RAISING THE DURABILLITY CURVES IN CASE OF WELDING ELEMENTS

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Abstract: *Raising the durabillity curves is very important, being a useful tool in assessing the duration of the fatigue life of an item or welded structure. Determination of life duration up to fail, indicate us the right time for the rehabilitation of welded structure leading to labor savings and avoiding catastrophic failurewe that would endanger people's lives.*

The paper will present for three welded specimens experimental determinations of variable load cycles until failure, then will rise durabillity curves using a mathematical program.

Key words: variable stresses; fatigue life; durability curves

1. Introduction

The present paper is based on the opinion that dynamically exposed weld elements, contain cracks of different sizes and that is why rehabilitation is required after a period of time given by the durabillity curves.

There are numerous welded structures likely to be exposed to stress in the course of time (bridges, power installations, etc.). Research has proved that such structures crack under stress concentrations lower than the tear resistance of the static materials they are made up of; the higher the stress concentration the sooner the fracture. The functioning time, that is the number of stress variation cycles a component is resistant to depend on its maximum stress level. This is graphically shown by an experimentally fixed curve (Wohler's curve)-figure 1.

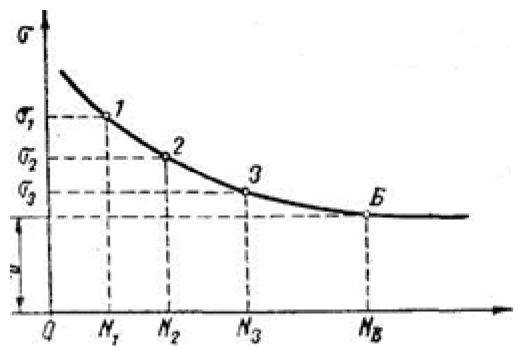


Fig. 1. Wohler's curve

Such a curve in N-σ (N-τ) system shows that the higher the number of cycles N any component is resistant to, the lower the stress σ. For a certain value σ_0 of overall stress, the component resists to numerous, countless reinitializing cycles.

This value σ_0 stands for fatigue resistance. Research has shown that ferrous metals resistant to 10^{7} variation cycles of the overall stress never crack. Hence, for such materials, fatigue resistance is defined according to NB=10^{7}. Fatigue resistance of welded joints is much lower than that of the material due to the overall welding stress concentration. Internal and external concentrators differ from the structure itself. Unlike the material, that may display lamination defects, the weld displays defects typical of molded materials. Internal concentrators are the result of pores of gases, the roots of the welds and joints of electrodes change, in the case of manual welding. External concentrators can be seen at the ends of the welding line as well as in the junction point of the welding and base material. The concentrators impact can be lowered or even eliminated by appropriate welding of the respective junctions. The concentration coefficient value is influenced by various factors typical of welded joints: the base material, additional material, the welding procedure used, internal and external welding defects, the junction form, the welding bead form, recurring stress concentrations, etc. The weld may bring about the lower fatigue resistance of the component even if the welding is of high quality and does not modify the strength lines flow of the respective component.

2. Research methodology

The research conducted, consists in an analysis of the fatigue life of three identical welded samples marked with I1; I2 and I3, using three values of the apllied forces.

3. Shape and dimensions of samples

Figure 2 illustrates the shape and dimensions of the samples to be subject to fatigue tests.

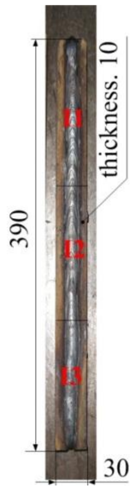


Fig.2 Shape and dimensions of weld deposited samples

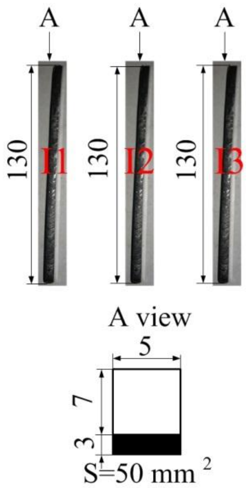


Fig. 3 Shape and dimensions of sampleswith seam weld deposit dynamically stressed

The sample is obtained from a 7 mm thick, 30 mm wide and 390 mm long wideplate and is made of common steel S235JR according to NF EN 10028-2.

