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TESTING THE TENSILE STRENGTH OF SAMPLES MADE FROM A COMPOSITE MATERIAL STAHL 1018 APPLIED TO THE STEEL SURFACE

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Abstract: *Tensile strength tests were performed on Stahl 1018 composite samples disposed on a steel surface. The strength tests were executed on samples with a layer 1.5, 3 and 4.5 mm thick. The conditional yield point and tensile strength were determined based on the obtained experimental results. The best strength properties, and so preservation qualities, were obtained for the 1.5 mm composite layer.*

Keywords: Composite, MM Stahl 1018, Tensile strenght, Strenght tests, Polymer.

1. Introduction

Composite Stahl 1018 is applicable to the preservation of machine elements and tools working in the mechanical wear conditions (Ischenko 2012). This material was designed for maintaining metal materials and construction materials, e.g. for fixing bridges, pillars, reservoirs (Arustamian et al., 2015)). Owing to its complex build, i.e. polymeric matrix and powdery filler, this material has maximal compressive strength 60 N/mm^2, tensile strength 80 N/mm^2, bending strength 89 N/mm^2, elasticity modulus 14000 N/mm^2 and heat resistance up to 90 ^{o}C . The polymeric matrix has high chemical resistance and does not tend to shrink after solidification. The filler materials, i.e. steel, ceramics and additives improving surface tension exhibit high chemical resistance (Królikowski, 2020), (Konopka et al., 2017), (Grabowska et al., 2012), (Lelito et al., 2015). Authors have already performed a series of experiments and analyses of the effect of temperature on compressive strength, measurement of microhardness, impact strength, tribological properties and microstructure analyses (Arustamian et al., 2016, Arustamian et al., 2020) . The analysis of the analytical results shows that this material can be also used for the maintenance of machines and devices used in metallurgy and foundry industry (Sołek et al., 2017).

2. Methods

The aim of the experiments was to analyze the tensile strength of polymeric material MM „Stahl 1018" placed on a the surface of a steel sample, which corresponds to the situation, when composite is used for the machine maintenance purposes. The experiments were performed on a testing machine RM-20, the schematic of which is presented in Fig. 1. RM-20 (Fig. 1) is a testing machine for samples. By means of the special device for samples of various size can be tested. Samples were applied to the tests of tensile strength with diameter of steel base D = 40 mm, H = 20 mm and height of composite layer H = 1.5 mm, H = 3 mm, H = 4.5 mm, D = 20 mm (Fig. 2).

Bearing in mind that the composite in the tests was used for preserving a steel surface, the critical stresses generated in the material during the tensile strength tests would not have the same values as for samples made of composite only. A series of experiments was made for a sample simulating a one-sided contact of composite MM „Stahl 1018" with a surface to be maintained (Fig. 3).

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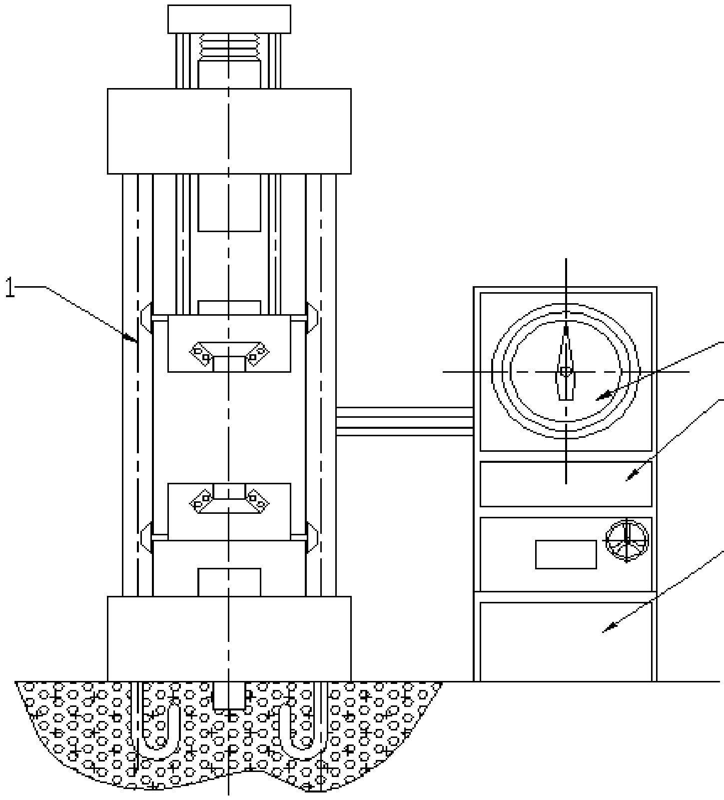

