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DETERMINATION OF GRAIN SIZE AND RESISTANCE TO CORROSION OF STAINLESS STEEL WELDED PIPES

Pavel Hudeček[1], Petr Dostál[1]

[1]Department of Technology and Automobile Transport, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

Abstract

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Discover problems of welds is not so easy from time to time. Specially, If welding was made in rough environmental conditions such as high temperature, humidity and dusty wind. It is necessary to provide good conditions to realize basic step of welding. For welding, have been used welding procedures specification and procedure qualification record. However, difficult conditions, documentations rightness or human errors are always here. Common weld defects like cracks, porosity, lack of penetration and distortion can compromise the strength of the base metal, as well as the integrity of the weld. According of site inspection, there were suspicion of intercrystalline corrosion, inclusions, leaker or segregation in root of weld, root weld stretches to the pipe inside, the welded pipes are not in axially level, the not proper surface treatment after welding and keep the intervals between single welds to not overheat the pipes.

Keywords: deficiencies, microstructure, grain boundaries, plugged surface, weld joint

INTRODUCTION

The microstructure of metals and alloys is made up of grains, separated by grain boundaries. Intergranular corrosion is localized attack along the grain boundaries, or immediately adjacent to grain boundaries, while the bulk of the grains remain largely unaffected. This form of corrosion is usually associated with chemical segregation effects (impurities have a tendency to be enriched at grain boundaries) or specific phases precipitated on the grain boundaries. Such precipitation can produce zones of reduced corrosion resistance in the immediate vicinity (NACE, 2015).

Intergranular corrosion and stress corrosion cracking of stainless-steel have occurred in a number of industrial applications. Many of these failures have been correctly attributed sensitization of steel. Sensitization is a term used to describe the depletion chromium along grain boundaries that occurs as a result of the growth of chromium-rich carbides (Briant C. L., 1988).

This shows that codes and standards created by the American Welding Society specify exactly how a joint must look when the job is accomplished. Depending on the usage, societies may have a say in the project for example American Society of Mechanical Engineers (ASME), the American Petroleum Institute (API), and the American Society for Nondestructive Testing (ASNT).

Code standards for welding the finished shape, sizes and extent of any anomalies in the end weld. A one crack is considered as a defect, automatically failing an inspection. The following problems should accrued:

- human irresponsibility or errors
- bad welding condition or preparation
- poor joint design or fit-up
- incorrect settings or a machine deficiency
- wrong shielding gas or flow rate
- inadequate pre or post-heat treatment
- using the wrong (or a defective) rod /wire
- a hot or cold ambient temperature, high humidity, or other atmospheric condition

MATERIAL AND METHODS

The goal of testing in this paper was to compare samples. Samples were tested to discover problems by laboratory. As show figures 1, 2, 3 and 4, defects were occurred. The pipeline is for firefighting in Iraq's refinery. The water contains chloride according of water analysis.

