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ANALYSIS OF PERFORMANCE OF THE NEW TYPE OF FOUR EQUAL OF THE INJECTION ONLINE PRESSURE SEALING FIXTURE

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ABSTRACT

Taking the leakage of steel pipe welding neck flanges with raised face as the research object, the structural characteristics of the traditional fixture and new type of four equal fixture were investigated, and the mechanical properties of the traditional fixture and the new type of four equal fixture were analyzed by using the finite element software Abaqus. The results show that, in the case of the same internal uniform pressure applied to the two kinds of flanges, the maximum circumferential tensile stress and the maximum tensile stress of the bolt of the new type of four equal fixture is 42.2% and 42.9% for the traditional fixture, respectively. The new type of four equal fixture is superior to the traditional fixture in both pressure bearing capacity and stress concentration. Therefore, it is of great significance to investigate the mechanical properties and concept design of the new type of four equal fixture for the wide application of pressure sealing technology.

KEYWORDS

Online leak sealing, traditional fixture, four equal fixture, finite element analysis

1. INTRODUCTION

Petrochemical and other industries at domestic and foreign to run the production process, pipeline leakage has always been an unavoidable problem. At present, the widely used technology for solving pipeline leakage in China is injection-type pressure sealing technology [1,2]. The injection-type pressure sealing technology originated in the United States. In 1920, American Klein Furman developed a leak sealing method under pressure in a pipeline at Newport's shipyard and expanded it to other industries [3-5]. China's pressure sealing technology began in the 1950s. It was the use to pressure welding to treat leaking pressure equipment in the steel industry [6].

However, it is forbidden for a long time in China's chemical industry, it obtain developed and applied of the injection-type pressure seal until the early 1980s [7]. And during the national "6th Five-Year Plan" period, it completed the development of model-to-technical innovation of pressure sealing technology, and was subsequently included in one of the 1986-1990 national key 70 new technology promotion projects [8, 9]. It has been reported that in China, the technology has successfully eliminated more than 500,000 leakages of various types, and economic losses have been recovered totalling more than 60 billion yuan, resulting in huge social benefits [10-12]. In 2007, China announced the world's first national industry standard HG/T20201-2007 "Pressure Sealing Technical Specifications", at an international in which the new theory of fixture design is an advanced level [13].

In this paper, the mechanical properties of the traditional fixture and the new type of four equal fixture under different pressures were analyzed by using the finite element software Abaqus. It is of great significance to the investigate results for the Promotion and application of the Injection Online Pressure Sealing technology.

2. MODEL AND MATERIAL PARAMETERS

In this paper, taking the leakage of steel pipe welding neck flanges with raised face as the research object, and medium pressure saturated steam

is taken. The operating pressure is 3.0MPa, 5.0MPa, and 8.0MPa, respectively. Traditional fixtures, new type of four equal fixtures and flange material parameters are shown in Table1.

Table 1: Material performance parameters

element	Traditional fixture	Four equal fixture	Flange
Material type	Q235-B	Q235-B	Q235-C
Modulus of elasticity/MPa	2.1×10^5	2.1×10^5	2.13×10^5
Poisson's ratio	0.3	0.3	0.3
Diameter/mm	105	105	105
Temperature/°C	220	220	220
Operating pressure/MPa	3、5、8	3、5、8	-

3. FINITE ELEMENT MODEL ESTABLISHMENT

This article uses abaqus software to establish a finite element analysis model. Because the traditional pressure sealing fixture is a two-part structure composed of two semicircles, select the 1/2 model that establishes of the overall structure of the traditional fixture as the research object, model symmetry plane set symmetrical constraints, apply fixed restraints to the lug plates on both sides [14,15]. The setting parameters are as follows: Unit type is C3D8R, Poisson's ratio 0.3, Elastic modulus 2.1×10^5 MPa, Apply uniformly distributed pressure to the inner wall of the fixture $P=3.0$ MPa, $P=5.0$ MPa and $P=8.0$ MPa, finite element model of the 1/2 traditional fixture shown in Figure 1.

