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PRESSURE TESTING OF THE NEW TYPE OF SPLIT SLEEVE FOR BRANCH CONNECTION REPAIRING

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ABSTRACT
Gas leaking defects located nearby the branch connection weld joint on the pipelines represents a serious type of defects. The reason is that such defects mostly requires removing of the damaged area. New type of split sleeve has been designed to repair this group of defects, which allows repairs of leaking defects without interruption of gas transport. One of the assumptions which allows real applications of repairing technique is sufficient strength of the sleeve against the internal pressure loading. In the contribution a mathematical modelling of stresses in the wall of the sleeve together with experimental testing of maximal pressure that can repairing method withstand are presented.
Keywords: branch connection repair, split sleeve, internal pressure

1. INTRODUCTION
Numerous kinds of repair techniques of the gas pipelines are now available including the cut out and replace of the pipeline, construction of the bypass along the damaged area, grinding, weld deposition, metallic or composite sleeves [1]. Although the repairing techniques for straight parts of pipelines are well established, only a few of them is applicable for branch connections defects (for ex. defects in the area of fillet weld between header and branch pipe). Recently a new type of split sleeve for such defects repairs has been designed [2,3]. Split sleeve (Fig. 1) consist of the cylinder part and sphere-like parts, which has to ensure safely installation of the sleeve to the repaired branch connection. Such type of split sleeve is joined together by butt welds and to the repaired pipes it is connected by full encirclement fillet welds. Whereas internal space of sleeve will be exposed to leaking gas during the assembling process, it is necessary to ensure sealing up of the internal space and places of welding. Sealing up of the internal space of split sleeve is designed with using sealants fixed to so-called "sealant carriers". Sealant carriers copy every separation surface of sleeve, as well as the holes in the places of connection of the sleeve and pipeline.

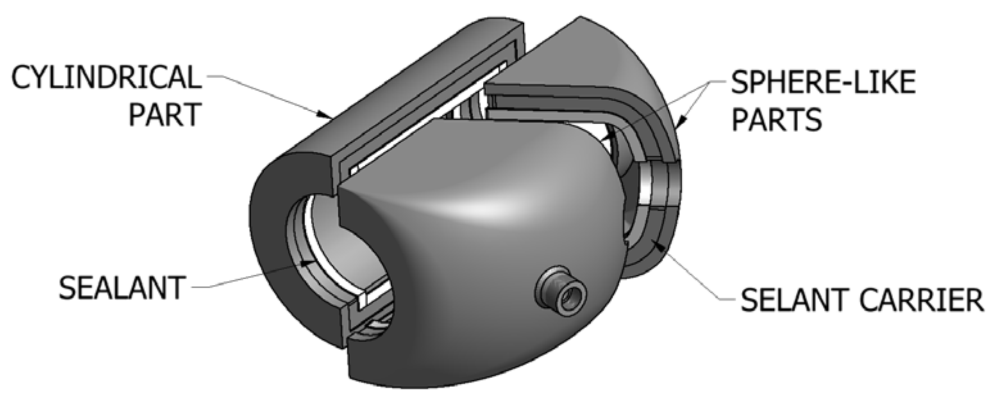

Figure 1. Split sleeve for branch connection repairs.

One of the most important requirement to the application of the sleeve as a permanent repair is containing the maximum allowable operating pressure (MAOP) by the sleeve. In this article, designation of the sleeve wall thickness and pressure testing of the manufactured split sleeve is presented.

2. DESIGNATION OF THE SPLIT SLEEVE WALL THICKNESS

Designed split sleeve can be considered as thin-walled pressure vessel. Since walls of the sleeve offer little resistance to bending, it can be assumed that the internal forces exerted on a given portion of the wall are tangent to the surface of the vessel (sleeve). The resulting stresses on an element of the wall will thus be contained in a plane tangent to the surface of the vessel [4,5]. Computation of the stresses in the cylindrical and/or spherical pressure vessel is simple, but determination of stresses in the complicated geometry of the split sleeve for branch connection repairs is more difficult. In such cases, it is possible to use finite element analysis [6]. Simulation software ANSYS was applied to computation of the stresses in the wall of the sleeve, and according to results, wall thickness was determined.

