Keywords: **FEM • Gasket • Pressure • Sealing**

Computer analysis of double cone metal gasket operation

One of the most effective methods of comprehensive analysis of pressure equipment operation is the Finite Element Method (FEM). In this article, the authors describe how the FEM can be used especially in cases of untypical flange connections.

By Radosław Sieczkowski & Janusz Zajączek, Spetech

Reliable operation of pressure equipment depends on many factors, including correct design of an installation, selection of materials, workmanship, installation and supervision. The occurrence of problems with obtaining tightness during operation may have many causes, the quantitative diagnosis of which can sometimes be difficult. One of the most effective methods of comprehensive analysis of pressure equipment operation is the Finite Element Method. FEM can be used especially in cases of untypical flange connections, when their calculation analysis with available algorithms using formulas does not give expected results. The subject matter of the analysis described in the article was a 1800 mm inner diameter metal seal of double cone type with silver layers in the reactor, of the following operation parameters: pressure 248 bar and temperature about 200°C. During many years of operation depressurization occurred time and again, that resulted in considerable financial losses connected with unscheduled reactor shutdown and repair.

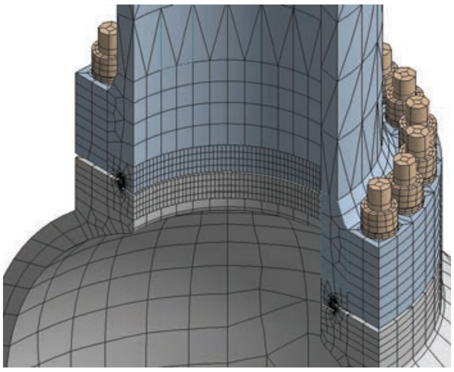

Fig. 2. FEM model, magnified

In order to diagnose the problem, the Finite Element Method (FEM) and ANSYS software were used to analyse the seal operation. The used method allowed the analysis of deformations and stresses in the flange connection, taking into account:

- emperature of the medium,
- bolts tightening,
- external loads.

In addition to that, the following phenomena were taken into account:

- friction between the double cone metal gasket and the layer and between the layer and the face of the flange
- thermal expansion of all reactor parts with the heat flow phenomenon taken into account

In order to conduct the FEM analysis a simplified, three dimensional (3D) model of the reactor was created, limited to the half of diameter (180 degrees).

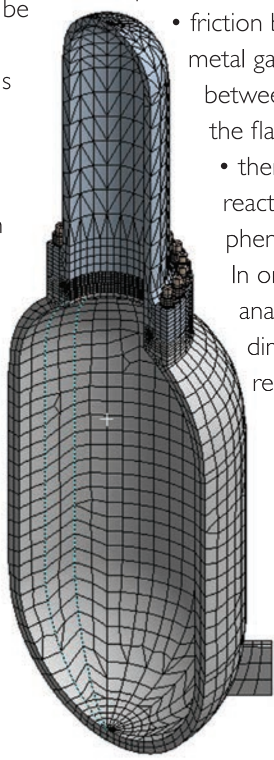

Fig. 1. FEM model

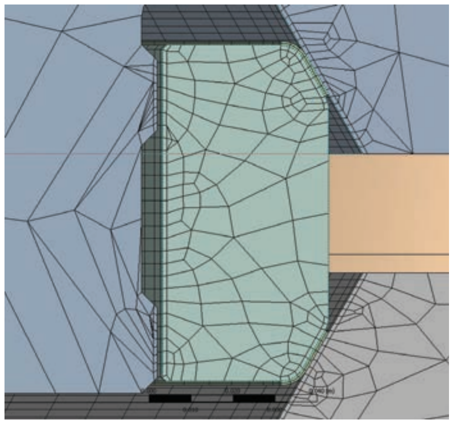

Fig. 3. FEM model – gasket joint zoomed in.

