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THE APPLICATION OF VSR METHODOLOGY ON DOUBLE GIRDER BRIDGE CRANE WELDED COMPONENTS

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ABSTRACT

Welding process has been leading technological process in the production of modern metal products and structures for a long time. Among others, a very important characteristic of welding technology is that in the appropriate zone of construction it creates large temperature differences during cooling of pieces, because of disturbed expansion and contraction, creating internal stresses, which in practical applications of welded structures represent a serious problem. Internal stresses incurred as a result of welding can have very high values, even to the value of yield stress, so that a regular occurrence that is still in the course of the welding parts deform. Consideration of stress kinetic shows that at elevated temperatures, in certain conditions, the intensity of residual stress may cross the border and cause breakdown of materials and fracture. Residual stresses are multidirectional, and in combination with other stresses (stresses from external forces or its own weight) or at low temperatures could create conditions for the development of brittle fracture. This danger is greater as the parts that connect are with larger thickness and of higher strength materials, as well as misdialled technology of welding. Residual stresses in welded construction are undesirable, and it is necessary to eliminate or at least reduce their negative impact on structural safety. The procedure that is commented on in this work is the implementation of vibratory stress relieving method on main carrier segments of double girder bridge crane with projected capacity Q = 150 kN and the range L = 24 m. The applied VSR method with the control of implemented process has enabled the release of residual stresses in welded construction of the crane.

Key words: vibratory stress relief (VSR), double girder bridge crane, welding.

1. INTRODUCTION

Residual stress relaxation process is applied to the main girders of double girder crane with weigh projected capacity Q = 150 kN and wheel main distance L = 24 m, and after completition of welding technology. Crane is designed for needs of Converter steel unit in the Department of the old iron preparation in company "Arcelor Mittal". The hall "South" is the place for unloading of old iron from wagons in the reception bunkers (Scrap Yard), and loading the same into the bed for converter feeding. Load-carrying steel structure of crane consists of two main bridge beams of box shapes. Geometrical properties of cross section of the main girders is shown in Fig. 1.b. The combination of longitudinal and cross girders has achieved with a group of bolts (a total of 4 connection points longitudinal and cross girders). Checking the load-bearing structure is made for the nominal load of Q = 150 kN. Carrying structure of bridge crane is designed as a welded box shape and made of sheet metal material Č.0461 (ČN26) according to JUS C.B0.501 or St 42.2 to DIN 17100. Characteristics of the selected material are: R_{eH} = 260 N/mm^2 i R_m = 420 N/mm^2.

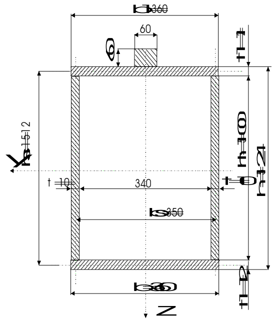
a)  b) 

Figure 1. Double girder bridge crane; a) realistic view, b) cross section

Maximum normal stress in the middle of support:

$$\sigma = \frac{M_y}{W_y} + \frac{M_z}{W_z} \le \frac{\text{Re}}{1{,}5} \quad ; \quad \sigma = 114{,}5\ N/mm^2 < \sigma_d = 173\ \ N/mm^2. \qquad \text{... (1)}$$

Allowed tangential stress is:

$$\tau_d = 0{,}6 \cdot \sigma_d = 0{,}6 \cdot 173 = 104\ N/mm^2. \qquad \text{... (2)}$$

For making of steel construction beams welding quality is prescribed as follows: the quality of "B" according to BAS EN25817 (for the continuation of carrier / profile, cross places) and the quality of "C" according to EN25817 BAS (welding of main girders, welding of stiffeners and platform). For purposes of determining the maximum girder stiffness, the maximum deflection from its own weight and the mobile weight is:

$$f_p \approx \frac{F_{K1}}{48 \cdot E \cdot I_y} \left\{ \left(l - \frac{l_v}{2} \right) \left[3l^2 - (l - \frac{l_v}{2})^2 \right] \right\} + \frac{5 \cdot G_{nosI} \cdot \ell^3}{384 \cdot E \cdot I_y} \qquad \text{... (3)}$$

$$f_p \approx 16{,}2 + 15 = 31{,}2\ mm < f_{dop} = 32\ \ mm\ .$$

Calculated deflection from its own weight of main girders is 15 mm, while the actual measured deflection in the middle of the main longitudinal girders in all measuring points for the zero state is higher than calculated value. Values of deflection in the middle of a free side and drive side of longitudinal girders of cranes before relaxation were -26 mm and -24 mm, and after the relaxation of -29 mm and -27 mm, respectively. Deviations of geometric parameters of the main girders are probably a consequence of deformation processes during manufacturing.

