HARDNESS DISTRIBUTION ON WELD PASS START AND STOP OF PROPANE/BUTANE HOUSHOLD PRESSURE VESSEL

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Abstract

The problem of weakening due to non-stationarity on the beginning and the end of the weld is especially dangerous on pressure vessels. At materials with lower weldability like the fine grained high strength steel type it is possible to point out to this problem by simple measurement and comparison of hardness on the weld pass start and stop and on the point that has an enough distance from both (weld pass start and stop). In this paper the presence of differences between hardness on the weld start and the point that has a enough distance from the circular weld pass start and stop wished to be researched.

1. INTRODUCTION

The problem of weakening on the weld pass start and stop is known from the beginning of the welding technology application. In the beginning, this problem was tried to avoid by application of entrance/exit (extended) plates. Were there is a possibility e.g. for performing a longitudinal welds on cylindrical part of pressure vessels, this technique is also used today. But, there are situations where the weakening problem on the weld pass start and stop can not be easily avoided e.g. while performing circular weld pass at pressure vessels, during reappear welding at certain distance from the plate end etc.

The weakening problem itself is mostly generated from the fact that on the weld pass start and stop there is a distinct non-stationarity of temperature field. In the other words, there is an unbalance between heat input and output on the welding spot. On the point with enough distance from the weld start and stop a balance between heat input and output occur, and so there is a quasi-stationary state in which the uniform mechanical properties of weld joint can be expected. This problem is partially investigated at fine grained high strength steels, so this paper address to steels used for production of propane/butane pressure vessels used in household.

2. DESCRIPTION OF PROPANE/BUTANE VESSEL USED IN HOUSEHOLD

Today, many of the households use propane/butane pressure vessel, regardless to the fact that they have or not access to natural gas. Application of propane/butane gas mixture in this way has a range of advantages that consumers have recognized and massively utilized. Different types of propane/butane pressure vessels (bottles) used in household, with different nominal capacity (capacity of liquefied propane-butane storage) are shown on figure 1.

Figure 1. Propane-butane pressure vessels for household with different capacity

Propane/butane bottle (pressure vessel) is compound of following parts [2]:

1. Pressure vessel “body” (R St 37.2 / Č.1216)
2. “Foot” (Č.0146)
3. Implant (Č.0361)
4. Valve
5. Valve protector (Č.0146).

The main part of propane-butane pressure vessel is pressure vessel «body». In table 1 the chemical composition of base material from, which the pressure vessel «body» is made from, and associate mechanical properties are shown. Pressure vessel body is compound of two parts made by deep drawing technique, and welded by SAW (Submerged Arc Welding) process. The view of welded joint is shown on figure 2.

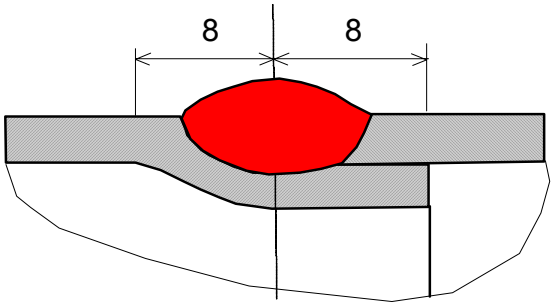

Figure 2. The view of circular weld on pressure vessel body

Table 1. Chemical composition and mechanical properties of base metal R St 37.2 [1]

Chemical element	C_{max}	Si_{max}	Mn	P_{max}	S_{max}	Al_{max}
Composition	0,16	0,1	0,35-0,55	0,035	0,035	0,02
$R_{e\ min}$ = 250 MPa						
R_m = 350-400 MPa $R_{e\ min}/R_m$ = 0,625 - 0,71 MPa						
A_5 = 22-27%						

Propane-butane pressure vessels are designed for working pressure of maximally 16 bars, while the testing pressure is 25 bars. The wall thickness of pressure vessel is 2,5 mm. In automated high serial production process, the production and control activities that have the goal to accomplish quality of welded pressure vessels are clearly defined. One of the activities for control and quality assurance is pressure test until destruction, performed on every 1000th produced vessel. On figure 3 one propane/butane pressure vessel after pressure test until destruction is shown.