The sample presented in Figure 2 will bring about three samples I1; I2 and I3, of approximately 130 mm long and 5 mm wide, the width is obtained by previous mechanical grinding on both sides of the wideplate width.

Once samples 1; 2 and 3 have been extracted, one set of samples will be obtained as follows: set 1: I1; I2 and I3 corresponding to sample I;

A stress variation ΔF1=±10 KN; ΔF2=±8 KN and ΔF3=± 6,5 KN respectively will be applied to samples 1; 2 and 3 corresponding to each sample/set in order to obtain a durability curve for each of the sample/set. The stress cycle will be alternating and symmetric and the stress factor is a tensile-pressure type. Figure 3 shows the shape and dimensions of samples 1; 2 and 3, as resulted from samples I.

The samples I are obtained, as follows: the sample set I1; I2 and I3 respectively, corresponding to the first sample I is obtained from a 7 X 30 X 390 mm wideplate with cycling weld deposition, by means of a manual welding SMEI covered electrode procedure, a 3 mm thick, 15 mm wide and 390 long weld bead, the resulting dimension of the samples obtained being 10 X 5 X 130 mm. A 10 mm tickness is achieved since 3 more mm are added to the initial 7 mm tickness of the wideplate.

4. The Welding Parameters

In the case of welding deposits as applied to samples I, SUPERBAZ E 7018 electrodes were used, in conformity with AWS A5.1, with a 3.25 mm electrode wire diameter. Tabel 1 indicates the weld deposit parameters corresponding to samples I.

Table 1

The parameters of the weld deposit		
No.crt.	Parameter	Sample I
1	Is [A]	180…190
2	Ua [V]	21-22
3	ts [s]	165
4	Lc [cm]	39
5	vs [cm/s]	0.23
6	El [KJ/cm]	10.656

5. Fatigue tests

Fatigue tests were based on the LVF 100 HM type of fatigue test installation, belonging to the laboratory of materials research within the Department of Materials and Welding Technology.

For all three samples I1; I2; I3, the stress cycle applied was alternating and symmetric, more precisely σ_{max}= - σ_{min}. Hence, σ_{med}= 0 and the asymmetry coefficient R= $\sigma_{min}/\sigma_{max}$= -1.

The tests were conducted at a 10 Hz frequency.

In order to elevate the durability curves for all three sample sets I; II and III, three variation values of the loading forces are required: ±ΔF1=±10 KN for sample I1; ±ΔF2 = ±8 KN for sample I2 and ±ΔF3 = ±6,5 KN for sample I3.

Fatigue tests followed several phases:

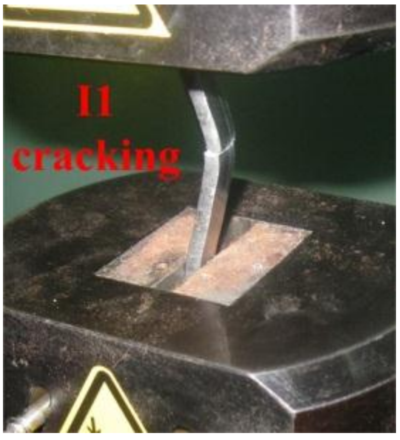
-fixing samples between the blades of the machine and tightening them with the dynamometric key;

- selection of the loading variation program, of the loading stress cycle and work frequency. Stress variations as above mentioned: ±ΔF1=±10 KN; ±ΔF2 = ±8 KN and ±ΔF3 = ±6,5 KN, the stress cycle was alternative and symmetric and the frequency was 10 Hz;

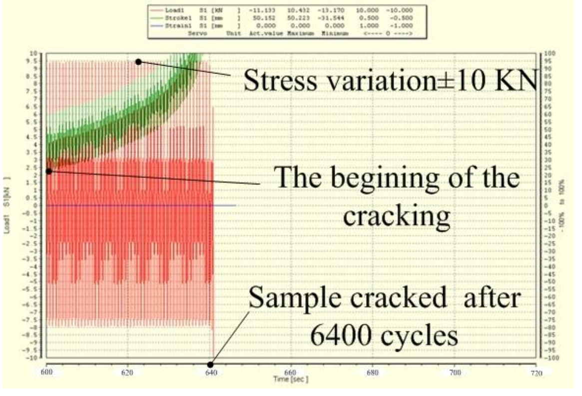
- extraction of frames during trials that show the number of cycle left until the cracking moment;

Then, the data were collected and the durability curves were processed by means of "Math Cad" program.

