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Comparative analysis of dimensional stabilization on welded steel pipes P265GH

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The paper includes a comparative study on the efficiency of dimensional stabilization of welded stitches in P265GH steel pipes by local-stress relief heat-treatment and low frequency mechanical vibration.
Considering the fields of use, these steels must provide high temperature resistance (creep) and ductility, especially elongation and cracking, at high, stable values during the use of the metal structure. Taking a decision on applying stress relieving treatment to a welded structure should take account of certain major factors. Also, depending on the level and distribution of the residual stresses, the volume of the weld structure and its complexity, it will be decided whether the stress will be done totally or locally. Also, one of the drawbacks of applying the method is that stress relieves the manufacturing time and cost of the welded structure. If for a thermally stressed part the duration is 24 hours or more in the case of mechanical vibration stabilization, the time shortens significantly.

Keywords: *steel pipes, stress relief heat-treatment, mechanical vibration stabilization*

1. Introduction.

Due to the unevenness of the thermal fields developed during the welding and the cooling of the parts, the residual stresses produce unfavourable effects, which influence negatively the quality of the welded joints [1].

In order to reduce the deformations caused by the residual stresses of the welded parts and structures, thermal relief stress is usually applied [2], [3].

This heat treatment has favourable effects on welded joints, such as increasing dimensional stability, reducing metallic sensitivity to corrosion, and reducing the likelihood of fracture.

Depending on the volume and complexity of the welded structures, strain relief can be applied to the entire structure or only locally, that is in the areas adjacent to the seam. In the case of carbon or low alloyed steels, the stress relief temperature is 550-650°C, and the retention time at this temperature depends on the thickness of the welded parts [4].

One of the biggest drawbacks is thermal and economic stress relief, as well as care for the protection of nature by replacing energy and fuel-intensive technologies. Thus, it resorts to the application of simpler technologies with multiple advantages, such as low-frequency vibration stress. This method ensures effectively that the parts and subassemblies with large gauge are stressed [4].

2. Comparative analysis

It is well known that these welding pipes are part of an assembly subjected to high mechanical and thermal stresses (pressures up to 140 and temperatures reaching 560 ° C) over a long period (up to 20 years of use) during operation.

The research was carried out on samples from welded pipes from welded P265GH steel joints, the welding process being manual welding with coated electrodes, 111. In order to determine the optimal parameters of the welding regimes, the welded samples were subjected to visual and dimensional control. The optimal welding parameters for the manual welding process with Superbaz electrodes of ≥ 2,5 mm were set, namely: I_s = (70 ... 75) welding current [A] = spring voltage U_a = 12 ... 14 [V] and the welding rate v_s = (8 ... 10) cm / min.

2.1. The stress relief heat-treatment

Figure 1 and Figure **2** shows the visual aspects of welded samples with E1-coated electrodes, thermally untreated samples and E1T, the same samples subjected to stress relief heat-treatment.

The joints did not show external welding defects.

Figure 1. Welded joint welding E1

Figure 2. Welded joint with local stress relief heat treatment

Traction test results for Welded joint welding E1 and Welded joint with local stress relief heat treatment show in Table 1.

Table 1. Welded joint with local stress relief heat treatment

Sample No.	Sample dimension (S_0 x B_0), mm	F_{max}, [N]	Rm, [N/mm^2]	The place of rupture
E1	5.9 x 12.2	34530	479	MB
E1T	5.8 x 12.3	33950	476	SUD

The microscopic examination reveals specific microstructures, namely:

In the base metals (BM_{rigt} and BM_{left}), ferrite-pearlite granular structures in rows with alternating ferrite and perlite strips with a grain size of 7-8, Figure 3 and Figure 4.

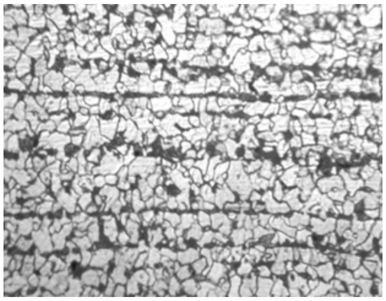

Figure 3. Sample E1, BM, Nital 2%,100X .