Figure 3. The view of propane/butane pressure vessel (nominal capacity of 10 kg) after pressure test

As a part of this investigation the thesis of difference in hardness on the SAW weld pass start and on the point that has an enough distance from weld pass start is set. That could have influence on the fact that the fracture of pressure test specimen is often on the weld pass start and stop. This assumption of possible differences in hardness is initiated due to previous experiences from experimental research of fine grained high strength steel types, at which that effect is noted, although that is a completely different material group.

3. HARDNESS MEASUREMENTS ALONG FUSION LINE ON HAZ SIDE FROM THE WELD PASS START TO THE MIDDLE OF THE WELD ON THE PROPANE/BUTANE PRESSURE VESSEL

3.1. Plan of experiment

In the regular production of the propane/butane pressure vessel the one half of circular weld joint on the propane/butane pressure vessel is performed, where the spot of the weld start with characteristic view of temperature field on the weld pass start can be observed (figure 4).

Welding is performed with SAW process with welding parameters used in regular pressure vessel production. After welding process, the specimens are cut out (figure 5) for hardness test HV1, so the progress of hardness on the weld pass start and on the given distance from the weld start is determined. Hardness is measured in sequences

A to F, on different distance from the weld pass start (5; 9,5; 15; 40; 79 and 115 mm from the weld pass start).

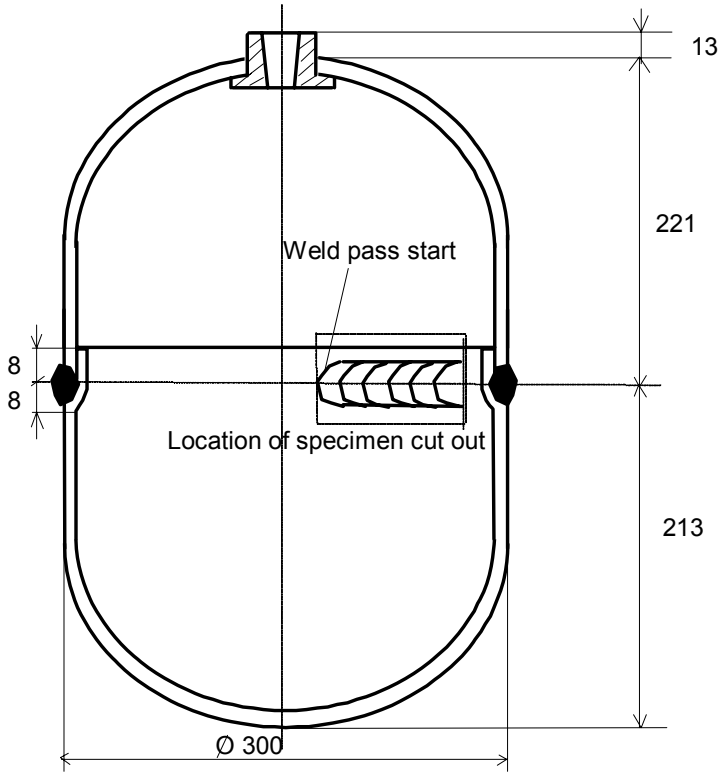

Figure 4. Experimental welding of ½ pressure vessel body, and location of hardness specimens cut out

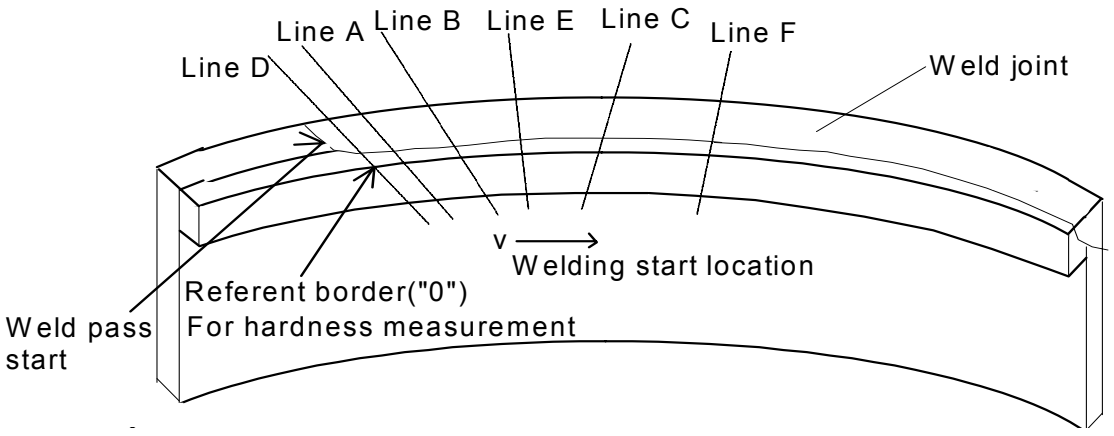

Figure 5. The locations of hardness HV1 measurement on the specimen cut out from the circular pressure vessel weld joint