Figures 4a and 4b show the crack of sample I1 fixed between the blades of the machine as well as a frame obtained due to the data analysis program, during the fatigue test, which reveals that the stress variation as applied to sample I1 was ±10 KN and the sample cracked after 640 seconds, more precisely, after 6400 stress cycles, based on a 10 Hz frequency.



a

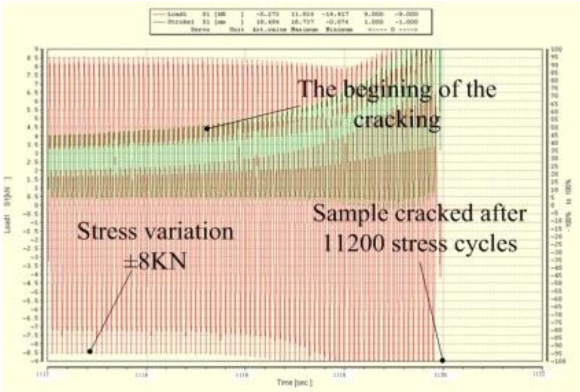


b

Fig. 4 Phases of fatigue test for sample I1

Figures 5a and 5b illustrate the cracking moment of sample I2 fixed between the blades of the machine as well as a frame obtained due to the data analysis program, during the fatigue test, which reveals that the stress variation as applied to sample I2 was ±8 KN and the sample cracked after 1120 seconds, more precisely, after 11200 stress cycles, based on a 10 Hz frequency. It is worth mentioning an increase in the number of cycles left until the crack moment as compared to sample I1, by approximately 75%.

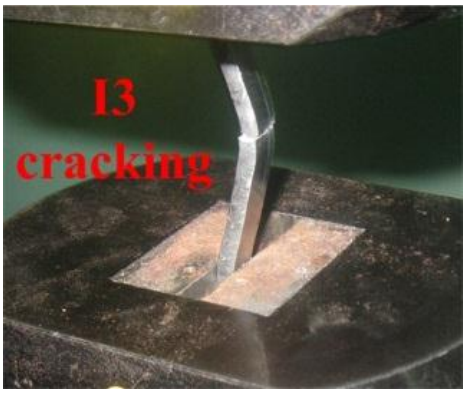
a



b

Fig. 5 Phases of fatigue test for sample I2

Similarly, figures 6a and 6b illustrate the cracking moment of sample I3 fixed between the blades of the machine as well as a frame obtained due to the data analysis program, during the fatigue test, which reveals that the stress variation as applied to sample I3 was ±6.5 KN and the sample cracked after 1877 seconds, more precisely, after 18770 stress cycles, based on a 10 Hz frequency. It is worth mentioning an increase in the number of cycles left until the crack moment as compared to sample I2, by approximately 68%.



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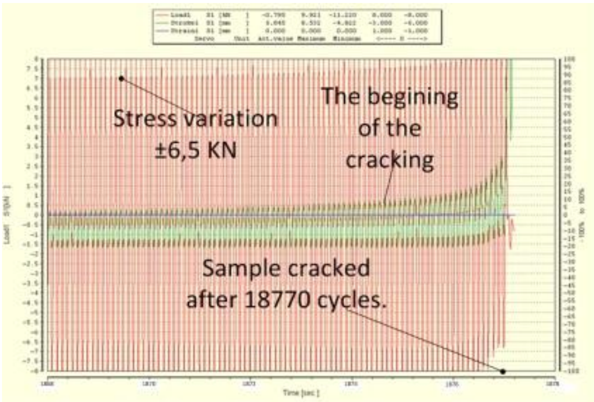

b

Fig. 6 Phases of fatigue test for sample I3

In the case of the sample set I1; I2 and I3, with rough seam weld deposit, the increase in the number of cycles left until the cracking moment from 6400 cycles for I1 until 18770 for I3 accounts for a decrease in stress variation as applied to the samples, from ±10 KN to ±6,5 KN.

