Keywords: Analysis • Bending test • External load • Pipeline ball valve • Weld seam

Testing and analysis of pipeline ball valves

Part II

In the second part of this two part article, the author focuses on the importance of pipeline ball valve external loading bending tests and the determination of bending load applying way and size. He also discusses the construction of the external loading bending test device and the content and method of the test. Through the external load bending test and analysis, it can be seen that when the displacement direction of the pipeline ball valve is the same as that of the bending load, the displacement at the bottom can be the maximum value at the maximum bending load with no effect on the sealing performance of the pipeline ball valve and the test pipe with the coactions of media pressure and external bending load. With regard to the strength safety of the pipeline ball valve body main welding and transition section material, the circumferential weld of the transition section material on the pipeline ball valve body and the test pipe is the weakest joint, and the tensile stress at the bottom near the circumferential welding in the test pipe approaches the yield strength of the test pipe. The torque of the pipeline ball valve increases but remains less than the design torque. Meanwhile if the safety coefficient of the selected actuator is more than 1.5, there is a higher safety allowance, the movement of the valve in the torque test is flexible and the performance stable.

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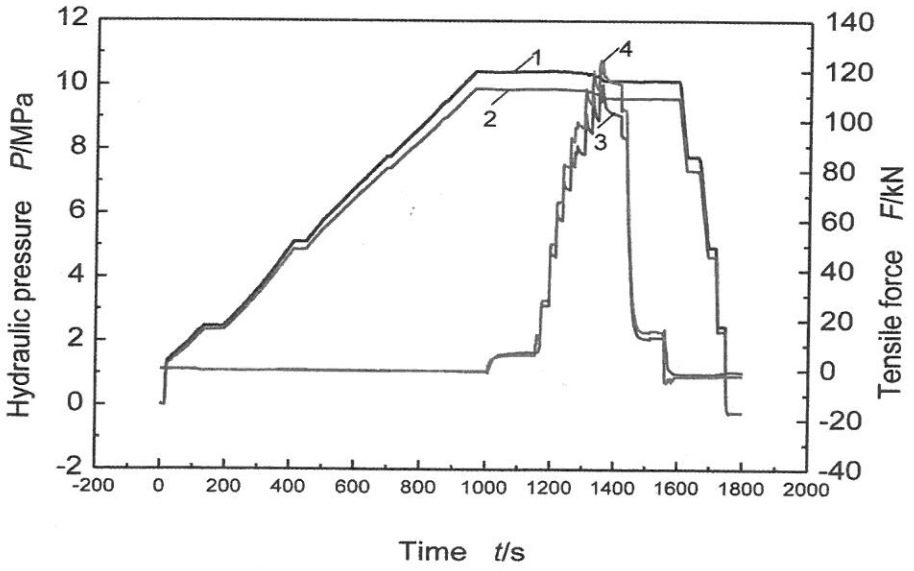
3. The test result and analysis

3.1. The measuring result of the test pressure and tension and analysis

The measuring result of the test pressure is shown as the curve 1 and curve 2 in the figure 8. From the measuring result, we can see the left pipe test pressure is 10MPa, the right pipe test pressure is 10.6MPa, and the difference of these test pressure is 0.6MPa. The measuring result of the bending load is shown as the curve 3 and curve 4 in figure 8.



1. Right pipe test pressure, 2. Left pipe test pressure, 3. Right pipe tension, 4. Left pipe tension.

Figure 8: The measuring result of the test pressure and tension.

3.2. The measuring result and analysis of the pipeline ball valve displacement

The measuring result of the pipeline ball valve displacement is shown as figure 9. From the result, we can see that the pressure variation of the media in the pipe has no obvious effect to the displacement of the valve, but the variations of the bending load affects the displacement of the valve much. The displacement of the valve increases as the bending load increases, and decreases as the bending load decreases. And the direction is the same with the direction of the bending load. When the bending load reaches 125KN, the relative displacement of the pipeline ball valve gets 165mm.

3.3. The shell and sealing performance

There is no visible leakage of the pipeline ball valve during the shell test and sealing performance test, therefore the combined

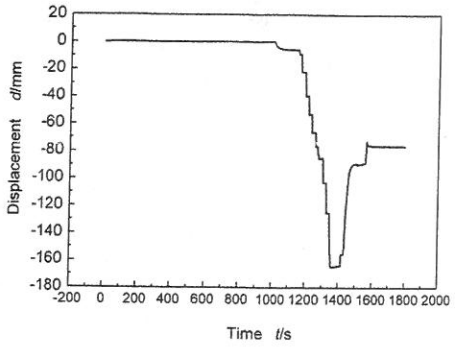


Figure 9: The measuring result of the pipeline ball valve displacement.

action of the media pressure and external bending load has no effect to the sealing performance of the pipeline ball valve and test pipe.

