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EXPERIMENTAL INVESTIGATIONS ON A PROCEDURE FOR WELDING THE MEMBRANE WALLS OF THE BOILERS WITHIN THE THERMOELECTRIC POWER STATIONS, IN ORDER TO INCREASE THE LIFETIME OF THE COMPONENTS

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Abstract: *Due to the high necessity to increase the lifetime of the thermoelectric equipment, many welding technologies have been adjusted in order to re-commission the installations, being successfully applied when executing the maintenance operations.*

The work presents a process for welding the membrane walls of the boilers or of the over-heated water vessels.

There are shown the results of the tests made on the welded joints in order to homologate the welding procedure and also the possibilities for the applying this method for other energetic vessels tubes.

Keywords: *welding procedure, boilers, lifetime*

1.INTRODUCTION

Replacing the used components is not seen today as an ultimate technical solution within the maintenance of the thermoelectric power stations anymore, because the using field of welding has highly developed. The reasons that support the decision taken for repairing an used component, as an alternative of its replacement, are not just of technical nature, but they present important economical aspects, like: increasing the availability of the installation, avoiding the unplanned breaking due to the damaging of the components, increasing the security of operation, prolonging the lifetime of the component, reducing the maintenance costs and the time necessary for replacing the component.

The damaging process by corrosion and erosion of the vessels tubes are seen as being important processes within a thermal station, and the causes that lead to the occurring of such damaging mechanisms are multiple (fuel quality, burning system, etc.). Because of the implementation of the systems for cleaning the waste gases, imposed by the environment protection legislation and because of the chemical burning processes that take place, a porous and non-adherent sulfide film is built on the outer surface of the tubes. This finally leads to the beginning of an accelerated corrosion process and to a strong damaging by erosion. The result is the premature ending of their lifetime, with serious effects in what concerns the installation efficiency.

The welding technologies, as reparation / prevention methods, represent a solution of high interest for the new components but also for the damaged ones, thanks to the advantages they have: they do not need the replacement of the existent tubes; they can be applied as on-site reparation methods without dismantling the component; they do not need thermal treatment before and after welding; the lifetime of the component is increased with approximately 10 years under normal operation conditions of the vessel; the method combines the high corrosion resistance of the outer surface of the welding coated tube with the advantage of using of a cheap and non-pretentious steel.

2. UTILIZED MATERIALS

The membrane walls subject to the welding are part of the CR 16 vessel, destined to the Paroseni thermal station.

The basis materials subjected to the welding procedure are: the OLT 45 K steel STAS 8184-87 under the form of tube having the dimensions Ø 38 x 4 mm, delivered by S.C. Silcotub S.A. Zalau, respectively the steel OL 37.2k STAS 395-88 made by S.C. Siderurgica S.A. Hunedoara, delivered under the form of strip steel having the dimensions 20 x 5 x 6 m.

Table 1 shows the chemical composition of the two steels.

Table 1. *The chemical compositions of the basis materials*

Material	C [%]	Mn [%]	Si [%]	P [%]	S [%]	Al [%]
OLT 45 K	0,18	0,68	0,26	0,31	0,17	0,24
OL 37.2k	0,15	0,64	0,26	0,024	0,025	-

The thermal treatment applied to the tube made of OLT 45 is normalizing.

The mechanical characteristics guaranteed by the producers are:

- *for OLT 45 K steel* – $R_{p0,2/350/450}$ = 217 N/mm^2; $R_{p0,2}$ = 366 N/mm^2; R = 508 N/mm^2; A = 29,4%. There are also guaranteed the toughness characteristic and the one reached as a result of the tube enlargement test.
- *for OL 37.2k steel* – $R_{p0,2}$ = 320 N/mm^2; R_m = 420 N/mm^2; A_5 = 34%.

The utilized addition material is welding steel wire, having ϕ1,2 mm, SG2 grade, delivered by Industria Sarmei S.A. Campia Turzii, that has the chemical composition shown in Table 2.

Table 2. *Chemical composition of the welding wire*

Material	C [%]	Mn [%]	Si [%]	P [%]	S [%]	Cr [%]	Ni [%]	Cu [%]
Welding steel wire	0,09	1,42	0,98	0,012	0,012	0,08	0,14	0,17

The welding wire has been delivered as *bright coppery,* having the breaking resistance minimum 900 Nmm.

3. SHAPE AND DIMENSIONS OF THE SAMPLES

The sample for homologation is to be made of a 6-tube register, having the length of 3000 mm, according to Figure 1a. Figure 1b shows the way of sampling the specimens, by indicating the areas of sampling.

