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Simulation of Static Behavior of Corroded Pipes in Operation, Reinforced Elastic

The pipes used for transport in chemical, nuclear or siderurgical domains, undergoes a strong internal abrasion as well as an external mechanical stress corrosion. Determination of the effective thickness of the wall is made with non-destructive ultrasound. Because of the danger of brittle fracture pipes 20-40 years old in operation, a weld consolidation solution with high residual tension is inadequate. Original solution applied in industry and certified on the basis of simulations is based on outer cuff bolted.

Keywords: *stress concentrators, corrosion, sleeve, pipe*

1. Introduction

Mechanical parts or elements of structure often shows characteristics that cause sudden changes in geometry. Under the action of loads, these geometries lead to increased efforts in local material and is usually the place where parts failing. The localization of this great stress is named effort concentrator. Features such as holes, notches, grooves, sudden changes of section, etc., which causes this phenomenon is called stress concentrators [1].

In most cases, stress concentrators have undesirable effects on the track, in extreme cases even leading to its destruction. Therefore, during design or by subsequent mechanical operations an attempt to mitigate some of the stress concentration is made by creating or strengthening geometries with added material in those areas [2].

As a positive side effect of stress concentration, engineers can create special elements designed for producing stress concentrations, so that they can help to release tension in a critical area. One example is the execution of additional concentrators who download the detrimental effect of the challenge of sudden change in diameter.

2. Testing a corroded pipe in SolidWorks

Pipe dimensions are:

- Outer diameter 264 mm;
- The inner diameter 249 mm;
- Wall thickness 7.5 mm;
- Pipe length 2 meters.

Corroded area size is determined by the ZWP-TÜV LIMATEC Sarlande firm's methodology [3]. Exact spatial corrosion surface can be reduced to the size of 80 x 40 mm.

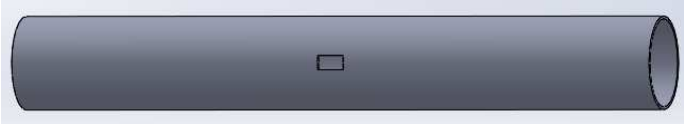

Figure 1. Corroded pipe

In the first instance the pipe is tested with the tensile force of 10 kN. Fixing of the pipe is at one end, only in the direction of the stretching to get more accurate results.

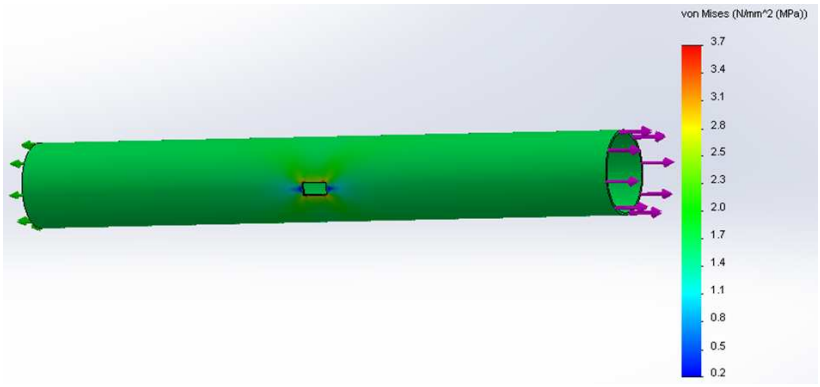

Figure 2. Corroded pipe subjected to stretching

From the resulting plot, there is the phenomenon of stress concentration around the corroded hole. There is found the maximum stress valued at 3.7 N/mm2.

In the case of tensile stress, the theoretical mechanical stress concentration coefficient is calculated. To determine the coefficient the following equation is used:

$$\alpha_k = \frac{\sigma_{max}}{\sigma} \tag{1}$$

Sigma nominal is calculated using the equation:

$$\sigma = \frac{F}{A} = \frac{10000}{6832} = \frac{1,463N}{mm^2} \quad (2)$$

So the coefficient of stress concentration is:

$$\alpha_k = \frac{\sigma_{max}}{\sigma} = \frac{3,7}{1,463} = 2,529 \quad (3)$$

For the bending test, the pipe was embedded at one end and at the other a cross force of 10 kN is applied.