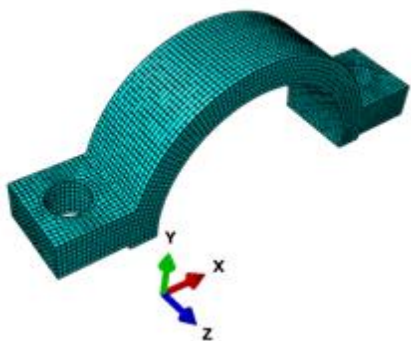


Figure 1: Finite element model of the 1/2 traditional fixture

The new type of four equal fixture structure is mainly composed of three parts: fixture, sealing film and fastening bolt. It is mainly applied to various damage seals of oil, water and other liquid media [16]. Because the new type of four equal pressure sealing fixture is a four-part structure composed of four quarter-arc structures, select the 1/4 model that establishes of the overall structure of the new type of four equal fixture as the research object, apply fixed restraints to the lug plates on both sides. Set the parameters as above, finite element model of the 1/4 new type of four equal fixture shown in Figure 2.

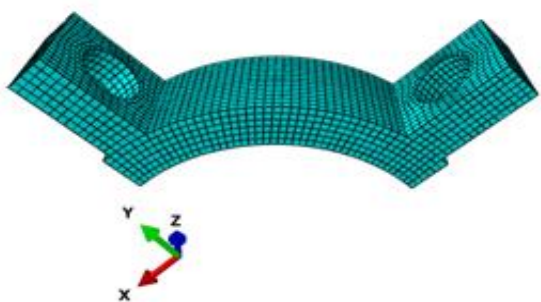


Figure 2: Finite element model of the 1/4 new type of four equal fixture

4. RESULTS OF COMPARATIVE ANALYSIS

The circumferential tensile stress of the traditional fixture under different pressures is shown in Figure 3. The arc portion of the fixture is subjected to most of the uniform pressure, and the circumferential tensile stress of the fixture increases first and then decreases, and the middle position of the arc part of the fixture is subject to the greatest circumferential tensile stress. As can be seen from the peak of the three curves, the circumferential tensile stress of the fixture increases with the increase of the pressure. When the pressure $P=8.0\text{MPa}$, the circumferential tensile stress value of the fixture is the largest, the maximum value is 46.73MPa . The bolt tensile stress of the traditional fixture under different pressure is shown in Figure 4.

The bolts are subjected to a large tensile stress, from overall view, the tensile stress of the bolt changes of a parabolic shape, increasing first to a maximum value and decreasing to a minimum value, and the more obvious the curve changes as the pressure increases, the steeper the shape of the curve and the greater the peak value. It can be seen that the tensile stress of the bolt increases as the pressure increases and the local stress concentration near the maximum, the greater the pressure and the more obvious the stress concentration. resulting in stress concentration. When the pressure $P=8.0\text{MPa}$, the tensile stress value of the bolt is the largest, the maximum value is 167.2MPa .

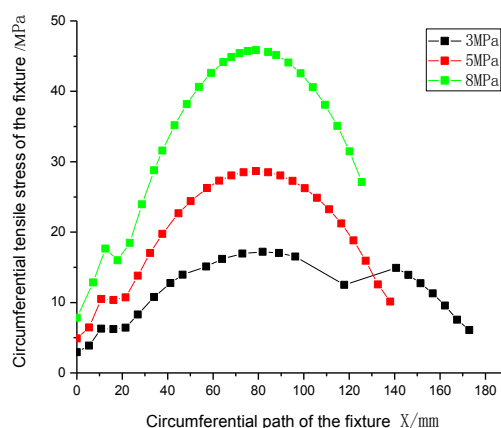


Figure 3: Circumferential Tensile stress of the traditional fixture under different pressures

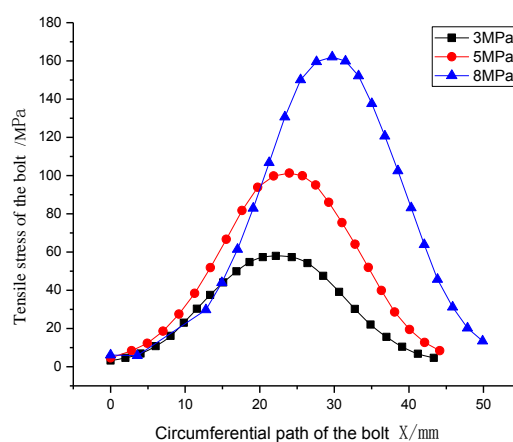


Figure 4: Bolt tensile stress of the traditional fixture under different pressures

The circumferential tensile stress of the new type of four equal fixture under different pressures is shown in Figure 5. The circumferential tensile stress of the new type of four equal fixture is symmetrically distributed from the middle to the two sides, and the circumferential tensile stress value of the fixture is the largest in the middle. It can be seen from the trend of the graph that the circumferential tensile stress value of the fixture increases first and then decreases and increases to the maximum value. The circumferential tensile stress value of the fixture increases with the increase of the pressure. When the pressure $P=8.0\text{MPa}$, the circumferential tensile stress value of the fixture is the largest, the maximum value is 19.71MPa .

