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IDENTIFICATION OF YIELD POINT OF POLYMER-BASED COMPOSITE MATERIAL IN THE CONDITIONS OF INCREASED TEMPERATURES

Theoretical and practical research on the influence of temperature on mechanical characteristics of the composite material MM "Steel 1018" has been conducted. Both laboratory equipment used to measure of mechanical properties, the technique of material preparation and the experimental procedure were described. The analysis of the the obtained results revealed that with temperature increase the material yield point goes down.

Keywords: mechanical properties, yield point, compression test, composite material

1. Introduction

Repairs with the use of polymeric and composite materials based on epoxy resins are a commonplace now. The significant changes is the resistance to influences of moisture and also chemical composition which enable repairs of the industrial equipment. However, it should be noted that the use of the polymeric materials in metallurgy is limited because of high temperatures and heavy conditions of operation of machines, especially because of dynamic loads and the required high reliability and durability. Multimetall "Steel 1080" was selected in the experiments and test son new equipment. A series of experiments in which samples were exposed to the compression test at high temperatures was carried out.

2. Study of the properties of Multimetall Steel 1080

This work is devoted to defining a conditional yield point of the material "Multimetall Steel 1018" (MM1018) and its dependence on deepening, excess and diameter. Pilot studies were conducted on the press (the explosive car) RMDO-20 [1-4]. As a result of the experiment the empirical dependence of a conditional yield point on such factors as deepening, excess, diameter was specified. In this work, groove depth in a protective level was modeled by deepening of metal - polymer in the tested samples. Experimental data, received in the course mathematical processing showed that the optimum value of a conditional yield point corresponds to samples with excess and deepening of 1 mm. Among the shortcomings of this technique of carrying out multiple - factor experiments is the fact that this technique was not suitable for any number of levels of factors, i.e. had a limited scope [5]. Thus, the received empirical dependence only approached reliable data that influence error size when determining theoretical sizes of the conditional yield point. Besides, it is limited to those limits of parameters within which it was defined.

The theoretical research of the bearing ability of a metal - polymeric layer in the conditions of comprehensive compression was carried out in the paper. Researches were conducted by means of a computer program of three-dimensional modeling of solid states of SolidWorks 2007 and its application for strength calculations of the solid-state models COSMOSworks 2006, using the final elements method (FEM) [6]. The models of test samples completely corresponding to those samples which were investigated in work were constructed and loading which was enclosed in experiments was simulated. At the final stage of studying of the bearing ability of the material MM1018 research of behavior of metal - polymeric material in grooves of lug of mill housing 3000 was conducted.

Also the three-dimensional model of a metal - polymeric layer in the COMPASS program from where was constructed imported to SolidWorks 2007 and calculated in the COSMOSworks 2006 appendix. The stress-strain and movements diagram is constructed. Also the similar analysis is carried out.

The analysis of the stress-strain diagram reveals that stress-strain in a metal - polymeric layer decreases with the increase of the diameter of grooves. It should be also noted that the adhesive property of polymer was not considered in the calculations.

The results of experiments showed that metal polymer in a free state maintains only insignificant shock loadings. In the conditions of volume compression the cyclic durability of metal polymer at dynamic loading repeatedly increases and the design is capable to sustain the loadings taking place in basic surfaces of hard loaded cars, in particular, beds of rolling mills (100-200 MPa) [7]. The experiments described in work were based on the most possible approach to the conditions of loading of metal polymer at the stage of designing beds

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of rolling mills. The elasticity module at compression and Poisson's coefficient for metal polymer of the material MM 1018 were defined in the work [8]. The elasticity module (proportionality coefficient) is a physical constant of material without which theoretical research is impossible. The value of the received module of elasticity equaled to 13200 MPa and was in the limits specified in the technical characteristics of material provided by the producer.

Results of experiments show that the maximum tension of dynamic cycle can exceed the maximum tension at static loading without metal - polymer deformation by 50%. MM 1018 can work without deformation with average load of P=31 kN, with an amplitude of loading of 6 kN. Deformation of samples takes place with an amplitude of loading of 10 kN, at average loading of P≤26 of kN. Placement of metal polymer in the closed volume can serve as the constructive decision for increasing its bearing ability in the conditions of an asymmetric cycle of loading. In the designs working at big vibrations it is necessary to apply metal polymers in the closed volume or in the reinforced option.

