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SECTION 7. Mechanics and machine construction.

STRESS-STRAIN STATE OF METALLIC ALLOYS AT DIFFERENT TEMPERATURES

Abstract: *The dependencies of stress from deformation of steels, irons and non-ferrous alloys in conditions of exposure to thermal loads are presented in the article.*
Key words: *stress, deformation, alloy, temperature, dependence.*
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Introduction

Under the exposure of external loads different materials (in particular metallic alloys) of the machine parts are exposed to elastic or plastic deformations [1]. Stresses occur in the materials which under sustained static or imposed dynamic loads lead toward partial fracture of the part [2; 3; 4; 5; 6; 7]. Since most machine parts are mated among themselves by the surfaces and are operated at high speeds, then it is necessary to identify stress-strain state of the materials taking into account the existing thermal loads on them.

Materials and methods

Calculation of the stress value in different structural alloys from deformation was implemented in the computer program LVMFlow. Following metallic alloys were taken for the research [8]: carbon steel 16MnCr5 (NBN), alloy steel SCMnCr3 (JIS), corrosion-resistant steel X10CrNiTi18-9 (DIN), grey cast iron EN-GJL-200 (EN), malleable cast iron EN-GJS-700 (EN), brass CuZn38Pb1.5 (DIN), without tin bronze CC330G (EN), aluminium foundry alloy G-AlSi11 (DIN) and zinc alloy ZA-12. Young's modulus of researched alloys at different temperatures: carbon steel 16MnCr5 – 211.4 GPa / 1 °C, 206.9 GPa / 100 °C, 199.6 GPa / 200 °C, 191.7 GPa / 300 °C, 183.4 GPa / 400 °C, 174.9 GPa / 500 °C, 166.1 GPa / 600 °C, 105.7 GPa / 1428 °C; alloy steel SCMnCr3 – 207.51 GPa / 25 °C, 181.29 GPa / 390 °C, 159.56 GPa / 670 °C, 149.52 GPa / 713.52 °C, 138.14 GPa / 773.86 °C, 135.97 GPa / 800 °C, 119.31 GPa / 1000 °C, 111.78 GPa / 1090 °C; corrosion-resistant steel X10CrNiTi18-9 – 209 GPa / 20 °C, 196.49 GPa / 200 °C, 181.47 GPa / 400 °C, 165.16 GPa / 600 °C, 150.09 GPa / 800 °C, 116.99 GPa / 1200 °C, 104.6 GPa / 1310 °C, 0.5 GPa / 1455 °C; grey cast iron EN-GJL-200 – 100 GPa / 1 °C, 84 GPa / 100 °C, 82.1 GPa / 200 °C, 80 GPa / 300 °C, 78 GPa / 400 °C, 75.7 GPa / 500 °C, 50 GPa / 1145 °C, 0.5 GPa / 1168 °C; malleable cast iron EN-GJS-700 – 164 GPa / 50 °C, 159 GPa / 150 °C, 154 GPa / 250 °C, 148 GPa / 350 °C, 139 GPa / 500 °C, 82.5 GPa / 1153 °C, 0.5 GPa / 1180 °C; brass CuZn38Pb1.5 – 97 GPa / 100 °C, 0.5 GPa / 925 °C; without tin bronze CC330G – 110 GPa / 100 °C, 0.5 GPa / 1045 °C; aluminium foundry alloy G-AlSi11 – 70 GPa / 100 °C, 0.5 GPa / 590 °C; zinc alloy ZA-12 – 133 GPa / 100 °C, 0.5 GPa / 435 °C. Maximum deformation of all alloys was taken as value of 0.2.

Results and discussion

The dependencies of stresses in considered alloys from deformation when exposed to temperature are presented in Figs. 1 – 9.

All metal alloys are characterized by decrease of stress when the temperature is increased. Given the same value of deformation, carbon steel 16MnCr5 in solid state and at small temperatures may be exposed by significant stresses.