Tensile stress of bolt of the new type of four equal fixture under different pressure is shown in Figure 6. The tensile stress of the bolt suffered gradually increase according to the parabolic trend, when the maximum value is reached, it tends to stabilize in a small interval, and then shows a downward trend. As the pressure increases, the peak of the curve also increases. When the pressure $P=8.0\text{MPa}$, the tensile stress value of the bolt is the largest, the maximum value is 71.73MPa . Comparison of analysis results of mechanical properties of fixtures under different pressures are shown in Table 2

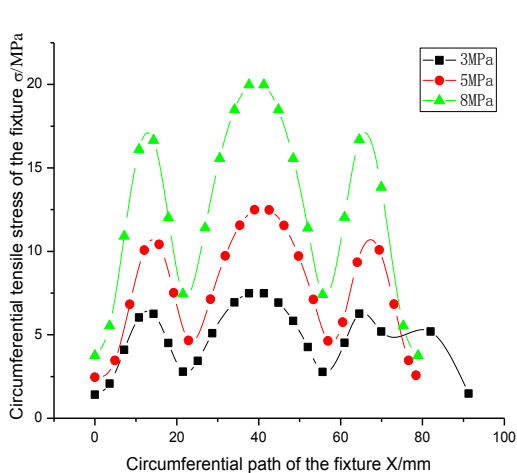


Figure 5: Circumferential tensile stress of the new type of four equal fixture under different pressures

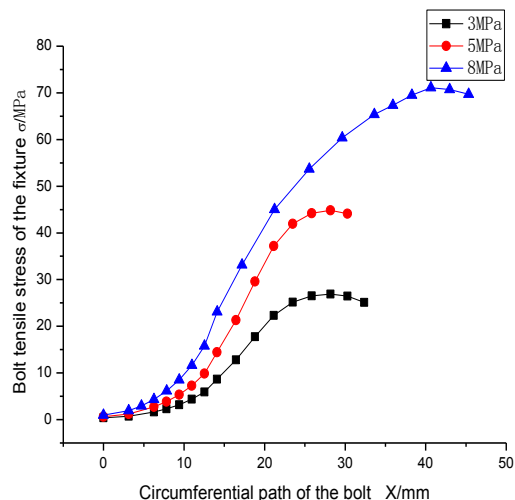


Figure 6: Tensile stress of bolt of the new type of four equal fixture under different pressures

Table 2: Comparison of analysis results of mechanical properties of fixtures under different pressures

Pressure	P=3	P=5	P=8
The bolt maximum tensile stress of the traditional fixture σ /MPa	62.71	104.5	167.2
The bolts maximum tensile stress of the new type of four equal fixture σ /MPa	26.91	44.83	71.73
Circumferential maximum tensile stress of the traditional fixture σ /MPa	17.24	29.82	46.73
Circumferential maximum tensile stress of the new four equal fixture σ /MPa	7.27	12.57	19.71
Circumferential maximum tensile stress difference of the fixture σ /MPa	9.97	17.25	27.02
Maximum tensile stress difference of the Bolt σ /MPa	35.81	59.67	95.47

5. CONCLUSION

Through the above analysis and Table 2, it can be clearly seen that the new type of four equal fixture is superior to the traditional fixture in both pressure bearing capacity and stress concentration. In the structural design, the new type of four equal fixture can also better solve the shortcomings such as poor surface adhesion, loose fastening bolts, etc., and increase the sealing performance and seal life of the fixture. Under the condition that the same internal uniform pressure is applied to the traditional fixture and the new type of four equal fixture, The analysis shows that within the allowable range of allowable stress of bolt, the new type of four equal fixture can withstand higher pressure and increase the pressure bearing capacity of the fixture. The maximum circumferential tensile stress and the maximum tensile stress of the bolt of the new type of four equal fixture is 42.2% and 42.9% for the traditional fixture, respectively.

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