3.2. Experiment results

After hardness HV1 measurement on the locations as it is shown on figure 4, the hardness HV1 values are obtained and presented on following figures.

Referent border from which hardness measurement starts is shown on figure 5 (inner side of the joint border).

On figure 12 the macro section and microstructure of individual weld joint zones are shown for the weld start on the propane – butane pressure vessel circular joint.

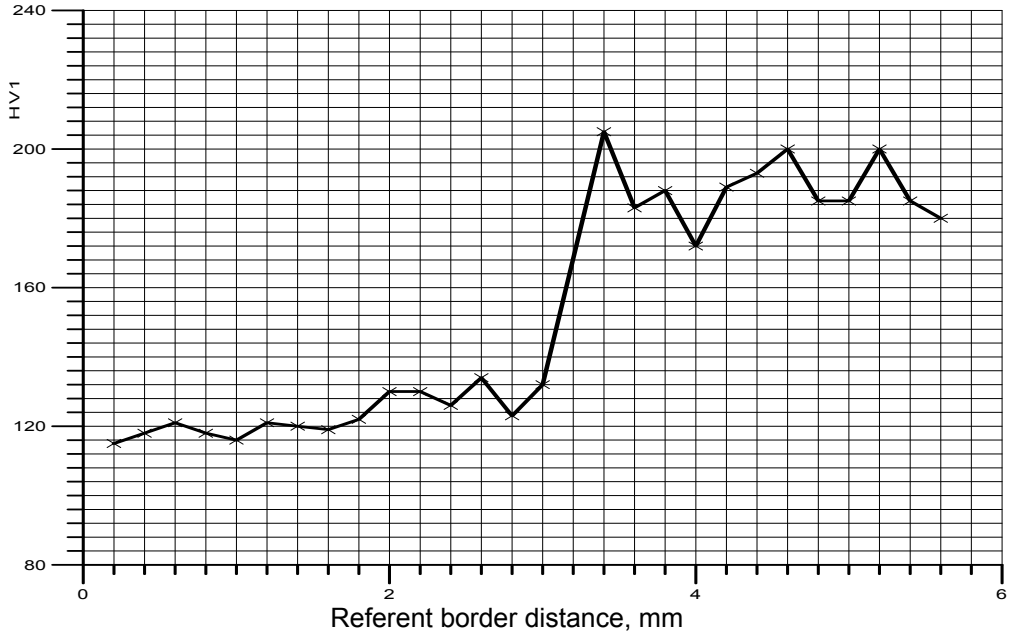

Figure 6. HV1 hardness on the 5 mm distance from the weld pass start (line D)

