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THE INFLUENCE OF THE SPECIFIC REHABILITATION TECHNIQUES „TOEGRINDIG" AND „WIG REMELTING" IN CASE OF WELDED STRUCTURE

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Preliminary Note – Prethodno priopćenje

The fillet welded structures, fatigue stressed, must have a concave shape in cross section and a smooth transition between weldseamand base material, without stress concentrators . In this issue for the welded structures with convex fillet welds, to improve the behavior in case of fatigue loads it will be necessary to apply rehabilitation techniques like toe grinding or WIG remelting. The paper wants to present the influence of that two rehabilitation technique and the behavior of the rehabilitated welded structures in case of static and dynamic loads.

Key words: weld, stress, concentrators, fatigue, welding

INTRODUCTION

In the case of variable solicitation of the welded structure in which the acting force could be variable, very important are the stress concentrators that reduced the lifetime of welded structure. These stress concentrators are placed on base material intersection with the filler material and weld seam route. The main paper's objective is to show the stress concentrator influence placed at the intersection of the base and filler material in the case of corner welding [1]. The used welding technology is a manual welding with covered electrode and protective active gas welding. The work was done in the case of static tensile solicitations and fatigue testing. The studies carried out before nowadays have proved that the decrease of the fatigue strength of parts when being welded, occurs even if there is a high quality welding which does not change the flow of the power lines of that part [2-4]. The explanation consists in the fact that, during the welding, the thick layer of the melt additive material flows over the basic material, cools fast and does not have enough heat to efficiently melt the basic material [6, 7]. This is why, there has not formed a link enough strong between the additive material and the basic material.

The melted layer solidifies quickly, the gas inclusions and impurities are not completely eliminated and they turn into power concentrators, which are more intense in the superficial layers of the deposited material, invisible from outside causing the decrease of the fatigue strength [8]. The remaining stress which inevitably appears in the welding process also contribute to the decrease of the fatigue strength [9].

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Welds fatigue is a very complex phenomenon, because the welding strongly affects the basic material after the subsequent heating and cooling process, and the fusion process with the additive materials causes the apparition in the region of the weld seam of some inhomogeneous materials [10].

The welding geometric characteristics that influence the structure life time are presented in the Figure 1 [11, 12]. The global welding parameters that influence the lifetime of the structure because of the stress concentrators are:

- the thickness of the base material - s;
- the weld length across the cathetus - L;

The local welding parameters are :

- the weld toe angle - θ.

To establish the life time of fatigue testing, other parameters like material surface quality on the weld toe and residual stress are needed.

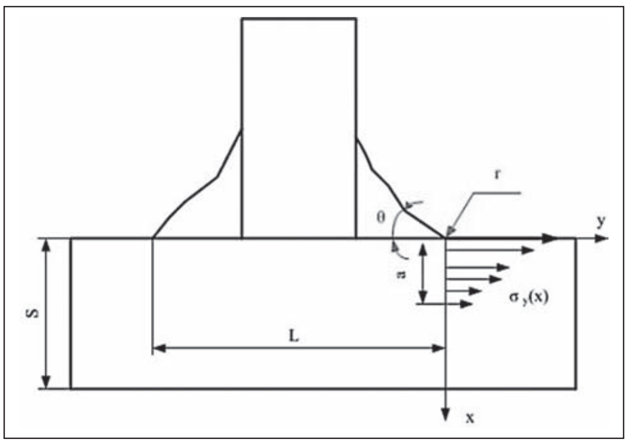
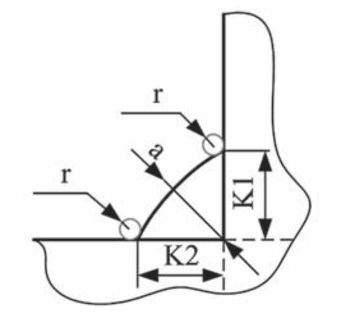
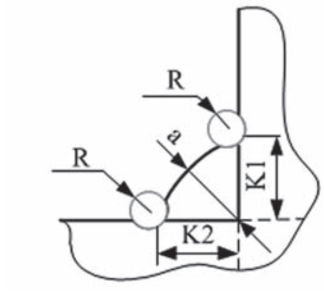
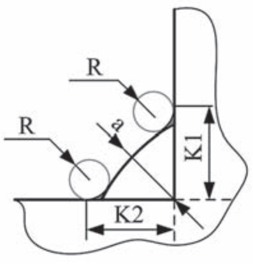