- Determination of grain size
- Determination of resistance to corrosion

Tubes 88,9 × 3,05 and 88,9 × 3,05

Material ASTM A 312 – TP316L and ASTM A 312 – TP316L

Welding method 141 + 111

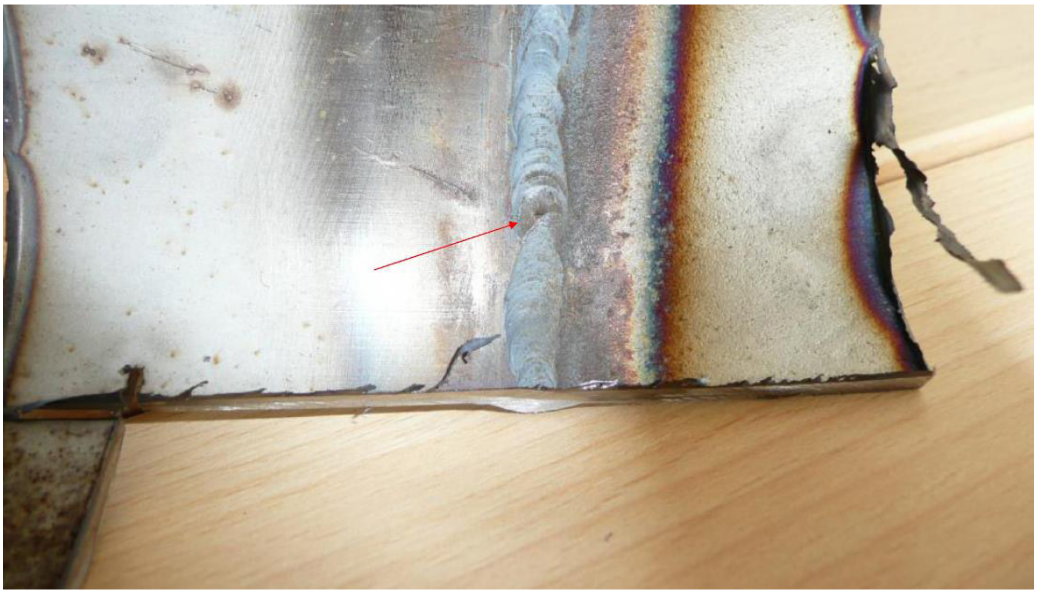
The experimental

The tube with a joint indicated as J3, J5 and elbow, see Fig. 5 and 6. The sample of tube was handed over for analysis. On the weld joint and vicinity were found deficiencies of surface, black spots (see Fig. 5, 6, 7 and 8) and plugged surface near weld joint (Fig. 9).

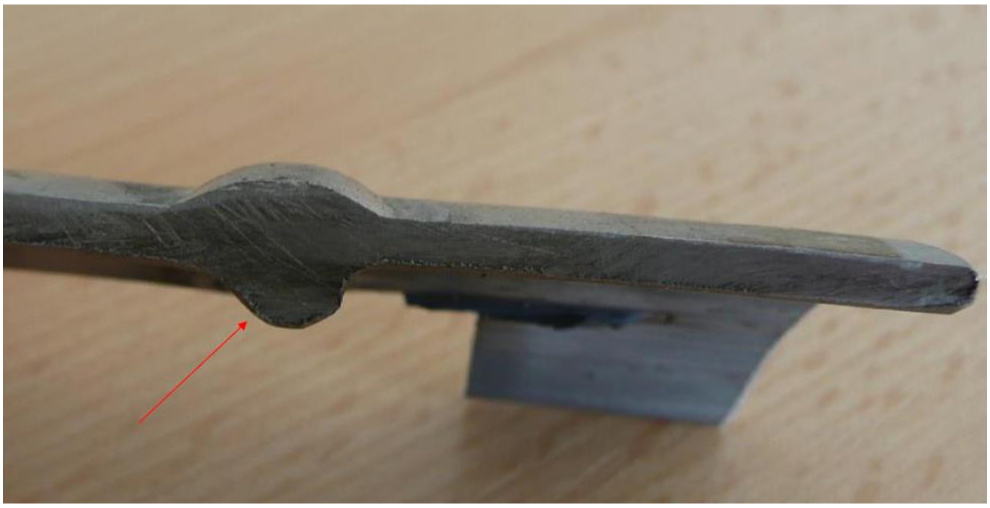
For the identification of the joint and tube external surface defects in zones in Fig. 5, 6 and 7, + cross cuts were made in these zones indicated as sample 1-J3, sample 1-J5 and sample 1-elbow. Samples 1 are for microstructure. Samples are c. 35 mm long.

Test of resistance to intercrystalline corrosion according to ČSN EN ISO 3651-2

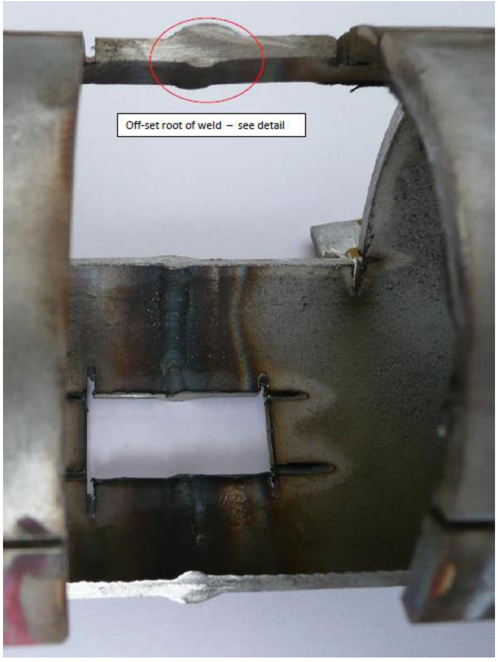
The test was conducted according of A method at the tube cut of 50 × 80 mm. There was a metallographic assessment at the cut of 35 mm. The exposure time was 20 hours. No deepening of intercrystalline corrosion, which was indicated in the TOO joint, was detected.



