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THE INFLUENCE MODALITIES OF THE QUALITY OF QUALITY OF WELDING JOINTS

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ABSTRACT
The welding joints quality depends on the residual stresses distribution on the width and around the welding wedge (line). Are presented the results of the some experimental studies related with the residual state of stresses in the welding joints.

1. INTRODUCTION

The expression "residual stresses welding owed" represents a comprised concept, including all residual states of stresses that occur like a result of all welding techniques. In this case, we can say that many causes will contribute to obtaining the global state of residual stresses. A really way to understand and decrease these is different processes comprehension that could generate the stresses, and those influence factors.
The high level of temperature conducts to the material structure transformations, because the weld operation applies a localized thermal treatment of the specimens. The temperature gradient of welding operation produces dilates of the metal, which varies point to point of the heated area. So, due to the variable contraction conditions, in the joints welding will appear residual stresses having signs and values different. The transformation in the welding line and in the thermal affected zone during the cooling will produce the change of the volume, and finally could appear residual stresses, stresses what influence the quality of the welding joints.
The paper presents results of the some experimental studies related with the residual state of stresses in the welding joints afore and after the application of the relaxation methods.

2. THE DISTRIBUTION OF THE RESIDUAL STRESSES IN JOINTS WELDING

Many authors treat the state of residual stresses in joints welding [1, 2, 3, 4], to allow for generating stresses processes and the influence factors. For instance, H. Wohlfahrt [3], made a model of anticipated distribution for residual stresses in welding joints.
The residual stresses distribution in the joint welding, head to head, is reviewing in figure 1 [3]. In the welding line and the heated area occur longitudinal stresses σ_l (tensile stresses).
The tensile longitudinal welding stresses (constant on the length of welding line) will produce shear strains ε_t like in the figure 1.

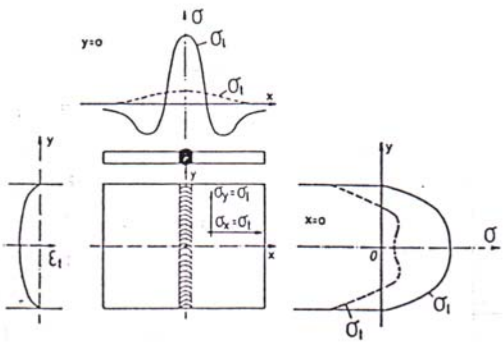

FIGURE 1. THE WELDING STRESSES DISTRIBUTION IN THE HEAD TO HEAD WELDING

These have a zero value to the end of the welding line and they values increase to the middle of the welding line. Therefore will appear residual shear welding stresses σ_t.
The schematization of the figure 1 is a basis model for the welding stresses in the joints. I reality exist deviations from that model, in case of appearing presented contraction of the welding line, as well as following factors: inhomogeneous cooling or non uniform phase transformation in comparison with the place and the time of them appearing.

3. EXPERIMENTAL TESTS

The experimental determinations was made in order to relieve the residual stresses that appear in the steel bands with σ_r = 500 N/mm^2 and the thickness 18 mm, longitudinal direction welded, before and after relaxation treatment. For comparing at identical samples, was made the relaxation by vibration using V.S.R. process (mechanical vibrations generated by electric motor with adjustable cams, using an installation V.S.R. produced by Martin Engineering Co, model LT 120 MX - 800). After that, was made the relaxation by vibrations using the process I.V.D. - 287 (vibrations produced by electro-dynamic vibrator, VED, installation I.V.D.-287, produced by I.E.I.A-Cluj Napoca).
Before welding, the tested samples was thermal relaxed, and after was manufactured joints welding along longitudinal axis according figure 2. The welding regime is identical for each samples: and has the following characteristics: electrode diameter 4 mm, U_a = 28 V, I_s = 150 A, v = 2,5 mm/s. In the qualitative evaluation and for quantitative residual stresses estimations used the blind-hole method with blank deformation test. The strain gauge rosettes were realized using strain gauge transducers (intern manufacturing TER 10 H 120) on the paper. The A and B constant determination was made by pure bending load of a steel sample (ARC 3) having with rectangular cross-section (90 x 6) for the load with bending moment M_i = 29 N·m. The figure 3 shows the positioning of the strain gauge rosettes (seven) cleaved on welded sample before relaxation (marked with continuous line) and after relaxation (marked with discontinuous line). The holes manufacturing was made using the mill with diameter 3,15 mm, in steps by depth 1,15; 2,15; 3,15 and 4 mm. So, was observed a increasing of the specific deformations with hole-depth until its value it id equal to its diameter. After that the depth did not influenced the specific deformations values indicated by the apparatus.