During experiments it was defined that various degreasers differently influence various materials, therefore for each material it is necessary to select degreaser individually. During experiment the degreaser to the material MM 1018 was chosen. It was observed that temperature influences polymer durability. At a temperature of 100°C, 20°C and 50-60 °C the durability of polymeric material equaled to 42.12 MPa, 93.63 MPa and 93.63 MPa, respectively. At temperature of 100°C the material was observed not to precipitate. The material precipitated at a temperature of 20°C – first it smoothly precipitated then was damaged. It means that the polymeric material broach is unsuitable for use at high temperatures or in poorly loaded knots. At the increasing temperature polymeric material practically does not increase in volume [10-13].

Thanks to good properties of MM 1018 with a range of accuracy of 1/100 mm, the 100% adjustment accuracy was obtained directly on the spot, without demanding any completion of material, i.e. traditional adjustment of maple locks and bridge support to the lower belt of the bridge. Multimetall Steel 1018:

- levels gaps from 0 to a move of 15 mm;
- high strength at long loadings, and also in extreme conditions, such as vibrations, temperature fluctuations from - 40 °C to + 90 °C;
- resistant to aging and weather conditions;
- resistant to gasoline, oils, acids, alkalis and to the cooling means;
- corrosion-resistant, does not rust, is not the conductor;
- simple in processing, does not require preliminary preparation and supportive applications.

3. Experimental

Zwick Roell Amsler HB 100 (Fig. 1) a testing machine for samples, can provide close to real conditions because it has a special furnace and ability to add vibration loadings. The furnace allows for precise control of temperature with wide range even up to 1200°C {14}. Using this equipment, viscoelastic and fatigue properties of samples are investigated at various temperatures. By means of the special device for test for the compression (established on a plate with T-shaped grooves) samples of various forms and the sizes can be fixed.

- the maximum load of 100 kN at compression;
- piston stroke of 120 mm.

The purpose of these tests is to define the shrinkage of material at loading in the static mode at the increased temperatures (to 80 °C). A decision was made to take a fluidity limit σ_T as a criterion in our research. It is known that MM Steel 1018 has no accurately expressed fluidity platform therefore instead of σ_T the conditional limit of fluidity σ 0.2 is used. It corresponds to the tension at which residual (plastic deformation) equals to 0.2% of height of the tested sample.

Cylindrical samples were applied to tests in a free state with a diameter of D=20 mm, and height of H=1.5 of mm, H=3 mm, by H=4.5 of mm.

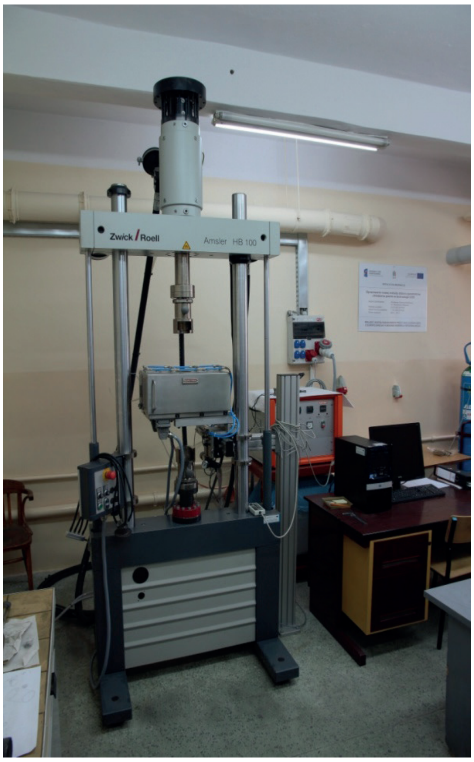

Fig. 1. Zwick Roell Amsler HB 100

The choice of such samples is caused first of all by the fact that layers of such thickness are most frequently used for repairs in the industrial equipment. The following temperatures were chosen: +20°C, +40°C, +60°C, +80°C. It is caused by declared range of working temperatures of material - 40°C – +80°C. The samples in a free state are performed in the following way:

- Forms are prepared prior to filling with material. Syringes of 20 ml are used as forms for samples in a free state - they provide the necessary diameter of samples and the need to apply a separator and a cleaner disappears,
- The prepared forms are filled with material. Thus it should be pushed carefully, preventing air bubbles,
- After material hardens, the edge of the syringe is cut and the material is removed from the cylinder with axial

loading. The received cylinders are cut off up to the necessary height,

- Face surfaces of the received sample are removed in one plane by abrasive paper.