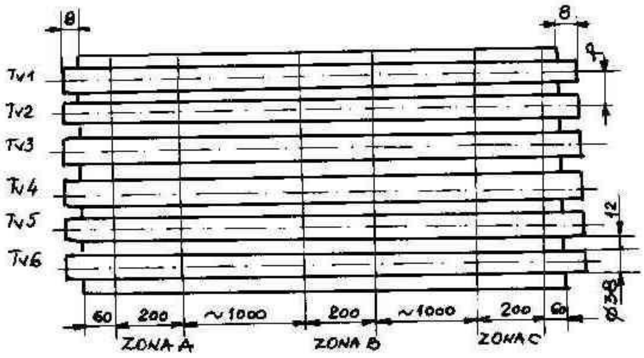

Figure 1a. *Shape and dimensions of the sample*

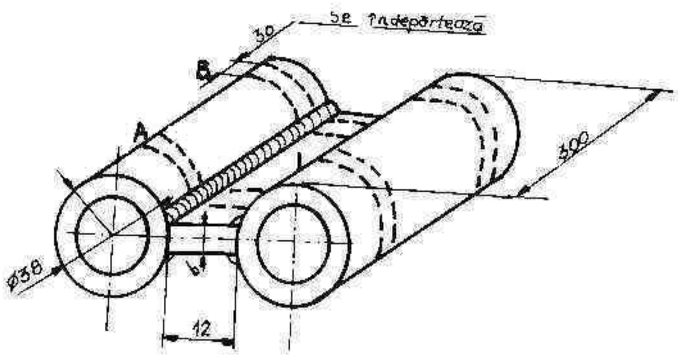

Figure 1b. *The way of sampling the specimens for lab tests*

The preparing and the welding of the sample is to be made accordingly to WPS and under the general welding conditions used in practice.

The preparing of the table and tube edges in the welding area is made by mean of a wire brush, or if necessary, by polishing. The sample does not require neither preheating nor thermal treatment.

4. RESULTS

The control of the membrane wall quality is performed as follows: visual and dimensional control of the weldings, dimensional control of the wall with checking the pitch, the width, the register length, checking the length for each tube of the register, checking the deflection in the register plane and in a plane that is perpendicular on the register plane, checking the strip steel movement as comparing to the middle axis of the register, respectively checking the surfaces of the welded joints by mean of 100 % penetration liquids.

The lab tests performed on samples taken from the areas A, B, C of the welding, according to Figure 1b, were as follows:

- tensile test on a specimen under the form of a strip having the dimensions 20 x 5 mm and the initial cross section of S_0 = 100 mm^2.
- bending test in the wing plane on each strip steel, the bending angle being 50°.
- rod enlargement test of each tube ring up to a deformation value of 10% of the tube diameter.
- twisting test of the strip steel at an angle of 90°.
- flattening test in wing plane, respectively in a plane that is perpendicular on the wing plane, at different distances.

Out of the sample register, i.e. out of each of the three areas marked with A, B, C, there were sampled specimens by mechanical cutting (mill cutting) on the entire width of the register, parallel side samples, as follows:

- all one 20 mm wide strip on which the flattening test is performed perpendicular on the wing plane (the pressure force has a direction that is perpendicular on the wing plane); before testing, each tube from each strip is to be separated by mechanical cutting on the middle of the strip steel.
- all one 20 mm wide strip for performing the transversal tensile test on the wing plane; before testing, steel disks are to be mounted inside each tube, in order to prevent the tube deformation during the test.
- all one 20 mm wide strip on which the flattening test in the wing plane is to be performed (the pressure force is located in the wing plane); before testing, each tube from each strip is to be separated by mechanical cutting on the middle of the strip steel.
- all one 10 mm wide strip that is to be subjected to the bending test in the wing plane (the bending axis is parallel to the longitudinal axes of the tubes).
- all one 10 mm wide strip that is to be subjected to the bending test perpendicular on the wing plane (the bending axis is perpendicular on the longitudinal axes of the tubes).
- all one 10 mm wide strip that is to be subjected to the twisting test of the strip steel, around an axis located in the wing plane.
- all one 15 mm wide strip on which the rod enlargement test of each tube ring is to be performed. The test is to be performed according to STAS 1111-79, by mean of a taper chuck, with 1:10 tapering.

There were also performed Vickers and HV5 hardness tests for the welded joints, i.e. for each welding seam according to SR EN 1043-1/1997.

Before measuring the hardness on one sample made of two tubes, from each of A, B, C groups there are performed the **macroscopic and microscopic analysis**, and the results are shown as follows.

At the macroscopic analyze of the area A, there was determined that the welding seams are made of a single layer, and a seam of the sample in the Figure 2b has an elongated pore. Figures 2a and 2b show the micro-fractographies of the samples.

