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ANALYSIS OF INTERNAL STRESSES IN WELDED JOINTS

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Abstract. *In some cases these devices repaired by welding exhibit residual stress due to welding heat cycle. The analysis of these voltages becomes necessary when one wants to ensure a good resistance part restored. A land drilling rig has a mast support composed of several structural pipes are repaired periodically using welding process. To analyze the total resistance of repair were evaluated three morphologies: Replacement volume, superimposed board and fill. With the objective of analyzing the internal stresses due to thermal cycle of rods welded held the tensile tests of the specimens soldiers and compared with the base metal. In order to evaluate this effect was numerically analyzed the points of stress concentration in specimens of the three morphologies employed apply finites elements. The results were consistent with the samples tested.*
Key words: *finite elements, WELDING, stress, tensile test*

1. INTRODUCTION

The incessant search for new energy sources and the oil exploration involves the continued use of drilling rigs (Fig. 1-a) in severe conditions of employment. The kinds of environments and severe operations conditions which the materials are exposed may cause the failure of the equipment by corrosion and the efforts of fatigue.

The cost for parts replace is a lot expensive. This fact make the welding repair a lot attractive solutions. After repair the poles, which form the structure of the probe, shown in Fig. 1-b, no one knows for sure the new mechanical proprieties of the repaired parts, which creates insecurities during the drilling. This uncertainty often results in reducing the burden that it operates, thus compromising the performance of drill work.

a)  b)

Figure 1: Images a) of a probe and b) the pole of the probe. (Oliveira, 2012)

The welding process with covered electrode constitutes a viable alternative for the recovery of pieces that suffered wear or faults in service (Still,1997).

The purpose of this study is to examine how the repairing with welding the probes poles can interfere with mechanical strength compared to the mast without repair. For this, three morphologies are used for repair were used to simulated steel tubing. They are extracted from the specimens of each tube is repaired and then made the tensile analyzes. Finite element simulations are performed on the same conditions of practical tests in order to verify the results obtained.

2. EXPERIMENTAL APPARATUS AND PROCEDURES

To perform the analysis, a tube similar to the tube structure of the drill rig is used, with an outside diameter of 152.4 mm and a thickness of 8 mm. The material of the steel pipe specification is unknown. A sample tube was analyzed in the laboratory to determine the chemical composition. The result of chemical analysis elements and their respective amounts (%) are shown in Table 1.

Table 1: Chemical composition

Elements	Results (%)
C	0,1852
S	0,0240
Al	0,0466
Cu	0,1158
Cr	0,0638
P	0,0126
Mn	1,2575
Mo	0,0174
Ni	0,0404
Si	0,4207

According to research Oliveira (2012), the probably tube material is SAE 1320 steel, which has a similar chemical composition. He also conducted tests to prove continuity of the solder in the pipes. And the tensile tests were done by a private company. The specimens followed the rules of ASME Section IX: 2010 - Boiler and Pressure Vessel Code, Section IX: Welding and Brazing Qualifications, Includes 2011 Addenda Reprint.

To simulate the potential problems that can occur on a mast in operation, different geometries are imposed on the tube. The first section reduction, represent in Figure 2 and Figure 3 a), to simulate the decrease in thickness due to corrosion. The second section represent a complete cut perpendicular to the tube, simulate the replacement of a mast section, is represent in Figure 3 b).

After preparation of section, the repair is made with fill of welding or applied another similar material of pipe also union through welding process. It is used AWS E7018-A1covered electrode with 2.5 mm diameter and welding current of 95 A.

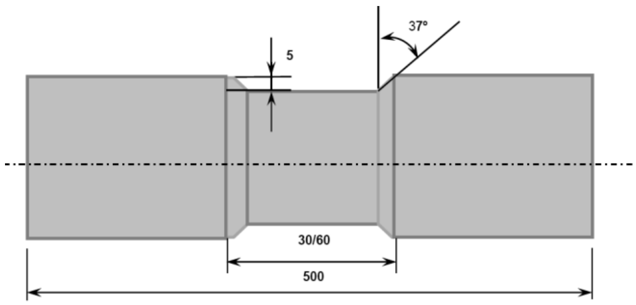

Figure 2: Base-metal test specimen 1 and 5- (30mm) and 2(60mm).

