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Impact Assessment of the Stresses in the Sheet Made by Welding

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Abstract The article presents determination of residual stresses in the material caused by production processes, concretely by welding manufacturing process. In this article we analyse welding methods and their impact on the formation of residual stresses. Objects used for conducting the experiment were two samples of welded metal plates. Plates are welded by MAG method, in a controlled atmosphere of carbon dioxide gas. Evaluation process of residual stresses on this plates was made by hole-drilling method by the System MTS-3000.

Keywords: *welding, residual stresses, hole-drilling method*

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1. Welding and Its Impact on Residual Stresses

In Welding is a technological process that joins materials, usually metals or thermoplastics, by causing fusion under high temperature. In addition to melting the base metal, a filler material is often added to the joint. Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Figure 1 shows a traditional method of welding done by man and the robotic welding system.

Basic ways of welding are:

- fusion welding: The joint is achieved by melting the material by the heat source. The heat source may be a flame, molten metal, the electric arc, chemical reactions, etc.,
- welding by heat and pressure: The joint is accomplished by melting of the material by heat and pressure, or by heating the material into the plastic state and its subsequent joining under pressure. The heat source can be a heat generated by friction, induction heating, etc.,
- welding by pressure: The joint of components is achieved through high pressure on the contact surfaces of components without heat source.

In our case MAG method is used for welding of plates, with an active gas carbon dioxide. Metal active gas (MAG) welding or welding with shielding gas, as it is often called, is a welding arc process which utilizes the heat of an electric arc established between a continually feeded wire and the workpiece. During this process the wire will melt and the weld metal is transferred to the workpiece. The weld pool is always protected by a shield of gas in order to protect both the melting wire and the weld pool from the oxygen and nitrogen in the air [1].

a)

b)

Figure 1. Welding a) manual, robotic welding system

1.1. Residual Stress from Welding

Change of temperature of the welding material causes a change of its mechanical and thermo-physical properties, e. g. yield strength, thermal expansion, toughness, ductility, thermal conductivity. Heated part of the welded material is trying to stretch, but as the surrounding parts are not hot enough, the heated part can not stretch enough. This process results in the formation of residual stresses in the welded material [2].

Our aim was to investigate whether the welding of the same materials under the same conditions will cause the same levels of residual stresses. To determine residual stresses a hole-drilling method was used.

2. Realisation of the Experiment

The two samples of steel plates used for the experiment were made from one piece of sheet metal and they had the same size (350 x 150 x 10 mm). The sheet metal was non-alloy steel S355J2 according standard norm EN 10025-2:2004. The samples were welded under CO_2, with abutting joint, at temperature t = 5000°C. The residual stresses were determined from both sides of the welds formed at distance x = 30 mm from the center of the welds, in the middle of the plates y = 175 mm (Figure 2).

The measurements of residual stresses were realised by system MTS-3000 from SINT. In Fig. 3 is a schema of the measurement chain, as employed in the experiment [3,4,5].