At the macroscopic analyze of the area B, there was determined that the welding seams are made of a single layer, the sample in Figure 2c does not show any defects, but the sample in Figure 2d shows a pore in one seam and a melting deficiency in another one.

At the macroscopic analyze of the area C, there was determined that the welding seams are made of a single layer and do not show any defects, and Figure 2e and 2f show the micro-fractographies of the samples.

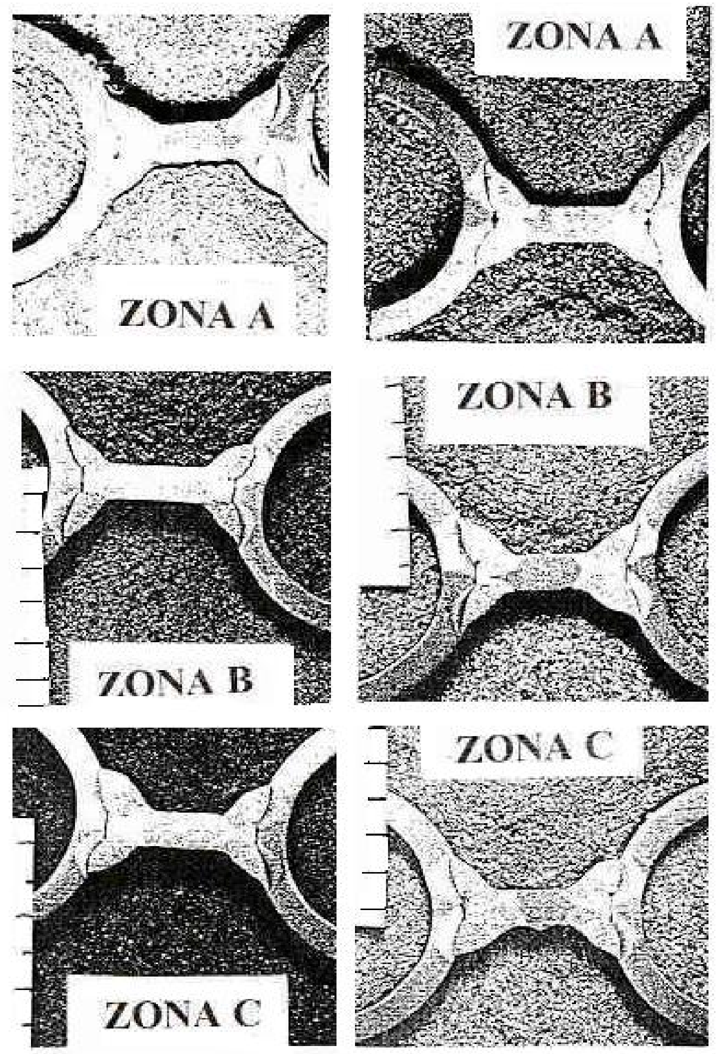

Figure 2. *The samples for lab tests – Nital 4% etching*

The microscopic analyze of the samples leads to the conclusion that all the samples from the three areas A, B, C show the same metallographical characteristics, i.e.:
Welding: casting structure; ZIT: normalizing structure; MB1-tube: pearlitic-ferrite structure; MB2-strip steel: pearlitic-ferrite structure and tertiary cementite, and also ferrite grain of 8 points.

After testing the welding with Helling Bid 1 type penetration liquids and after a previous abrasive and chemical cleaning of the welding there were not detected any surface defects, like: pores, cracks, craters and edge notches.

As a result of these tests, no defects of the welding joint or of the welding seams were detected.

5. CONCLUSIONS

The checking carried on in order to homologate the welding procedure performed on a steel within the group 1 according to CR 7/96, leads to the homologation of the welding procedure on any other lower alloyed steels from this group or steels from this group having a lower yield point, under the condition that the welding materials used for the homologation of the procedure can be also used for steels from other groups.

The homologation is valid even if other adding metals are used, if these have an equivalent chemical composition and if they are part of the same class of tensile strength. The homologation for the protection gase is limited at the type of the gas used when checking in order to homologate the welding procedure is performed.

In what concerns the thickness of the basis material, the thickness of the homologated sample represents the minimal wall thickness that can be used. In what concerns the diameter, the validity field of the procedure is 0,8 D … 2D.

The welding process has multiple potential possibilities to modify the initial characteristics of the basis material and of the adding material, to perform in welded joint the non-homogenity of the chemical composition, of the structure and of the mechanical characteristics, and also to create residual strains and plastic deformations, with effects on the quality of the welded joint and on the operational security, that can be diversified thanks to the welding capacity factors.

Hence, the influence of welding is that demonstrated more pronounced and diversified when manual welding with adding material is performed in enclosure. In this case interferes the recognized easiness for generating technological deviations and welding defects.

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