2. DEFINITION OF RELAXATION PROCESS PARAMETERS

In order to determine the parameters for relaxation methodology natural frequencies of crane structure oscillations are obtained, [1,2,3]. Results for the first six modes of oscillation are shown in Fig. 2 to 7, and Tab. 1. Relaxation of residual stresses on the main girders was performed using the pneumatic vibrator with selected parameters for induced force of 5000 N and frequency of vibrator of 70 to 100 Hz. With the selection of appropriate parameters it is possible to obtain the necessary amplitude of oscillation ranging from 0.3 to 0.6 mm in the treated area. Selection of treated places is made according to stress state fields which the main carrier exposed in the exploitation.

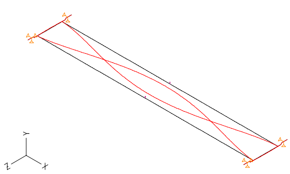


Figure 2. f_{o1}= 38,13 Hz, x-z plane

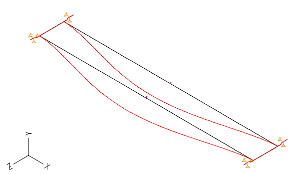


Figure 3. f_{o2}= 39,21 Hz, x-z plane

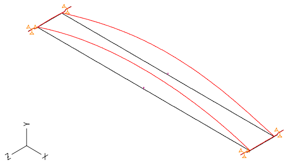


Figure 4, f_{o3}= 63,87 Hz, x-y plane

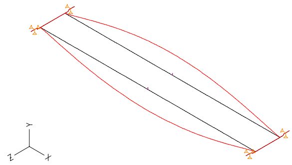


Figure 5. f_{o4}= 75,9 Hz, x-y plane

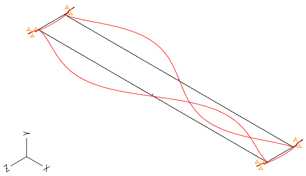


Figure 6. f_{o5}= 109,7 Hz, x-z plane

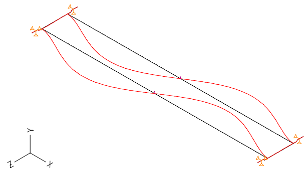
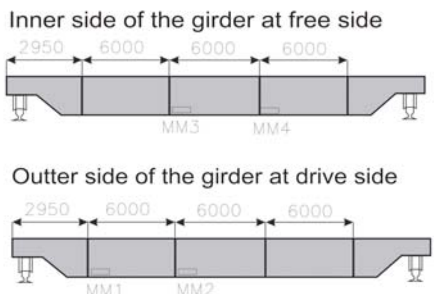


Figure 7. f_{o6}= 115,1 Hz, x-z plane

Table 1. Natural frequency values

Natural frequency	Value [Hz]	Max. displacement [cm]	Plane of movement
f_{o1}	38,13	0,128	x-z (horizontal plane)
f_{o2}	39,21	0,129	x-z (horizontal plane)
f_{o3}	63,87	0,116	x-y (vertikal plane)
f_{o4}	75,90	0,119	x-y (vertikal plane)
f_{o5}	109,7	0,128	x-z (horizontal plane)
f_{o6}	115,1	0,128	x-z (horizontal plane)

a) 

b) 

Figure 8. Measurement points at main girders; a) positions, b) realistic view

Working and residual stresses are balanced in exploitation conditions, so it is desirable to remove the welding stresses that have tension character in the zone closer to the lower band, while the presence of tension stresses in the zone of upper band are balanced with working stresses of compression character. VSR process is accompanied on the four measurement positions using strain gauges. The main girders are of identical construction, so the process on both beams are performed with the same parameters and continuity. Acquisition of microdeformation datas was performed using the measurement system, "Spider 8-55" and software "Catman" by HBM-Darmstadt. Frequency of oscillations are registered with stroboscopic lamp type DT2299. Measuring of oscillation amplitude is done by using uniaxial acceleration sensor with a frequency range 1-12 kHz ±10%. Measuring points are given in Fig. 8. Places for vibrator positioning are chosen so that residual stresses of lower band plate and the vertical plates are treated simultaneously.