Fig. 1: Schematic of RM-20. 1 - Charging device, 2 - Control panel, 3 - Pumping unit, 4 - Loading scale.

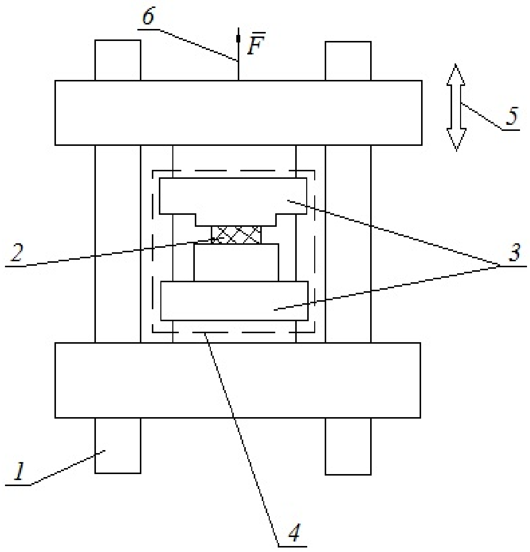

Fig. 2: Scheme of experimental instalation. 1 - Frame column of testing machine, 2 - Sample, 3 - Anvils, 4 - Adapter, 5 - Upper traverse, 6 - Load.

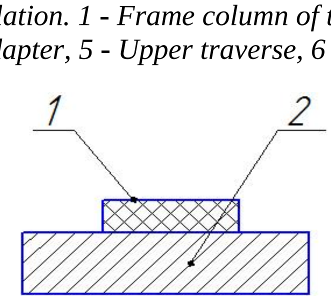

Fig. 3: Sample imitating maintenance of a surface with a composite – a one-sided contact of composite and steel base, 1 - composite layer, H = 1.5 mm, H = 3 mm, H = 4.5 mm; 2 - steel base.

2.1. Results of experiments

The analyzed samples had a composite layer H = 1.5 mm, 3 mm and 4.5 mm thick. The results of analyses of samples with H = 1.5 mm, imitating one-sided stiff contact of the composite with the regenerated surface showed a drop of tensile strength. It was observed that under the impact of force F = 60 000 N the sample thickness has changed by 0.005 mm, which proves the beginning of plastic strains in the material. The magnitude of the conditional yield point is defined with equation (1)

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot P}{\pi \cdot D^2}, \quad \text{MPa} \tag{1}$$

After introducing actual values, the yield point equals to:

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot 60000}{\pi \cdot 20^2} = 159.24, \quad \text{MPa} \tag{2}$$

After increasing the force value by 1 000 N up to 100 000 N, the first microcracks appeared and they started to grow. For F = 120 000 N the cracks were 1.5 ÷ 2 mm in size. On this basis the tensile strength could be determined (3):

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot 120000}{\pi \cdot 20^2} = 382.17, \quad \text{MPa} \tag{3}$$

Next a sample with a 3mm composite layer was analyzed. As compared to the previous case, the strength of the material was observed to lower with the increasing composite thickness. Analogous to the first sample, the force was increased by 1 000 N up to 50 000 N, when the sample thickness has changed by about 0.01 mm. Further impact confirmed that the composite layer stopped acting in the plastic strain areas. On this basis the yield point of the sample was determined (4):

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot 50000}{\pi \cdot 20^2} = 143.31, \quad \text{MPa} \tag{4}$$

The first microcracks along the side surface started to appear for F = 80 000 N, and after reaching the value of 100 000 N the cracks were 1 ÷ 2 mm in size, which means that the material was destroyed. On this basis the tensile strength value was defined (5):

