Specifics of Flanged Pipeline Joints

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Introduction

Flanged pipeline joints are one of the most commonly used joint connections between pipes and components (Fig 1-steel and 2-stainless steel in vakuum system). They have their own specifics compared to other types of bolted joints. The most important parameter is the tightness, determined by the correct tightening of the screws and corrosion resistance.The main costs of any piping system are the costs of securing against liquid (Fig. 3) or gas leakage and the costs of repairing that system to prevent and eliminate leaks. A liquid leak is visible to the naked eye, while a gas leak must be indicated by special instruments and signaling sensors. Vacuum systems (Fig. 2) require special attention, as there, leakage of flange connections means loss of vacuum. On the other hand high vacuum causes a change in the preload of the bolted joints and they need to be checked frequently. In addition it should be taken into account that pipelines are often located in difficult-to-access terrain, making their inspection problematic.

Fig. 1

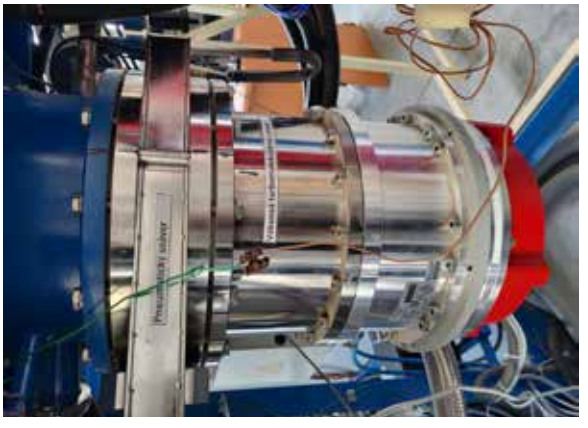

Fig. 2

Fig. 3

About construction and materials

A cross-sectional view of a typical flanged connection is provided in Fig. 4. It can be seen that there is a gasket between the individual flanges (red strip in this picture). This is a very important structural element that ensures tightness.

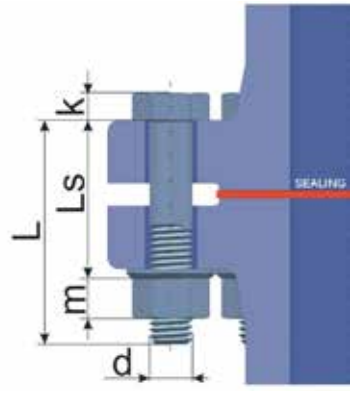

Fig. 4

Most important materials used for pipe flange are:
Carbon steel (Fig. 1) - good mechanical properties, highly resistant to stress corrosion cracking.

Alloy steel - requiring high pressures and temperatures, more corrosion resistant

Stainless steels (Fig. 2) - contain at least 18% Cr, further Ni and to increase corrosion resistance also Mo. Resist oxidisation and specific corrosion of virtually all chemicals

over a wide temperature range (-200oC to 900oC). Stainless steels are more expensive than carbon steels. The most commonly used are shown in Tab. Nr. 1.

Table Nr. 1 Basic types of stainless steels:

Austenite					Martensite		
A1	A2	A3	A4	A5	C1	C3	C4

To create a protective passivation layer on the surface of stainless steel parts, a sufficient supply of oxygen is necessary.

Corrosion

The general precondition of the battle against corrosion is knowledge of specific corrosion system which is always unique. What is valid for one case does not have to be valid for another one. It is aptly expressed by the title:
"There is no universal Panacea against corrosion".

The specifics of piping systems are external and so-called internal corrosion. External corrosion occurs due to the aggressive environment surrounding the pipeline. It is easily visible, so the necessary anti-corrosion measures can be taken. Much more dangerous, however, is internal corrosion, which is a consequence of the influence of the transported gaseous or liquid medium. Its insidiousness lies in its invisibility. A typical example of such corrosion can be seen in Fig. 5. Condensate at the bottom of the dilatation arc can cause corrosion over a long period of time. An effective measure lies in the optimal choice of steel or opposite orientation of the dilatation arc.

Hydrogen embrittlement (Fig. 6) is an equally insidious form of corrosion. It occurs when hydrogen penetrates the crystal grid of steel. In this case too, the right choice of steel is important.