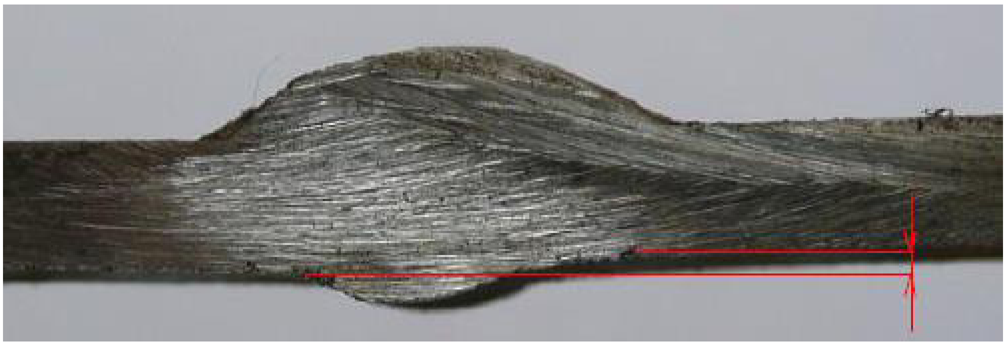
1: *Leaker or segregation in root of weld*



2: *Internal protrusion in root of weld*



3: *Off-set root of weld*

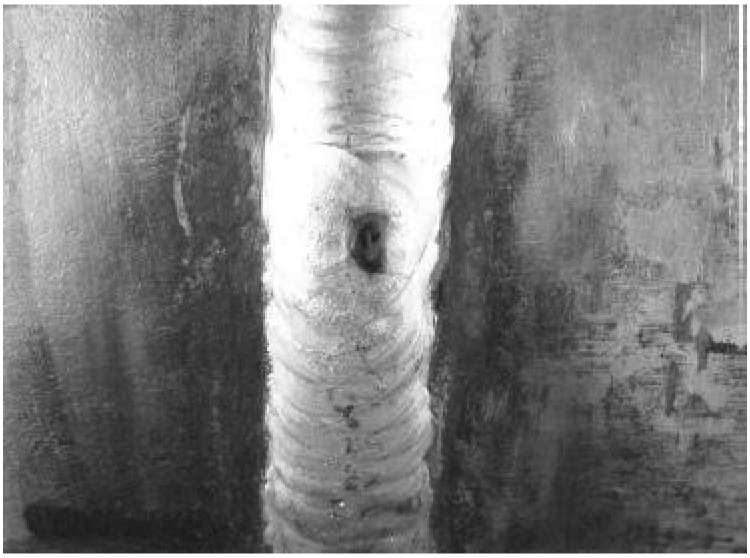


4: *Detail Off-set root of weld*

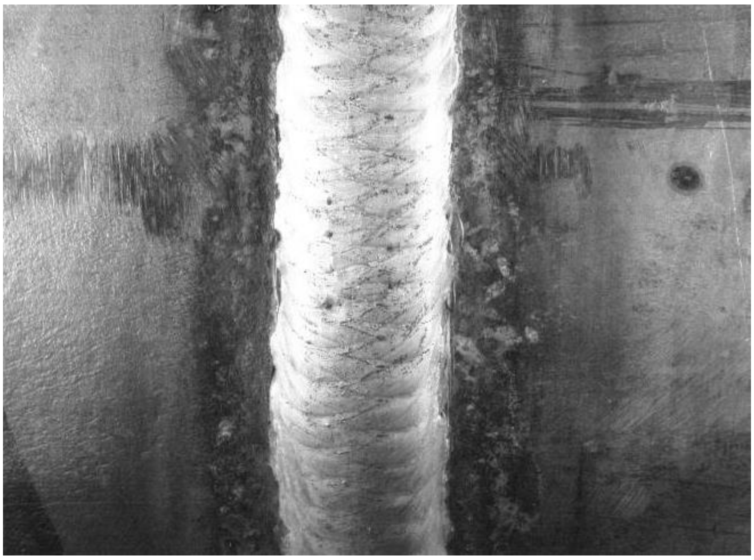
5: *Tube sample J3*

6: *Tube sample J5*

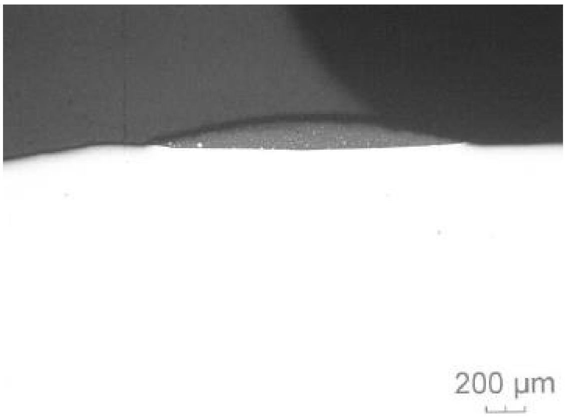
7: *Elbow sample*

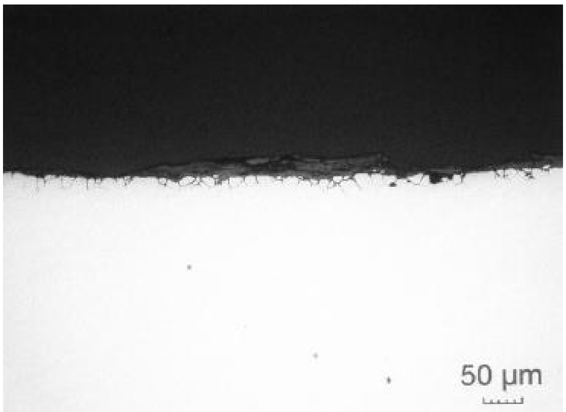