Numerical simulation was performed on the model representing a half of the sleeve with the symmetry plane crossing the axis of the branch connection. Prototype of the sleeve was designed to branch connection with dimensions of Ø159x4.5 mm for header pipe and Ø60.3x4 mm for branch pipe. Angle between the pipes was 60°. Several values of thickness and dimensions of sealant carriers were applied during thickness designation (thickness varied from 10 to 16 mm). Sealant carriers will serve not only to isolate internal space during welding but also as the reinforcement of the sleeve against pressure. Results of the equivalent stresses for the final dimensions of the sleeve (thickness of 16 mm, sealant carriers dimensions 8x35 mm) and internal pressure 6.3 MPa (63 bar) are shown in the Fig. 2 and Fig. 3.

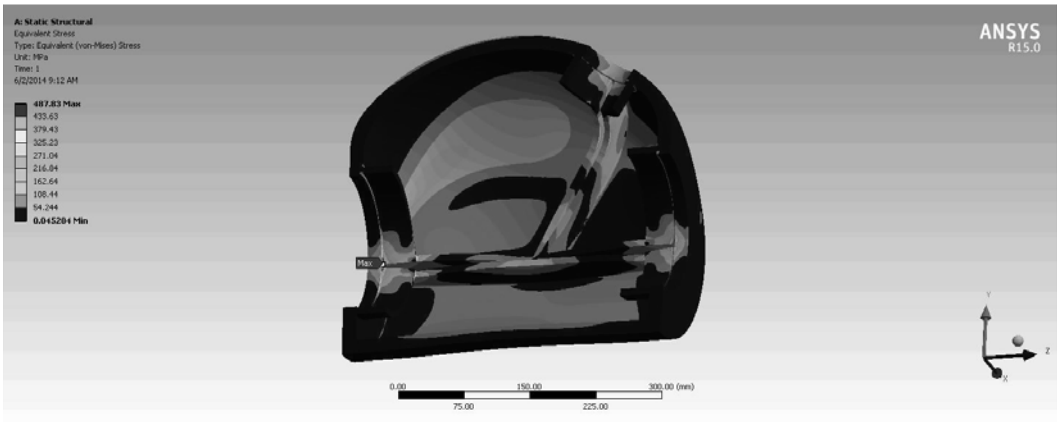

Figure 2. Equivalent stresses in the wall of the split sleeve – inner surface.

Figure 3. Equivalent stresses in the wall of the split sleeve – outer surface.

3. PRESSURE TESTING OF THE SPLIT SLEEVE

Standardized pressure test can be performed according to several standards. For designed sleeve, hydrostatic pressure test was used in terms of EN 12 327 and Slovak technical rule TPP 702 02. Testing procedure was based on the filling the test section of pipe equipped with the repairing sleeve (Fig. 4a) with water and pumping the pressure up to a value that is higher than maximum allowable operating pressure (MAOP) and holding the pressure for a period of one and a half hours. During the testing period, pressure decrease was measured by pressure gauge (Fig. 4b). According to the standards, value of the pressure should be higher than 1.5xMAOP. Dimensions of the sleeve was designed to MAOP with value of 6.3 MPa and minimal testing pressure was proposed to 10 MPa (real value 10.17 MPa). During the testing period, no significant decrease of the pressure was detected.

a) b)

Figure 4. Pressure test of the split sleeve for branch connection repairs: a) experimental setup; b) detail of pressure gauge with value of the pressure (10.17 MPa) during standardised test.

Pressure test to destruction was used to determine weak area of the branch connection with applied split sleeve. During the test, internal pressure was constantly increased to the destruction of the analyzed sample. Destruction occurred at the internal gauge pressure 27.3 MPa (273 bar). The crack was situated on the flat surface of the sleeve (Fig. 5).

a) b)

Figure 5. Position (a) and detail (b) of the crack after pressure test to destruction.