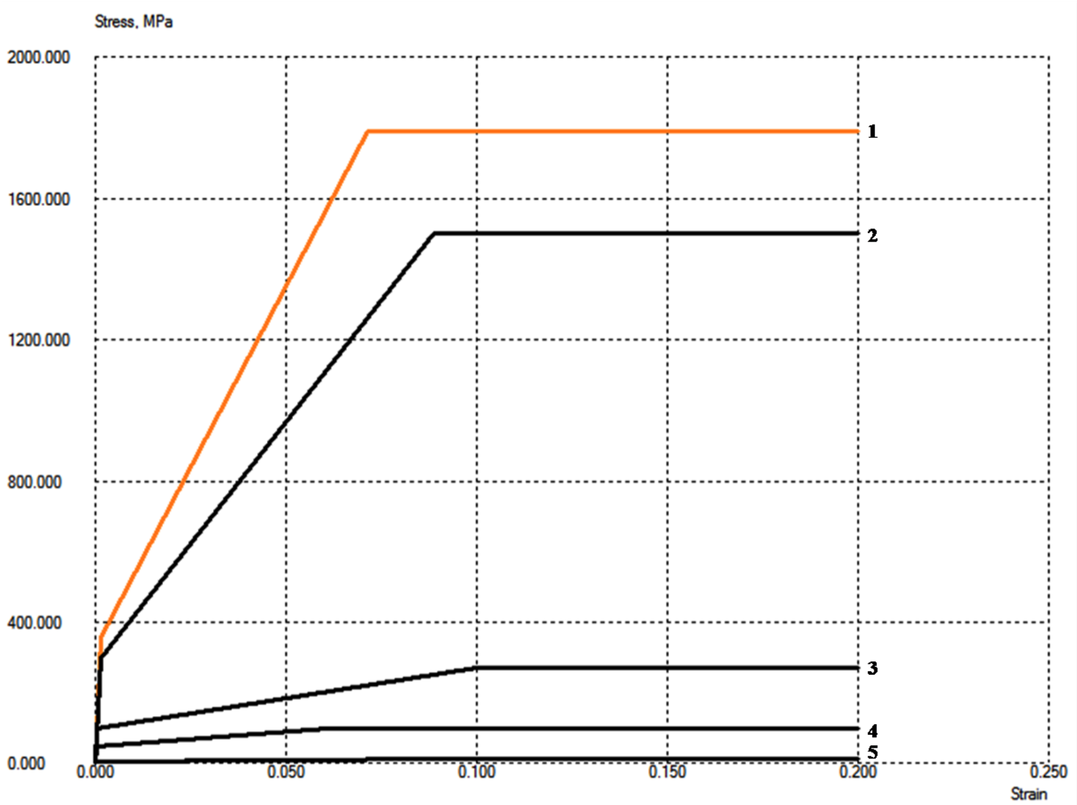

Figure 1 – The dependencies of stress in carbon steel 16MnCr5 from deformation: 1) T (temperature) = 1 °C, 2) T = 100 °C, 3) T = 600 °C, 4) T = 1000 °C, 5) T = 1450 °C.