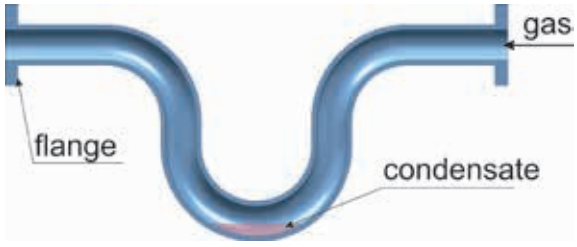

Fig. 5

Fig. 6

Assembly

The assembly of flange joints follows the same rules as for classic joinings (Fig. 7). This means exact tightening to the prescribed torque and to respect the accuracy of the tightening method (Table Nr. 2).

Table Nr. 2: Variation of bolt load according VDI 2230

Method of assembly	Variation in bolt load [%]
Controlling yield strength	± 9 % to ± 17 %
Controlling angle of rotation	± 9 % to ± 17 %
Hydraulic tensioning (Fig. 9)	± 9 % to ± 23 %
Torque wrench	± 17 % to ± 43 %
Impact wrench or spanner	± 43 % to ± 60 %

The least accurate is the manual tightening of screw joints.

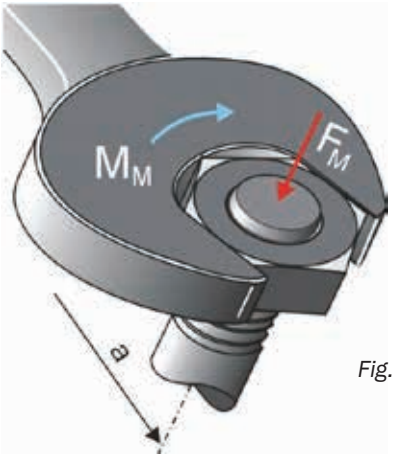

Fig. 7

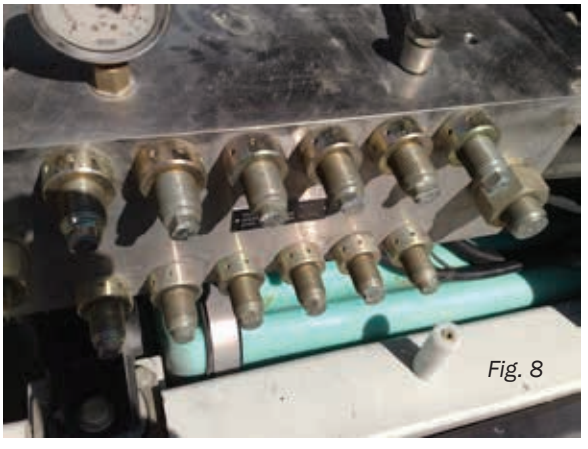

Fig. 8

Assuming tightening to 90% Rp0.2, the assembly preload force F_M is:

$$F_M = 0,9Rp_{0,2}A_S$$

while the tension cross-section As according to DIN 13 is equal to:

$$A_S = \frac{1}{4}\pi\left[\frac{d_2 + d_3}{2}\right]^2$$

where d2, d3 - is the medium and small diameter of the screw

One of the factors that determine the success of the joint tightness when tightening a flange is the tightening sequence of the bolts, which ensures a balanced tension throughout the joint (Table Nr. 3).

Table Nr. 3

Number of Bolt	Bolt Tightening Sequence											
4	1	3	2	4								
8	1	5	3	7	2	6	4	8				
12	1	7	4	10	2	8	5	11	3	9	6	12

Precautions against spontaneous loosening of bolts and nuts

Any loss of bolted joint preload on flanged pipes indicates loss of tightness. This was also the reason why designers, in difficult cases, secure their construction with appropriate measures. The lock point application (Fig. 9 and 10) is suitable for pipeline systems from several options. Unlike check points, they not only signal the release of the nuts, but also block their spontaneous retightening.

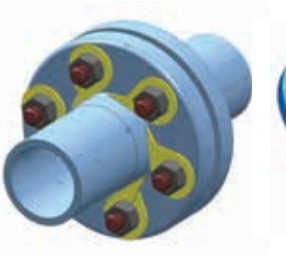

Fig. 9

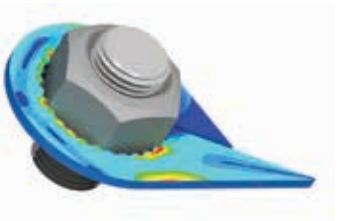

Fig. 10

However, loss of tightness can also be caused by degradation of the sealing washer (Fig. 4), therefore special attention must be paid to the selection of a suitable material.

Conclusion

As can be seen from the text, apparently classic screw connections have their own specifics in pipeline systems. The dominant parameter there is pipe tightness and corrosion. The specificity of pipe flange connections is often a long distance in hard-to-reach terrain, which makes their inspection difficult.