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STAINLESS STEEL PLATE ONE SIDE WELDING

Bálint FELVÁRI,[1] Dávid DUNAVÖLGYI,[2] János KUTI[3]

Óbuda University, Donát Bánki Faculty of Mechanical and Safety Engineering, Budapest, Hungary

[1] *felvari.balint@bgk.uni-obuda.hu*

[2] *dunavolgyi.david@bgk.uni-obuda.hu*

[3] *kuti.janos@bgk.uni-obuda.hu*

Abstract

The authors in this research investigated a cost-effective welding setup for stainless steel following the industrial trends. Ajustments, movements and tests can be avoided during plate welding by welding the piece from one side. During the research, the applied layout is investigated, any deformities that may be caused, and whether it can maintain the inter-row temperature.

Keywords*: welding, plate, stainless steel.*

1. Research goal

In our research, we studied whether it is possible to sufficiently weld an austenitic corrosion-resistant thick disc with narrowed V stitches from one side. One-sided welding has multiple benefits, however it can cause major deformation due to the greater energy input over a small area **[1, 2].**

2. Experimental method

2.1. Test sample preparation

The samples had been cut using some kind of thermal cutting technique, so their sides required some rework. Before starting the work we needed to clarify the geometries necessary to carry out the welding, and the processing aids of the processes of examining the welding (such as the placement of thermoelements). The standardised V stitches were trained to 15⁰ per disc using a plane.

2.2. Thermoelements setup

With the help of thermoelement measurement, we can specify the flow of heat and the temperature near the stitches, and in this way we are able to describe metallurgical processes **[3]**. Therefore, how and where we place the temperature measuring units on our piece plays a crucial role. Our main goal with the placement of thermoelements was the exact determination of interlinear temperature, and to be able to create a serious heat flow model in the future **[4, 5]**.

2.3. Assembly

The chamfering and drilling of the pieces was followed by assembly. The two pieces were pieced together at the chamfering using two tack welds, leaving a 5 mm gap between them (**Figure 1**). We used added space for the welding joint to begin and at the end. The main reason for this was that the welding arc would develop already on the aiding discs, together with the melt, and stepping into the material it would run stable already. The continuous welding of the weld root was aided by ceramic support.

Figure 1. *The prepared test sample.*

2.4. Assembly and configuration of the automatic welding machine

The measures needed for reference were carried out on a unique robot, developed at the university. Our automatic welding machine aids the exact, reproducible welding position via a user interface, the positioning of limit switches and the set up of the equipment responsible for the reception of the welding head. We linked the automatic machine and EVM welding machine together using a modified work cable. We connected the push-button of the cable into the control unit of the robot, which this way activated the power source at the given moment, and stopped it when it was needed. The UI of the robot worked with the help of an Arduino. On the panel, the welding speed could be adjusted with the use of push buttons, in cm/meter steps. After configuration, only the limit switches needed to be adjusted to the workpiece. This step was followed by the setup and tooling of the welding power source [6].

The welding machine is an EVM Taurus Synergic, perfectly suitable for the carrying out of complex tasks and processes [7]. The machine contains so-called JOB-s, which keep the welding parameters in the territory programmed by the manufacturer. So we selected the following from the manual of the machine: the type of welding (in our case MIG: Metal Inert Gas), the type of material we wanted to weld (austenitic corrosion-resistant steel) and the JOB. At this point, the electrical set up of the machine has been part one, now we just had to adjust the amperage according to the melting, the stitches and series of stitches. For the welding, we choose a mixed gas: Linde Corgon gas mixture. Corgon is a given name, this mixture contains 18 % CO_2 and 82 % Ar, the standardised name for it is „ISO 14175 –M21 – Arc – 18". We introduced the gas into the machine using a reducer, and even though the desired amount of gas flow can be set up using the machine and the reducer, we set up the specific values using a rotameter attached to the end of the welding torch.