6. Research results

Table 2 presents all data collected during fatigue tests for all the three seam welded based samples I1; I2 and I3.

Table 2

Fatigue tests data						
No.	Sample status	Reference	F [Hz]	±ΔF	Duration [s]	N
1	seam welded based	I1	10	±ΔF1=±10	640	6400
2		I2		±ΔF2=±8	1120	11200
3		I3		±ΔF3=±6,5	1877	18770

References in Tabel 2 indicate: F-frequency; ±ΔF variation of stress applied; N-number of cycles left until cracking moment.

6. Marking durability curves

The durability curve $(\sigma = f(n)$- Wohler's curve) for steels can be approximated according to logarithmic scales (lg-lg), in the form of a logarithmic regression expressed as [2]:

$$lgn = lgA - p * lg\Delta\sigma \tag{1}$$

where: lg A is the junction point between the curve and the vertical axis; 1/p – inclination of the straight line; $\Delta\sigma$ - variation of stress due to variation of force exerted between a maximum and a minimum; n- number of cycles.

Equation (4) can be also depicted as:

$$lg(n * \Delta\sigma^p) = lgA \tag{2}$$

If lgA ha a certain value r, then, equation (5) becomes (6).

$$10^r = n * \Delta\sigma^p \tag{3}$$

$$\Delta\sigma(n) = \sqrt[p]{\frac{10^r}{n}} \tag{4}$$

Equation (7) represents the variation of the durability curve based on linear coordinates.

By means of Mathcad program, for samples I1; I2 and I3, we have obtained the values p=2 and r=5.83, for which the graph of the function $\Delta\sigma I(n)$ reaches the test points of the type I samples, aI= (6400; 11200; 18770) and f1=(10; 8 6). The graph is shown in Figure 7 as follows:

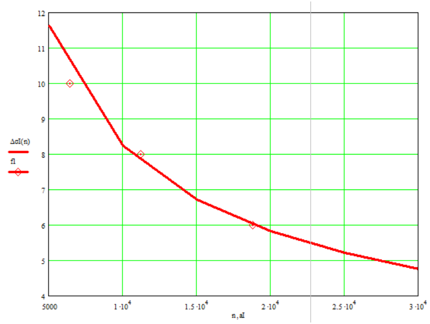

Fig.7 Durability curve in linear coordinates for samples I1; I2 and I3; material S235JR; symmetric cycle- σ_{med}= 0; σ_{max}= - $\sigma_{min;}$ R= -1; frequency=10 Hz

7. Conclusions

We can observe from figure 7 that the durabillity curve is not asymptotic to the horizontal. This means that in case of welded elements does not exist a fatigue resistance that in case of unwelded elements.

It becomes noteworthy the fact that the existence of a weld bead on a machine part exerts a negative effect on the number of cycles until cracking, reduced to almost 40% as compared to the situation in which the machine part is not seam welded based. This reduction of fatigue life when welding is applied occurs even if the welding is of high quality and does not modify the forces within the respective machine part. This is due to the fact that, during welding, the thin layer of the melted material drips over the original material, cools off quickly and it is not hot enough to melt the original material. Hence, there is no proper welding, the melted layer hardens quickly, gases and pollutants are not entirely exhausted and they transform into stress concentrators highly visible in the faying surface of the weld deposits but invisible from the exterior and lead to fatigue resistance. Furthermore, welding residual stresses also reduce resistance to fatigue, when a weld bead is applied. By processing both the machine part and the welded bead, cutting off a few millimiters, most of these defects are eliminated (representing the stress concentrators), thus, the machine part becomes more resistant to fatigue. In conclusion, the grinding process can be considered a highly efficient technique likely to improve resistance to fatigue of some welded structures.

8. References

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