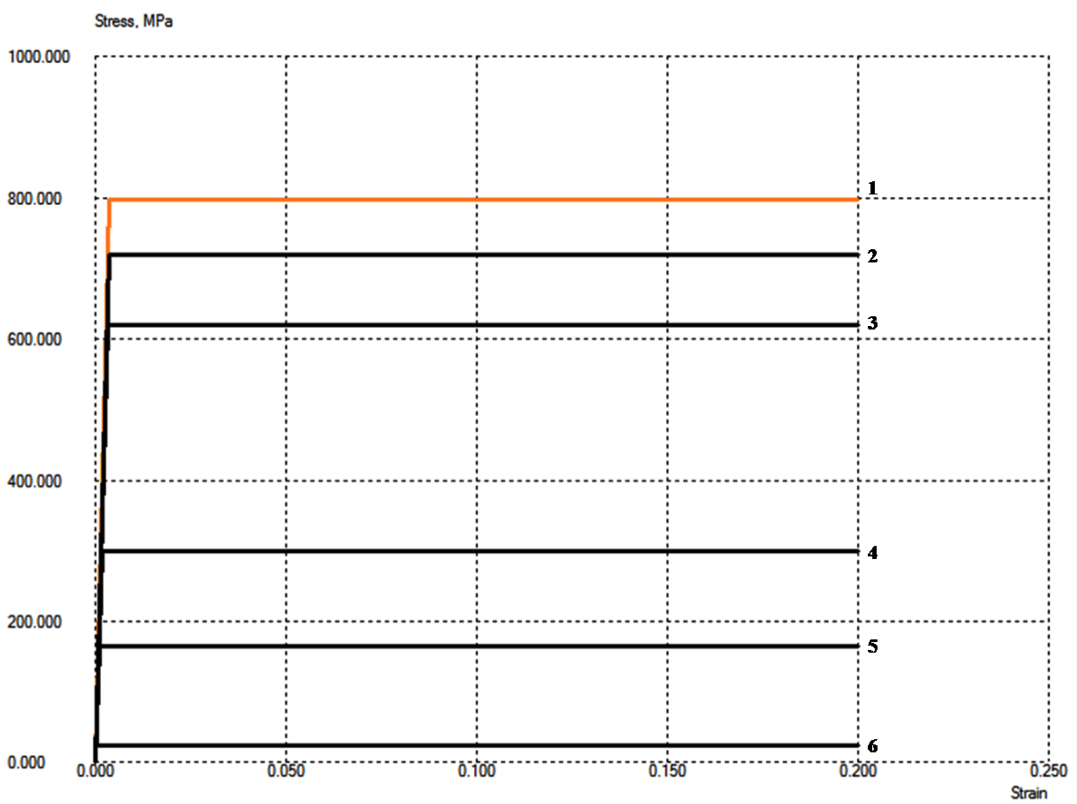

Figure 2 – The dependencies of stress in alloy steel SCMnCr3 from deformation: 1) T = 25 °C, 2) T = 200 °C, 3) T = 400 °C, 4) T = 600 °C, 5) T = 800 °C, 6) T = 1090 °C.

