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DESIGN OF THE FILTER PRESSURE VESSEL OF HTR-10 SAFETY VALVE TESTING LOOP

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ABSTRACT

When nuclear class I helium safety relief valves are tested in the safety relief test loop HTR-10 (10 MW High Temperature Gas Cooled Reactor), in order to prevent particles in flow medium from damaging the sealing surface of the safety valves, the flow medium has to be filtrated. For this, a high efficient filter was installed in the upstream of the safety valves. This paper presents the design and manufacture process of the filter pressure vessel. The hydraulic pressure test and air pressure test results have shown that the pressure vessel satisfies the design requirements.

Key words: 10MW High temperature gas cooled reactor (HTR-10); safety relief valve; high efficient filter，pressure vessel, cleanliness

1. Introduction

In the primary loop pressure relief system of 10MW High Temperature Gas Cooled Reactor（HTR-10）, there are two helium safety valves installed in the two parallel branches, which are the important equipment of the reactor. Whether the two safety relief valves can pop at the set points is directly related to the safety of the reactor. The set point of the safety relief valve in the first branch loop is 3.5MPa, and the set point of the safety relief valve in the second branch loop is 3.75MPa. The discharge capacity of each branch loop is 85l/s. Both safety relief valves constitute part of the primary loop boundary and are classed as nuclear class I equipment. According to the requirements of ASME codes, before the reactor is put into the operation, it is necessary to test the set points and discharge capacity of the safety relief valve on site. For the in-service inspection, it is required that the inspection must be conducted every 30 months under the same test conditions as the pre-service. The safety relief valves are part of the primary loop pressure boundary and will be contaminated after period of operation of the reactor. Therefore, in-service inspection needs being done in the reactor. For this, the safety relief valve test loop connected to the reactor was designed and constructed.

When the safety relief valves are tested in the safety relief valve test loop, the flow medium moves very fast, and striking exists between the valve clack and the clack seat. If there are impurity particles, the sealing face of the valves could be damaged and tightness of the valves cannot be kept. In order to guarantee no damage to the sealing face of the valves, the pressure medium upstream of the safety valve must be filtrated. Therefore, a high efficient filter was installed in the upstream of the safety relief valves. In this paper, the design and manufacture processes of the filter pressure vessel were introduced. The hydraulic pressure test and air pressure test results have shown that the pressure vessel satisfies the design requirements.

2. Filter design parameters and its construction

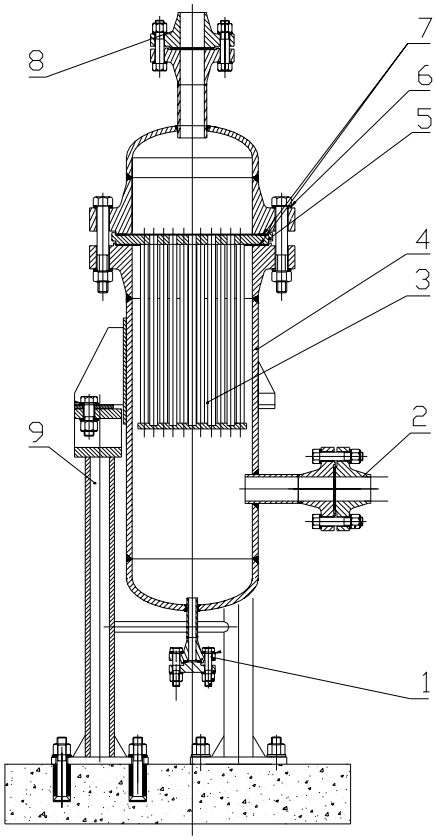

Figure 1 Schematic diagram of the filter
1 —drain; 2 —inlet opening of flow medium; 3 —filter core; 4 —pressure vessel; 5 —tube plate of filter core; 6 —main bolt of the pressure vessel; 7 —upper, lower seal packingrings; 8 — outlet opening of flow medium;
9 —pressure vessel supports

2.1 Design parameters

Filter vessel class		Non nuclear
Working pressure	(MPa)	3.75
Design pressure	(MPa)	4.3