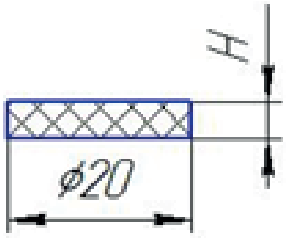

Fig.2. Sample drawing before deformation

4. Results and discussion

Researchers investigated the dependence of mechanical properties of analysed material at the increased temperatures. Earlier a number of experiments were carried out at the room temperature. The load was subjected to samples at a temperature of 40, 60 and 80°C, compression were brought to the final destruction. Figures 3 – 14 show the results of experiments.

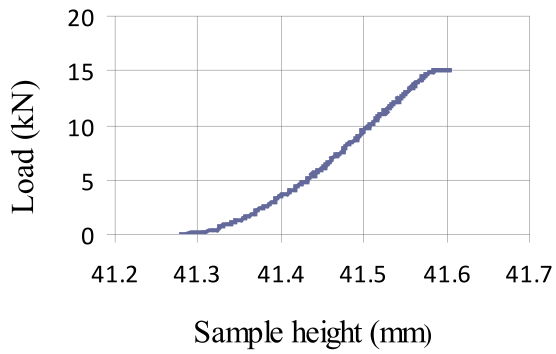

Fig. 3. Change of sample height under the influence of applied load of 15 kN at ambient temperature

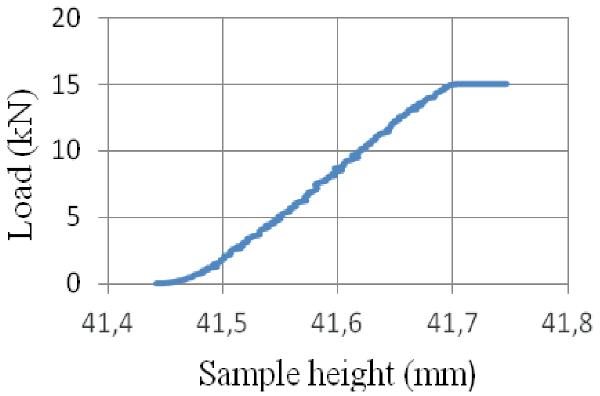

Fig. 4. Change of sample height under the influence of applied load of 15 kN at temperature of 40°C

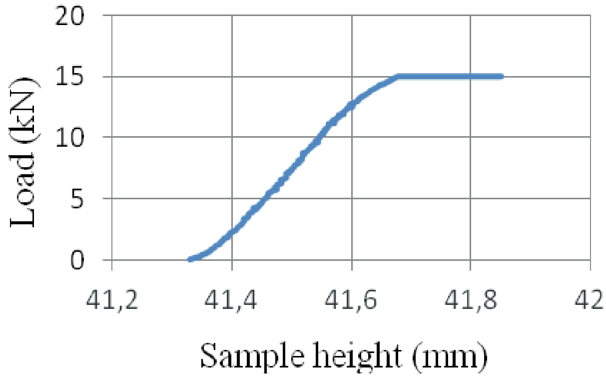

Fig.5. Change of sample height under the influence of applied load of 15 kN at temperature of 60°C

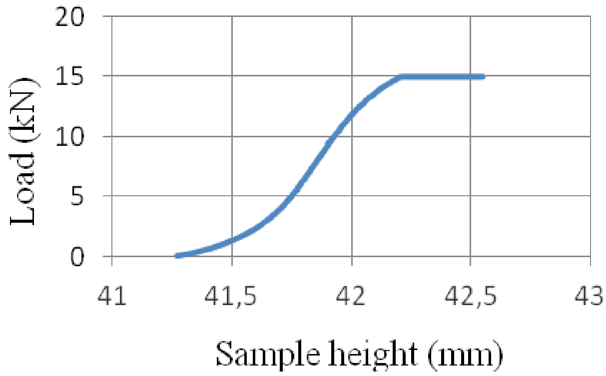

Fig. 6. Change of sample height under the influence of applied load of 15 kN at temperature of 80°C