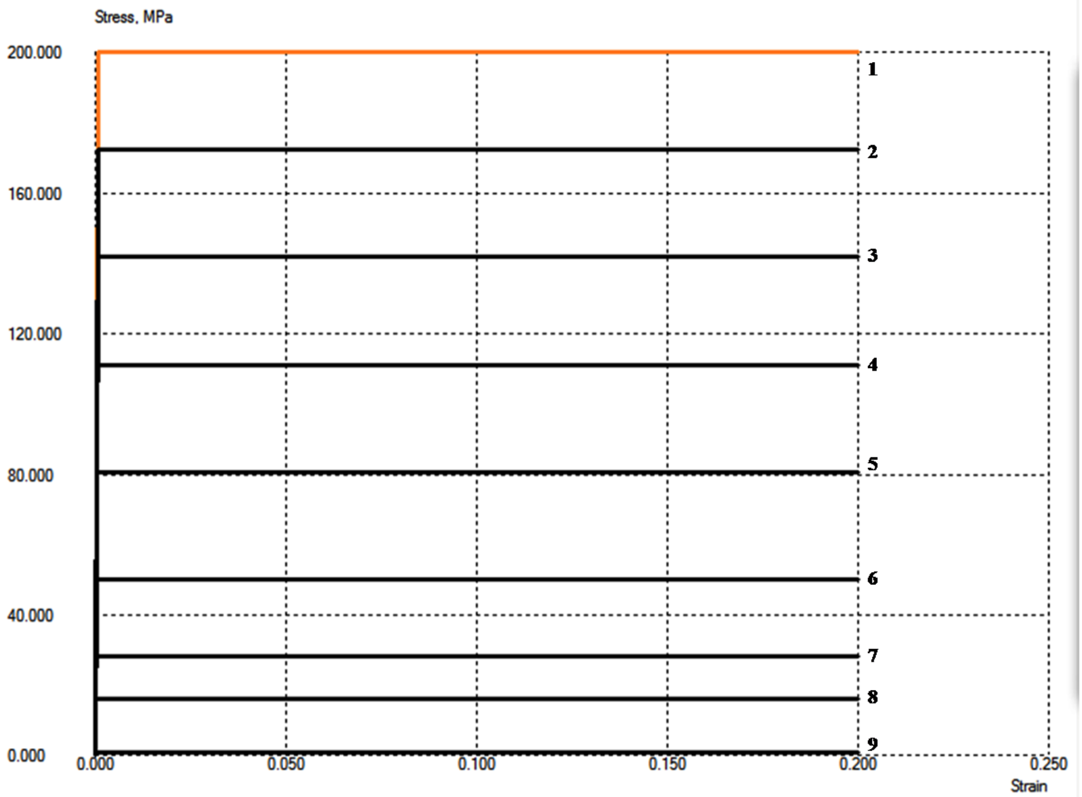

Figure 3 – The dependencies of stress in corrosion-resistant steel X10CrNiTi18-9 from deformation: 1) T = 20 °C, 2) T = 200 °C, 3) T = 400 °C, 4) T = 600 °C, 5) T = 800 °C, 6) T = 1000 °C, 7) T = 1200 °C, 8) T = 1310 °C, 9) T = 1455 °C.

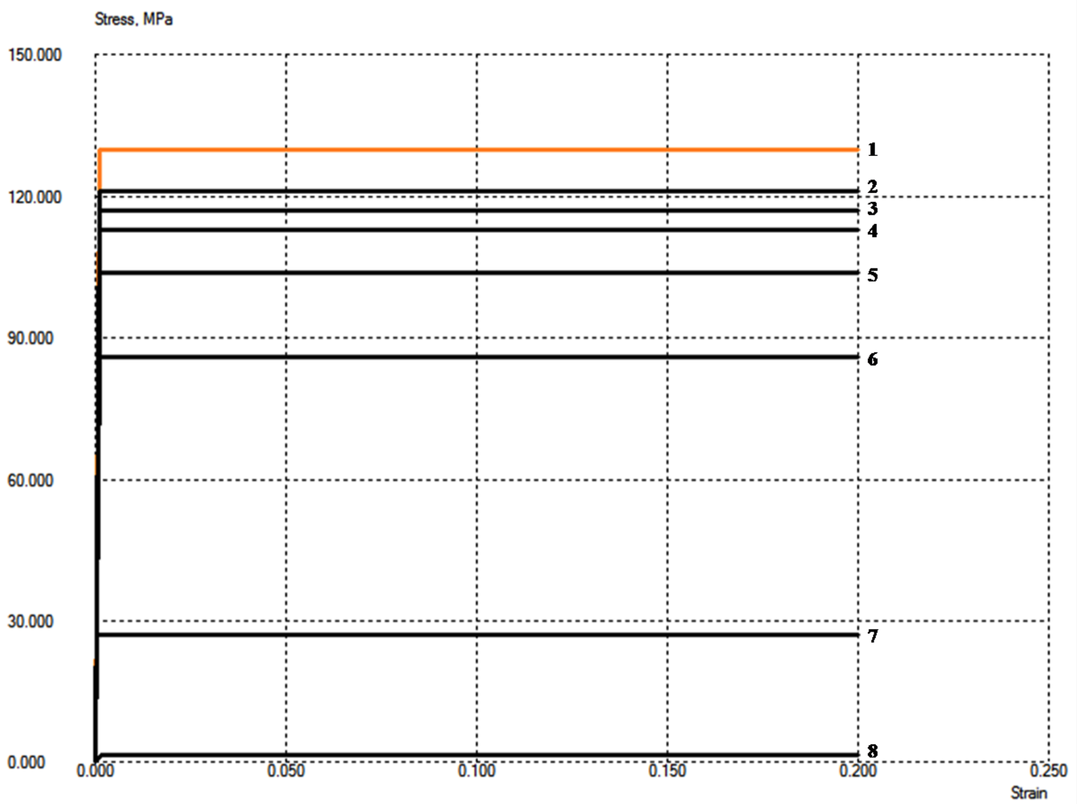

Figure 4 – The dependencies of stress in grey cast iron EN-GJL-200 from deformation: 1) T = 20 °C, 2) T = 100 °C, 3) T = 200 °C, 4) T = 300 °C, 5) T = 400 °C, 6) T = 500 °C, 7) T = 1000 °C, 8) T = 1168 °C.

