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REDUCTION OF DEFORMATIONS DURING WELDING METAL WIRE MESH WITH FRAMES

The article presents an issue referring to a reduction of deformation during welding metal wire mesh into the frames. A problem of a possible reduction of deformations was described taking into account characteristics of a construction of a welded element. Technological tests and their results are provided. Technological recommendations relating to the reduction of deformations of the welded element are given.

Keywords: welding, stresses, deformations, moment of inertia.

1. Introduction

An analysed element is made of a metal wire mesh joined on the circumference with a steel frame. The metal wire mesh is made of the steel wires of S235 type with a diameter ranges d = 2,5 ÷ 3,2mm, and sizes of the mesh 40 x 40mm. The size of the frame is 1000 x 4000 mm and 1000 x 3000mm, and was made of a structural section of S235 steel of a square cross section 35mm, and thickness of the wall 2,5mm. Joining wires of the metal wire mesh with the structural section is made by means of section fillet welds 15mm long by the MAG method in automated conditions using robots. Elements used in welding are folded and blocked in the frame of the positioner cooperating with robots.

The key issue is to obtain a straight element i.e. a welded metal wire mesh with the frame in the process of an automated welding on the automated line. The core of this issue is a symmetry of a geometric position, and actually a symmetry of a moment of inertia of a cross section, and a symmetry of a pattern of stresses caused in the process of welding, and locked-in stresses left in the used materials. An asymmetry of above sections will cause considerable deformations in the elements, the greater an asymmetry of sections is, the bigger deformation in the elements will become. Deformations will appear in those areas of the element, where an asymmetry will appear. An important issue can be metallurgical process [17,18] and other properties of the materials [19-21]. Figure 1 presents a cross section of the metal wire mesh with a frame in a place of joining particular elements of a considered problem.

In order to obtain a straight element certain operations can be done:

- the use of straightening after a process of welding,
- the use of a pre-distortion of the main element before welding,
- the use of a balanced thermal influence on the opposite side of the element just opposite of the weld

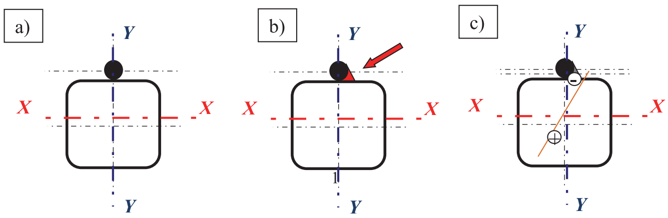

Fig. 1. A scheme of a cross-section of a metal wire mesh with a frame in the place of joining: a) with a distribution of axes of inertia on the section, b) with a distribution of axes of inertia on the section, and the weld causing stresses, c) with a distribution of axes of inertia on the section, and the stresses which cause deformations of an element

2. Possible options of an assembly

It is possible to use different options of an assembly in order to obtain an established goal due to accepted general assumptions of the technology of making welded metal wire mesh with frames. Table 1 presents a general characteristics of possible options of an assembly.

Presented methods of an assembly require adapting a construction of an assembly stand, and using appropriate equipment, as well as preparing technological devices of a chosen process depending on the particular type [4]. In order to reduce an influence of a thermo-mechanical effects caused by made welds, it is vital to reduce their length and sections [5-16].

A proper choice of parameters can be implemented by analytical methods (not very precise taking into account present level of knowledge), or in a practical way – experimental (require doing numerous tests in the conditions close to the real ones), and in the mixed analytical-experimental methods (often give the best results).

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TABLE 1

Possible options of an assembly

No.	Aims to obtain	Requirements	Comments
1	• an assembly of straight elements in a flat rigid device, • welding by the MAG method in automated conditions,	Preparation of detailed technological conditions of welding: linear energy of a process, sequence of making section welds,	An element after welding will require straightening
2	• an assembly of pre-distorted elements in the rigid device with a curvature fitted into the element, • welding by the MAG method in automated conditions	Preparation of detailed technological conditions of welding: linear energy of a process, sequence of making section welds,	An element after welding will be straight, repeatability of an element is required
3	• an assembly of straight elements in a device allowing to give an adjustable pre-distortion, • welding by the MAG method in automated conditions	Preparation of detailed technological conditions of welding: linear energy of a process, sequence of making section welds,	An element after welding will be straight, series of types of elements possible to make
4	• an assembly of straight elements in a flat rigid device, • welding by the MAG method in automated conditions with a simultaneous heating of the element on the opposite side by a balanced source of heat, and the same linear energy,	Preparation of detailed technological conditions of welding: linear energy of a process, sequence of making section welds, and the parameters of heating by the balanced source of heat,	An element after welding will be straight, series of types of elements possible to make

3. Purpose and the scope of technological tests

The purpose of technological tests was to evaluate the size of deformation of welded metal wire mesh with the frame in the simulation conditions similar to automated welding capabilities. Tests were done by using welding capabilities of symmetrical (simultaneously by two welders in a proper sequence) in the manual conditions with proper parameters for these conditions. Tests were done on one type of metal wire mesh of the size of the wire d=3,2 mm, and the mesh 40x40 mm welded with the frame made from the structural section 35x35x2 mm, and a size 1000x3000 mm.