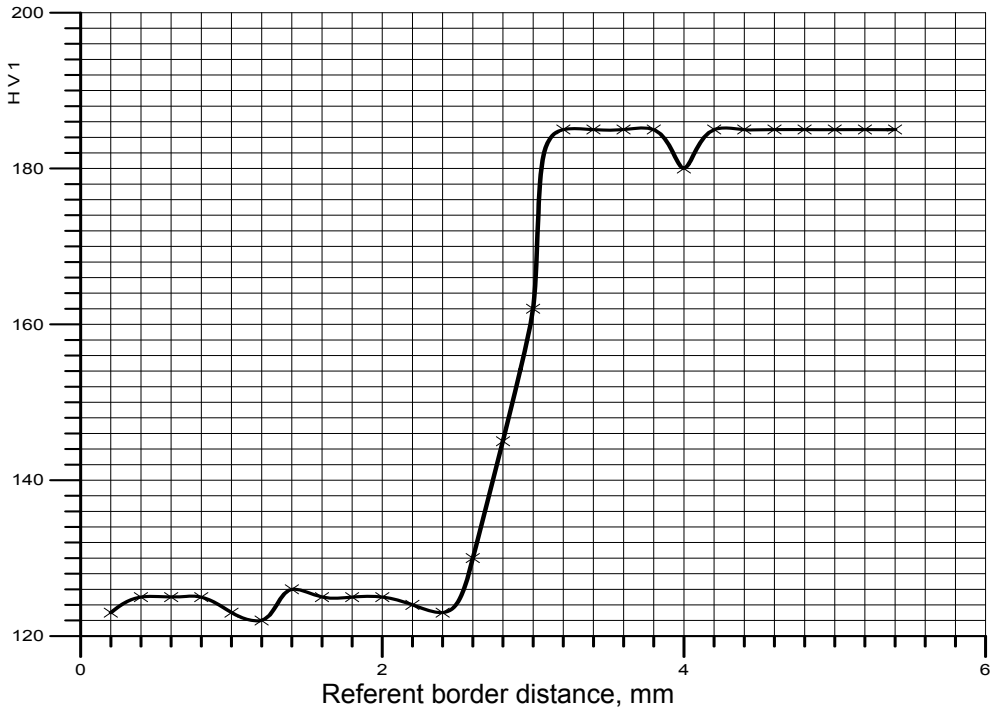

Figure 7. HV1 hardness on the 9,5 mm distance from the weld pass start (line A)

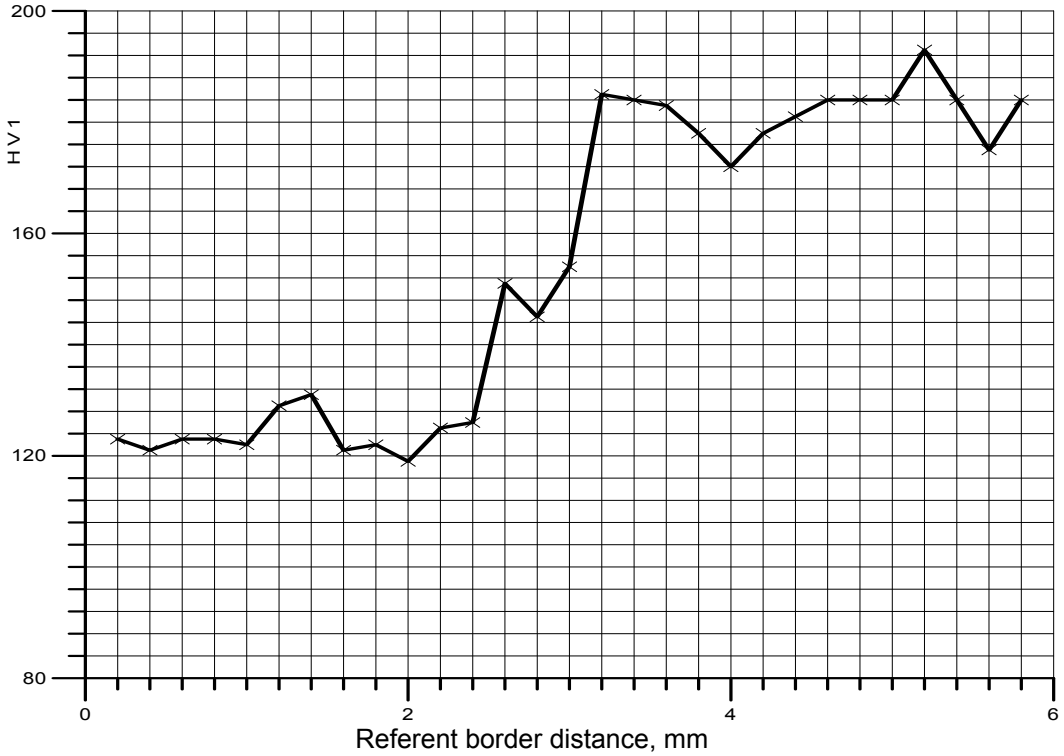

Figure 8. HV1 hardness on the 15 mm distance from the weld pass start (line B)