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot 100000}{\pi \cdot 20^2} = 318.47, \quad \text{MPa} \tag{5}$$

The last sample imitating the one-sided contact of the material with the steel base was H = 4.5 mm thick. The tests confirmed that the sample had the worst result of all the analyzed samples. The change of the linear size of the sample by 0.01 mm was recorded for F = 40 000 N. The strain corresponding to this load was calculated from the following equation (6):

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot 40000}{\pi \cdot 20^2} = 111.46, \quad \text{MPa} \tag{6}$$

During further tests made for F = 60 000 N the first microcracks were observed to appear on the side surface of the material. After applying a bigger force the number of microcracks increased; at F = 90 000 N the cracks were 1 ÷ 2 mm in size, which classified the sample as destroyed. The yield point for this sample was calculated from the formula (7)

$$\sigma^{1,5}{}_{02} = \frac{4 \cdot 90000}{\pi \cdot 20^2} = 286.82, \quad \text{MPa} \tag{7}$$

The plots in Fig. 4 represent the effect of force on the strains of the samples.

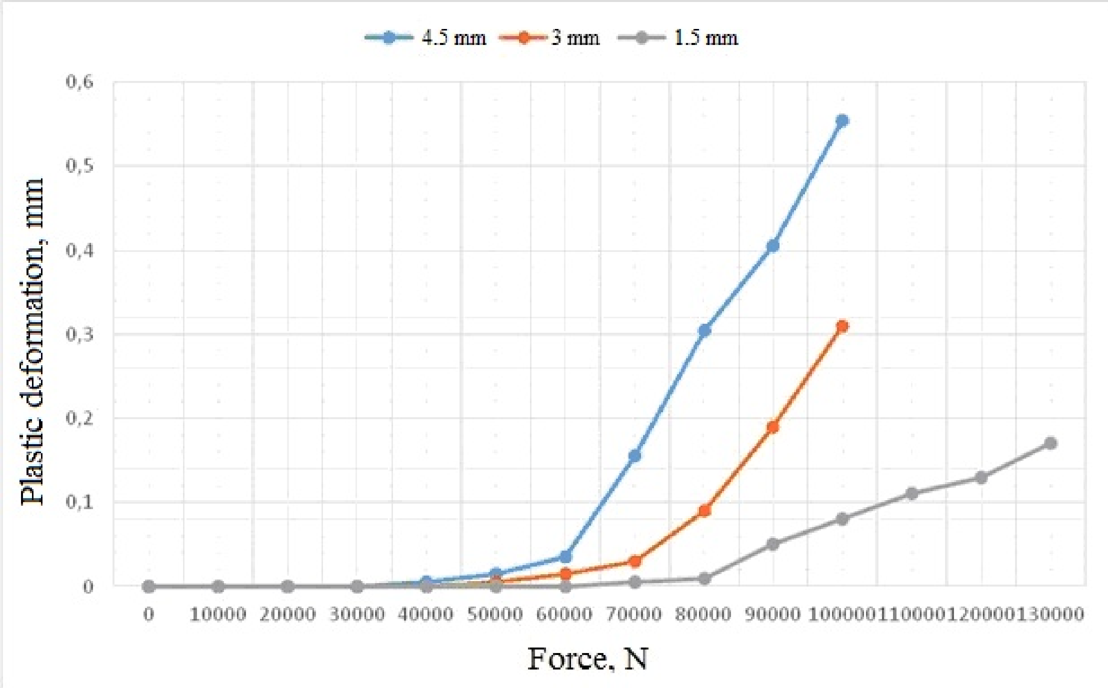

Fig. 4: Strain vs. force [N] in samples simulating surface maintenance.

3. Conclusions

Tensile strength tests of composite samples put on a steel surface showed that the best strength parameters were observed for a sample with a 1.5 mm thick composite layer. In samples with a composite layer H = 3 mm and H = 4.5 mm the sample was destroyed under a force of 100 000 N and 90 000 N, respectively. In the sample with a 1.5 mm composite layer the first cracks appeared under the force F = 100 000 N, and was destroyed at F = 120 000 N. Concluding, the best maintenance properties were observed for a thin composite layer.

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