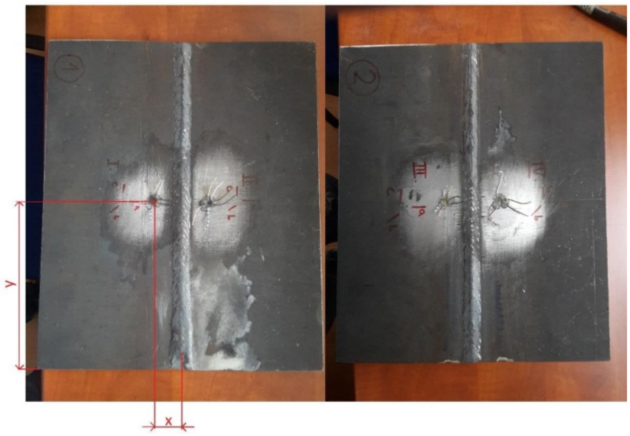

Figure 2. Examined plates

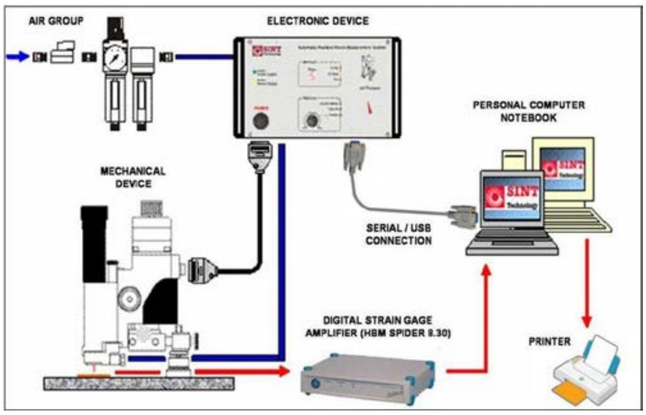

Figure 3. Schema of the measurement chain

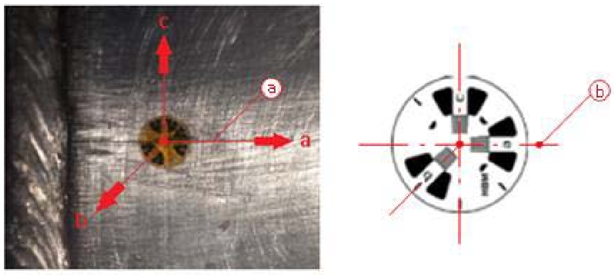

Figure 4. Installed strain gauge a) RY61 1,5/120S, b) reference axis

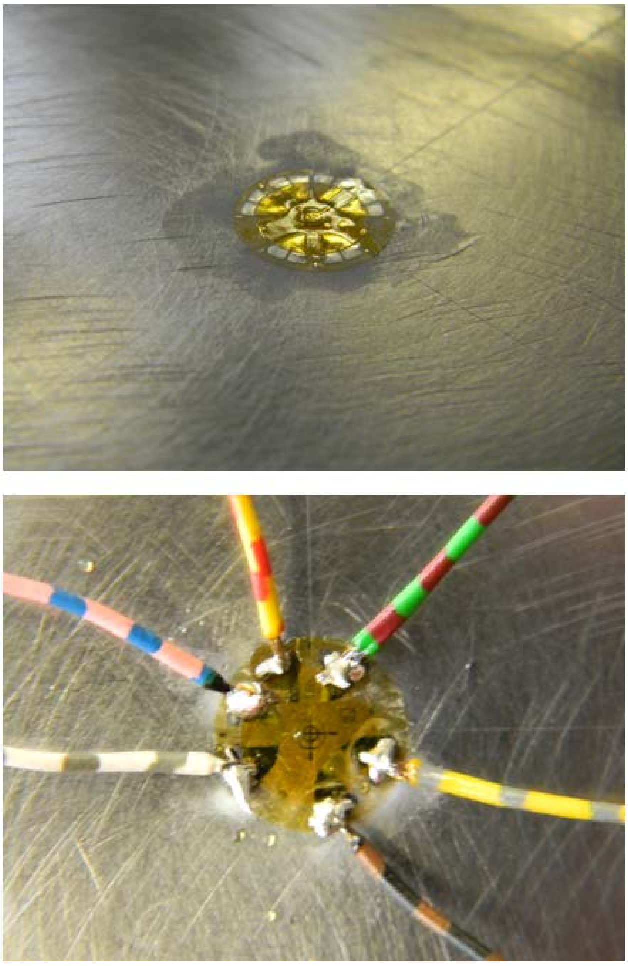

Figure 5. Application of the strain gauge RY61 1,5/120S

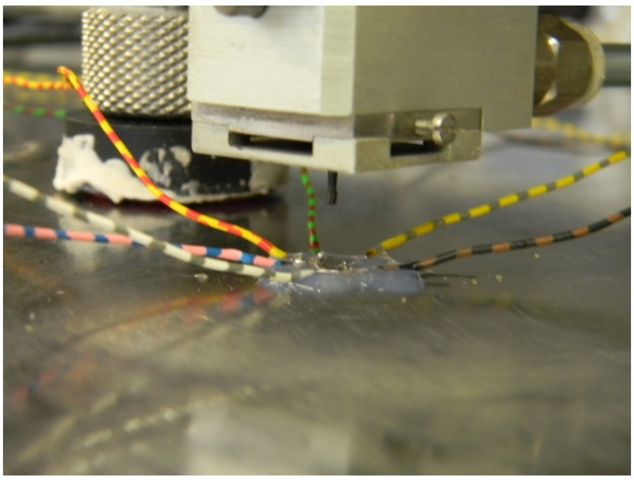

Figure 6. Drilling by the system MTS-3000

Figure 4 shows the orientation of the installed strain gauge RY61 1,5/120S on a welded plate.

Figure 5 shows application process of the strain gauge RY61 1,5/120S [6] on a welded plate.

Process of the drilling by the system MTS-3000 is shown on Figure 6. Figure 7 shows measuring place no.1 after drilling.

The measured values of relative deformations were evaluated by the ASTM method. On Figure 8, Figure 9, Figure 10 we can see results of the evaluation of the residual stresses on place no. 1 plate 1.

The resulting values of residual stress on all places are shown in Table 1.