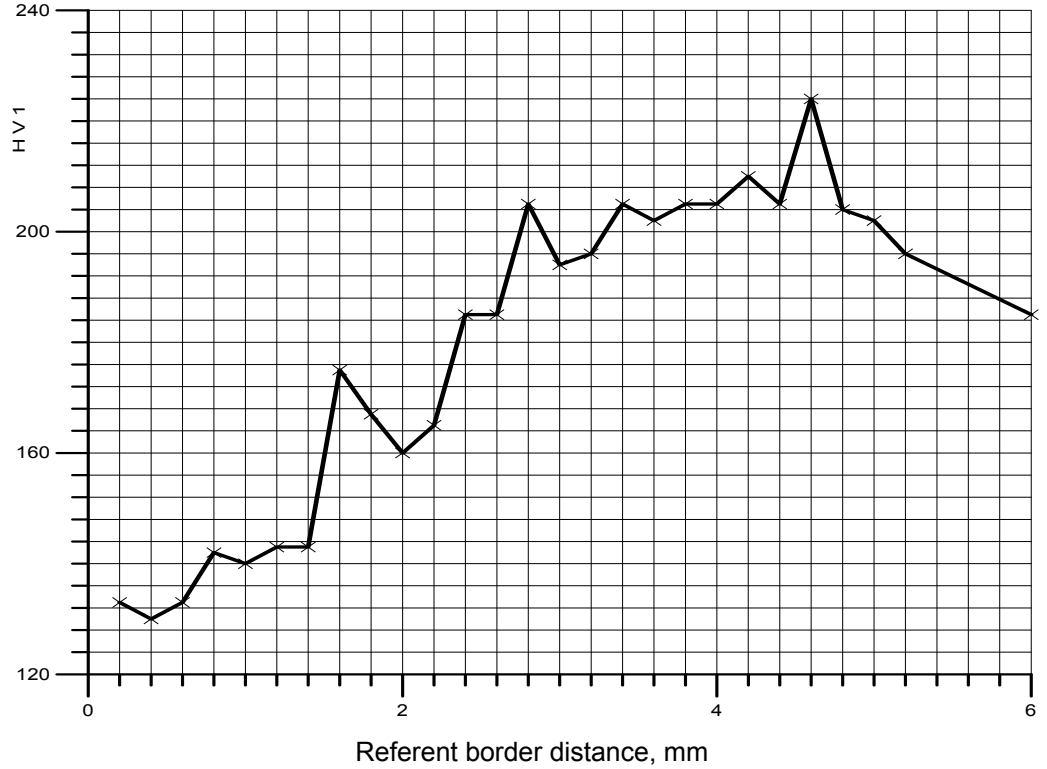

Figure 9. HV1 hardness on the 40 mm distance from the weld pass start (line E)