Test pressure	(MPa)	5.5
Helium test pressure	(MPa)	0.2
Working temperature	^{o}C	room temperature
Design temperature	^{o}C	≦100 ^{o}C
Pressure medium		Helium, nitrogen
Flow (m^3/h)		350
Filtrating precision of filter tube (μm)	(absolute)	0.5
Medium cleanliness after filtrating		≦100
Flow pressure drop of the filter	(MPa)	≦0.05

2.2 Construction of the filter

The construction of the filter is shown in figure 1. From the figure, it can be seen that the filter consists filter core and pressure vessel. The air tightness between the filter core and the pressure vessel is realized by the two seal packingrings that are located between the filter core and the pressure vessel. When the filter works, the pressure medium flows into the inlet opening, gets through the filter and flows out of the filter from the outlet opening.

3. Pressure vessel design and manufacture

3.1 Pressure vessel design

The pressure vessel consists of upper container head, upper main flange; lower maim flange, cylinder and lower container head. The thickness of the upper container head, lower container head and cylinder is 12mm, and material of the cylinder is 1Cr18Ni9Ti, and the material of the upper container head and lower container head is 0Cr18Ni9. The material of the upper main flange and lower main flange is 0Cr18Ni9Ti. Material of main flange bolts is steel A. Chemical composition and mechanical properties of these materials are given in table 1 to table 6. Mechanical property of steel A is given in table 7.

Table 1 Chemical composition of 1Cr18Ni9Ti

Items / Material	Chemical composition							
	C	Mn	Si	P	S	Cr	Ni	Ti
1Cr18Ni9Ti	0.04	1.01	0.58	0.028	0.017	17.26	8.89	0.30

Table 2 Mechanical properties of 1Cr18Ni9Ti

Items / Material	Tensile strength (MPa)	Yield strength (MPa)	Elongation persentage (%)
1Cr18Ni9Ti	555	256	50

Table 3 Chemical composition of 0Cr18Ni9

Items / Material	Chemical composition						
	C	Mn	Si	P	S	Cr	Ni
0Cr18Ni9	0.04	0.85	0.53	0.026	0.025	17.45	8.08

Table 4 Mechanical properties of 0Cr18Ni9

Items / Material	Tensile strength (MPa)	Yield strength (MPa)	Elongation persentage (%)
0Cr18Ni9	680		52

Table 5 Chemical composition of 0Cr18Ni9Ti

Items / Material	Chemical composition							
	C	Mn	Si	P	S	Cr	Ni	Ti
0Cr18Ni9Ti	0.06	1.10	0.90	0.034	0.008	17.10	8.50	0.32

Table 6 Mechanical properties of 0Cr18Ni9Ti

Items / Material	Tensile strength (MPa)	Yield strength (MPa)	Elongation persentage (%)
0Cr18Ni9Ti	640	390	48

Table 7 Mechanical properties of steel A

Items / Material	Tensile strength (MPa)	Yield strength (MPa)	Elongation persentage (%)
Steel A	1250	1150	16

Size of the main flanges was designed according to Waters Method, and then rigidity was checked, as shown in figure 2 and figure 3. Design of the main flange bolts and calculation of the pretightening load was conducted according to the method in the reference (Zhang, 1987).

The other three pairs of pipe flanges are selected from the standard pipe flanges according to their working conditions (Third Newsroom of China Standard Publishing Company, 1998). All the flange seal packing rings are B model stainless steel wound graphite gasket (China National Pipeline Accessories Standardization Committee, 1998).