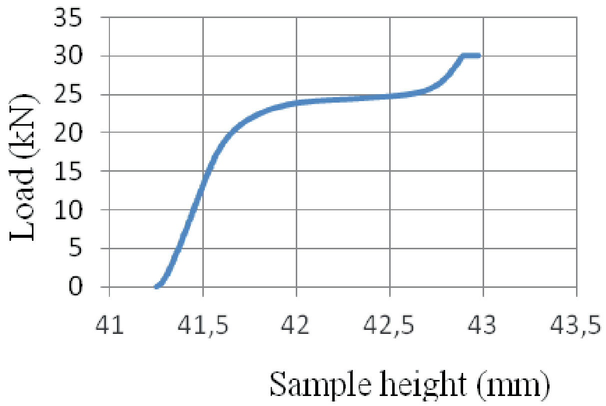

Fig. 7. Change of sample height under the influence of applied load of 30 kN at ambient temperature

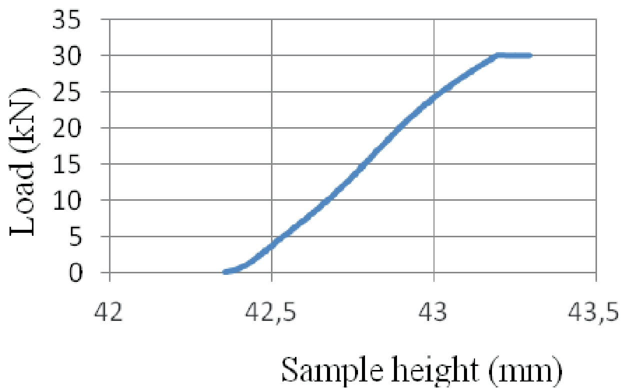

Fig. 8. Change of sample height under the influence of applied load of 30 kN at temperature of 40°C

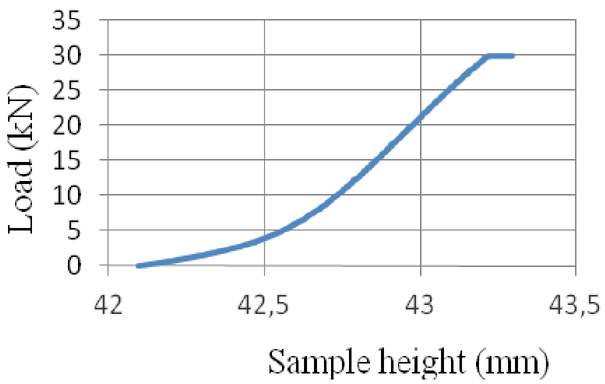

Fig. 9. Change of sample height under the influence of applied load of 30 kN at temperature of 60°C

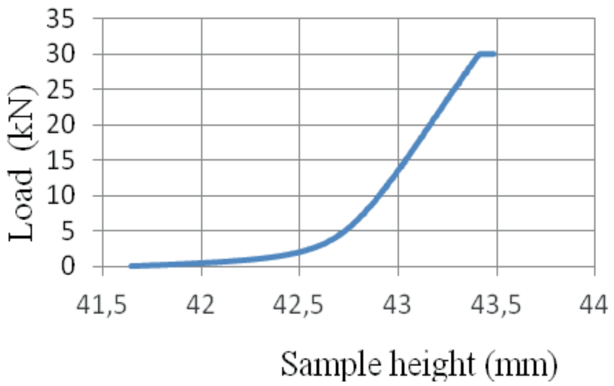

Fig.10. Change of sample height under the influence of applied load of 30 kN at temperature of 80°C