8: *Deficiencies of surface and black spot sample 1 - JR3*

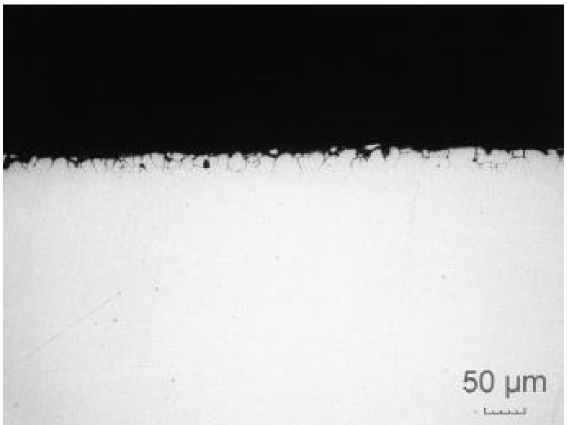


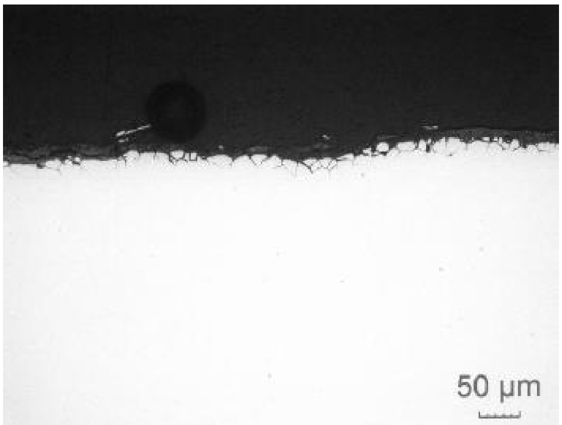
9: *Plugged surface near weld joint*



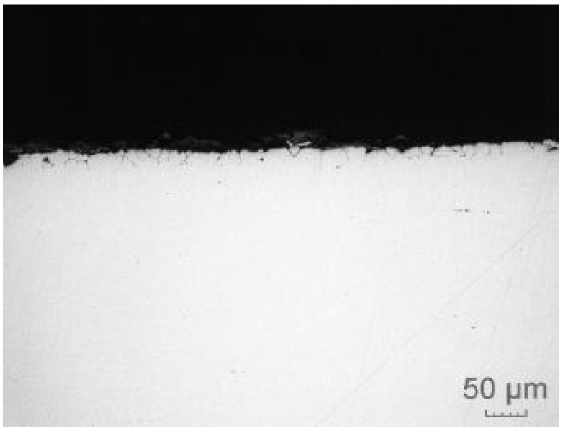


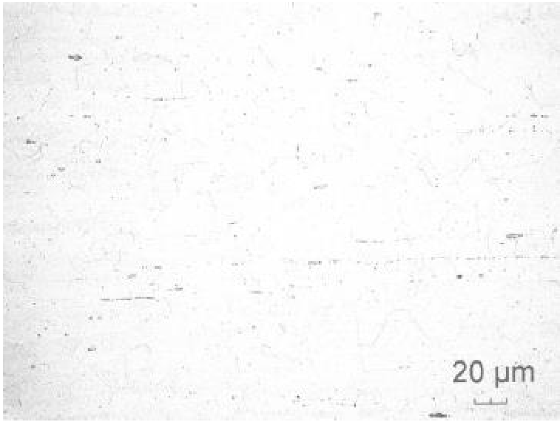
10: *Sample 1 50:1 not etched*
11: *Sample 1-J3 200:1 HAZ on the left – not etched*



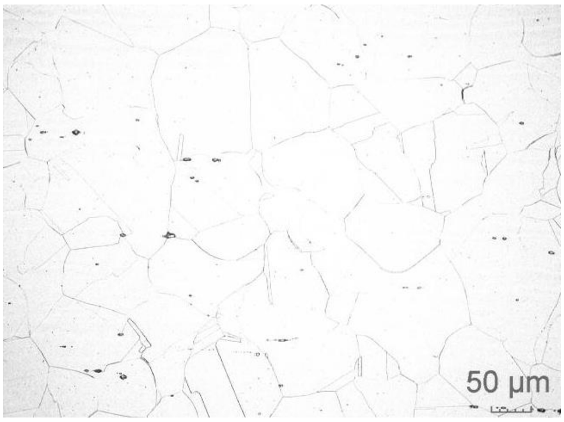