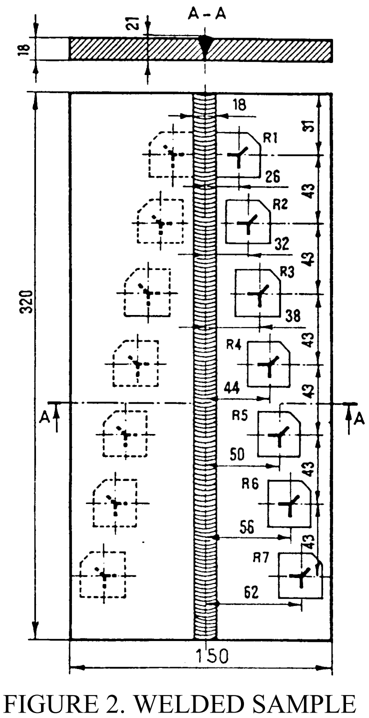

FIGURE 2. WELDED SAMPLE WITH LONGITUDINAL JOINTS LINE

The experimental results within these 7 points of the welded sample, before and after thermal treatment, are shown in the table 1.

TABLE 1. THE RESIDUAL STRESSES VALUES AND THE HARDNESS, BEFORE AND AFTER THERMAL RELAXATION TREATMENT

SAMPLE 1								
Rosette	Before relaxation			After relaxation			Stresses decreasing [%]	
	Principal stresses [N/mm^2]		Hardnes s HRC	Principal stresses [N/mm^2]		Hardnes s HRC		
	σ_1	σ_2		σ_1	σ_2		σ_1	σ_2
1	-12,94	13,84	36,5	3,79	-1,98	42	71,3	86,2
2	27,506	-12,417	39,5	3,19	0,43	51	88,7	96,8
3	23,99	-32,44	42	-1.21	3,93	46	95	88
4	24,93	-47,25	46	2,64	-6,92	55	89,6	85,4
5	29,97	-20,92	42,5	0,43	1,38	47	98,6	93,8
6	23,57	-16,03	36,5	0,97	-5,49	49	96,1	66,3
7	9,63	-6,61	34,5	1,11	-6,85	41	87,8	3

Basis on the data shown in the table 1, and in figure 2, was plotted the residual stresses diagrams σ_1 and σ_2, before and after applying the thermal relaxation treatment (maximum temperature of the relaxation, 650 ^{0}C).

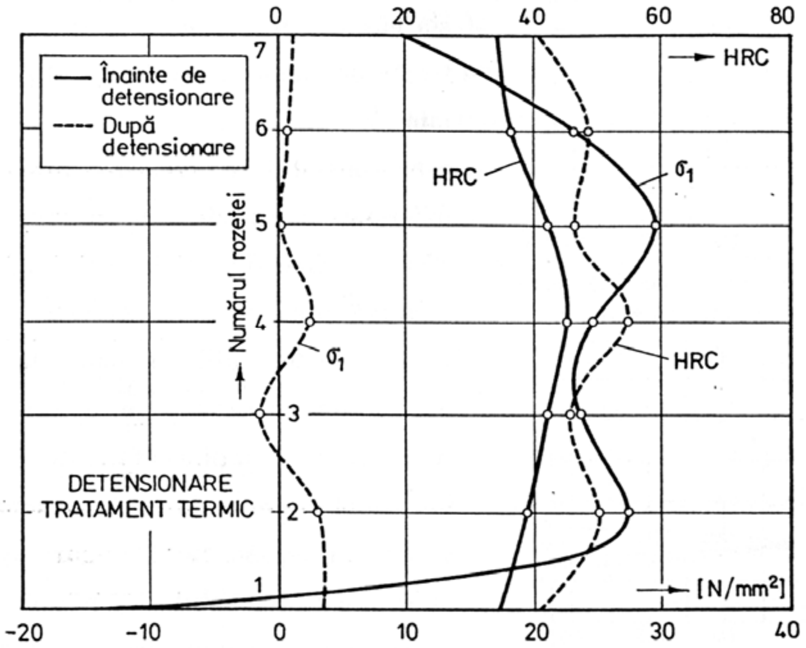

FIGURE 3. THE PLOT OF THE RESIDUAL STRESSES VARIATION AND THE HARDNESS, BEFORE AND AFTER RELAXATION BY THERMAL TREATMENT

TABLE 2. THE RESIDUAL STRESSES VALUES AND THE HARDNESS, BEFORE AND AFTER VIBRATION RELAXATION (V.S.R. PROCESS).