4. A description of technological tests

Test 1

A test of surfacing by welding two-sided structural section as a simulation of welding a metal wire mesh with the structural section with a simultaneous balanced heat input on the opposite side of the frame. A purpose of the test was to check a possibility of using the MAG method of welding with a simultaneous heating of an element on the opposite side by the balanced heat input, and the same linear energy – this method appeared to be the most favourable for an automated welding. This test was done on the structural section of the square section of 35x35x2, and the length 240 mm. Five surfacing welds, which are transverse in a sequence on both sides of the structural section with a scale about 25 mm, were made. Above welds kept a symmetry of geometrical system, and a heat input into the element. As a result, any deformation was observed in the structural section right after finishing the test, as well as 24 hour later. The results of the test were given in the figure 2, where figure 2a shows the structural section from the side of surfacing welds, and 2b provides a view on the transverse surface of the surfacing welds. Pictures were taken 24 hours after making surfacing welds. In order to make an evaluation of rectiliearity of an element simpler, there are straight red lines on both sides of surfacing welds as the reference lines in the figure 2b.

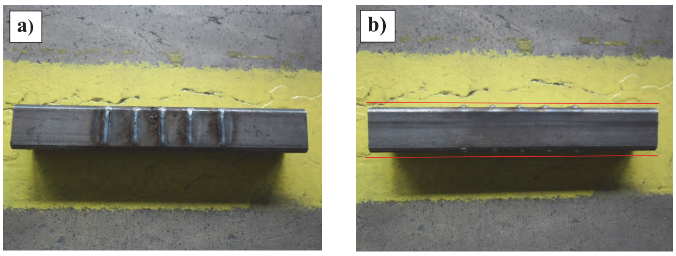

Fig. 2. A view of a surfacing by welding sample: a) from the side of surfacing welds, b) from the transverse side

Surfacing welds were made in the manual conditions of welding with a use of the MAG method, and a standard process with a dip-transfer arc of a current parameters range from 110 to 115 A, and the voltage of an arc ranges from 17,5 to 17,7 V. An inverted device with a current range 400 A was used to do tests. Filler materials were used such as the G3Si1 electrode with a diameter 1,0mm, and shielding gas as the M21 mixture with 82% of argon and 18 % CO_2 content [1, 2, 3]

Test 2

Test no. 2 was done as welding a metal wire mesh with the frame keeping the symmetry of the system alongside the axe of the metal wire mesh in non-automated conditions bearing in mind appropriate sequence and parameters of welding. The test was done in order to specify the size of deformation in one-sided welding conditions without a possibility of balancing a symmetry of the system by an additional source of heat for the structural section of the frame. The test was done for the metal wire mesh of the wire d=3,2 mm and the mesh 40x40 mm welded into the steel structural section of the square section equals 35x35x2, and the whole frame 1000x3000 mm. The test was done on the welding stand shown in the figure 3, which allows to fix welded elements by the manual clamps, and a simultaneous welding by two welders according to the previously accepted sequence, and the same parameters that were used previously. A sequence of welding alongside the frame was accepted in the central zone starting from the centre alternately into the ends with a sequence every fifth wire. While, in the end zones every fifth wire was surfaced by welding in a sequence starting from the central zone into the end of the frame. After completing the first series of welds, another series every fourth wire according to the same rules was made, and than, again until all the joints were made alongside the frame of the metal wire mesh. After making joints alongside the frame of the metal wire mesh, the joints at the ends of the frame according the rules accepted for the central zone were made.

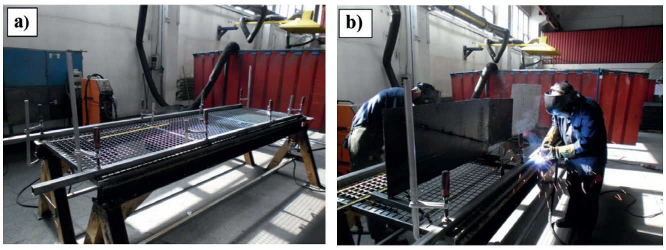

Fig. 3. A view of the welding stand for welding metal wire mesh: a) a stand with fixed elements by the manual clamps, b) during a welding test

As a result of an experiment, after a few minutes from the end of a welding test there was a deformation on the longitudinal section of deflection equals f=6 mm (a view of a measurement fig. 4), and after 24 hours from the end of the test deflection increased till f=10 mm

