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VERIFICATION OF RAPID METHOD FOR DETERMINING THE S-N CURVE IN LIMITED LIFE REGION

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Abstract: *The paper presents the method for determining the S-N curve in limited life region. To verify the method, C45material was tested to estimate fatigue characteristics. The load was applied by rotating bending and the testing equipment used had been designed by us. The data analysis confirms a good functioning of the testing machine. The verification of the method proposed and the results are presented.*

Keywords: ***fatigue design, S-N curve, high-cycle fatigue, accelerated method***

1. Introduction

To estimate the life or fatigue strength of the component, we use, depending on the assumed load conditions, the corresponding computational models. By using any of the calculation models, we need to know the fatigue characteristics of this component. To acquire such characteristics, experimental, analytical and experimental-analytical methods can be used. The method of determining the fatigue characteristics for high-cycle material fatigue can be found e.g. in PN H 04325:1976. Analytical characteristics determination methods have been presented, among others, by Neimitz A. et al. (2008), Lee Yung-Li et al. (2005) and Strzelecki & Sempruch (2011).

The above accelerated and approximated fatigue curve plotting methods need defining the fatigue properties determining accuracy. To do so, the use of a specially planned experiment is most applicable. An attempt at determining the error made applying the methods presented has been given in Strzelecki & Sempruch (2011) and Sempruch & Strzelecki (2011).

2. Experimental procedures

In order to determine the reference curve, own-design research testing equipment was applied. The research involved the use of C45 + C material (Rm = 826 MPa Rp0.2 = 647 MPa) supplied in a form of the rod 10 mm in diameter the sample shown in Figure 1a was made of.

Figure 1b presents C45 + C material fatigue plot. In its upper right corner regression equation and the coefficient of determination (0.952) are found.

3. Method of verification

Based on the experimental results, it was possible to perform statistical calculations verifying the null hypothesis which assumes that the slope and the absolute term of the regression line determined based on the experimental data are equal to the coefficients of the line obtained by applying the analytical method.

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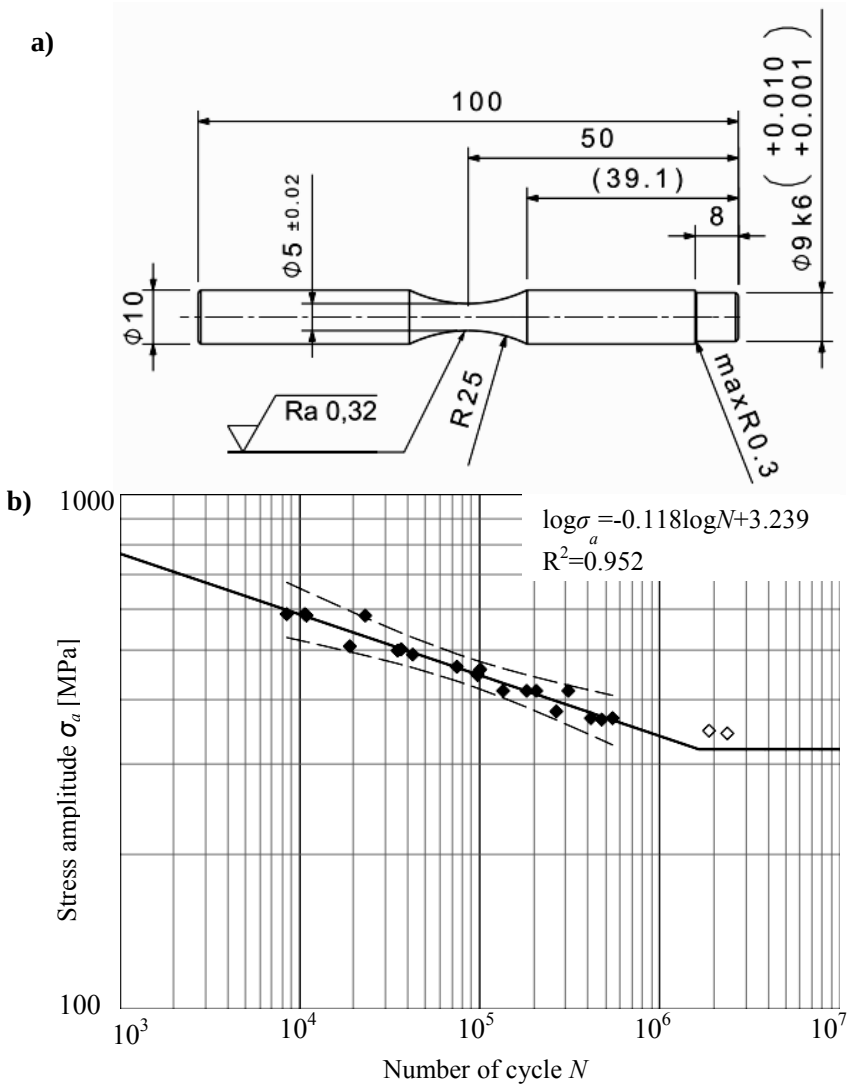