SAMPLE 2								
Rosette	Before relaxation			After relaxation			Stresses decreasing [%]	
	Principal stresses [N/mm^2]		Hardnes HRC	Principal stresses [N/mm^2]		Hardnes HRC		
	σ_1	σ_2		σ_1	σ_2		σ_1	σ_2
1	-19,73	8,98	38	-15,725	0,3376	45	20,30	96,62
2	23,28	-25,69	43	-2,19	-15,001	59	90,94	41,40
3	15,02	-36,21	46	13,204	-18,03	60	12,00	50,27
4	20,11	-37,72	45	6,12	-16,68	62	65,65	55,96
5	20,11	-45,48	44	15,14	-32,24	55	24,87	28,19
6	19,19	-25,37	44	7,66	-22,15	50	60,20	12,64
7	10,08	-3,51	36	-14,48	-32,59	47	-44	-89,23

It is important to remark that the maximum stresses values was obtained in the points situated in the middle zone along the joints welding. (rosette 2, 3, 4 and 5), due is the normally (because in the end zone of the joints welding the residual stresses is relaxing). After, applying a thermal relaxation treatment to the joint welding sample is observed a decreasing the principal stresses values measured in the points symmetrically placed beside the joints welding.

Table 2 contained the experimental results made on the sample nr. 2 before and relaxation by vibration (V. S. R. – process).

From the table 2, in the figure 4 was plotted the principal stresses distribution σ_1 and the hardness, before and after relaxation by vibration.

The Rockwell hardness measuring is made a the 5 - 8 mm distance from the left to the right of the rosettes centers, after specific deformations measuring ε_a, ε_b, ε_c.

In the table 3 is shown the

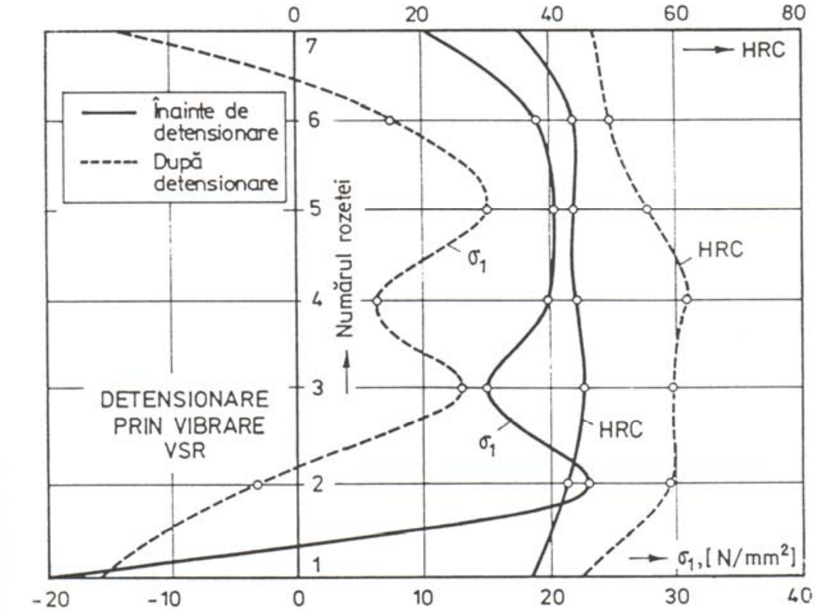

FIGURE 4. THE PLOT OF THE RESIDUAL STRESSES VARIATION AND THE HARDNESS, BEFORE AND AFTER VIBRATION RELAXATION (V.S.R. PROCESS)

experimental results obtained on the sample nr. 3, before and after the vibration relaxation using the I. V. D. method.

TABLE 3. THE RESIDUAL STRESSES VALUES AND THE HARDNESS, BEFORE AND AFTER VIBRATION RELAXATION (I.V.D. PROCESS).

SAMPLE 3								
Rosette	Before relaxation			After relaxation			Stresses decreasing [%]	
	Principal stresses [N/mm^2]		Hardnes HRC	Principal stresses [N/mm^2]		Hardnes HRC		
	σ_1	σ_2		σ_1	σ_2		σ_1	σ_2
1	-12,98	7,55	36	13,02	-31,26	46	0,77	75,9
2	25,05	-22,93	39	9,78	-5,56	57	61,2	75,9
3	24,74	-31,98	44	8,07	-13,81	66	67,6	56,7
4	25,87	-51,52	45	19,72	-28,47	66	23,64	44,9
5	30,09	-34,02	41	9,97	-15,71	47	67	53,82
6	21,53	-22,43	37	15,04	-11,12	40	30,23	50,44
7	10,54	-9,63	34	11,12	-13,31	46	5,71	38,54

With the data from the table 3, in the figure 5 was plotted the variation graphs of the principal stresses σ_1 and the hardness before and after relaxation.