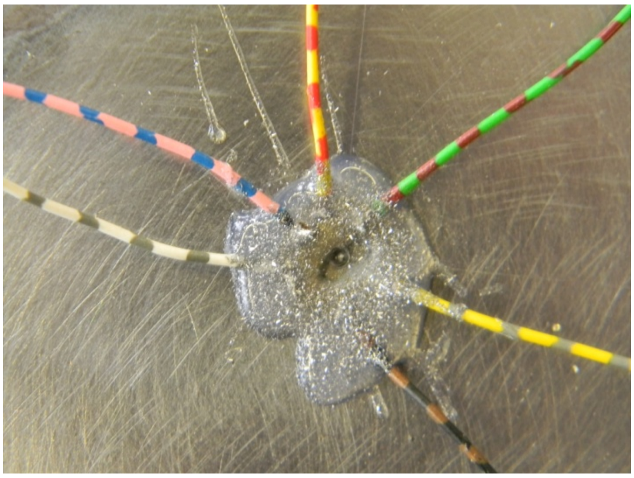

Figure 7. Place no.1 on plate 1 after drilling

Depth [mm]	ε_a [1e-6]	ε_b[1e-6]	ε_c [1e-6]
0,01	0,99	3,78	4,03
0,02	1,13	3,71	4,29
0,04	0,99	3,30	3,96
0,08	-5,24	-3,02	-2,89
0,12	-7,76	-5,14	-4,80
0,18	-8,96	-8,07	-9,12
0,24	-10,73	-9,15	-10,20
0,32	-12,06	-9,99	-9,83
0,41	-19,15	-22,73	-21,08
0,50	-30,63	-33,85	-36,27
0,60	-48,51	-36,16	-40,66
0,72	-62,21	-42,39	-53,73
0,84	-72,34	-48,94	-68,18
0,98	-78,00	-53,72	-81,63
1,12	-81,23	-58,65	-93,28
1,28	-82,92	-59,83	-101,76
1,45	-83,38	-58,17	-107,72
1,62	-85,23	-57,91	-110,00
1,80	-86,38	-58,22	-112,28
2,00	-86,73	-58,63	-112,00

Figure 8. Measured strains on place 1 plate 1

Table 1. Values of residual stresses in the investigated places

Plate no.1		Plate no.2	
Place 1 [N/mm^2]	Place 2 [N/mm^2]	Place 3 [N/mm^2]	Place 4 [N/mm^2]
σ_{min} = 90,97	σ_{min} = 94,11	σ_{min} = 94,70	σ_{min} = 100,23
σ_{max} = 132,76	σ_{max} = 149,35	σ_{max} = 143,59	σ_{max} = 158,99

