PRIMJENA VSR METODOLOGIJE U CILJU POSTIZANJA KVALITETA NEKIH INDUSTRIJSKIH PROIZVODA

VSR METHODOLOGY APPLICATION IN THE MANNER OF THE QUALITY ACHIEVEMENT FOR SOME INDUSTRIAL PRODUCTS

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REZIME

U ovom radu je prikazana primjena metodologija za umanjenje zaostalih napona (VSR) na dva modela zavarenih konstrukcija za potrebe automobilske industrije. Sa primjenom VSR procesa na velikim konstrukcijama često je neophodno umanjenje napona uz postizanje dimenzionalne stabilnosti, tj. sprječavanje daljnjih dimenzionalnih promjena nakon mašinske obrade ili transporta elemenata do odredišta za montažu. To znači da je postizanje "dimenzionalnog kvaliteta" proizvoda (pored ostalih) veoma bitno za ovakav tip konstrukcija. Za primjenu procedure je neophodno definiranje vibracionih parametara, primjena senzora za monitoring promjena u strukturi za vrijeme VSR procesa. Detaljan monitoring procesa sa mjernim senzorima se izvodi na svakoj konstrukciji sa naponskom i dimenzionom kontrolom, za vrijeme i poslije implementacije procesa na uzorcima.

Ključne riječi: VSR - umanjenje napona vibracijama, zavarena konstrukcija, zaostali napon, dimenziona stabilnost.

SUMMARY

In this paper the implementation procedure for vibratory stress relief (VSR) on two models of welded construction for the needs of railway and automotive industry is presented. With vibratory relaxation process application at large constructions it is usually necessary to release residual stresses in the structure with the realization of dimensional stability of the pieces, i.e. preventing further dimensional changes in terms of allowed geometric tolerance after machining process or after their transportation to the destination for assembling. It means that the achievement of the ''dimensional quality'' of products (among the other qualities) is essential for these types of constructions. To implement the procedure it is inevitable to define the parameters of vibration, perform the installation of sensors for quantifying and monitoring of changes in the structure during vibratory relaxation procedure. Detailed monitoring of the process with measurement sensors is performed on each construction with stress and dimensional control during and after the process implementation on examples.

Key words: VSR - Vibratory Stress Relief, welded construction, residual stress, dimensional stability.

1. INTRODUCTION

There are two kinds of residual stresses in the welding technology: *forced*, resulting from assembling of parts with free ends, where the effect is present only on the observed parts, and *reactive* which occurs in parts whose ends are trapped and they are prevented from forming, and transferred internal stresses in the whole welded structure. Residual stresses, formed in above mentioned ways, are multi-axial and combined with other stresses or low temperatures could create conditions for the occurrence of brittle fracture.

In the past 60 years, VSR has grown from a little known area to a respective primary process, which was established as an alternative to heat treatment of castings, manufactures, pieces requiring additional machining, and non-metallic materials. Effects of reduction of residual stresses in various previous studies have a wide range from 20% to 95%. Effect of vibratory relaxation method depends on many factors, such as type of construction, structural dimensions, weight and rigidity of the structure, characteristics of VSR equipment, suspension of construction, etc. The procedure of residual stress relieving on structures can be done in several ways, the best results can be achieved with heat annealing treatment, but due to limitations on the dimensions of structures that need to be treated alternative methods have been developed. One of these alternative procedures is vibratory relaxation process, [1,2].

2. VSR TREATMENT OF WELDED GRID STRUCTURES

Among the other types of construction grid constructions are very suitable for VSR treatment. The first example of VSR process application is grid welded type of construction with application as a special tool holding construction, Figure 1. Geometrical characteristics are: overall dimensions 6300 x 3100 x 600 mm, with embedded profiles 160x80x4; 160x120x6; sheet thickness of 30, 25, 15, 10, and 8 mm, with total weight about 2400 kg.

Figure 1. Treatment of the construction 1

The aim of the VSR technology application in this case is to reach dimensional stability of the component in requested tolerance value. The procedure of vibratory relaxation treatment involves placing the structure on the corresponding supports schedule, and excitation of the structure corresponding to vibratory frequencies and mode shapes. It is very important to know dynamical characteristics of the construction treated (eigen-frequencies and modal shapes) for the application of the process. Two approaches could be used: numerical analysis of the construction or frequency scanning of the construction with the equipment. Places of the weldments over construction are very important and must be related to vibration mode shapes. Also, because of the treatment of bending and torsion shapes locations of construction supporting must be changed in several positions. In terms of procedure monitoring the corresponding sensors are used: strain gauges LY-11 with the aim of measuring strain changes in the selected places of the structure, Figure 2, acceleration sensors Metrix and displacement transducers WA 100 and 200.

