REHABILITATION TECHNIQUES APPLIED TO FILLET WELDED JOINTS IN ORDER TO INCREASE THE FATIGUE LIFE TIME

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Abstract:*The rehabilitation of the fillet welded joints in order to increase fatigue life time is a delicate issue of great importance. In principle, all rehabilitation techniques, in one way or another, reduce the stress concentrators by increasing the connection radius from the intersection between filler and the base material. The paper presents a practical method of calculating the stress concentrators at the cruciform fillet welded joints and the results obtained on the fatigue lifetime, following the application of the rehabilitation techniques on several cruciform fillet welded joints.*

Keywords:fatigue, welded joints, rehabilitation techniques

1.Introduction

The fillet welded joints and the cruciform fillet welds may have welded seams with convex, flat and concave shapes. In the case of static stresses, the convex shape of the welding seams is preferred at the fillet welded v joints, this vform vproviding a higher load bearing capacity. In the case of variable stresses in which the fatigue phenomenon occurs, that meens, cracks at stresses below the yield limit of the material, the most favorable geometrical shape of the welding seams is the concave one [1],[2]. This concave shape shows a minimal stress concentrators at the passage between the base and the filler material due to the large connection radius and the smooth transition between filler and base material.. Therefore, variable stressed fillet welded joints are very sensitive to the stress concentration. In the case of fully-groove fillet welded joint with convex shape of the seam, traction stressed according to the figure 1, the theoreticalrelation for calculation of the concentration coefficient determined by photoelasticity analysis is:

$$\alpha_k = 1 + 0{,}2 * \left(\frac{s\,(2c_2 - c_1)}{c_2 * r}\right)^{1/2} \qquad (1)$$

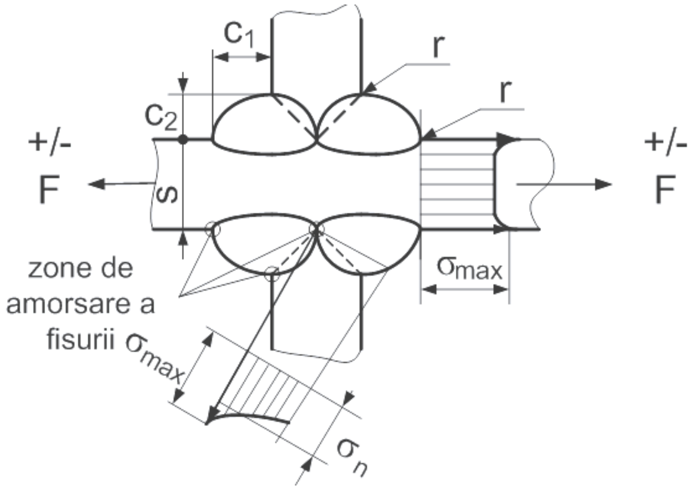

Fig. 1 The stress distribution in the dangerous sections of the fully-groove fillet welded joint

At the fully-groove fillet welded joint having the form of an isosceles triangle ($c_1 = c_2 = c$), the relation 2 is used in calculating the theoretical concentration coefficient.

$$\alpha_k = 1 + 0{,}2 * \left(\frac{2s - c}{r}\right)^{1/2} \tag{2}$$

The normal variation limits of α_k are $\alpha_k = 2{,}0\text{-}2{,}6$. A more favorable situation presents the fully-groove fillet welded with the conave shape, to which the theoretical concentration coefficient is calculated with the relation 3.

$$\alpha_k = 1 + 0{,}4 * \left(\frac{2s - c}{R}\right)^{1/2} \tag{3}$$

Since the connecting radius R of the closure surface at the concave fillet welded joints $R >> r$ results in lower values of α_k than in the previous cases and this is why this joint shape is preferred.

In order to reduce the stress concentrators between the filler and the base material in case of fillet welded joints, some rehabilitation techniques are used, among which: "welding toe grinding" and "WIG remelting welding toe" [3],[4],[5].

The "grinding weld toe" rehabilitation technique consists in the milling of the top of the welding cord, along the intersection line between the filler and the base material, for the joints between pipes (T, Y or K) and for fillet weld joints between tables.

The tools recommended for this process are the wolfram high-speed finger cutters. The tool radius, must be in accordance with the thickness of the plate. Milling should be done at a minimum depth of 0.8-1.0 mm below the surface of the table or 0.5-0.8 mm below the deepest visible notch at a total depth of 2 mm, or 5% of the thickness of the table, which one is smaller. The "WIG remelting weld toe" rehabilitation technique [11] consists of remeltinging the weld metal to a depth of about 2 mm across the welding toe, without adding a filler material. The welding surface will be cleaned of rust, thunder and slag. The tip of the infusible Tungsten electrode must be sharp and clean and should be positioned from 0.5 to 1.5 mm above the welding toe, as shown in figure 2.