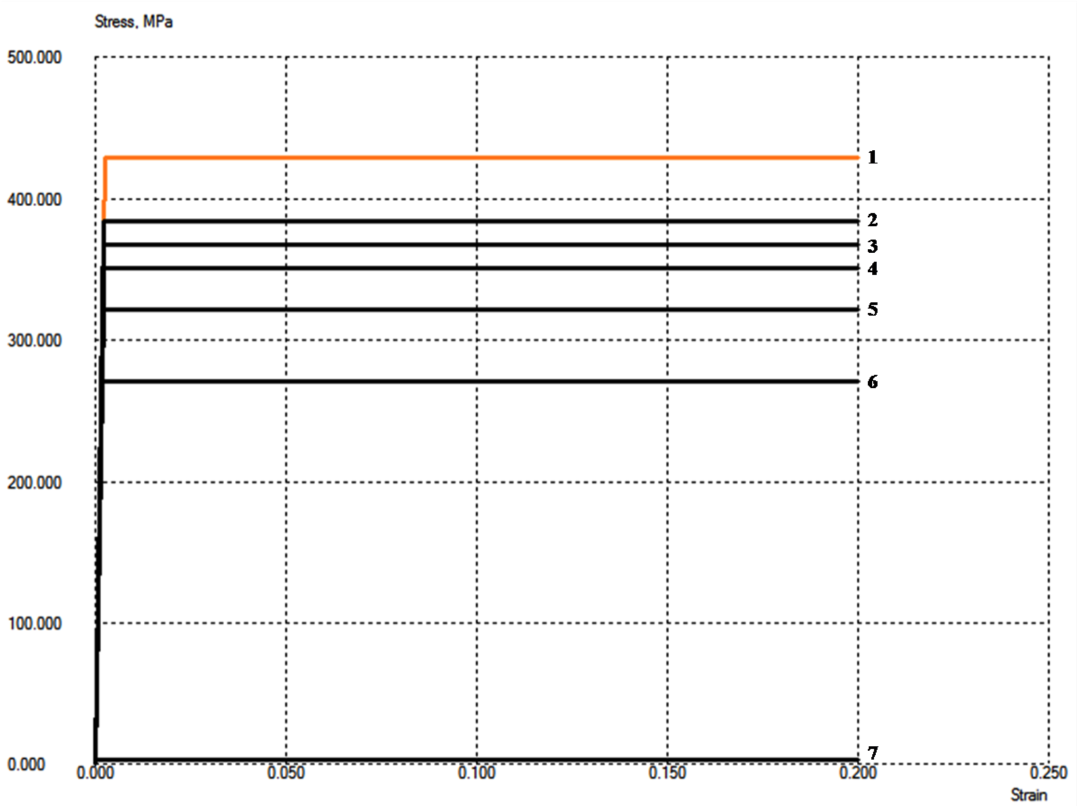

Figure 5 – The dependencies of stress in malleable cast iron EN-GJS-700 from deformation: 1) T = 20 °C, 2) T = 100 °C, 3) T = 200 °C, 4) T = 300 °C, 5) T = 400 °C, 6) T = 500 °C, 7) T = 1153 °C.