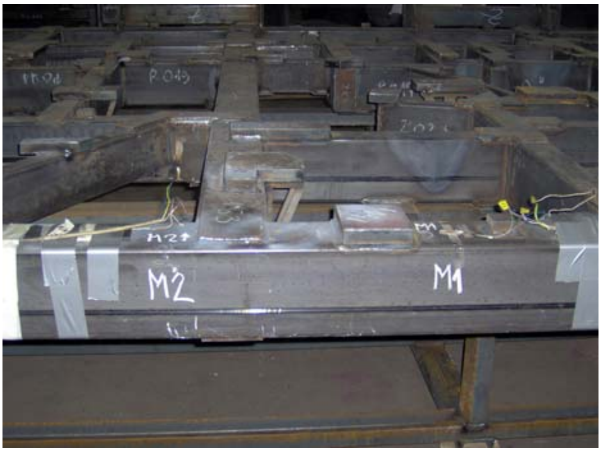

Figure 2. Strain gauges at the construction 1

Data acquisition was performed using the measurement system "Spider 8-55", and the results were processed using the software "Catman 5.0 Professional". For the monitoring of process the stroboscopic lamp DT-2259 is used. For the vibratory excitation of the structure an electro-force inducer with step regulation is used.

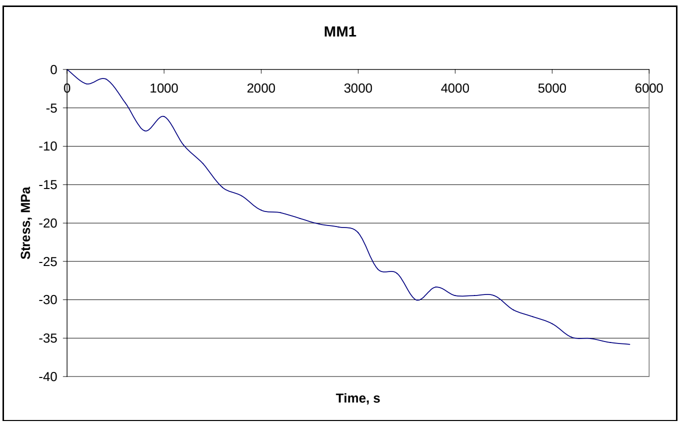

Figure 3. Stress changes during VSR of the construction 1

After a "scanning" of the construction the "sensitivity" of structure in the range of 20-30 Hz is appointed. Stress changes at the measuring point M1 is presented in Figure 3. Displacement changes regarding the geometrical influence are presented in Figures 4 and 5.

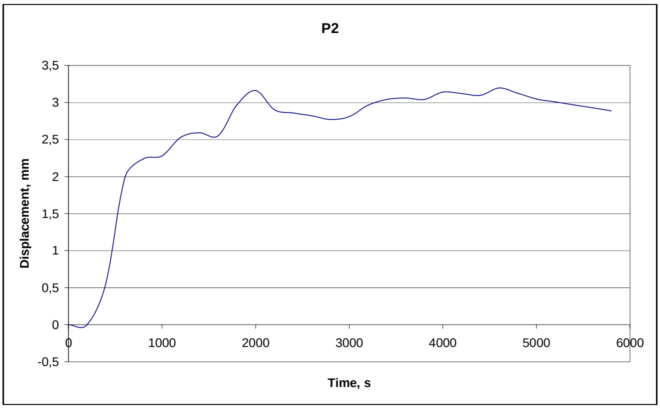

Figure 4. Displacement of the construction 1(point P2)

The values of "relative stress" change are: -35,8 MPa and changes in geometry of points P1 and P2 are: -2.17 mm, +3.194 mm, respectively.

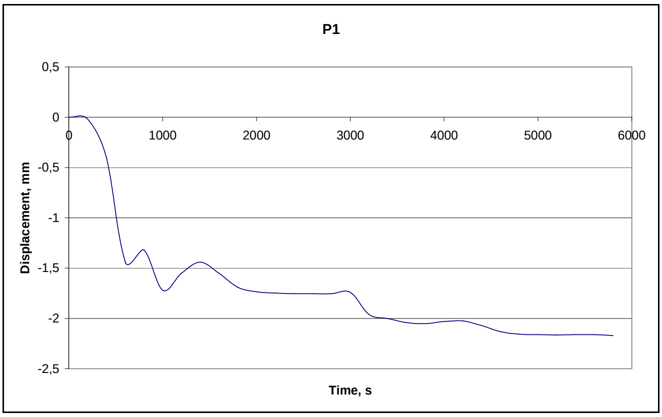

Figure 5. Displacement of the construction 1(point P1)

In the same manner with the same goal of the dimensional changes, one more type of grid welded construction is treated. In this treatment of the construction 2, geometrical, frequency and other characteristics of this construction are accepted. Positions of measuring places M1 (strain gauge) and P1, P2 (displacement transducers) are selected for two locations at the construction, Figure 6.

After a "scanning" of the construction the "sensitivity" of structure in the range of 30-40 Hz is appointed. Stress changes at the measuring point M1 are presented in Figure 7.