In the first case (FIG. 2), simulated corrosion problem, the joint were welded by coated electrode. In the second case was placed a section all about the machined part and filling done by welding (Fig. 3).

Five joints were made, combining the geometries repair used. To determine the tensile strength of the material base was also made one joint of reference without any change (Fig. 4).

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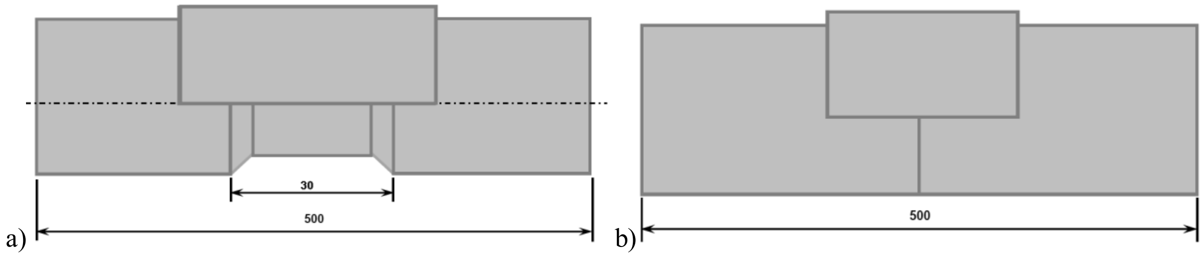

Figure 3: All-weld metal test specimen a) 3 and b) 4.

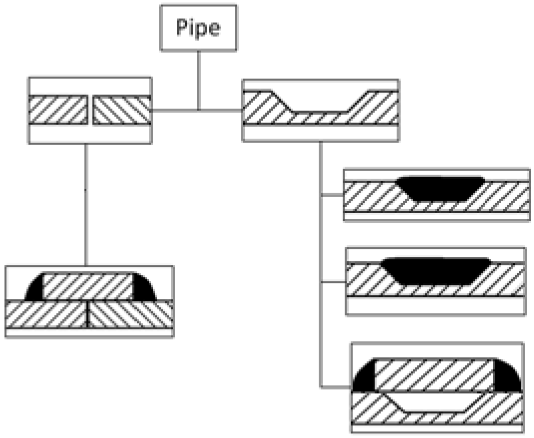

Figure 4: Specimens with different types of repair

The test pieces for the different joints were removed from welded joints for tensile resistance test. Figure 5, shows location the sample for analyze.

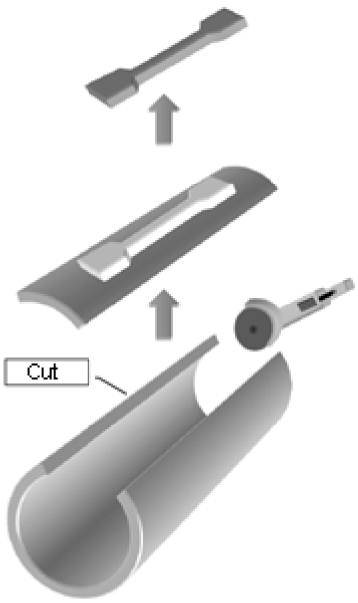

Figure 5: mode of preparation of the specimens of tubes

Computational simulation using the finite element analysis was used to perform the stress analysis of each sample, with the same parameters of the samples removed from the tubes repaired. In order to simplify the simulation was considered only the central portion of the specimen containing the smallest cross-section. In the tests was considered full penetration in specimens 1 and 2.

The properties used in the simulation are represent on Table 2. The average values from properties of the electrodes are represent on Table 3. This results are obtained from tensile test of the probe 5. The analysis with the aid of the program was performed using only the elastic phase analysis. Therefore the tension obtained does not show the tensile strength of the material subjected to the real tensile test.