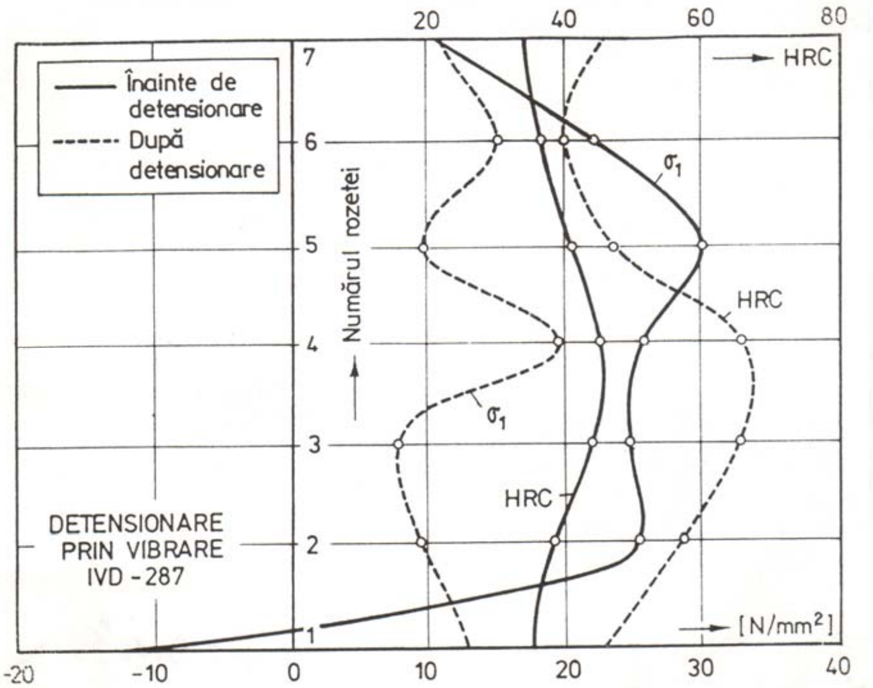

FIGURE 5. THE PLOT OF THE RESIDUAL STRESSES VARIATION AND THE HARDNESS, BEFORE AND AFTER VIBRATION RELAXATION (I.V.D. PROCESS)

4. CONCLUSIONS

After evaluation of the size of the residual stresses, distribution in the welding joints, before and after applying relaxation processes, results:

- the thermal relaxation process realized the most increasing residual stresses (86 %), from the made welding samples;
- the technology of relaxation using the vibration process LT -120 - MX 800, realized a decreasing of the residual stresses 30,7 % medium, a little less then that obtained by applying the relaxation process using the I. V. D. process, where was realized a mean decreasing of 34,9 % ;
- within the thermal relaxation technology the grade of relaxation is not depending only on the relaxation temperature, but the time of the temperature maintenance. So, the totally removing stresses from the steel pieces having mean

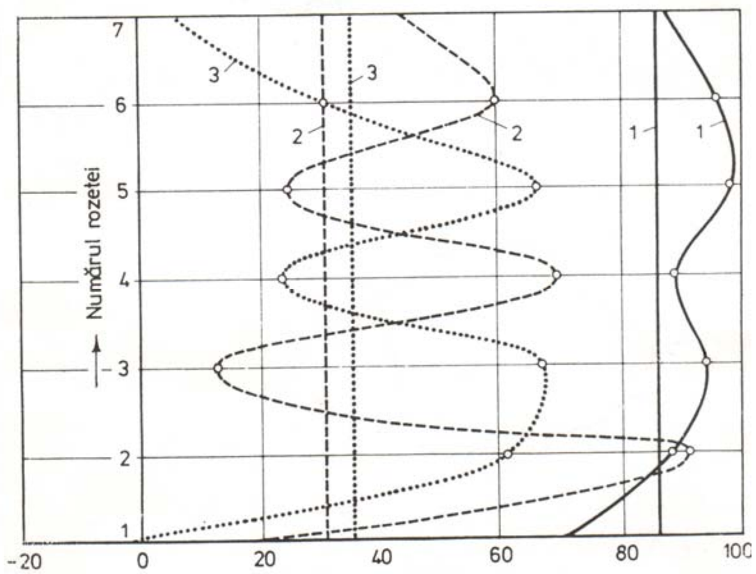

FIGURE 6. THE DIAGRAM OF DECREASING RESIDUAL STRESSES FOR SOME RELAXATION PROCESSES [%]
1. THERMAL RELAXATION. 2. VIBRATION RELAXATION (VSR)
3. VIBRATION RELAXATION (IVD)

contain of carbon [4] are necessary 150 hours of maintenance at the 550 ^{0}C temperature, 15 ore at 650 ^{0}C and only 0,8 ore at 750 ^{0}C. The thermal relaxed sample was maintained for 4 hours at 650 ^{0}C, more over the recommended time of an hour, so the relaxation process increases;

- the measuring of the hardness give the quality image of the residual stresses values, and that can be used for the established statistical data with help of another processes.

The plot from figure 6 shows the decreasing of the residual stresses, comparatively, by different relaxation processes.

5. REFERENCES

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