Fig. 1. a) Figure of the sample b) S-N curve for C45+C

For the statistical value calculations, the following equations were used:

$$S_a = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2}{(n-1)\left[\sum_{i=1}^{n} X_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} X_i\right)^2\right]}}, \tag{1}$$

$$t_a = \frac{a - a_0}{S_a}, \tag{2}$$

$$S_b = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 \cdot \sum_{i=1}^{n} X_i^2}{(n-2)\left[n\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2\right]}}, \tag{3}$$

$$t_b = \frac{b - b_0}{S_b}, \tag{4}$$

where: $X=logN$, $Y=log\sigma$, n – number of data, $\hat{Y}=a_0X+b_0$ – equation derived using the analytical method, $Y=aX+b$ – equation derived using the experimental data.

4. Results of verification

It is assumed that there is no reason to reject the null hypothesis when the following is met:

$$|t_a| < t(p,n-2) \text{ or } |t_b| < t(p,n-2) \tag{5}$$

Examples of calculations results are presented in Table 1.

Tab. 1: Results of statistical calculations

Statistics type	*Method given in the paper Strzelecki & Sempruch (2011)*	*FITNET method*	*Method by Lee Yung-Li et al. (2005)*
t_a	*-1.063*	*2.163*	*-3.099*
t_b	*1.435*	*-2.506*	*3.242*
p_{value} *(97.5%,t_a)*	*22.1%*	*4.36%*	*0.66%*
p_{value} *(97.5%,t_b)*	*14.1%*	*2.27%*	*0.48%*
t(97.5%,19)		*2.093*	

For a qualitative comparison, the curve estimated applying each of the methods was plotted (see Fig. 2.). In the upper right corner the equations for every curve are given. With a black line the figure demonstrates the experimental curve, with the blue line – the method proposed by Strzelecki & Sempruch (2011), with the green line – the FITNET method and with the violet line – the method by Lee Yung-Li et al. (2005).

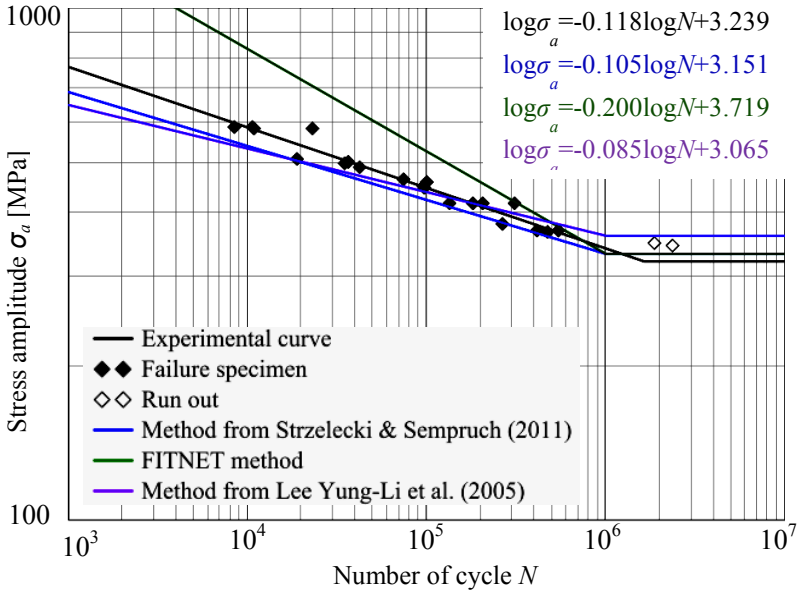

Fig. 2. Diagrams of fatigue curves according to experimental (black line) and analytical methods by Strzelecki & Sempruch (2011) (blue line), FITNET (green line) and Lee Yung-Li et al. (2005) (violet line)

5. Conclusions

Based on the statistical calculations made, one can note that the method provided by Strzelecki & Sempruch (2011) is the only one which facilitates assuming the hypothesis of the equality of slope and

the absolute term of the equation determined and the equation of the regression curve defined drawing on the experimental data.

The conclusion is reflected in Figure 2. The diagram shows that the curve plotted with the method suggested by Strzelecki & Sempruch (2011) matches the experimental line better than the other methods.

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