Figure 1 The local geometrical parameters of the corner welding in T shape

Table 1 **Geometrical elements of the welding**

Samples	Without rehabilitation			Weld toe milling			WIG remelting		
	Load	± 14 / kN	± 7 / kN	Load	± 14 / kN	± 7 / kN	Load	± 14 / kN	± 7 / kN
A	a = 5,5 / mm; K1 = K2 = 7 / mm; r = 0,5 / mm			a = 5,5 / mm; K1 = K2 = 7 / mm; R = 2 / mm			a = 5,5 / mm; K1 = K2 = 11 / mm; R = 6 / mm		
E	a = 5 / mm; K1 = K2 = 7 / mm; r = 1,25 / mm			a = 5 / mm; K1 = K2 = 7 / mm; R = 2 / mm			a = 5 / mm; K1 = K2 = 10 / mm; R = 4,5 / mm		
A and E									

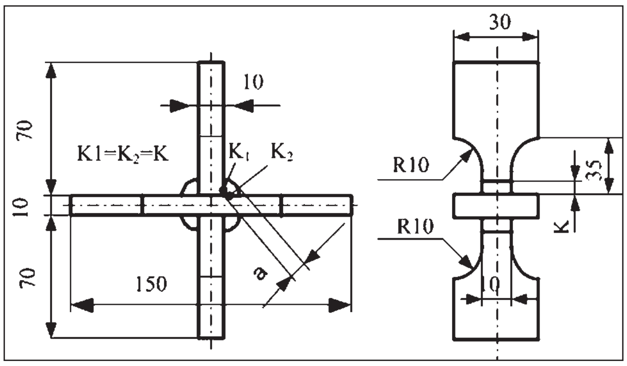


Figure 2 Geometric shapes and dimensions for A and E samples

EXPERIMENTALS

The experiment consists in two material pieces welding on cross position. The gabarit dimensions are 10X150X370. The pieces are notated with A for MAG welding technology and with E for manual welding with basic electrode. The horizontal position was used followed by post welding techniques: milling and WIG remelting of the weld toe (Table 1). From this weld structure nine samples were cut away to release static tensile test and nine samples for fatigue testings. The dimensions and position of the welded samples are presented in the Figure 2.

The material used to release the sample, according to NF EN 10028-2, is S 235 JR.

According to post welding reconditioning techniques the cathetus dimensions and interface radius will be modified. In the Table 1 the new values are presented and the following notations were used:

- r and R are the connect radius between the welded seam to base material;
- a - high of the weld seam;
- K1 and K2- the horizontal and vertical cathetus of the weld seam.

The welding parameters are presented in the Table 2. The filler material for the A sample is G3 Si 1- EN 440 with the diameter Ø = 1,2 / mm. The gas mixture is M21 MIX (Ar/CO2) – EN 439.

Table 2 **Welding working parameters**

Row	Is /A	Ua / V	t_s / s	v_s / cm/s	Vas / m/min	El / kJ/ cm
1/A	220÷228	19,9÷20,1	85	0,41	5,3	7,67
1/E	122÷125	21÷22	165	0,21	-	7,6

The filler material for the E samples, with convex seam, was E42 4 B 42 H 10 (according SR EN 499) with Ø = 3,25 / mm.

THE REHABILITATION TECHNIQUES INFLUENCE UPON VARIABLE SOLICITATION BEHAVIOR

All the fatigue testing was conducted at the frequency f = 10 / Hz, with symmetrical shape, with asymmetry coefficient R= -1. The Figure 3 presents phase of fatigue testing for A2 and A3 sample.

Because of the force reducing during testing, the life time increase from n = 5 940 and n = 22 840 cycles. In the Figure 4, moments for A5 and A6 samples are presented. For these, milling weld toe rehabilitation technique was used.