After manually trying out the process of the welding, we observed that the gas deflector did not fit into the prepared area of the disc. Because of this, we would have to keep a very long arc, which would set back or even prevent the continuous closure of the arc, the free formation of the melt and the development of the welding stick. To prevent all this, we made some changes to the gas deflector. We also provided the gas deflector with a ceramic coating to prevent any permanent contamination caused by any spatter or the contamination of the gases themselves. Throughout the experiment, during the cooling of the series of sticks, we replaced and cleaned this ceramic coating multiple times to enable the free flow and constant quantity of the gas.

2.5. Setup and calibration of thermoelements

We followed up the experiment using thermoelements, which were connected to a central data processing system and a notebook (Figure 2).

We carried out the welding in such a way that each line became 20 mm shorter as we proceeded, this way we were able to create a grinding from each line (Figure 3 shows the assignment of the sections). This enabled us to measure the heat conduction zone and the welding stick line by line.

We prepared the cross-sections using a band saw, making sure we provided constant cooling

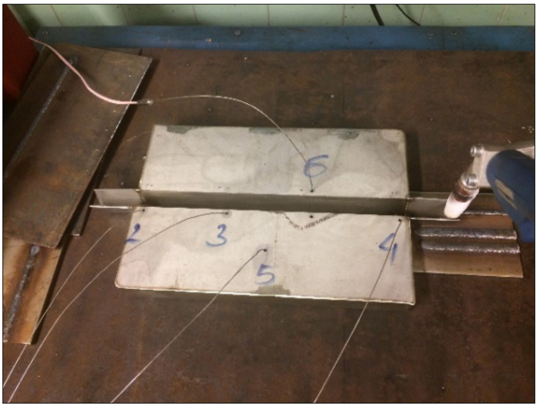


Figure 2. *Assembled prototype.*

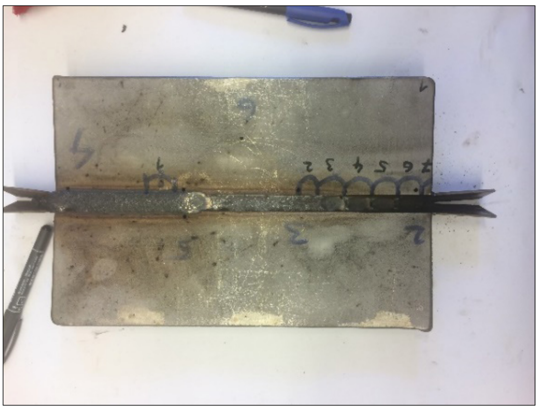


Figure 3. *Assignment of sections.*

2.6. Surfaces preparation

The cut segments were of different size and of different surface roughness, so to be able to analyse them with a microscope, we further refined them using a surface grinder, then prepared them by grinding and polishing.

The etching of the samples was done using a KALLING etching substance, with the following consistency: $CuCL_2$ 5 gramm, hydrochloric acid 100ml, ethanol 100 ml.

On the grinding, we can easily distinguish the building of the stitches onto each other and the gas inclusion at the border of the second line, the run and the material (**Figure 4**). Excluding the first line, we can see the symmetry and consistency of the line of stitches. From the first line, we can see that the arc pulls to the left, this way the melt is asymmetrical. We can also see a constant push forward and the amperage as well because, with the growth of the gaps, the height of the stitches decreases. Ideally, these two values grow exponentially.

On the left side of the picture (**Figure 5)**, we can see the stick, in which the delta ferrite appears as black lines. The columns spread in the direction of the heat dissipation. Between the edge of the stitch and the edge of the material, we can see a 10 µm wide heat affected zone.

The grain coarsening is not significant, but at the borders Cr-carbide precipitation can be detected (**Figure 6**).

The direction of the shaping is well distinguishable in the material because of the micro enrichments (**Figure 7**). At the beginning of solidification, the grains are equiaxial and at the edge of the lines, they are finer and become coarser as we advance inwards. The columned and homogeneous structure is typical of the stitches.

Furthermore, it is remarkable that unlike on the micro recording, on the microscope measuring hardness, it can be observed that there is a difference between the inner and outer structure of the stitch. On the outside, it is coarser than on the inside (**Figures 8** and **9**).