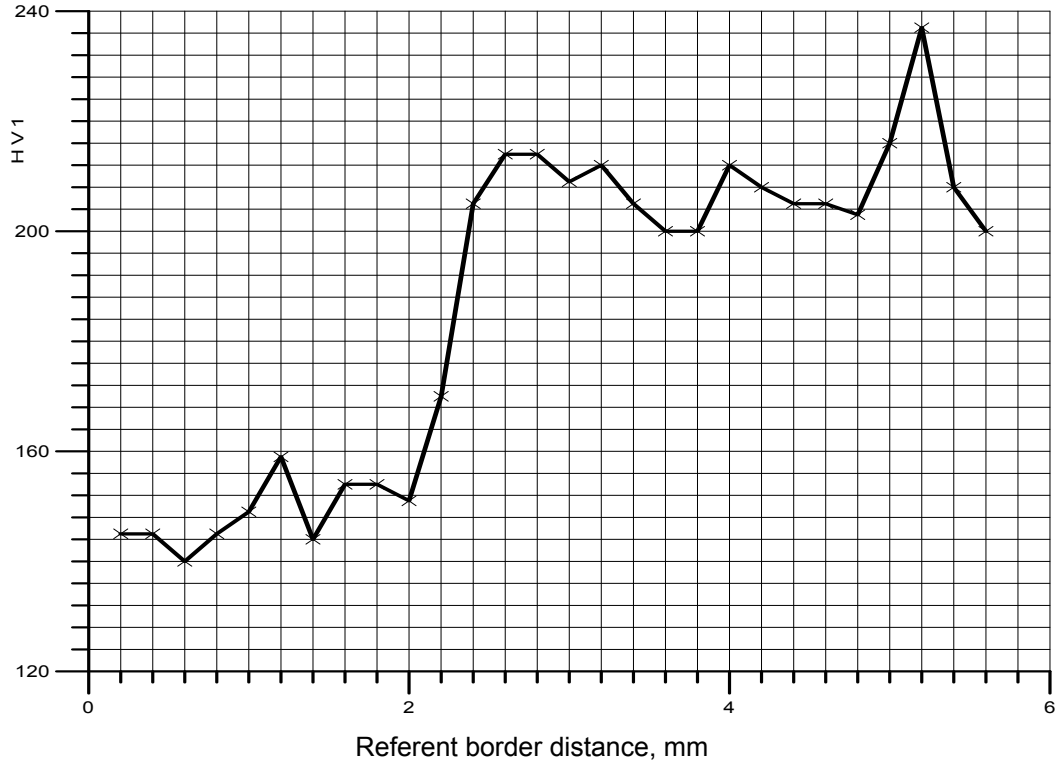

Figure 10. HV1 hardness on the 79 mm distance from the weld pass start (line C)

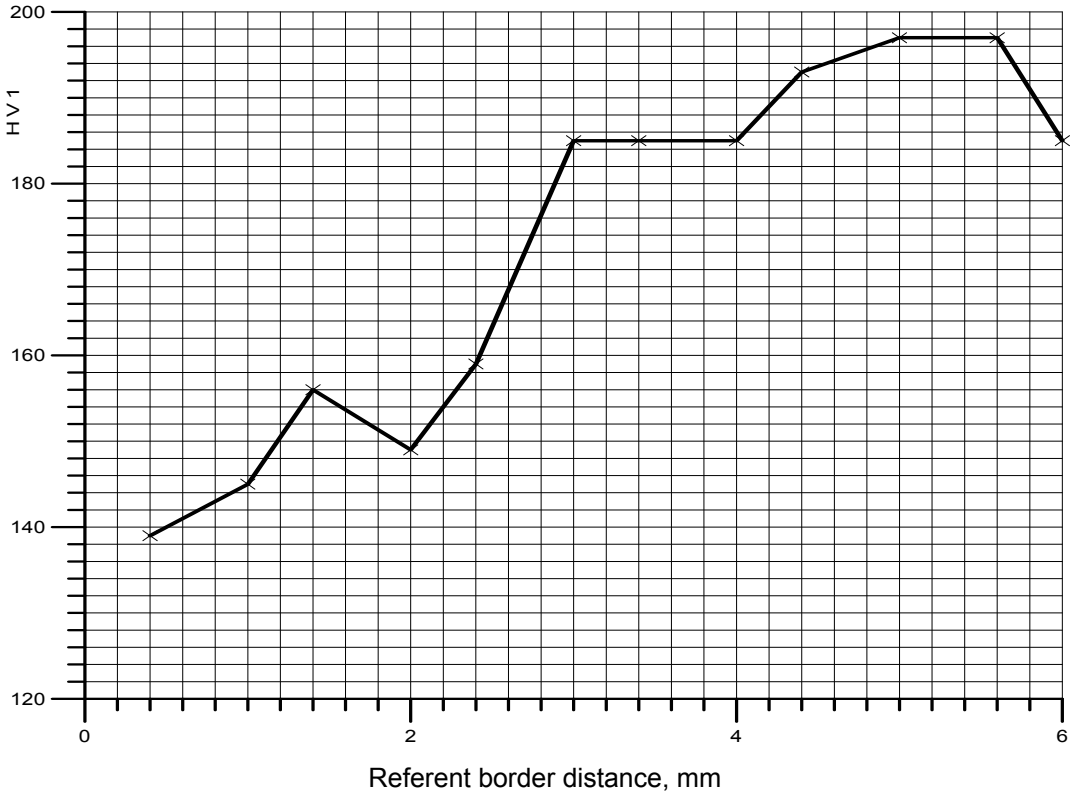

Figure 11. HV1 hardness on the 115 mm distance from the weld pass start (line F)