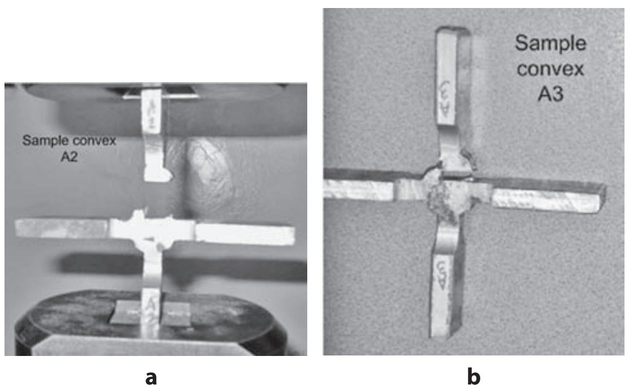
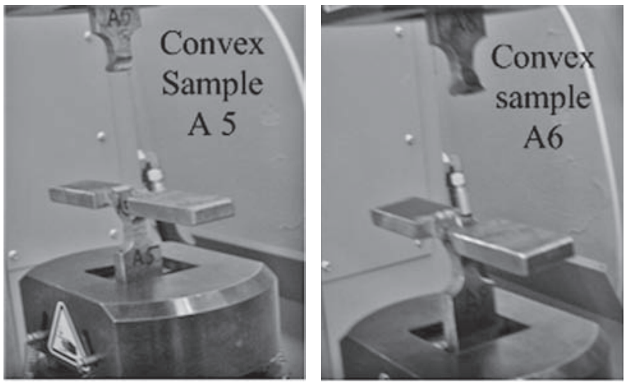


Figure 3 Phase from A2 and A3 fatigue testing - break moment: a - A2 sample; b - A3 sample



a b

Figure 4 Phase from A5 and A6 fatigue testing - milling weld toe rehabilitation - break moment: a - A5 sample, b - A6 sample

Because the force F = ± 14 / kN the A5 sample breaks after n = 8 430 cycles and at decreasing force F = ± 7,5 / kN the sample breaks at n = 107 060 cycles. By comparison with A2 and A3 samples, because the rehabilitation technique the lifetime improves. In the Figure 5, moments for A8 and A9 samples are presented. The stress concentrator is reduced by this technology. The third set of samples consists in A8 and A9 structures with WIG remelting of the weld toe rehabilitation technique.

The A8 sample breaks after n = 17 520 cycles at force F = ± 14 kN and A9 sample after n = 221 520 cycles at F = ± 7,5 kN. In this case, the lifetime increase in comparison with the A5 and A6 sample.

The second case of welding technology is represented by manual welding with covered electrode (E sample). For this case, the Figure 6 presents the E2 and E3 fatigue testing without rehabilitation.

The testing results shows that at force F = 14 kN the life time is n = 4 760 cycles and the force reducing implies an increased lifetime up to n = 59 100 cycles. Comparing with the similar samples A2 and A3 (MAG technology) a decreasing with 20 / % of lifetime is revealed. The Figure 7 presents the breakout moment of the E5 and E6 sample rehabilitated by welding toe milling.

The Figure 7 shows that E5 sample breaks at n = 6 920 cycles under F = ± 14 / kN load and E6 breaks after n = 82 710 cycles and F = ± 7,5 / kN in load. Compared

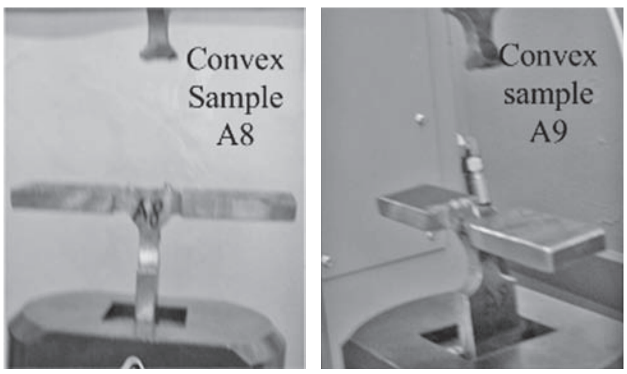


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Figure 5 Phase from A8 and A9 fatigue testing - WIG remelting: a - A8 sample, b - A9 sample

