bar on the standard stem.

Negative aspects eliminated

The stem seals on the balanced construction will be a combination of two or three seals, high pressure lip seal, Chevron rings and a metal stem seal for fire-safe applications. The wear on these seals will be very low as none of them are compressed packings. In case of a leak after many years in service, the stem will be installed with fitting for injecting sealing component. This will stop a potential leak and allows you to wait with the replacement without having a leaky valve.
The construction on the balanced stem eliminates all the negative aspects of a normal raising stem: there is no danger of over-tightening the stem seal, a skewed installation of the compression ring and the compression gland, a wrong installation of the stem parts or galling the stem threads.
At the moment, Téchne is designing 2” wedge gate and globe valves with the balanced stem construction.
In my humble opinion, we have realized a massive improvement of the gate and globe valve construction. However, there is also a flip side. Is the market willing to pay more for a dramatic quality improvement? This is what the future is all about: more sustainable production by reducing CO_2 emissions/fugitive emissions and subsequent impact on the environment. This mission requires investments in assets, including flow control equipment, across various parts of the supply chain. At one point, the industry needs to walk the walk and not only talk the talk.

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	Standard Needle Valve	*Balanced Stem*
Pressure [bar]	Torque [Nm]	Torque [Nm]
50	1,8	0,9
100	2,5	1,2
200	5	1,8
300	7	2,2
400	11,8	2,6
570	18	3,3
700	23	3,9
800	/	4,2
1000	/	5,5

Functional test - Needle valve ϕ7mm
Date: 20/01/2020

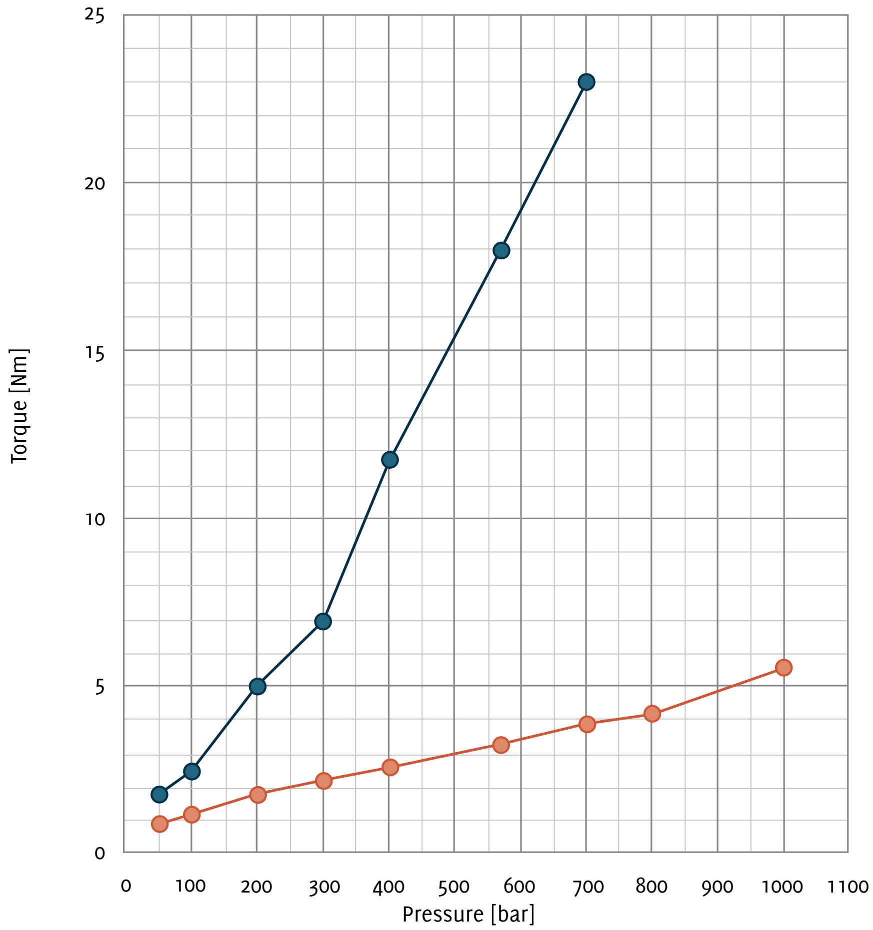
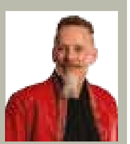


Fig. 7

About the author



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