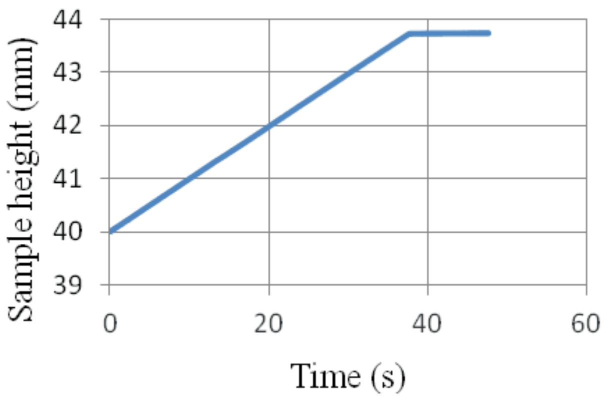

Fig. 11. The value of control channel during compression tests

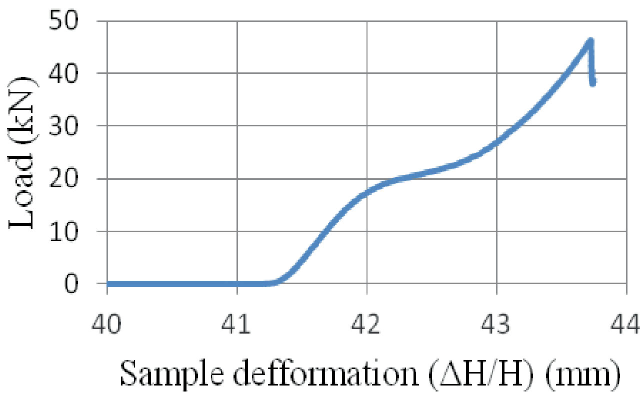

Fig. 12. Compression curve for temperature of 40°C

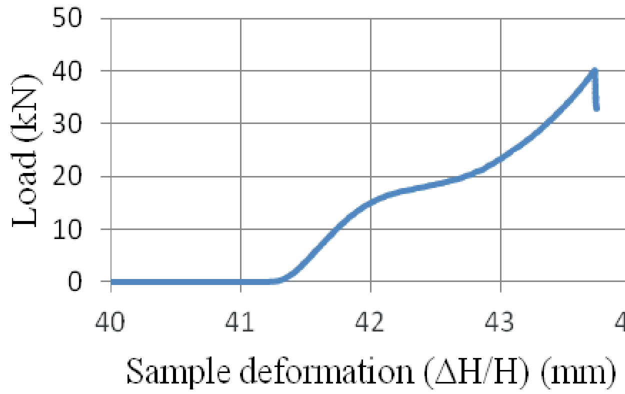

Fig. 13. Compression curve for temperature of 60°C

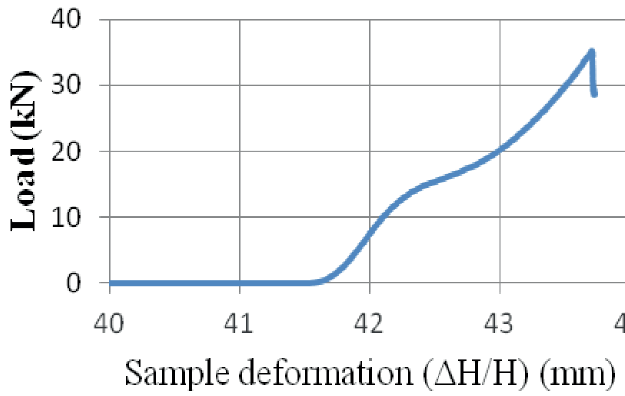

Fig. 14. Compression curve for temperature of 80°C

Fig. 3 illustrates the dependence of thickness of a sample under the influence of load of 15 kN at ambient temperature. The same dependence is shown in fig. 4-6 for temperatures of 40°C, 60°C and 80°C. They make it clear that the set loading does not suffice to overcome the fluidity limit. In fig. 7-10, similar dependences are shown for the maximum load of 30 kN. We can see the parameter reach the fluidity limit and, then decrease with the growth of temperature. In fig. 11 authors showed the dependence of thickness of a sample in time, during the samples were compressed with constant velocity as long time as they were damaged. Fig. 12-14 shows compression curve at different temperature. Besides, the sample was brought to destruction and at temperatures of 40°C, 60°C and 80°C. The analysis of the diagrams reveals that the yield point of material depends on ambient temperature. With the increasing temperature, the yield point decreases.

5. Conclusions

Theoretical and pilot studies of the bearing ability of composite material on a polymeric base MM «Steel 1018” at the increased temperatures and analysis of mechanical properties of composite materials at high temperatures showed that, durability of polymeric material in a free state falls with increase of temperature almost 30 times. Besides, the yield point values for samples from MM "Steel 1018" N, H= 4 mm at T = 40, 60 and 80 °C differ with the increasing temperature, and with the decreasing yield point.

Concluding, should by clearly showed that the investigations of composite material were conducted in order to identify the maximum pressure, which could be exerted by liquid metal on the mould during casting process to avoid destruction of protective coating from this material.

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