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ASSESSMENT OF THE QUALITY, SAFETY AND RELIABILITY OF WELDED CONSTRUCTION WITH NUMERICAL MODELING METHOD

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SUMMARY

Welding process is a very complex process, sensitive on the speed of welding and cooling in welded metal during heat transfer which imposes the driving energy. Thermal cycles of points in zone melting and heat affected zone has a very large impact on the final results of the welding process.
In particular welding experimental samples shall be calculating thermal cycles certain points in order to gain insight into the effect of heat (as an input parameter in the experiment) in terms of heating and cooling of welded joints. Calculations are performed using the finite element method.
Research, analysis and description of these processes need to ensure the optimal technology and additional materials for welding, which will produce welded joints with the structure, chemical composition and mechanical properties that match the requirements of a given conmstruction, and to ensure the safety and reliability of construction in exploitation.
Keywords: metal structures, thermal cycle, numerical modeling, simulation residual stresses, deformations

1. INTRODUCTION

There are a number of commercially available software packages for solving various problems, but also, for specific applications highly specialized software are made. Welding, as one of the most widely applied technologies in the production of metal structures, is not the exception in the application of numerical simulation. However, in this application should be very careful in terms of reliability and interpretation of results. Welding is a very specific process, which is characterized by local heat input, very dynamic changes in temperature, which leads to changes in the physical material properties, changes in the mechanical properties of elastic -plastic area, changes in the structure of the heat affected zones. All of these processes are difficult to describe the precise mathematical expressions, which are needed to solve the set problems. In eksperimenal part of this work were used two software packages (Ansys and Adina) and there were tested their reliability to solve certain problems, such as temperature changes and the residual stresses and strains as a result of local heat input.

2. COMPARISON OF EXPERIMENTAL RESULTS WITH A NUMERICAL STIMULATION RESULTS

Simulations are very suitable for scientific researches and for solving certain specific problems of engineering practice and should be used. But there are the question is RCR's reliability. That's why these investigations were carried out on the welded samples and therefore was made a comparison of experimental results with those obtained by simulation.

Table 1. shows the results of maximum temperature of welding obtained with the experimental measurements and numerical simulation software package ANSYS.

Table 1. Results of comparing the maximum temperature, the measured and simulated

Sample	Tmax (measured) [°C]	Tmax (simulated) [°C]	Δ Tmax [%]
A3	657	665	1,217
A4	438	475	8,447
A5	986	1003	1,724
B2	789	792	0,381
B3	946	935	1,163
B4	866	870	0,461

Based on the data from the table an analysis of reliability of numerical simulation methods in relation to the measured results was made. The deviation of the reliability of the method(OPM) is: (measured)

$$OPM = \frac{\sum \Delta T_{\max} \%}{\sum X_{uzoraka}} = 2{,}232\ [\%], \quad \text{.............(1)}$$

Reliability of the method(PM) is: PM = 100 - 2,232 = 97,768 [%] ....(2)

So, the conclusion is that the result at the numerical simulations very well coincide with the real values when it comes to simulation of thermal cycles .

To determine the reliability of numerical simulation method in predicting the expected conditions, in terms of residual stresses was made comparison of measured residual stresses using drilling rosette on real experimental samples witch obtained by numerical simulation for the same measurement point .

Figure 2. Shows the comparative diagrams of the residual voltage measured and calculated by finite element method .

For the example was selected pattern "A3", where three rosettes are placed at different distances from the weld (15 mm = y1 , y2 = y3 and 25 mm = 35 mm) . Measured residual stresses decreases with distance from the weld, as clearly visible in Figure 1. Principal stresses σ_{11} measured strain gauges are shown in blue dots, principal stresses σ_{11} calculated using finite element method are presented in red **.**

Although in calculating the finite element method, there are some limitations due to the complexity of the welding process, it is evident that in this case the residual voltage decreases with distance from the weld .

In relation to the matching results in the calculation of the thermal cycle in the software package Ansys, the result is much unfavorable. However, considering the complexity of the welding process can be said that there is a coincidence of the results but not that the results are satisfactory.