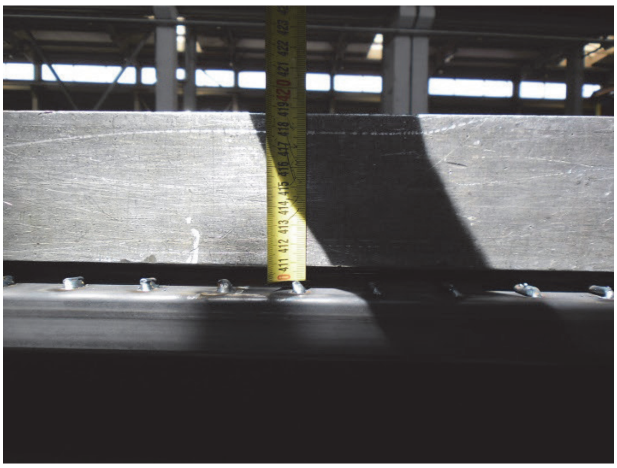

Fig. 4. A view of an element during measuring a deflection after a couple of minutes from the end of the test (f=6 mm)

Test 3

The next test was done on a pre-distorted element with a deflection in the central zone fu=8mm using appropriate pads, and in the side zones (1m distance from the ends) 6mm. All other conditions of an assembly, sequence and welding parameters were repeated from the previous tests.

As a result, a deflection in the central zone (on the distance of about 1m) about 1mm was obtained, and in total on the entire length of the element (3m) about 6mm (a measurement was made after a couple of hours after finishing welding).

Test 4

Test no. 4 was done after a detailed analysis of the previous test. As a result a correction of a pre-distortion for the central zone fu=10mm was made, and in the side zones 6mm pads were left. A sequence of welding was also modified, taking into account the same scheme as for the central zone. Welding parameters were similar as in the previous tests.

As a result a deflection on the entire length of the element was equal to about 4-4,5 mm (a measurement was made after a couple of hours after finishing welding), and the deflection in the central zone was not observed. The total deflection was focused at the ends of the frame of the structural section.

Test 5

In the test no. 5 a correction of a pre-distortion was made resigning from the central zone, whereas in the side zones about 900mm from the ends of the frame 10mm pads were used. All other conditions related to the sequence and parameters of welding were used as in the test 4. Cooling longitudinal sections from inside by a compressed air was an additional modification, until their complete cool down. Cooling was made from the end of the welding process, and with the elements blocked by the pressure system.

As a result the deflection on the entire length of the element was equal to about 5 mm (a measurement was made after cooling and taking out the element). Similarly, like in the previous test a total deflection was focused at the ends of the frame, and in the central zone (this time widened and equals to about 1200mm) deflection was not observed.

5. Summary and recommendations

Taken tests revealed numerous vital elements which have an influence on the size of deformation in the process of welding metal wire mesh with structural sections. The key conclusions are as following:

1. There is a complete possibility to eliminate deformations using a rule of a balanced heat input into a welded element what was proved by the test no. 1. This type of solution requires choosing an appropriate additional source of heat, and synchronizing it with the source of welding.
2. There is a possibility to reduce a deformation significantly (up to a couple of mm) by applying a proper technology of welding, i.e. a sequence of sections of welds made, and well chosen welding parameters what was proved by

the test no. 2. The rule is that the welds should be the shortest, and their cross-section should be the smallest. Robotized welding conditions completely guarantee above conditions.

3. There are additional possibilities to reduce a pre-distortion by using slight initial deformation e.g. up to 15 mm, and cooling a structural section only from the inside, and during an operation of a pressure system what was proved by the tests 3 to 5.
4. All conclusions can be taken into account in a designed process of welding of these elements on the robotized stand with a use of welding robots.

There are numerous factors which have an influence on the final result for a designed process of welding of the metal wire mesh with frames in robotized conditions. They are as following:

1. A position of the structural section of the frame – repeatable position of longitudinal weld, the best from the centre of the frame.
2. Proper conditions of the grinding of the element after welding, because a process of grinding causes stresses, and therefore deformation of the element. It can be additionally used to straightening the element, and not enlarging a deformation.
3. A proper storage of the metal wire mesh, the best in the reversed position, not to make a deformation bigger.

Another important advantage of the newly proposed process can be the use of modern low-energy MAG welding technology in a variation of a so-called cold arc. Using this method will be possible to limit the heat input to the material during welding, and therefore should occur less deformation of the welded component. Therefore, in this way it will be possible to reduce deformation. In order to verify and confirm the effectiveness of this method, it is essential to carry out a comparative test. For this purpose, welding tests should be performed using the classical method of welding namely the MAG method, and a new variety of cold arc on prepared elements of the metal wire mesh or on specially prepared samples which are compatible with real elements. Tests must be done under the same conditions with the most preferred parameters for both processes and subject to the same assessment. Only a very positive end result will be a justification for the introduction of a new method, which will require an increased funding and high purity surface of the welded elements to minimize a tendency to generate incomplete fusions. Therefore, the proposed test is necessary both technically and economically before making the right decision about the implementation of new low-energy technology in a variation of the cold welding arc.