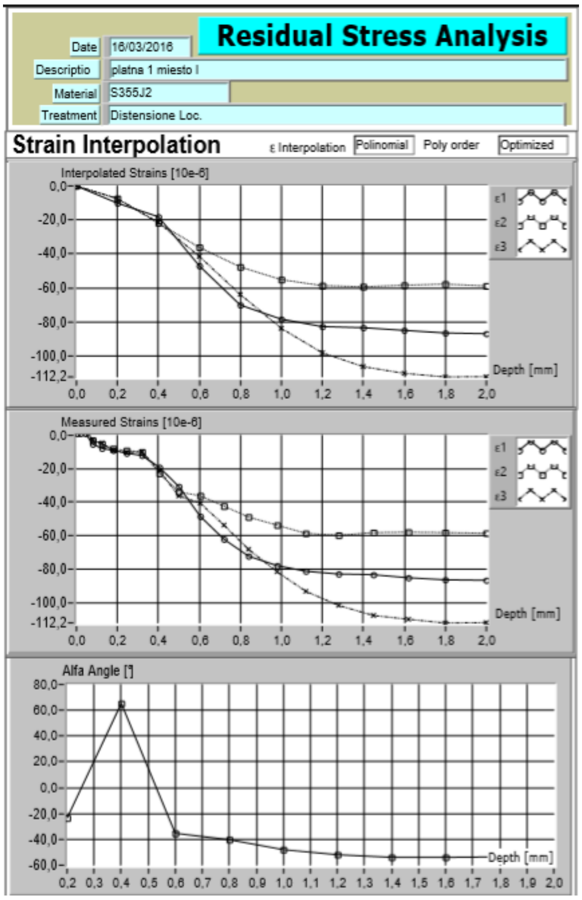

Figure 9. Strain interpolation on place 1 plate 1

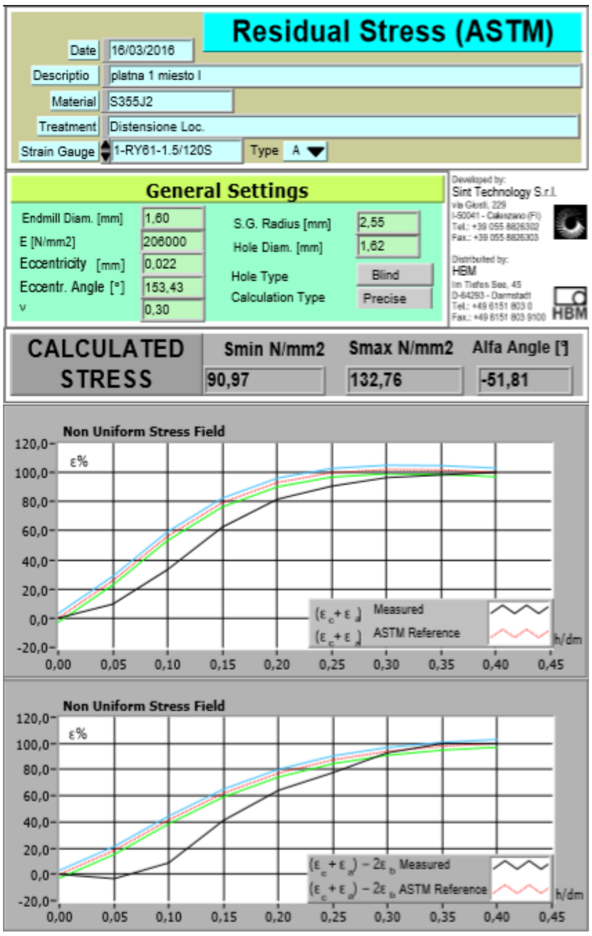

Figure 10. Calculated residual stress on place 1 plate 1

3. Conclusions

The results of the experiment show that the welding joints created under the same conditions, have approximately the same level of residual stresses. These residual stresses should be considered in determining the total life of welded structures. It should be borne in mind that any change in the welding process can have a significant impact on the level of residual stresses. Therefore, it is still necessary to ensure the stabile conditions of the welding process, which are easily reachable by the robotic welding systems.

Acknowledgements

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