4. DISCUSSION

Numerical computation of the split sleeve for branch connection repair shows importance of the designing phase during the manufacturing process mainly in case of the new repairing solutions and prototypes. Results of equivalent stresses leads to increasing of the wall thickness of the sleeve up to 16 mm (initial value was 10 mm). The reason is relatively complicated shape that was designed to ensure the possibility of sleeve installation and without unwanted increasing of the sleeve volume (causing increase of the weight). Some areas shows after computation higher equivalent stresses as the Yield stress of the proposed material (steel S355 grade with minimal Yield stress 355 MPa). Such behavior was observed at the sharp edges or in the areas of connection of the sealant carriers to the

wall of sleeve. This increasing might be influenced by the finite element computational method. Analyzed construction is during the computation meshed and computation is done in the generated nodes. After computation, a post-processing follows, which is strongly dependent on the shape of the elements. Sharp edges might cause that created mesh contains elements that might during post-processing leads to rapidly increased values of the stress. The main body of the sleeve (Fig 3) shows presence of the stresses with values below material Yield stress initiated by MAOP. Thickness with value of 16 mm and sealant carriers with dimension of 8x35 mm are thus sufficient to contain MAOP of the pipeline with value of 6.3 MPa.
Two pressure tests were proposed to the construction. First test was designed to verify the proposed dimensions. Standardized testing procedure selected to this purpose shows sufficient resistance during the loading of the sample by internal gauge pressure with value of 10 MPa. Except of this, correctness of the manufacturing technique of the pipes and split sleeve was also verified as there was not detected leakage of the water. Second testing procedure was selected in order to obtain information about the weak places of the construction. Constantly increased internal gauge pressure leads to destruction and formation of the crack on the flat surface of the sleeve. This place (Fig. 5) is in good agreement with the maximal equivalent stresses of the sleeve main body after finite element computation (Fig. 3). Maximal measured gauge pressure (27.3 MPa) also pointed out a possibility of application of the sleeve with lower wall thickness in practical applications.

5. CONCLUSIONS

New type of the split sleeve for branch connection repairing can bring decrease of the repairing costs compared to repairs by replacing of the damaged area with interruption of the gas supply or with bypass construction. Several conclusions can be stated form the designation of the wall thickness and pressure tests of the designed sleeve as follows:

1) Minimal required thickness and sealant carriers' dimensions for selected pipe dimensions are according to finite element computation 16 mm an 8x35 mm, respectively.
2) Designed construction and welding process satisfies conditions required by the standard EN 12 327 and Slovak technical rule TPP 702 02.
3) The weakest place of the construction is flat surface of the sleeve where the maximal stresses of the main sleeve body were computed and also crack after destruction pressure test was present.

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6. REFERENCES

[1] Batisse R.: Review of gas transmission pipeline repair methods, Safety, Reliability and Risks Associated with Water, Oil and Gas Pipelines. Dordrecht: Springer, 2007.
[2] Mician M., Patek M., Sladek, A.: Concept of repairing branch pipes on high-pressure pipelines by using split sleeve, Manufacturing Technology, Vol. 14, No. 1, 2014.
[3] Mesko J., Fabian P., Hopko A., Konar R.: Shape of heat source in simulation program SYSWELD using different types of gases and welding methods, Strojírenská technologie, č. 5, 2011.
[4] Beer F.P. et al.: Statics and Mechanics of Materials, McGraw-Hill, New York, 2011.
[5] Savicevic S., Janic M., Vukcevic M.: Theoretical Calculations of Loaded Shells and Comparison with Obtained Numerical Results, 18th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2014, Budapest, Hungary, 2014.
[6] Cep R., Janasek A., Cepova L., Hlavaty I.: Effect of post-welding heat treatment on secondary hardening of welded joints of Cr-Mo-V steel, Metal Science and Heat Treatment, Vol. 53, No. 7-8, pp. 374-378, 2011.