12: *Sample 1-J5 200:1 HAZ on the left– not etched*
13: *Sample 1-J3 200:1 HAZ on the right – not etched*

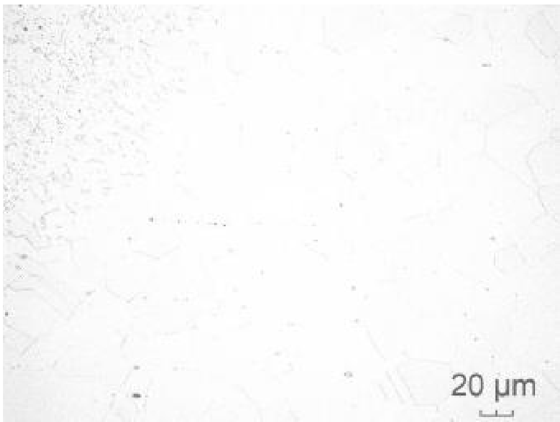




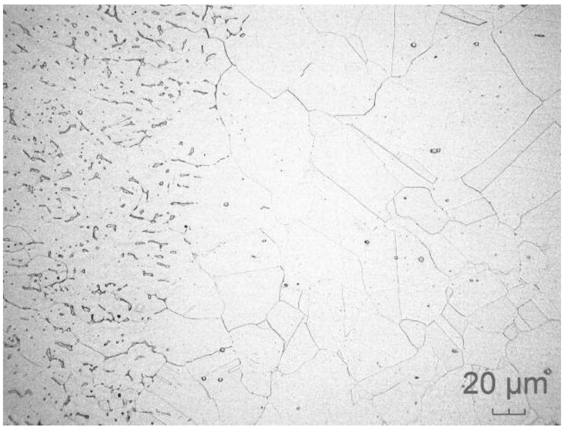
14: *Sample 1-J5 200:1 HAZ on the right – not etched*
15: *Sample 1-J3 400:1 Base material* HNO_3, *HCl*

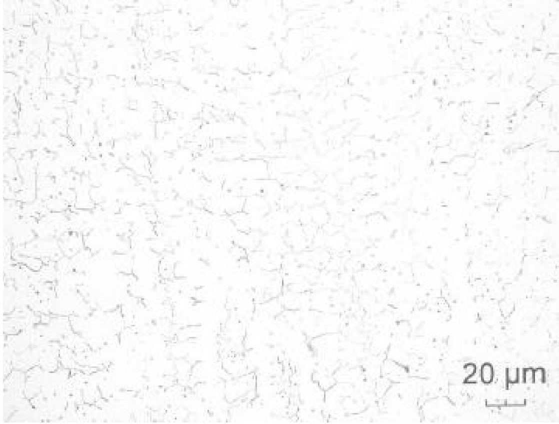


16: *Sample 1-J5 400:1 Base material* HNO_3, *HCl*
17: *Sample 1-elbow 200:1 Base material* HNO_3, *HCl*