3. ANALYSIS OF STRESS STATE MEASURING RESULTS

The results of stress state measuring during the VSR process after welding are shown in Fig. 9.a. to 9.d. Character of these is not the same voltage, stress at the measuring point MM2 is positive

(σ_{MM2}=9,5MPa), while at MM3 and MM4 are negative (σ_{MM3}=-9,5MPa, σ_{MM4}=-8,0MPa). This difference can be attributed to possible torsionally relaxation of carriers or relaxation in the horizontal plane. The value of stress is minimum at measuring point MM1 because weldments are near to the transversal girder. The second vertical weldment at the girder of drive group is also treated by this procedure with the same parameters as well as for measuring place MM2.

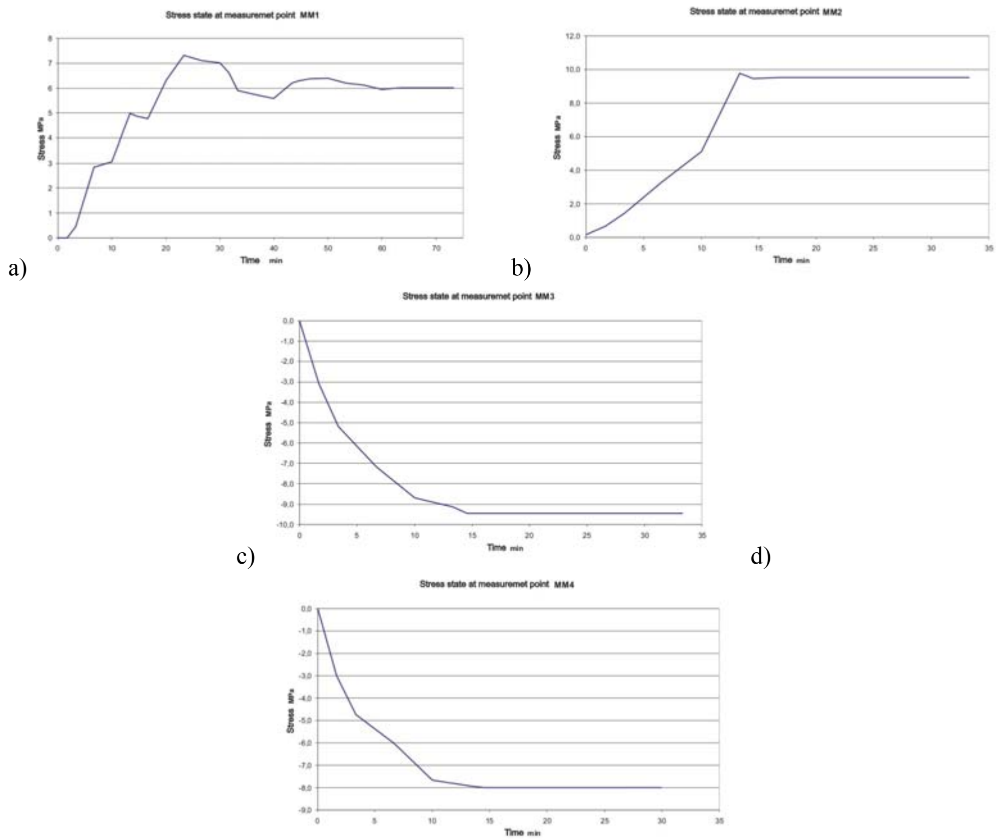


Figure 9. Stress state changes at measuring points MM1, MM2, MM3 and MM4

4. CONCLUSIONS

The applied VSR method with monitoring of process parameters has enabled the releaxation of residual stresses in welded construction of double girder bridge crane. The effect of residual stress relaxation is considerably influenced with stiffness of the main carrier (unfavorable ratio between cross-section and length). Also, results achieved contribute to increasing of stability and security of the crane during the exploitation.

5. REFERENCES

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