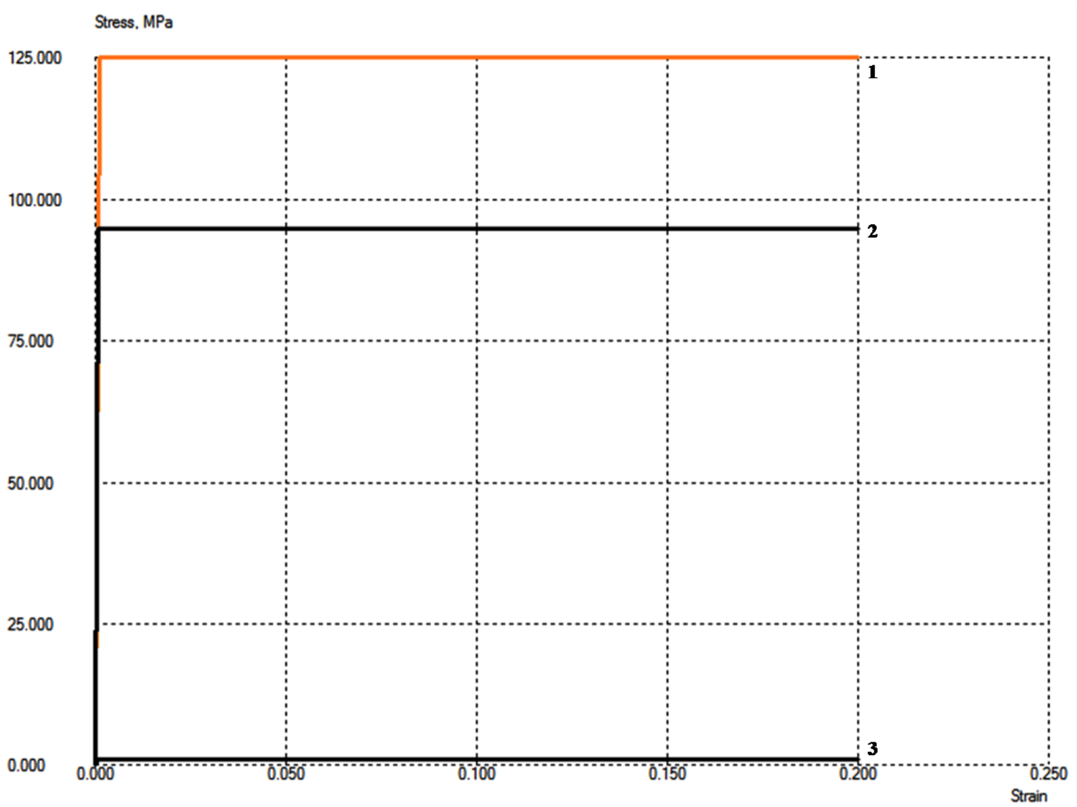

Figure 6 – The dependencies of stress in brass CuZn38Pb1.5 from deformation: 1) T = 100 °C, 2) T = 300 °C, 3) T = 925 °C.