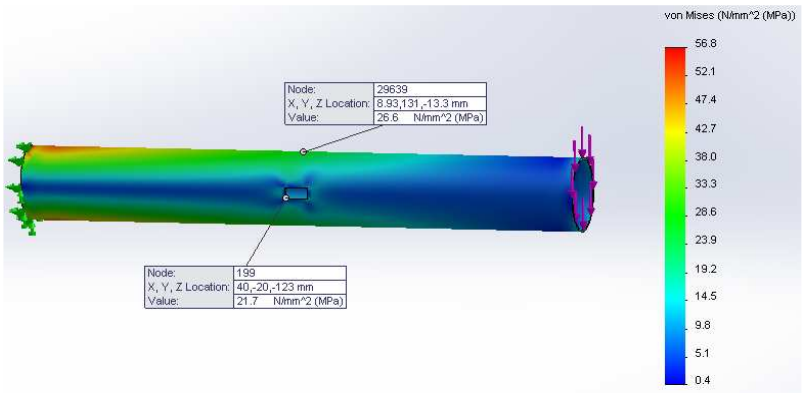

Figure 3. Pipe subjected to bending

Maximum tension at the perforation of the pipe is 21.7 N/mm2 and at mid pipe (1m) stretched fiber of 26.6 N/mm2. These values will be compared with those obtained after applying a sleeve. Torsional testing follows the same principle, simulating a 10 KNm twisting moment.

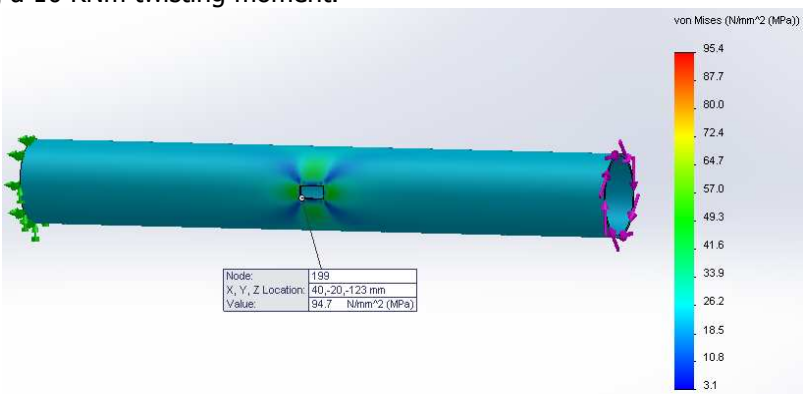

Figure 4. Pipe subjected to torsion

As in the case of application of tension, stress concentration is found at the opening and is approximately equal to 95 N/mm2. This value will be compared to

that obtained after the sleeve is applied for the hole clogging and lower stress concentration.

3. Testing a corroded pipe with a sleeve applied, in SolidWorks

Figure 5. Pipe with sleeve, assembled /3/

Pipe is identical to that of section 2. Sleeve dimensions are:

- Length 1 meter;
- Outer diameter 280 mm;
- Inner diameter 264 mm;
- Thickness 8mm
- Length 180 mm plate;
- Plate width 50 mm;
- Plate thickness 10 mm;

Figure 6. Sleeve

Sleeve, applied to the surface pipe is fixed with three screws Metric 16.

Pipe is tested again with the stretching force of 10 kN.

From the graphical representation is observed that the maximum stress was reduced to 2.1 N/mm2 and at the edge of the hole up to a maximum of 1 N/mm2.