Table 2: Mechanical properties of steel

Yield Strength (MPa)	Ultimate Strength (MPa)	Elongation (%)	Young Modulus (GPa)
405	530	26	1.56

Table 3: Mechanical properties of E7018-A1.

Yield Strength (MPa)	Ultimate Strength (MPa)	Elongation (%)	Young Modulus (GPa)
465	575	26	2.25

3. RESULTS AND DISCUSSION

The Figures 6, 7, 8 and 9 represent simulations traction refer to probes 1, 2, 3, and 4, respectively. The No. 5 test piece was used to analyze the mechanical properties of the material. In these simulations the red represents the highest stress intensity obtained. The reduction in stress intensity is represented by a gradual change to blue.

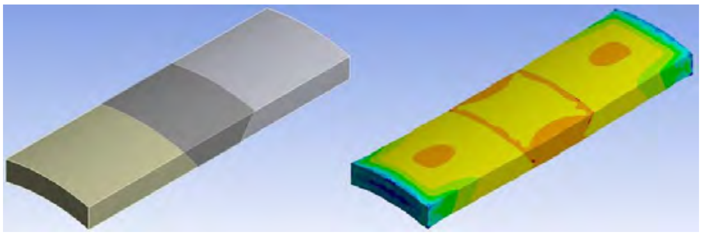

Figure 6: Traction simulation for probe 1

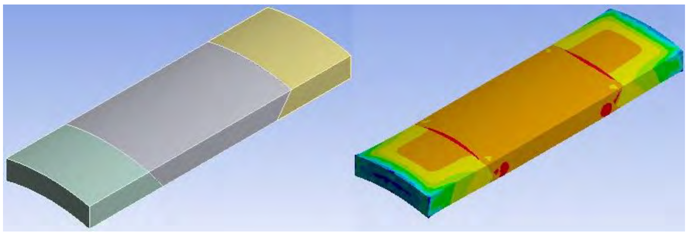

Figure 7: Traction simulation for probe 2

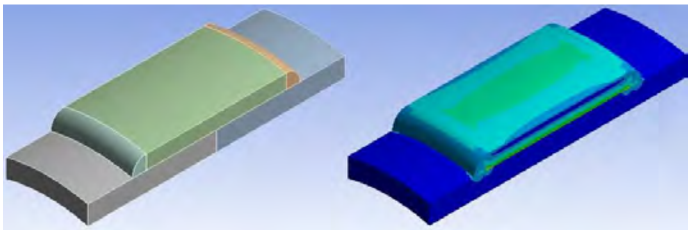

Figure 8: Traction simulation for probe 3

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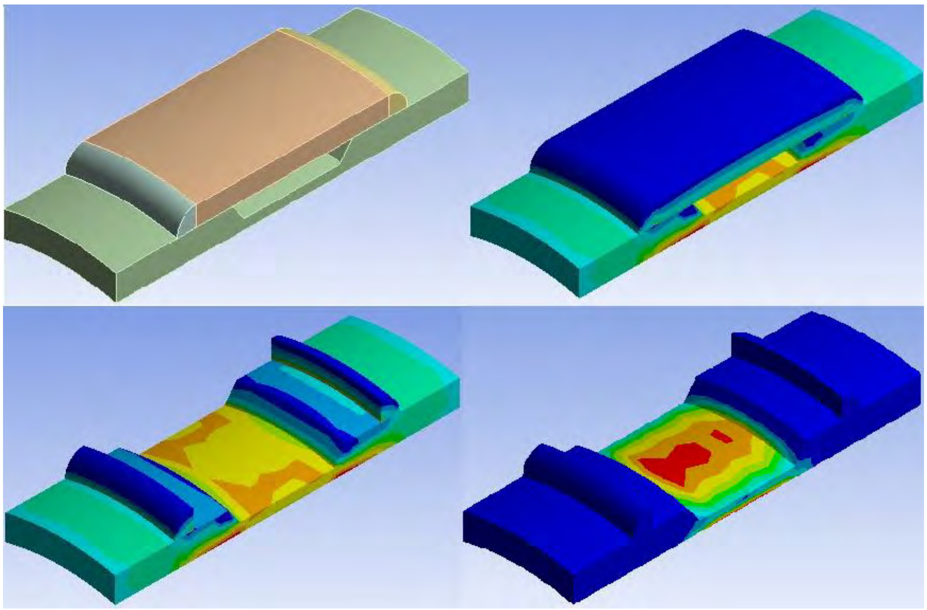