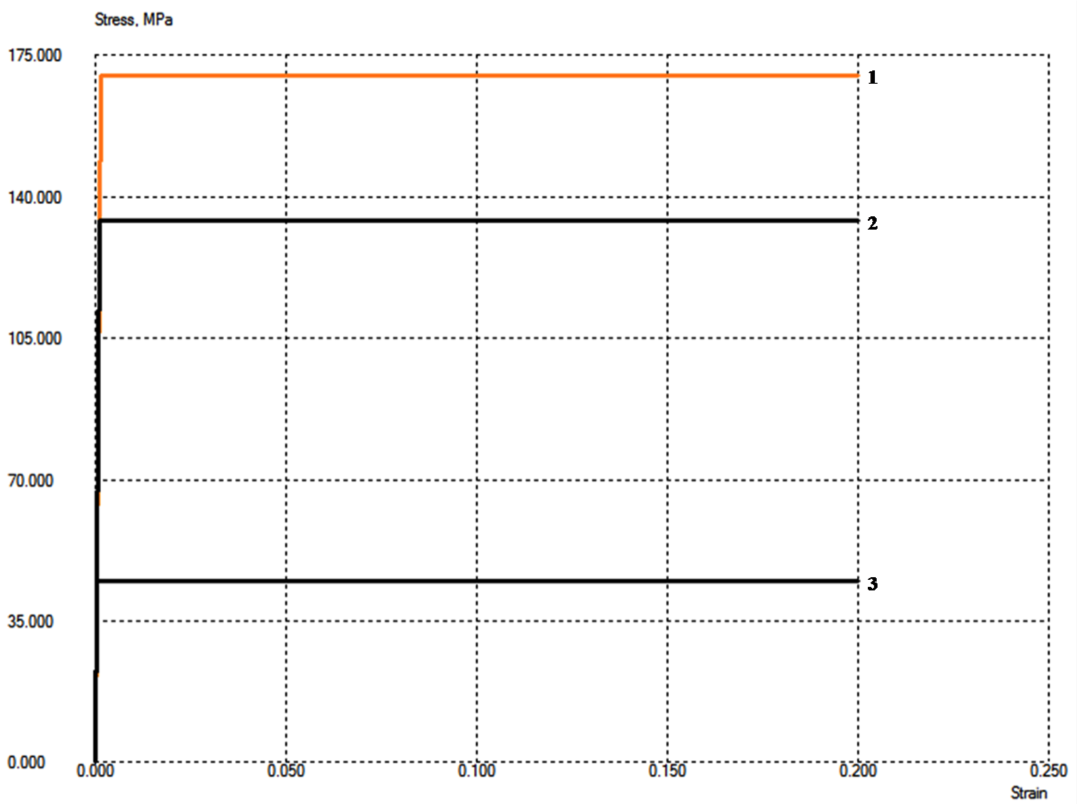

Figure 7 – The dependencies of stress in without tin bronze CC330G from deformation: 1) T = 100 °C, 2) T = 300 °C, 3) T = 800 °C.

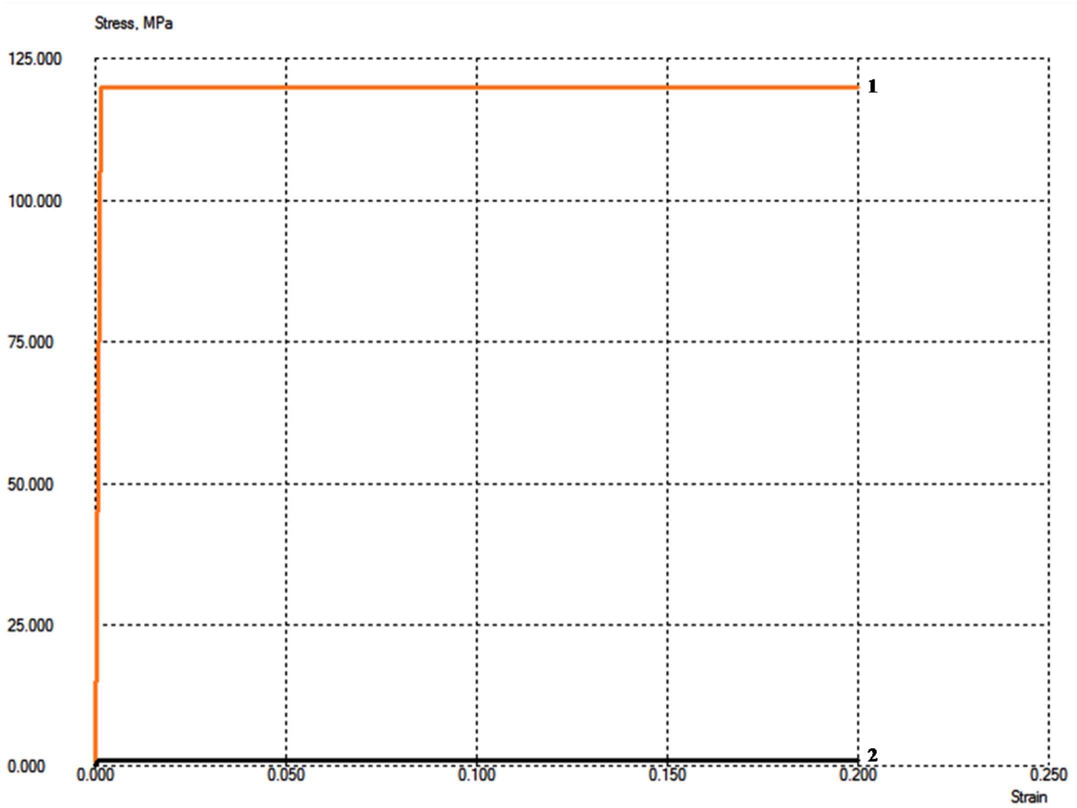

Figure 8 – The dependencies of stress in aluminium foundry alloy G-AlSi11 from deformation: 1) T = 100 °C, 2) T = 590 °C.