2. Experimental research

For fatigue tests, specimens such as those in figure 2 were used. The six specimens were cuted from a cruciform fillet -welded sample with 4 welding seams. All cords were welded in a vertical position. The specimens are made of S 235 JR general purpose steel.

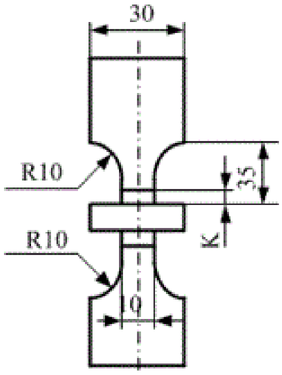

Fig. 2 The specimen type for fatigue tests.

There was no rehabilitation technique applied to the first set of two specimens.marked with E1 and E2. The technique of "grinding weld toe" was applied to the second set of specimens marked with E3 and E4 and on the third set consisting of E5 and E6 the "WIG remelting welding toe" technique was applied. Two loading forces were used. On the first sample frome those three sets was applied force F1 = ± 14 kN on the second the force F2 == ± 6kN. The load cycles were symmetrical alternating and the asymmetry coefficient wasR = 1. The test frequency was 10 Hz. The test machine was LFV 100-HM. shown in figure 3.The test machine is composed of the following elements: 1-Hydraulic box, type PAC-44; 2-Set WGR 100M for clamping specimens; 3-Lod cell; 4-The tire cross of the LFV 100-HM servo-hydraulic test machine; 5-Monitor ACER AL 1917 c; 6-Test and Digital Control System, Type PCS 200 T1 Version 580; 7-HP Deskjet D 2460 Printer; 8-Software package typeDIO Nstat; 9-HP Type Keyboard; 10-Computer table 1400 x 800; 11-Touchscreen workbench; 12-Central-PC.

Fig. 3 The Components of the fatigue test machine

Some of the technical characteristics of the LVF 100 HM are shown below: Maximum Static Load: +/- 100 KN; Maximum Dynamic Load: +/- 100 KN; Maximum working frequency: 50 Hz; Piston stroke 100 mm; Distance between gripping devices: 1200 mm; Overall dimensions WxDxH: 900x600x2510mm; Weight: about 830 Kg; Working pressure of the cap 44-200 bar; Pump flow 44 l / min / 200 bar.

One sample of those three trapped in the test car grippers are shown in figure 4.

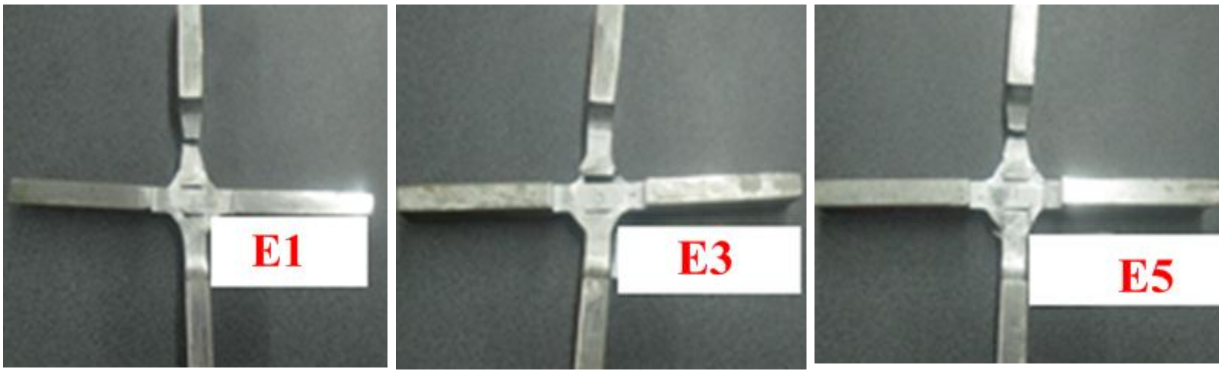

Fig. 4 Fatigue test specimens variable loaded

3. Experimental results

In Table 1, there is presented a centralizer with the data obtained from the dynamic fatigue tests for the sixspecimen tests.