Figure 9: Traction simulation for probe 4

The probe 5, which is originated from the tube that has not changed, obtained a tensile strength of 530 MPa in tensile test. The Figure 10 represent de probe after the test. These tensile test were performed by Oliveira (2012).

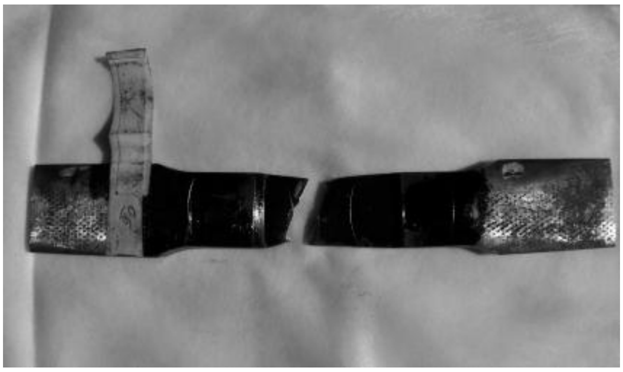

Figure 10: Results of the tensile test - sample 5 (Oliveira, 2012)

The result of the tensile test performed on specimen 1, which has the union only weld two pipes, demonstrates that the welding process did not negatively affect the mechanical properties of the mast. The stress at the time of fracture is 605 MPa. Furthermore, it is noted that the break occurred away from the weld (Figure 11).

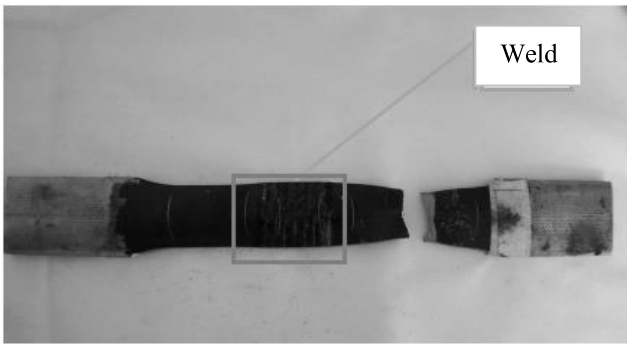

Figure 11: Results of the tensile test - sample 1. (Oliveira, 2012)

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In the second probe (Fig 12) was obtained a value of 607 MPa as tensile strength. The location that the breakage also located away from the weld.

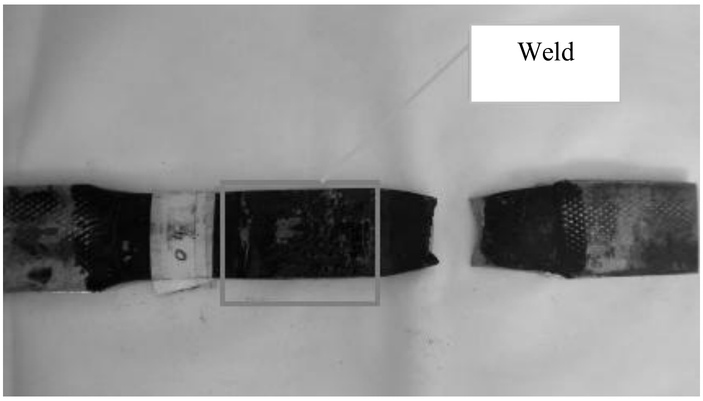

Figure 12: Results of the tensile test - sample 2 (Oliveira, 2012)

The break in the weld also occurred in probe 3 (Fig. 13), which broke at 246 MPa. The low stress value obtained in this essay is justified by the way it was mounted repair. In this case, only the weld bead is responsible for supporting the entire load. In addition, the load in the axial direction of the tube causes a shear stress of the weld fillet.