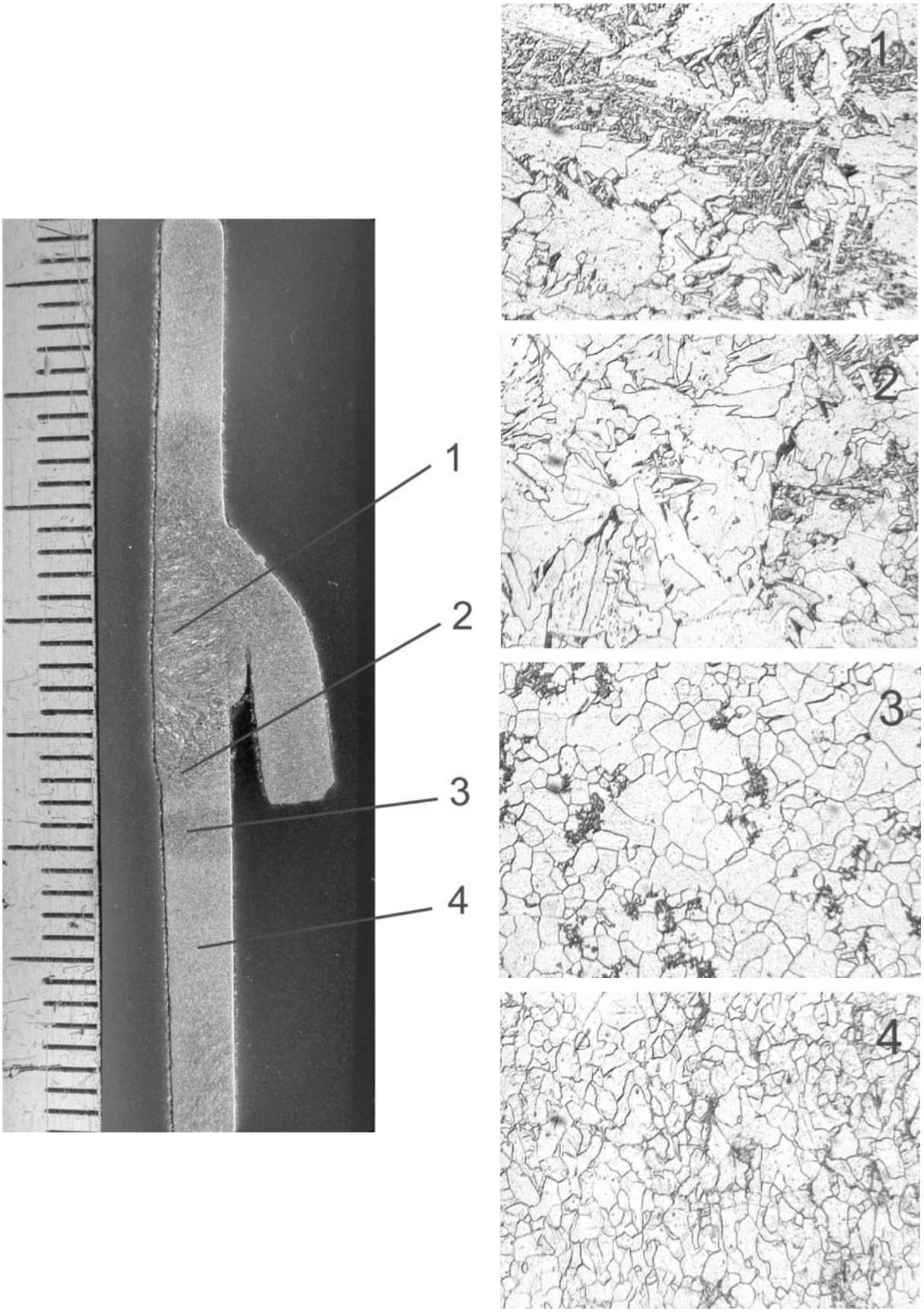

Figure 12. Macro and micro analysis of the welded joint on the weld start

4. CONCLUSION

After hardness HV1 tests on weld pass start and on the on the point that has an enough distance from circular weld pass start on the propane/butane pressure vessel for household, the increase of hardness on the weld pass start in respect to zone with enough distance from the weld pass start is not noted. But, since that during pressure test until destruction, propane/butane pressure vessels fracture is perpendicular to circular weld joint centre line (the place of maximum stresses) and very often placed on the connection between weld pass start and stop, that point out the fact that the certain weakening in the presence of welded joint did occur (e.g. the thesis of influence of stress concentration etc. are possible).

Obviously that this phenomenon is not possible to determinate by simple and practical hardness measurements, so some other methods should be applied in order to investigate weakening on the weld pass start and stop on the propane/butane pressure vessel for household.

5. REFERENCES

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