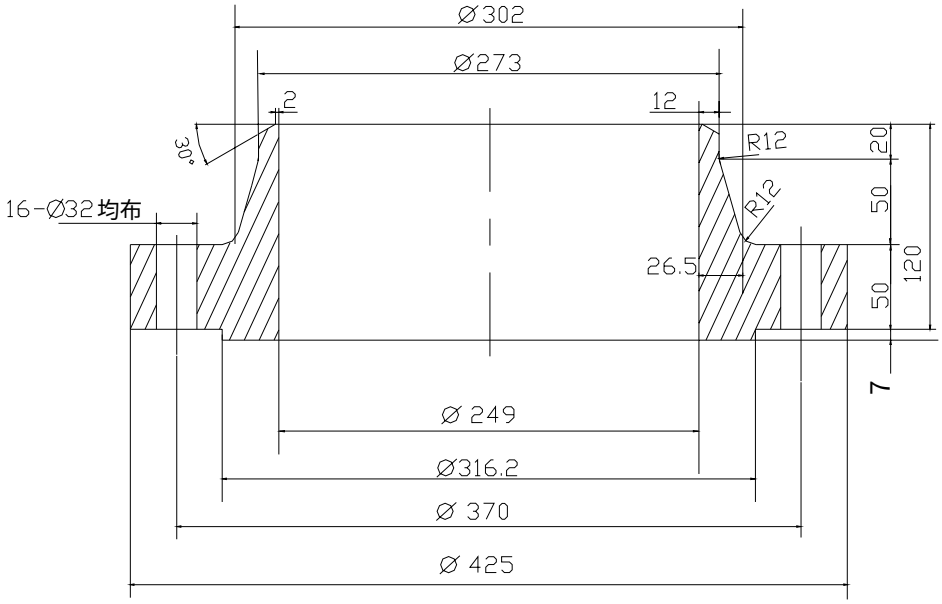

Figure 2 Schematic diagram of the filter main convex flange

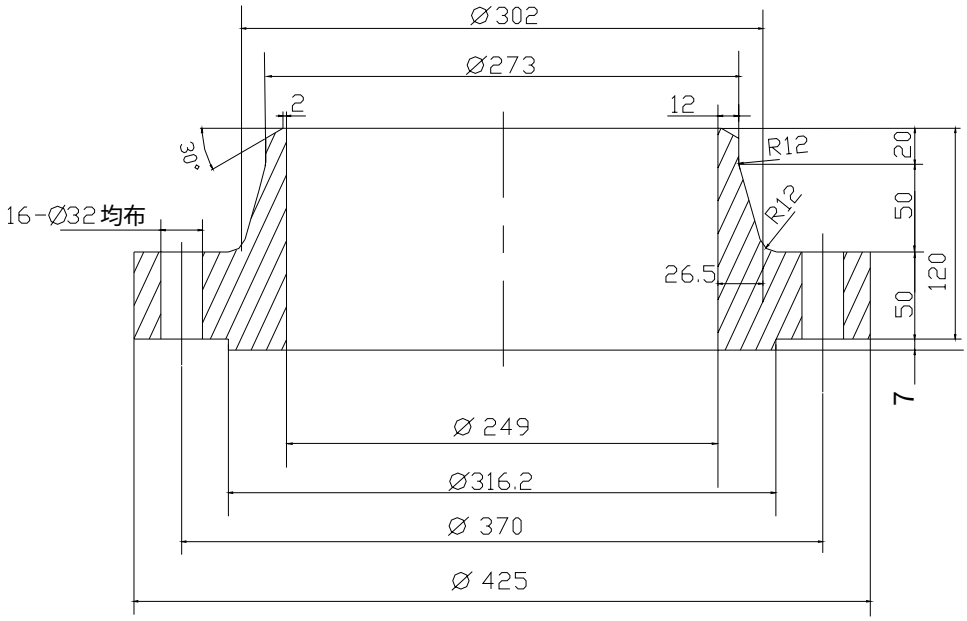

Figure 3 Schematic diagram of the filter main concave flange

3.2 Hydraulic pressure test and leakage test

After manufacture of the pressure vessel, the hydraulic pressure test and air pressure test were conducted. The pressure of the hydraulic pressure test is 6.88MPa; and the pressure of the air pressure test is 5.78MPa. During the tests, no unacceptable leakage, no visible abnormal deformation and noise were found. The test conclusion is that the pressure vessel is qualified for being the pressure vessel of the filter.

4. Conclusion

The test results of the pressure vessel have shown that the design methods adopted of filter pressure vessel is reasonable and the manufacture quality is high.

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