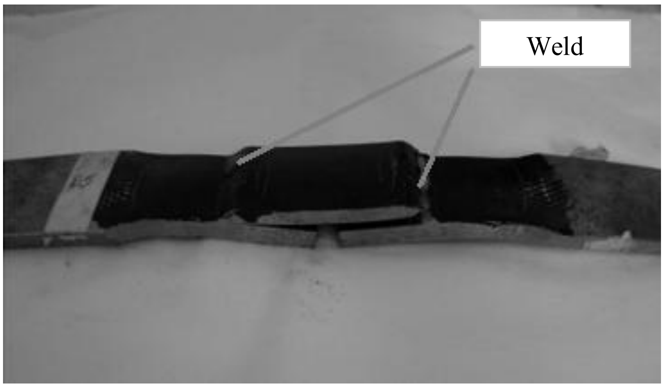

Figure 13: Corpo de prova 3. (Oliveira, 2012)

The probe 4 (Fig. 14) fractured at a stress of 536 MPa. The rupture of the material occurred exactly in the weld bead. The rupture of the weld in this case is due to the geometry formed, machined below the region where the tube was not filled by welding causing a buildup of tension in the weld bead.

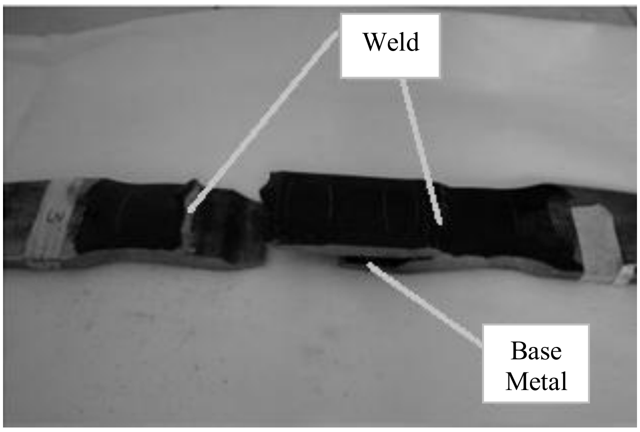

Figure 14: Results of the tensile test - sample 4 (Oliveira, 2012)

In this case one can establish a relation between the load supported by the weld bead and the equivalent load that the pipe supports in pure traction loading. Considering the area shear stress is equal to the thickness of the weld fillet and being Scs the limit shear stress supported by the filled metal, we can establish a relation to determine the thickness H of the weld fillet. As the radius r and R, respectively inner and outer radius of the tube, the cross sectional area At, and the limit of tensile strength of the tube material Lt, we can calculate the thickness of the weld bead so that the final construct possesses the same load resistance traction a tube without repair. Were disconsidered the thermal effects caused by welding.

According Budynas and Nisbett (2008), the shear stress is given by the ratio of charge over the area sheared:

$$\tau = {}^{P}/_{As}$$

The strain resulting from the traction loading is a function of the applied load and the area of cross section:

$$Lt = {}^{P}/_{At}$$

The shear stress is proportional to the maximum tensile strength for steels in general:

$$Scs = 0.577 * Lt$$

$$\frac{P}{As} = 0.577 * \frac{P}{At}$$

$$\frac{At}{As} = 0.577$$

$$\pi * (R^2 - r^2) /_{2 * \pi * R * H} = 0.577$$

Then, the required thickness of the weld bead can be written as:

$$H = \left({}^{1}/_{2} * R\right) * (R^2 - r^2)$$

4. CONCLUSIONS

Through finite element analysis of the probe welded can predict the breaking point with good accuracy.
Considering the welding procedures adopted realize that the repair of the pipe drilling rigs can be accomplished by the methods applied where the tension values obtained in the specimens soldiers was higher in the test specimen without preparation.

5. REFERENCES

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