Tab.1 Centralizer results in fatigue tests for test specimens E

No.	Shape seam	The rehabilitation techiques	Mark	F [Hz]	+/-Fi [kN]	t [s]	N=t*f
1	convex	without	E1	10	±F2=±14	476	4760
2			E2		±F3=±7,5	5908	59080
3		"grinding weld toe"	E3		±F1=±14	690	6900
4			E4		±F3=±7,5	8271	82710
5		"WIG remelting weld toe"	E5		±F1=±14	1413	14130
6			E6		±F3=±7,5	17546	175460

With the Math Cad program, taking into account the results obtained in the above table, the durability curves for those three sets of specimens were drawn. These durability curves are shown in figure 5.

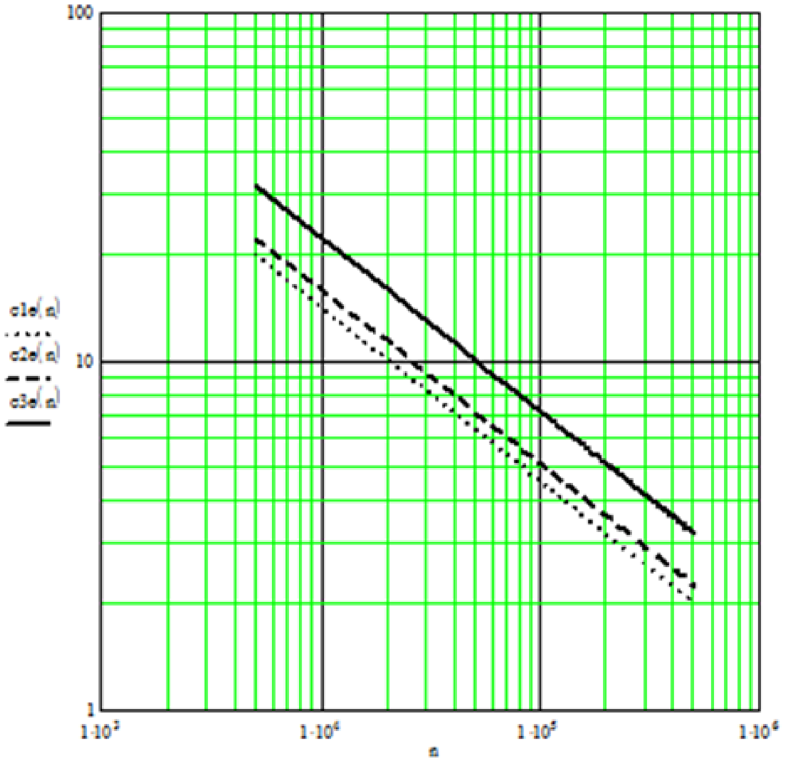

Fig.5 The durability curves for the three sets of specimens

4.Conclusions

Using the Math-Cad calculation program, for the case E and E2, where no reconditioning technique was applied, we found p = 2 and r = 6.3, for which the graph of the function σ1e (n) approaches the most by our points e1 = (4760; 9520; 59080) and f representing the force vector, f = (14; 9; 6). The shape of this curve is shown in figure 5 of the black dot line.

For the second set of specimens marked E3 and E4 to which the "grinding weld toe"rehabilitation technique was applied, also using the Mathcad program, the values p = 2 and r = 6,4 were found for which the graph of the function σ2e (n) is closer to our points e2 = (6900; 13328; 82710) and the force vector f = (14; 9; 6). The shape of this curve is also shown in figure 5 with an interrupted black line.

For the third set of specimens marked with E5 and E6 on which "WIG remelting weld toe" technique was applied, also using the Mathcad program, the p = 2 and r = 6.7 values were found for which the function graph σ3e (n) , is closer to our points, e3 = (14130; 28084; 175460) and the force vector f = (14; 9; 6). The shape of this curve is also shown in figure 5 with a continuous blue line.

As can be seen from figure 5 for the three sets of specimens, the durability curves are not asymptotic at the horizontal axis. This means that practically we can not talk about the existence of infinite fatigue resistance.

Also, from figure 5 it can be seen that at a certain value of the Δσ stress variation, the "WIG remelting weld toe" specimens resist the highest number of cycles, and the specimens without rehabilitation resist the smallest number of cycles. The intermediate place is occupied by the "grinding weld toe"rehabilitated specimens.

There is an increase of approximately 40% in the number of cycles to fatigue at the application of "grinding weld toe"technique (E3 and E4), respectively up to 195% in the case of application of "WIG remelting weld toe"(E5 and E6) compared to the case if no reconditioning technique (E1 and E2) is applied.

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