REFERENCES

[1] Praca zbiorowa; Poradnik inżyniera – Spawalnictwo tom I i II, WNT, Warszawa 2005.

[2] B. Pierożek, J. Lassociński, Spawanie łukowe stali w osłonach gazowych. WNT, Warszawa 1987.

[3] R. Krawczyk, Zakresy parametrów spawania w zależności od przenoszenia metalu w łuku spawalniczym. Biuletyn Instytutu Spawalnictwa. Nr 4/2014.

[4] J. Słania, Plany spawania. Teoria i praktyka. Agenda wydawnicza SIMP, Redakcja Przegląd Spawalnictwa, Warszawa 2013.

[5] M. Myśliwiec, Cieplno-mechaniczne podstawy spawalnictwa. Warszawa, PWN 1972.

[6] T. Węgrzyn, J. Piwnik, B. Łazarz, D. Hadryś, Main micro-jet cooling gases for steel welding, Archives of Metallurgy and Materials, **58** (2), 555 – 557 (2013).

[7] T. Węgrzyn, J. Piwnik, D. Hadryś, Oxygen in steel WMD after welding with micro-jet cooling, Archives of Metallurgy and Materials, Vol. 58, issue 4, 2013: pp. 1067 – 1070.

[8] W. Tarasiuk, B. Szczucka – Lasota, J. Piwnik, W. Majewski, Tribological Properties of Super Field Weld with Micro-Jet Process, Adv. Mat. Res. 1036, 452-457 (2014).

[9] T. Węgrzyn, J. Piwnik, J. Wieszała, D. Hadryś, Control over the steel welding structure parameters by micro-jet cooling. Archives of Metallurgy and Materials, **57** (1), 679-685 (2012).

[10] T. Węgrzyn, The Classification of Metal Weld Deposits in Terms of the Amount of Oxygen. PROC OF ISOPE, IV,1999, 212 – 216.

[11] T. Węgrzyn, The Classification of Metal Weld Deposits in Terms of the Amount of Nitrogen. Procedings of ISOPE´2000, V, 2000, 130 – 134.

[12] B. Szczucka-Lasota, B. Formanek, A. Hernas, K. Szymański, Oxidation models of the growth of corrosion products on the intermetallic coatings strengthened by a fine dispersive Al2O3. Journal of Materials Processing Technology, volumes **164-165**, 935 - 939 (2005).

[13] J. Słania, Influence of phase transformations in the temperature ranges of 1250-1000ºC and 650-350ºC on the ferrite content in austenitic welds made with T 23 12 LRM3 tubular electrode. Metallurgy and Materials, **3**, 2010-2014 (2005).

[14] A. Lisiecki, Diode laser welding of high yield steel. Proc. of SPIE Vol. 8703, Laser Technology 2012: Applications of Lasers 87030S (January 22, 2013), DOI: 10.1117/12.2013429.

[15] A. Lisiecki, Welding of titanium alloy by Disk laser. Proc. of SPIE Vol. 8703, Laser Technology 2012: Applications of Lasers 87030T (January 22, 2013), DOI: 10.1117/12.2013431.

[16] G. Golański, P. Gawień, J. Słania, Examination of Coil Pipe Butt Joint Made of 7CrMoVTib10 - 10(T24) Steel After Service, Archives of Metallurgy and Materials, **57** (2), (2012).

[17] R. Burdzik, P. Folęga, B. Łazarz, Z. Stanik, J. Warczek, Analysis of the impact of surface layer parameters on wear intensity of friction pairs. Archives of Metallurgy and Materials, **57** (4), 987 – 993 (2012).

[18] B. Oleksiak, G. Siwiec, A. Blacha-Grzechnik, J. Wieczorek, The obtained of concentrates containing precious metals for pyrometallurgical processing, Metalurgija 53(4), 605-608 (2014).

[19] R. Burdzik, Ł. Konieczny, Research on structure, propagation and exposure to general vibration in passenger car for different damping parameters, Journal of Vibroengineering 15(4), 1680-1688 (2013).

[20] R. Burdzik, Research on the influence of engine rotational speed to the vibration penetration into the driver via feet - multidimensional analysis. Journal of Vibroengineering, **15**

(4), 2114 – 2123 (2013).
[21] G. Perun, J. Warczek, R. Burdzik, Simulation and laboratory studies on the influence of selected engineering and operational parameters on gear transmission vibroactivity. Smart Diagnostics V Book Series: Key Engineering Materials, **588**, 266-275 (2014).