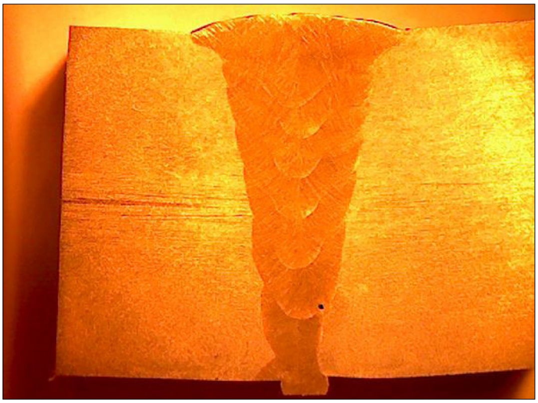


Figure 4. *Cross-section of the joint.*

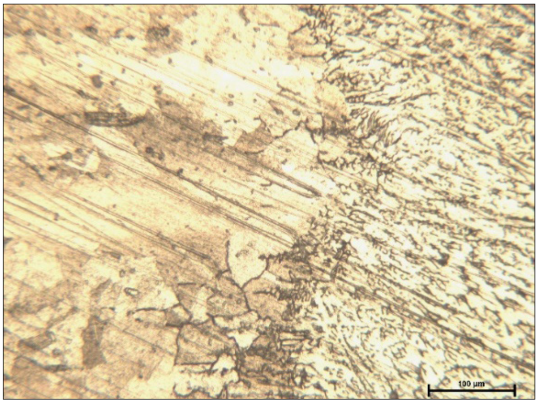


Figure 6. *A minimal amount of grain coarsening at the border of the stitch.*

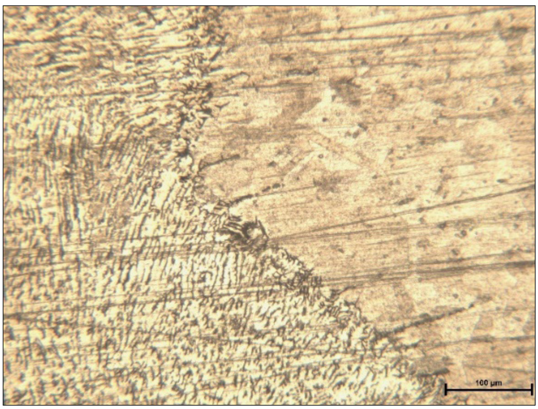


Figure 5. *The joint and the material.*

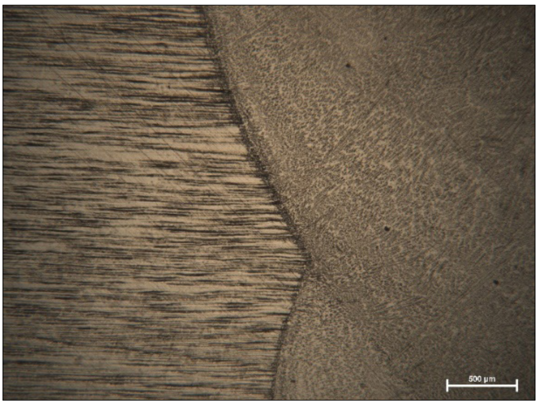


Figure 7. *The shaping of the material.*

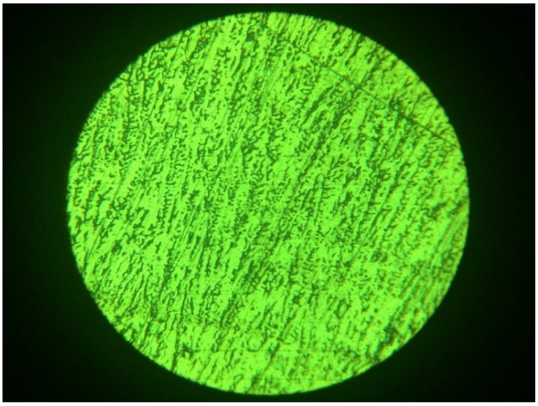


Figure 8. *The side of the stitch.*

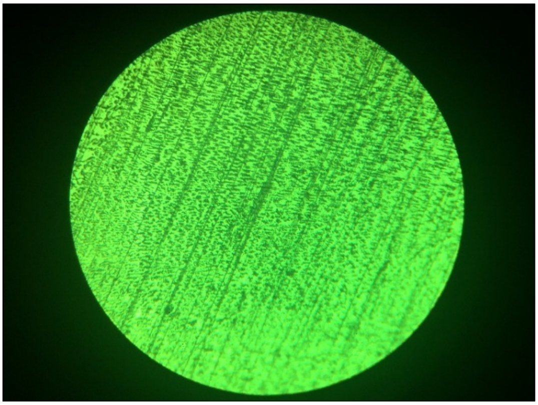
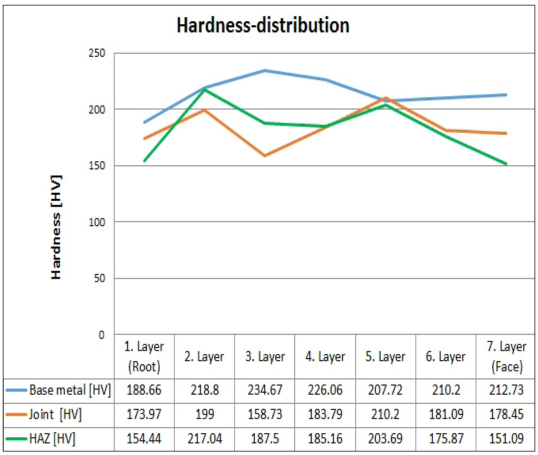


Figure 9. *The middle of the stitch.*



	1. Layer (Root)	2. Layer	3. Layer	4. Layer	5. Layer	6. Layer	7. Layer (Face)
Base metal [HV]	188.66	218.8	234.67	226.06	207.72	210.2	212.73
Joint [HV]	173.97	199	158.73	183.79	210.2	181.09	178.45
HAZ [HV]	154.44	217.04	187.5	185.16	203.69	175.87	151.09

Figure 10. *Values of hardness.*

2.7. Measured hardness

The measurement of hardness was done using a Vickers micro-hardness measuring instrument. We measured with a load of 0,2 kg. We split up the sample into rows and measured the following. In every row, we measured the hardness of the material and the stitches three times. In every row, we measured the heat-affected zone three times as well (**Figure 10**).

3. Summary