3.4. Stress measuring result and analysis

The largest main stress measurement is shown in the figure 10, the four districts in the figure stands for different loading conditions, they are: district I is the loading hydraulic pressure, from 0MPa, 2.5MPa, 5MPa, 7.5MPa, 10MPa loading level by level. District II is the loading tension, from 0KN, 10KN, 20KN, gradually to 125KN. District III is unloading tension, from 125KN, 120KN, 110KN, to 0KN level by level. District IV is unloading hydraulic pressure, from 10MPa, 7.5 MPa, 5MPa, 2.5MPa till to 0MPa. The comparison of the largest main stress measuring result and the finite element analysis result is shown as the table 1:

The material of the pipeline ball valve body is LF2, the yield strength is 250MPa, and the measuring position stresses are all the pressure stresses, the biggest value is less than -55 MPa, so we can know the strength safety of the pipeline ball valve under the combined action of media pressure and external load. The measuring position stresses are all pressure stresses. This is because exert pressure or bending load in the pipeline ball valve and the test pipe, there is a downward movement of

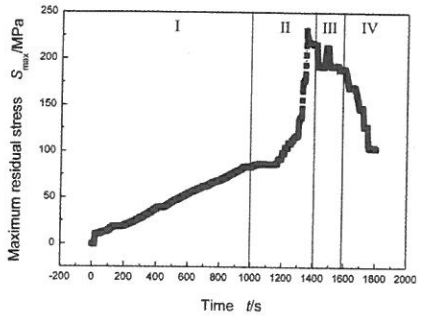


Figure 10: The largest main stress measurement diagram.

the pipeline ball valve under the combined action together with gravity. As the measuring position of the pipeline ball valve body main weld is on the middle and upper part, thus the pipeline ball valve is extruded.

The transition section material of the pipeline ball valve body is LF6, the yield strength is 415MPa. The measuring position upper stress is the pressure stress, the middle and lower part stress is tension stress, they are all smaller than the yield strength. Therefore, the strength safety of the pipeline ball valve body transition section material under the combined action of media pressure and external load can be determined. When the load gets the largest, pressure 10MPa and tension 125KN, the tension stress on the bottom is the largest, 238MPa.

The measuring position upper stress of the pipeline ball valve body transition section material and the test pipe circumferential weld is pressure stress, and the middle and lower stress is tension stress. The tension stress of the bottom gets its largest 456MPa when the load reached the largest, which is pressure 10MPa, tension 125KN. The test pipe is yielded, therefore this section is the weakest link. Through analysis, this is because the deformation of the pipeline ball valve body transition section material and test pipe is discordant, and stress concentration.

The stress near the circumferential weld measuring point of the test pipe is the pressure stress, and the middle and lower stress is tension stress. The stress of the bottom is the largest, 415MPa, approximate to the yield strength, when the load gets its largest, 10MPa 125KN.

Finite element analysis and the measuring position	Measuring position	Finite element analysis result	Measurement result
Main weld of the pipeline ball valve body	Upper part	-31	-40
	Middle part	-55	-50
Transitional material of the pipeline ball valve body	Upper part	-75	-100
	Middle part	115	140
	Lower part	205	238
The circumferential weld of the pipeline ball valve body and the test pipe	Upper part	-400	-433
	Middle part	350	368
	Lower part	447	456
Near the circumferential weld of the test pipe	Upper part	-409	-423
	Middle part	200	240
	Lower part	378	415

Table 1: The comparison of the largest main stress measuring result and the finite element analysis result.

3.5. Torque measurement of the pipeline ball valve

The torque measuring result comparison between 10MPa media pressure without any bending load to the pipeline ball valve and 10MPa media pressure and bending load to the pipeline ball valve and test pipe. See table 2:

The design torque of the NPS24 CLASS 600 pipeline ball valve is 23750N.m, the torque mostly increased by 14.9% if 10 MPa media pressure and bending load exerted to pipeline ball valve and test pipe, but they are all smaller than the design torque. Meanwhile the safety coefficient when select the type of actuator is more than 1.5, there is much

Measuring method	(N.m) The torque test result of only 10MPa media pressure without any bending load	The torque test result of 10MPa media pressure and bending load	Torque changes
From open to close of the valve, 10MPa pressure to each end of the valve, the cavity connected to the open air	14382	16527	Increased by 14.9%
From close to open of the valve, 10MPa pressure to each end of the valve, the cavity connected to the open air	19414	20662	Increased by 6.4%
From close to open of the valve, 10MPa pressure to one end of the valve, the cavity connected to the open air	16054	17813	Increased by 11%
From close to open of the valve, 10MPa pressure to the other end of the valve, the cavity connected to the open air	17921	19715	Increased by 10%

safety allowance; the movement of the valve in the torque test is flexible, the performance stable.

4. Conclusion

From the external load bending test and analysis of the pipeline ball valve and test pipe, we can get that:

1) The effect of the pressure changes of the pipeline ball valve and test pipe to the displacement of the pipeline ball valve is not obvious, but the bending load changes to the displacement is great, and the direction of the pipeline ball valve displacement is the same with that of the bending load, the displacement of the bottom gets its maximum value at the maximum bending load.

2) There is no visible leakage during the whole shell test and sealing performance test of the pipeline ball valve and test pipe, therefore the combined action of the media pressure and external bending load has no effects to the sealing performance of the pipeline ball valve and test pipe.

3) With the combined action of the media pressure and external bending load, the stresses of the pipeline ball valve body main weld and transition section measuring position are both smaller than the yield strength of the material, thus the strength is safe.

4) The stress of the pipeline ball valve body transition section material and test pipe circumferential weld bottom is the largest, and the test pipe has yielded, therefore this section is the weakest link. Through analysis, this is because the deformation of the pipeline ball valve body transition section material and test pipe is discordant, and stress concentration.

5) The stress of the bottom near the test pipe circumferential weld is the largest, approximate to the yield strength of the test pipe.

6) The torque of the pipeline ball valve is increasing but smaller than the design torque, meanwhile the safety coefficient when select the type of actuator is more than 1.5, there is much safety allowance; the movement of the valve in the torque test is flexible, the performance stable.

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