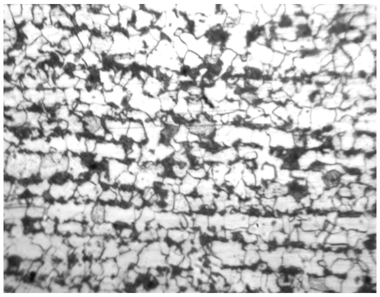

Figure 4. Sample E1T, BM, Nital 2%, 100X

In Welded joint welding, dendritic ferrite-perlite structures with elongated dendrites (Figure 5 and Figure 6).

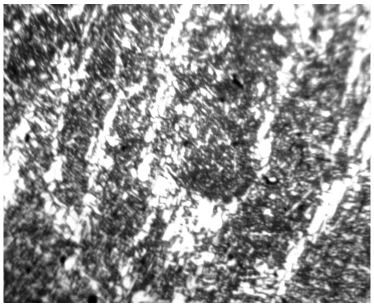

Figure 5. Sample E1, Joint, Nital 2%, 100X

Figure 6. Sample E1T, Joint, Nital 2%, 100X

In thermo mechanical influenced zones (TIZ_{right}, TIZ_{left}), perlite-ferrite coarse structures with acicular ferrite zones, the granulation score does not exceed 4 (Figure 7 and Figure 8).

Figure 7. Sample E1, TIZ, Nital 2%, 100X

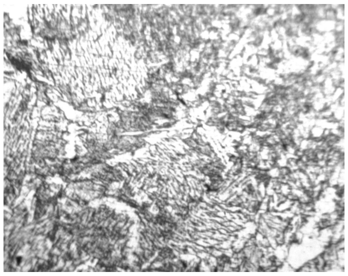

Figure 8. Sample E1T, TIZ, Nital 2%, 100X

In order to reduce the internal stresses due to the SEM111 welding processes and the uniformity of metal welding structures and thermo mechanical influenced areas, after welding, thermal stress relief treatments TD with the parameters presented in the Table 2. [4]

Table 2. Parameters of thermal treatment regimes, TD

Temp. min, ^{0}C	Temp. max, ^{0}C	Warming speed ^{0}C/h	Cooling speed, ^{0}C/h	Warming time, h	Maintaining time, h	Cooling time, h
0	600	150	200	3,86	0,50	2,90

Thermal stress relief treatments on the pipe assembly were performed in a electric furnace with fixed hearth type L 600 manufactured by Caloris S.R.L. Bucharest.The welded structure can only be removed from the oven after temperature has reached 315^{0}C.

2.2. Dimensional vibration stabilization

Dimensional vibration stabilization consists of the use of controlled vibrations to reduce the deformations due to residual stresses in the structure of the parts.

By applying vibrations a change in the positions of unstable atoms moving at very small distances is achieved. This stabilizes each crystal and at the same times the entire structure [5].

In order to set the vibrator so that the welded assembly is in balance, place three insulation blocks. Set the vibrator speed to 6500 rpm, 2300 watts. The operating mode of the vibrator consists of the following steps:

Increase the speed of the vibrator until a voltage peak has been found. This causes the amp meter to jump suddenly.

Table 3. The vibration test report for a welded ring-type assembly

Nr. crt.	Name welded assembly	Speed [rpm]	Initial Current [A]	Final current[A]	Time [min]
1	Pipe Assembly	2221	1.36	1.36	09.03
2		1917	1.22	1.22	04.53
3		1267	1.00	1.00	04.01
4		1066	0.96	0.96	03.15
5		0800	0.87	0.87	04.00

Select 5 resistive voltage and resistors, then increase the speed of the vibrator drive motor, and validate one of them, as in Table 3. On the tab. mechanical vibration test of the welded pipe assembly is presented. It is possible to observe the variation of the speed of the drive motor of the vibrator, the current and the maximum oscillation peaks chosen.