Both from the hardness measurement results and the tissue examination, we can conclude that the narrowed V stitches from one side were conducted successfully. We do have to mention though that as a result of welding, our piece warped significantly. This is what we have to eliminate as a continuation of our study, with the help of pre-loading and with welding techniques, that require less energy input.

Acknowledgement

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References

[1] Gáti J.: *Hegesztési Zsebkönyv*. Cokom, 2003 .

[2] Bagyinszki Gy., Bitay E.: *Hegesztéstechnika I. Eljárások és gépesítés*. Műszaki Tudományos Füzetek 9., EME, Kolozsvár, 2010. https://doi.org/10.36242/mtf-09

[3] Bagyinszki Gy., Bitay E.: *Hegesztéstechnika II. Berendezések és mérések*. Műszaki Tudományos Füzetek 10., EME, Kolozsvár, 2010. https://doi.org/10.36242/mtf-10

[4] Cloos: *Rapid Weld - That's what efficiency looks like!* (accessed on: 2017.04.11) https://www.cloos.de/de-en/processes/details/rapid-weld/

[5] Biszku G.: *Vastaglemezek hegesztése*. Miskolci Egyetem. (accessed on: 2017.04.11) http://docplayer.hu/15987490-Vastaglemezek-hegesztese.html/

[6] Kuti J.: *Vastaglemez X varratos kötésének kiváltása szűkített V varrattal.*

[7] Tóth L., Haraszti F., Kovács T.: *A felületi érdesség hatása a hegesztett rozsdamentes acél korróziós ellenállására/Surface Roughness Effect in the Case of Welded Stainless Steel Corrosion Resistance.* Acta Materialia Transylvanica 1/1. (2018) 53-56. https://doi.org/10.2478/amt-2018-0018 https://doi.org/10.2478/amt-2018-0017