Modeling New Constructions of T-joint Connection of the Pipeline to Increase Efficiency

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Abstract. The oil and gas pipeline system is currently the most common way to transport oil and gas. One of the main hazardous areas of this system is the T-joint connection. The object of my research will be a T-joint connection. Branch nodes and taps are the most dangerous sections of the pipeline system. The tee assembly, which includes the main pipe and pipe, experiences a stress-strain state caused by a number of reasons, which relates it to tasks requiring increased control and attention. Such reasons include the operating conditions of the pipeline system, constant loads, the environment in the pipes and the presence of defective areas. One of the ways to strengthen the T-joint connection is the use of special reinforcing elements, which have their own manufacturing and assembly technology with the pipeline.

1. Introduction
Ensuring the operability and reliability of hazardous sections of the pipeline remains an urgent task. This paper presents a technical solution aimed at increasing these indicators. This is the use of two patch rings on a tee pipe connection instead of one.

To assess the stress-strain state, it is necessary to model the tee connection of the pipeline using these structures in the ANSYS WORKBENCH program.

2. Technical solution of the research problem
The main way to strengthen this unit is the use of patch rings [1]. The main objective of the study is the development of designs of T-joint connection. The technical solution is to use two patch rings instead of one [2]. This will redistribute stresses from the main pipe to the ring of smaller diameter (Fig. 1) and reduce the heat affected zone of the weld of the patch ring. The steel construction of the main pipeline will not be able to destroy. The hazardous statement will not be created which means that an emergency situation will not appear and the efficiency of the T-joint connection will increase [3].
3. Tools and materials
Analysis of the technical solution was carried out in the ANSYS WORKBENCH program. After analyzing models with different aspect ratios, the calculation formula was derived in ANSYS WORKBENCH [4]. The most important issue is the selection of the ratio of the diameters of the patch rings. After analyzing models with different aspect ratios in the ANSYS WORKBENCH program, a calculation formula was derived. The technical problem is achieved by the fact that the adjacent ring element is welded coaxially on the pipe, welded to the pipe and pipe with fillet welds, the ring element is two patch rings of different diameters, the sum of the wall thicknesses of which is equal to the thickness of the pipe wall [5-10]. A patch ring of a smaller diameter is welded to a patch ring of a larger diameter, which in turn is welded to the main pipe.

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k_1 = \frac{D_L}{D_B} = 2.2; \quad k_2 = \frac{D_S}{D_B} = 1.7
\]

\(k_1\) – the coefficient that characterizes the ratio of the diameters of the larger patch ring and branch node;
\(k_2\) – the coefficient that characterizes the ratio of the diameters of the smaller patch ring and branch node;
\(D_L\) – the diameter of the larger patch ring, mm;
\(D_S\) – the diameter of the smaller patch ring, mm;
\(D_B\) – branch node diameter, mm.

Numerical modeling of the stress-strain state and field studies have shown the possibility of using the design of two overhead rings on the tee connection of the pipeline in order to increase the efficiency and reliability of the node.

4. Practical tests of technical solution
To test the design, as an example of welding two sheets of different thicknesses, sheets 10x10 mm and 10x5 mm thick were taken. The weld was a lap joint. The macrostructure of full-scale samples of the joints of the overhead rings with the body (Fig. 2) shows that the 10x10 mm sample has a much larger thermal influence zone than the 10x5 mm sample [10-13].
Figure 2. The heat affected zone (HAZ) on model samples.

Thus, numerical modeling of the stress-strain state and field studies have shown the possibility of using the design of two overhead rings on the tee connection of the pipeline in order to increase the working capacity and reliability of the node.

5. Test of technical solution for cyclic load installation
After three-dimensional modeling, the next step in the study will be a test in laboratory facilities (Fig. 3).

1 – type 1U sample according to GOST 25.502-79; 2 – passive capture; 3 – active capture; 4 – supporting rollers; 5 – guides; 6 – rocker arms; 7 – lever; 8 – connecting rod; 9 – crank; 10 – double hinge

Figure 3. Installation for testing type IV flat specimens for cyclic load

The model of the laboratory sample is shown in Fig. 4. To compare the use of two plates and one plate in a setup for testing cyclic bending type IV samples, we prepared two models. Thus, the
operability of technical solutions by methods of computational analysis in engineering programs and tests will be confirmed [14].

Figure 4. Models of laboratory specimens for cyclic bending tests.

6. Summary
At present, issues of ensuring the reliability and operability of the T-joint connection of the pipeline remain relevant. Existing ways to strengthen this unit does not provide for safe operation. A number of technical solutions presented in this paper, according to the assessment of the stress-strain state, showed their feasibility in practice. After modeling the unit with one patch ring and two patch rings and comparing these results, it was determined that the use of two patch rings reduces the stress-strain state of the tee assembly. Based on the results obtained, formulas were derived for calculating the diameters of the overhead rings for any pipe size.

7. References
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