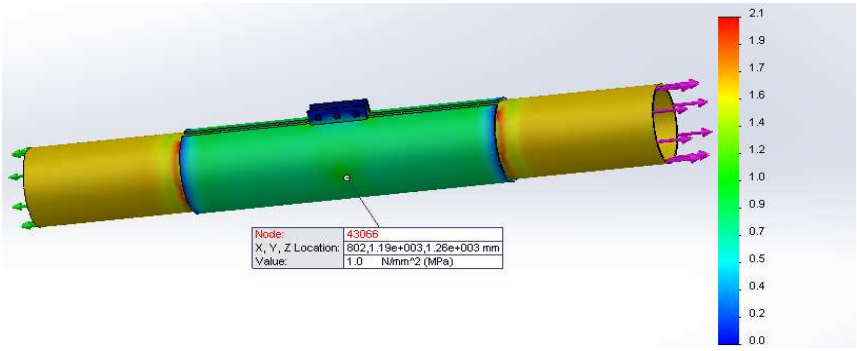

Figure 7. Stretching

For the bending test results following case:

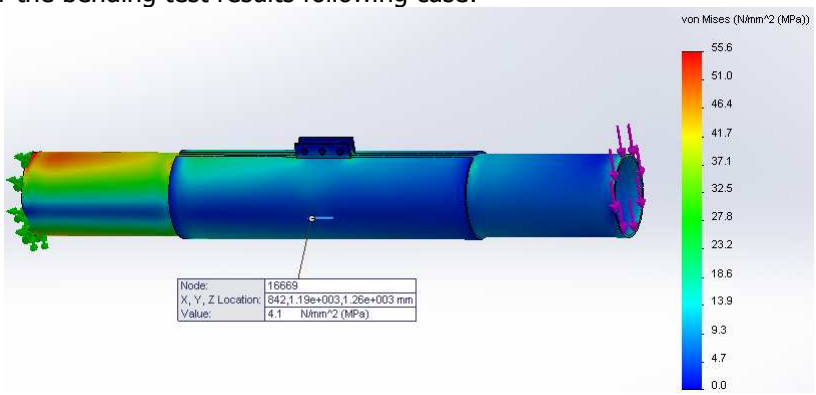

Figure 8. Bending test

After applying the cuff, stress occurs due to corrosion is reduced drastically from the value of 21.7 N/mm2 up to a maximum of 4.1 N/mm2.

The last test is the twisting of pipe-sleeve fitting.

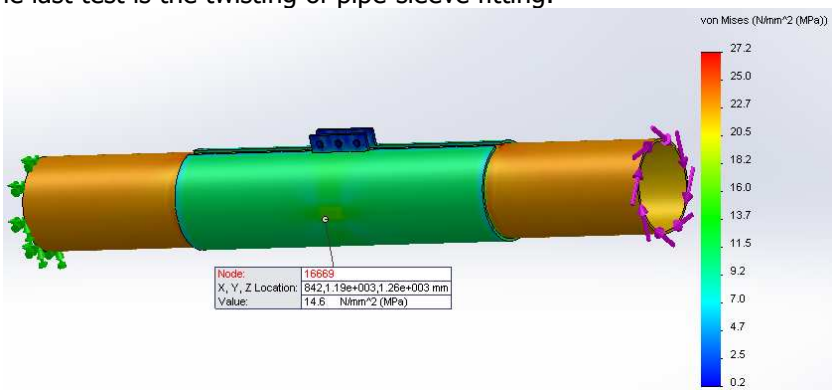

Figure 9. Twisting test

After the test a significant improvement in the strength of the assembly is observed. Maximum tension was reduced fro the value of 95.4 N/mm2 to that of 27.2 N/mm2. At the edge of the etched surface is only 14.6 N/mm2!

4. Conclusions

Calculations show the following: mechanical efforts in sleeve are inferior to an un-corroded, new pipe, similarly tested, which proves the viability of expected solution that can be approved. Calculations were made for extreme situations: perfectly rigid and elastic, real behavior lies between the two situations and is dependent on the strength and tightening of the screws, the pipe-sleeve friction, dependent on the roughness of the surfaces in contact, etc.

References

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