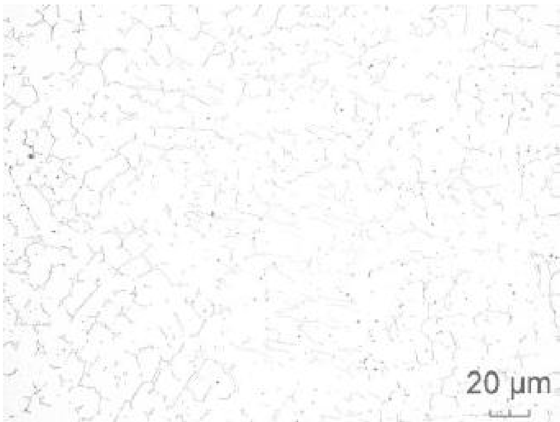


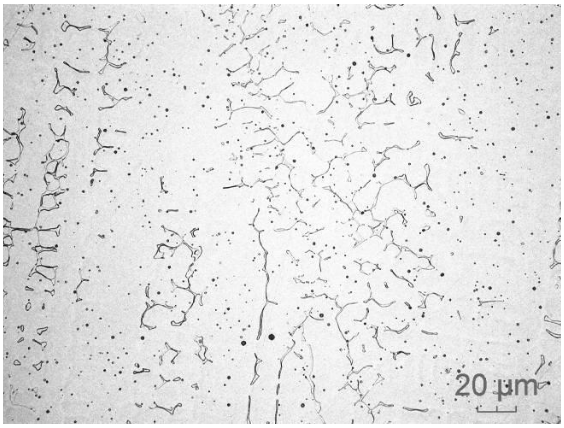
18: *Sample 1-J3 400:1 Base material HAZ* HNO_3, *HCl*
19: *Sample 1-J5 400:1 Base material HAZ* HNO_3, *HCl*



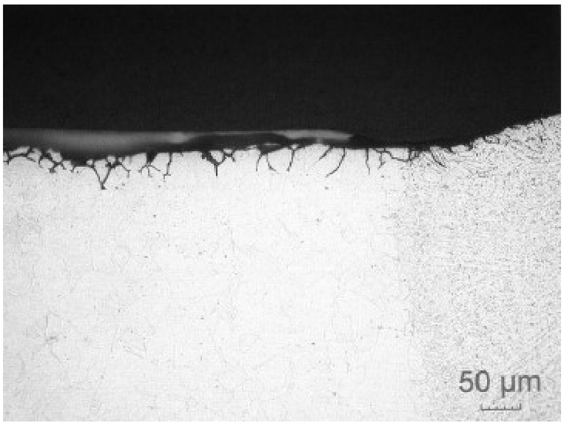


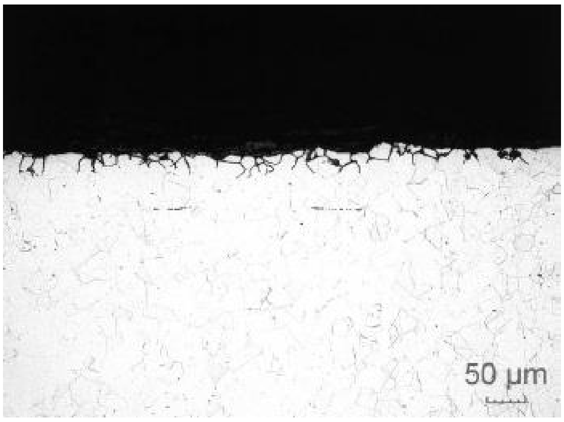
20: *Sample 1 - elbow 400:1 Base material HAZ HNO_3, HCl*
21: *Sample 1-J3 400:1 Weld metal HNO_3, HCl*