The vibrator speed was set on the selected peaks, corresponding to the highest speed, and the vibrator was allowed to work, following the alphanumeric device indications, stabilizing at that speed and ending when the current value was stabilized. The other peaks are treated the same way. After passing through all of these peaks, the piece is dimensionally stabilized. If, in the case of thermal stress relieving, the time spent in the oven is 24 hours, in the case of stabilization by low frequency vibrations, the duration of a DE tensioning cycle is 30 minutes, making the latter method the most economically advantageous.

With the experimental results of the shaking table shown in table 1, we plotted a chart of the Current and Time (see Figure. **9**).

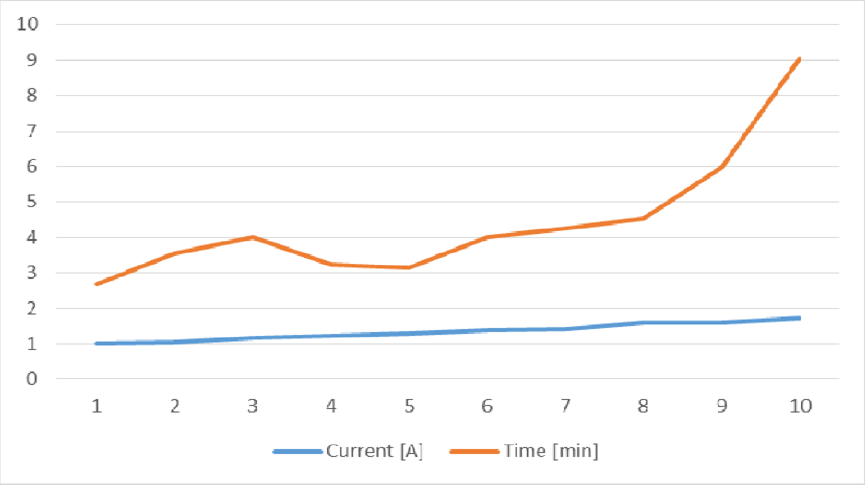

Figure. 9. The operating mode of the vibrator

Conclusion

The fracture surfaces of the traction sample have a ductile net appearance, specific to base metals subjected to stretching stresses and elongated features specific to tough welds without defects in the tearing area. The microscopically examined areas did not show cracking. In any welded structure residual stresses remain, which can be diminished both by thermal stress relief and by mechanical vibration. Time and cost of final control by heat treatment increase compared to mechanical vibration control where time is at least 10 times lower. The dimensional stabilizer is portable and can be used for parts of any size, shape or weight resulting from the welding process. It is worth noting that the process is ideal for large parts with critical dimensions, which require very large furnaces to be thermally de-stressed.

References

[1] Yang F., Liu, K., Wang S., a.o., A thermal-stress field calculation method based on the equivalent heat source for the dielectric fitting under discharging, *Applied Thermal Engineering*, 138, 2018, 183–196.

[2] Hațiegan C., Gillich N., Popescu C., Răduca E., Cîndea L., Predus M.F., Terfăloagă I.M., Study regarding the influence of environmental temperature and irradiation conditions on the performance of a photovoltaic solar module, *IOP Conference Series: Materials Science and Engineering,* 294, 2018, 012-075.

[3] Sachajdak A., Sloma J., Szczygiel I., Thermal model of the Gas Metal Arc Welding hardfacing process, *Applied Thermal Engineering*, 141, 2018, pp. 378-385.

[4] Iancu V., Gillich G-R., Iancu A., Chioncel C.P., *Consideration regarding the use of time-frequency representations in analysis of vibration*, 3rd WSEAS International Conference EMESEG, 2010. pp. 492-495.

[5] Suciu L., Hatiegan C., Gillich G.R., Marta C., Nedeloni M., Research Regarding Vibration Damping in Systems with a Degree of Freedom*, Scientific Bulletin of the „Politehnica" University of Timisoara, Romania, Transaction on Mathematics&Fhysics*, 57(71), Fascicola 1, 2012.

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