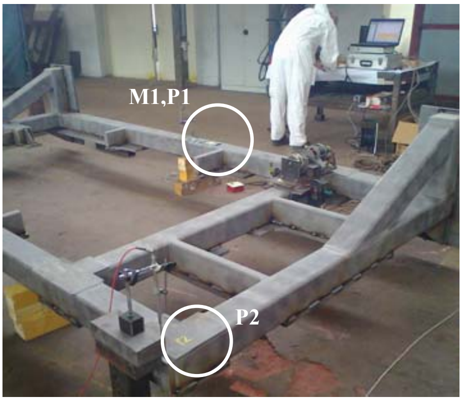

Figure 6. Treatment of the construction 2

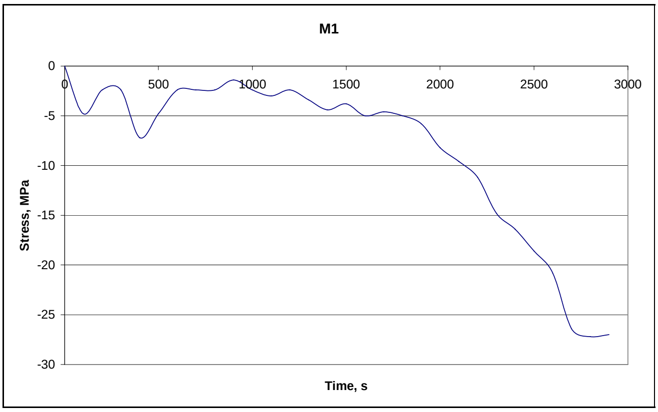

Figure 7. Stress values of the construction 2 (point M1)

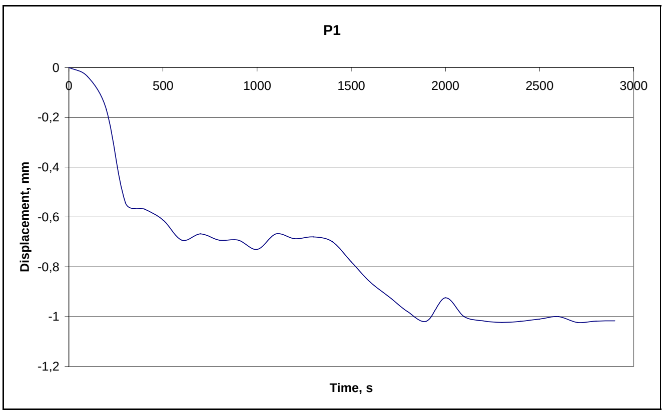

Figure 8. Displacement of the construction 2 (point P1)

Displacement changes regarding the geometrical influence on construction 2 are presented in Figures 8 and 9.

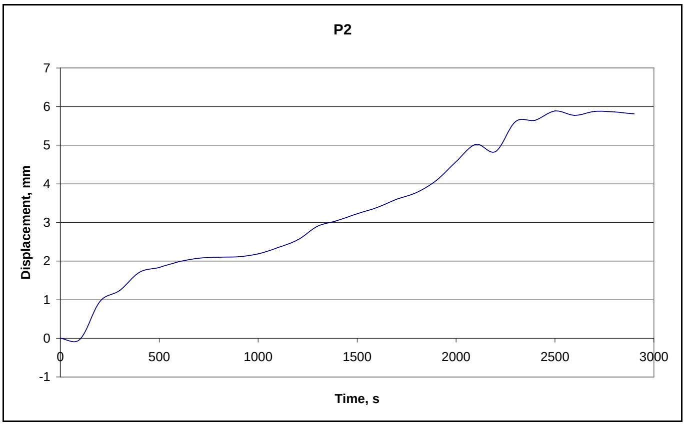

Figure 9. Displacement of the construction 2 (point P2)

The value of "relative stress" change is: -27 MPa and changes in geometry are: P1: -1,023 mm, P2: +5,875 mm.

3. CONCLUSION

In the above presented material it can be seen that VSR technology has a success as alternative method to the heat treatment for large constructions, but the effectiveness of the method is related to several crucial characteristics or parameters. Effect of vibratory relaxation method depends on many factors, such as type of construction, structural dimensions, weight and rigidity of the structure, characteristics of VSR equipment, suspension of construction, etc. Based on the results of measurement carried out after the application of vibratory relaxation procedure on both examples, it can be concluded that the application of treatment led to a change in stiffness of treated samples, and resulted in changing of stress state and geometry, i.e. the dimensional stability of treated samples. Changing the strain state of both structural and geometric changes at observed points clearly indicate their mutual relationship and the effect of treatment. Percentage visualisation of procedure success (an absolute value) is possible if the process of residual stress measuring is used. In two examples presented with results: (first example) stress: -35,8 MPa and changes in geometry of points P1: -2.17 mm and P2: +3.194 mm, (second example) stress: -27 MPa and changes in geometry P1: -1,023 mm, P2: +5,875 mm, the application of the process clearly shows changes in stress and displacement. It means that constructions have reached ‘’new equilibrium states’’ in the positive manner regarding dimensional tolerances. Sign (-) in stress results shows the relaxation and signs (-/+) in displacements depends on the initial signs and values of construction displacement after welding process.

4. REFERENCES

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