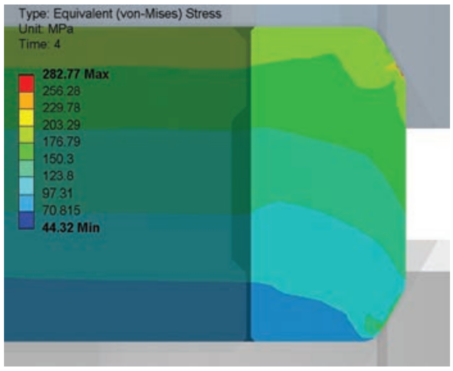

Fig. 4. Stresses reduced in the gasket

In the connection a double cone gasket operating with silver foil layers for tightness improvement was used.

As a result of the conducted analysis it turned out that in the upper gasket layer a local stress concentration occured. It was caused by different values of upper and lower flange radial displacement, as a

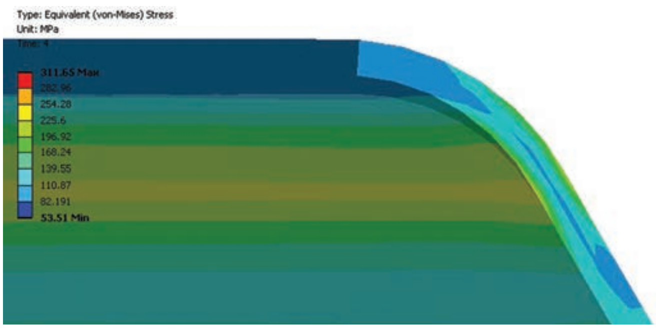

Fig. 5. Stresses reduced in the upper layer

result of differences in the flanges' stiffness. The lower flange of the reactor, in point 10, Fig. 6, deforms due to pressure and thermal expansion in the radial direction by 2.2 mm, whereas the upper flange, in point 9, Fig. 6, deforms only by 1.5 mm. The arising difference of 0.7 mm (Fig. 7) was most probably the main cause of the lack of tightness occurrence.
Next, using the same FEM model, the gasket shape and dimensions optimization was conducted.
As a consequence, making of the radius R=150 mm on the double cone gasket conical surfaces (Fig. 8) was proposed. This solution resulted in reduction of stresses and their better distribution in the whole section of the layer (Fig. 9). In this way wear was significantly reduced. Additionally, made radius gave the gasket much greater ability to adjust to the face surfaces.

Conclusions.

Conducted FEM analysis allowed us to discover the main cause of the lack of tightness of the connection with the double cone metal gasket. As a result, quantitative values of deformations and stresses were obtained, which, as it turned out, caused accelerated wear of the gasket and its layers. Thanks to the analysis results the gasket was modified, i.e., its conical surfaces were rounded. It allowed the reduction of stresses in the gasket and better adjustment of its position with regard to flange deformation.

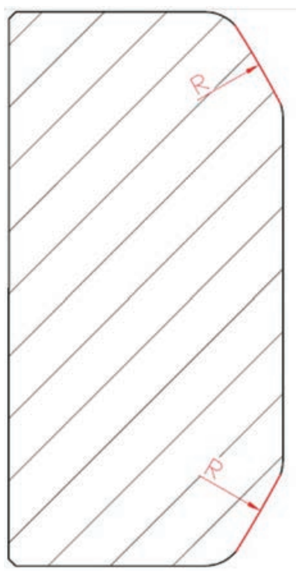

Fig. 8. Modified gasket

The new gasket was installed in the described reactor and it has been operating without a failure for a year now. Similar analyses and modifications of seals in existing installations can eliminate problems with obtaining tightness. The Finite Element Method also allows the design of new pressure equipment in accordance with the Pressure Equipment Directive 97/23/EC.