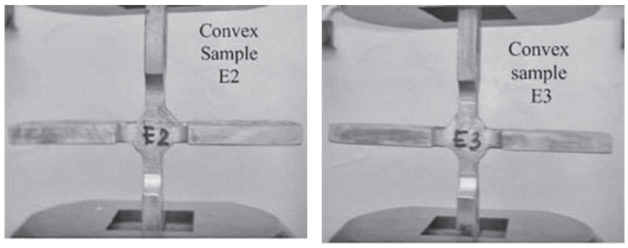

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Figure 6 Fatigue testing of E2 and E3 samples in the case of manual welding with covered electrode - break moment: a - F = ± 14 kN; b- F = ± 7,5 kN

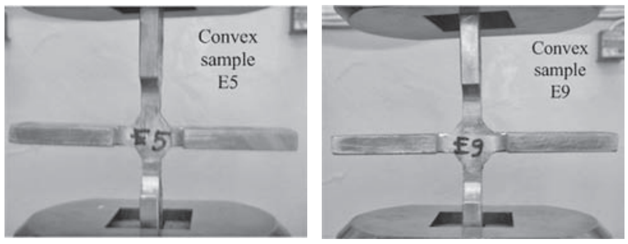

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Figure 7 Fatigue testing of E5 and E9 samples in the case of manual welding with covered electrode - break moment: a - F = ± 14 kN; b – F = ± 7,5 kN

with the E2 and E3 samples (without rehabilitation) the life time increased but a decrease by 20 / % is observed by comparing with A5 and A6 samples (MAG welding technology). The cause of life time reducing is because of penetration decreasing in the case of manual welding compared with MAG technology.

The Figure 8 presents the break moment for the E8 and E9 samples. These samples were rehabilitated by the WIG remelting technique of the weld toe.

The E8 sample breakage at n = 14 130 cycles under F = ± 14 / kN. The E9 sample, with the applied load F = ± 7,5 / kN, breakage after an = 175 460 alternative cycle. The results show an increasing cycle number comparing to correspondent E5 and E6 samples. A decreasing cycle numbers with 20 / % is available in comparing to with A8 and A9 samples. The decreasing is due to WIG remelting and the increasing due to lower penetration resulted in manual welding with covered electrode compared with MAG welding.

In the Table 3, the test results are presented in the A and E samples.

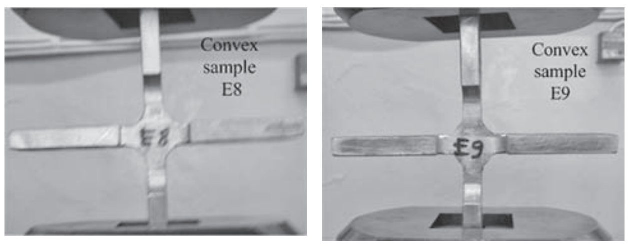

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Figure 8 Fatigue testing for E8 and E9 samples in the case of manual welding with covered electrode - break moment: a - F = ± 14 kN; b - F = ± 7,5 kN

Table 3 **Fatigue testing results**

No.	Welding technology	Loads / kN	Samples	Number of cycles	Samples	Number of cycles
1	Without rehabilitation	F2 = ± 14	A2	5 940	E2	476
2		F3 = ± 7,5	A3	73 840	E3	5 908
3	Weld toe milling	F2 = ± 14	A5	8 430	E5	690
4		F3 = ± 7,5	A6	107 060	E6	8 271
5	WIG remelting	F2 = ± 14	A8	17 520	E8	1 413
6		F3 = ± 7,5	A9	221 520	E9	17 546

CONCLUSIONS

The rehabilitation technology provides an increasing life time of the welded structure. In the case of manual welding with covered electrode the lifetime is 20 / % lower in comparison with MAG welding indifferent of the rehabilitation technology. The weld toe milling rehabilitation technology induces a 40 / % lifetime increasing in comparison with each welding technology. The WIG remelting rehabilitation process produces a 195 / % lifetime increasing compared with each welding technology.

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