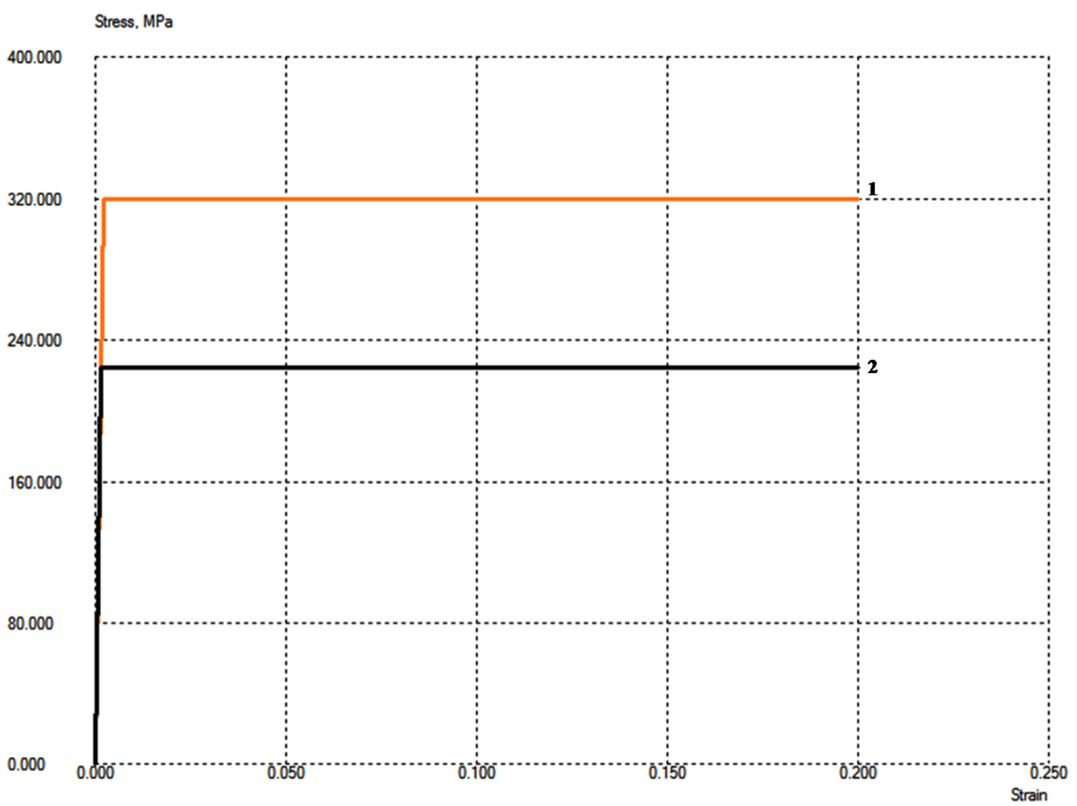

Figure 9 – The dependencies of stress in zinc alloy ZA-12 from deformation: 1) T = 100 °C, 2) T = 200 °C.

It is defined that alloy steel SCMnCr3 and corrosion-resistant steel X10CrNiTi18-9 are exposed to less stress than carbon steel 16MnCr5 at appropriate temperatures. Deformation of malleable cast iron EN-GJS-700 at a temperature of 100 °C is accompanied by the appearance of the stress value of 380 MPa. This is two times more than stress for corrosion-resistant steel X10CrNiTi18-9, and three times more than stress for gray cast iron EN-GJL-200. For non-ferrous alloys same stress at a temperature of 100 °C is observed in brass CuZn38Pb1.5 and aluminum foundry alloy G-AlSi11. In zinc alloy ZA-12 in conditions of plastic deformation occurs stress which exceeds stresses of all non-ferrous alloys. Maximum stress in carbon steel 16MnCr5 has been calculated when deformation is more than 0.07. Maximum value of stress for all other alloys is observed when deformation is less than 0.05.

Conclusion

Given the results of the research, highest stress occurs in the deformed machine parts made of carbon steel 16MnCr5. With increasing of thermal load, stress of alloy reaches maximum at a higher value of the coefficient of plastic deformation. The least stress occurs in the deformed machine parts made of grey cast iron EN-GJL-200.

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