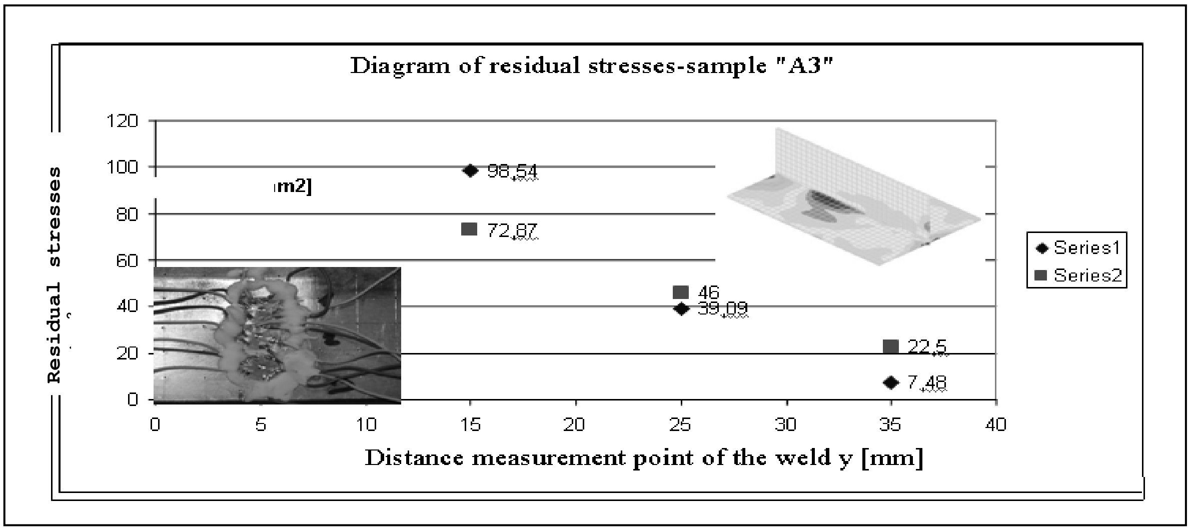

Figure 1. Comparative diagram of residual stresses and strain gage measurements calculated by finite element method, depending on the distance from the weld (sample "A3")

In Figures 2 and 3 are given the comparative value of residual stresses, measured strain gage on real samples and residual stresses, obtained by numerical simulation using finite element software package Adina , depending on the driving energy , and the sample "A" (sheet thickness 2 mm) and sample "B" (sheet thickness 5 mm).

Generally speaking, the results are logically coincide, respectively, with increasing heat input increases and the residual stresses with measured results and also with the results obtained by numerical simulation, but their values are significant differences and can amount to up to ± 30 % of the maximum measured residual voltage.

Regardless of the limiting factors in numerical simulations and possible errors in measurement, these differences are too large to be carried out by means of numerical simulation software package Adina could be accepted as correct, and the results are relevant for further considerations and practical application.

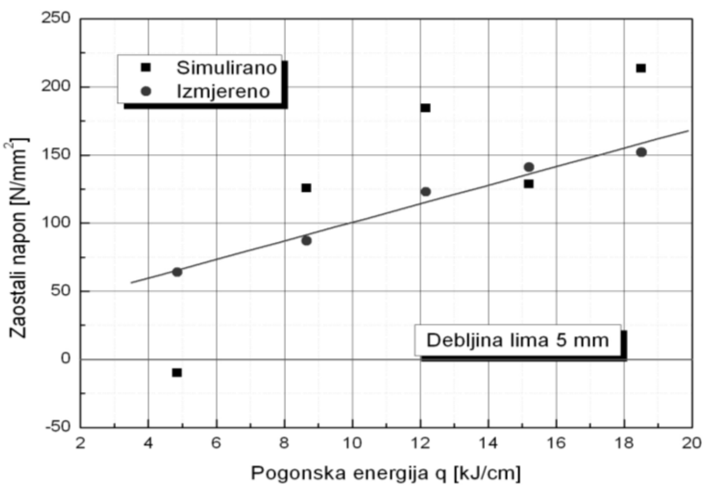

Figure 2 .Comparative diagram of residual stresses and strain gage measurements calculated by finite element method, depending on the driving energy (samples "B")

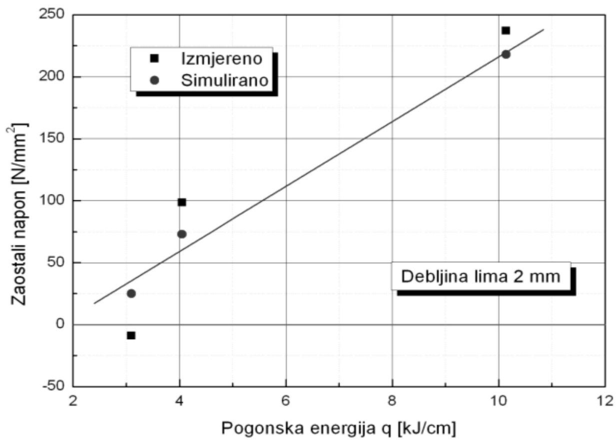

Figure 3. Comparative diagram of residual stresses and strain gage measurements calculated by finite element method, depending on the driving energy (sample " A ")

3. CONCLUSION

Conducted experimental studies have shown that the results of numerical simulations correspond very well with the values measured in real samples (97.8%), when it comes to simulation of thermal cycles. However, the results are less favorable comparisons with the results of residual stresses. The residual stresses obtained by numerical simulation are different from the residual stresses measured on a real experimental samples and up to 30% of the maximum measured residual voltage on the welded sample. These deviations are too large to be carried out by means of numerical simulation software package Adina could be accepted as correct, and the results are relevant for further considerations and practical application.

Optimising welding technology, through prediction of the expected conditions, it can certainly work well using methods of numerical simulations. However, this requires a software package that will give reliable estimates, not only of stresses and strains, but also changes of the structure of the heat affected zone and the changes in mechanical properties as a result of these changes.

Therefore, it is necessary to work on improvements used software packages, so they can give reliable results in the elastic - plastic range, which is characteristic of the welding process. Also, it is necessary to precisely define the legality of the behavior of materials at very rapid heating and cooling wich is relatively slow, trough the expansion and contraction of materials, in the elastic and in the plastic range.

In addition, it is necessary to establish the appropriate database material that software could work, in where there are all the necessary information about the material - mechanical and physical properties of the material (yield strength, modulus of elasticity, thermal conductivity , specific coefficient of thermal expansion...) in the temperature range from room temperature to the melting point .

4. REFERENCES

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