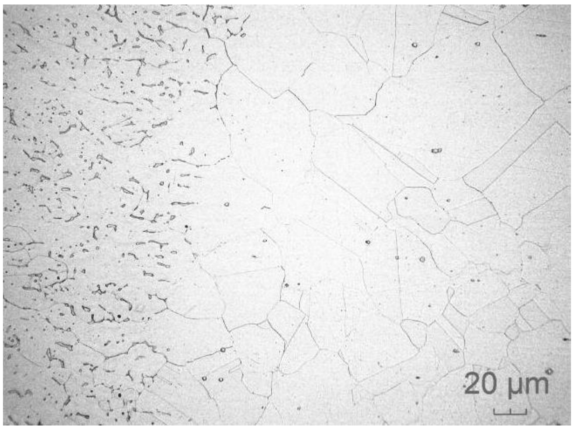


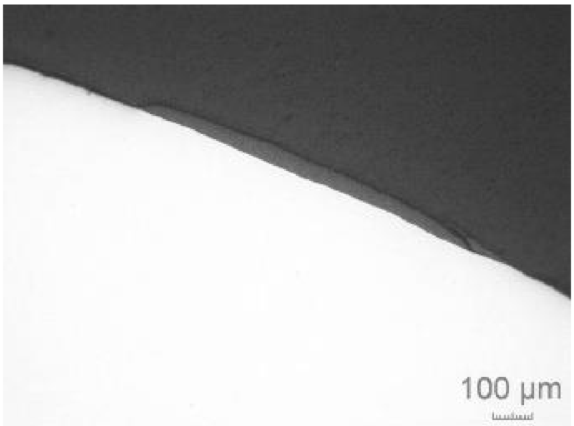
22: *Sample 1-J5 400:1 Weld metal HNO_3, HCl*
23: *Sample 1-elbow 400:1 Weld metal HNO_3, HCl*





24: *Sample 1-J3 200:1 Base material- HAZ HNO_3, HCl*
25: *Sample 1-J5 200:1 Base material- HAZ HNO_3, HCl*





26: *Sample 1-elbow 400:1 Base material- HAZ HNO_3, HCl*

27: *Sample 1-elbow not etched 100:1*

RESULTS AND DISCUSSION

Sample 1-J3

On this sample, i.e. the cut through the zone from Fig. 5 an adhered particle of slag was indicated on the joint surface. It is obvious in the Fig. 10, Fig. 11 and 13 there are parts of heat affected joint zones. Fig. 6 the damage of tube surface along the grain boundary is visible – intercrystalline corrosion which reaches the depth of 0. 03 mm. The width of these zones is 2.0 mm on the left (reaches 0.3 mm to the joint) and 1.8 mm on the right side. The damage of surface TOO on the left side and the damage of the joint part in the etched specimen is in the Fig. 24.

The joint microstructure in this zone is in Fig. 15, 18 and 21. The base material has an austenitic structure with lines of δ-ferrite, grain size G = 6-7, in the heat affected zone Gmax = 4. The structure of weld joint is austenitic with δ-ferrite.

Sample 1-J5

There is a surface damage, which reaches the depth of 0.03 mm along the grain boundary - intercrystalline corrosion. The width of these zones is 2.0 mm (front end from the joint toe in the distance of 1,2 mm) on the left and 2,8 mm (front end from the joint toe in the distance of 1,8 mm). The damage of surface in the heat effected joint zone in the etched state is in the Fig. 25. The joint microstructure in this zone is in Fig. 14, 19 and 22. The base material has an austenitic structure with lines of δ-ferrite, grain size G = 6-7, in the heat affected zone Gmax = 4. The structure of weld joint is austenitic with δ-ferrite.

Sample 1-elbow

The sample, the cut through zone Fig. 7 no damage of surface TOO was detected. The joint microstructure in this zone is in Fig. 23–28. The joint microstructure in this zone is in Fig. 17, 20 and 23. The base material has an austenitic structure with lines of δ-ferrite, grain size Gmax = 3, in the heat affected zone Gmax = 4. The structure of weld joint is austenitic with δ-ferrite. In the joint a slag inclusion of 0,9 mm was found out Fig. 28.

CONCLUSION

All of the tested samples were investigated and tested of determination grain size and resistance to corrosion. According of testing and analysing the microstructures ssamples and those joint metals are not affected or damaged by an adhered particle of slag on the joint surface. The samples 1-J3 and 1-J5 are damaged along the grain boundary intercrystalline corrosion. The sample 1-elbow the surface was not detected and joint metal is not affected or damaged by slag inclusion. Internal protrusion in root of weld is still in the limit according of standards and strength is no touched.

Acknowledgement

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Contact information

Pavel Hudeček: xhudecek@node.mendelu.cz