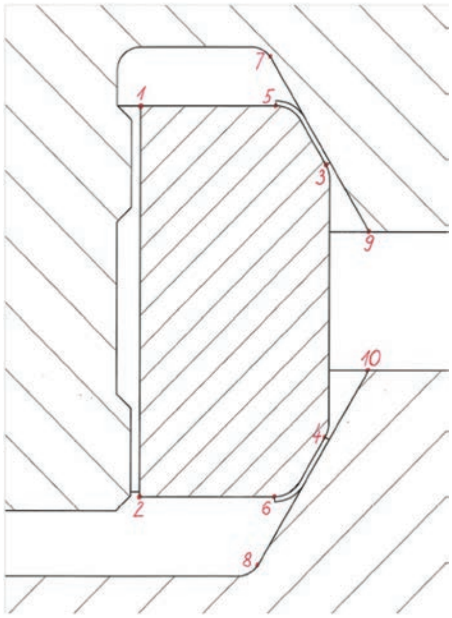

Fig. 6. Gasket before installation

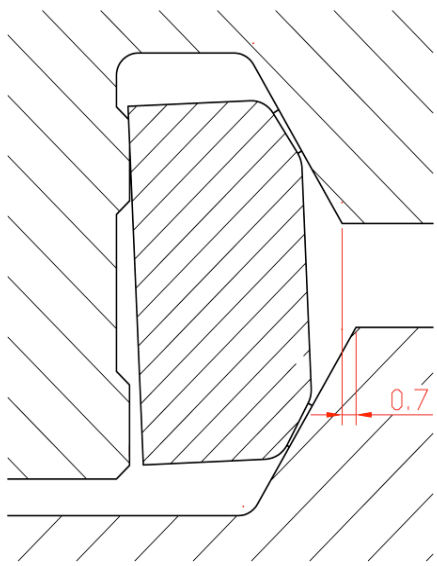

Fig. 7. Gasket in operating condition

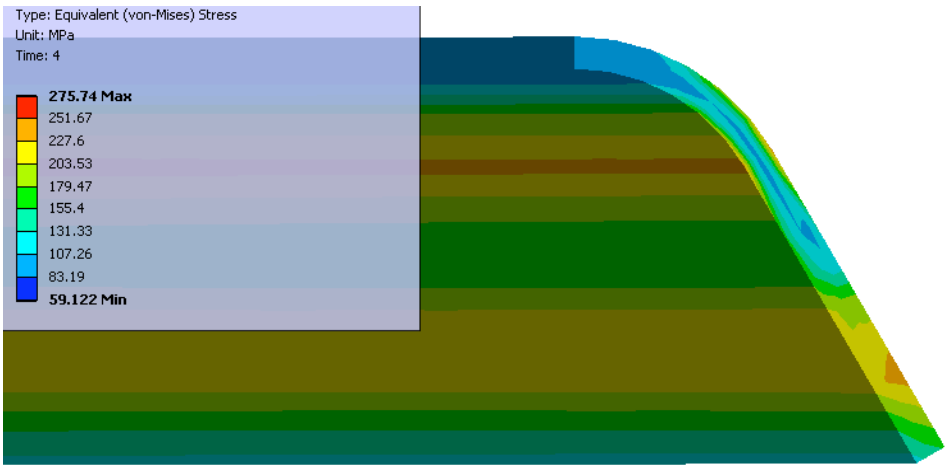

Fig. 9. Stresses reduced in the modified gasket upper layer

About the Authors

Mr Radosław Sieczkowski, Ph.D. is a product manager at Spetech gasket manufacturer. His knowledge and 12 years of experience contribute to solving the most difficult sealing problems. He focuses on the problems of static semi-metallic and metallic industrial seals. He can be contacted at rsieczkowski@spetech.com.pl

Mr Janusz Zajączek is a manager of Sealing Materials Testing Laboratory. He focuses on the problems of tests of gaskets and calculation methods. He also works as a software author for the Europartner flange calculation program. He can be contacted at jzajaczek@spetech.com.pl