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Stress-Strain Behavior – Deformation Degree Relationship Investigation of Alloy CrNi60WTi

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ABSTRACT

The article presents the results of a research of the dependence of the mechanical properties of the CrNi60WTi alloy on the degree of cold deformation. As part of the study, five samples were taken from a pipe with an outer diameter of 89.0 mm and a wall thickness of 11.0 mm. The samples were cold-deformed to varying degrees and static tensile tests were performed on an SSI MTSInsight tensile testing machine. Based on the test results, the dependences of the mechanical properties on the degree of cold deformation were calculated.

1. INTRODUCTION

Nickel-based alloys are used in mechanical engineering, chemical industry, electrical engineering, electronics and power plants. High alloy nickel alloys are sometimes referred to as "superalloys" [1-5].

The issues of deformability of nickel-based alloys without fracture have been studied insufficiently. There is a need to study the deformability of nickel-based alloys, depending on the conditions of deformation [6-10].

This article discusses the issue of changing the mechanical properties of a nickel-based alloy of the CrNi60WT grade during its cold deformation. Experimental studies were carried out to determine the range of permissible degrees of cold plastic deformation of the CrNi60WT alloy.

2. METHOD FLOW

A hot-extruded pipe with a diameter of 89.0 mm and a wall thickness of 11.0 mm from an alloy of the CrNi60WT grade was used as a starting material. Five cylindrical bars with a diameter of 10 mm and a length of 210 mm were taken from the pipe (Figure 1).

Figure 1. Bars made of alloy grade CrNi60WTi

A two-roll stand was used for cold deformation of the bars. The bars were deformed in 110 mm roll calibers according to the "oval-oval" scheme. This pressure treatment process is similar to the stress state diagram of a real rolling process in a cold-rolling mill.

After reaching the required degree of deformation, 2 samples were taken from the bar for static tension. Static tensile tests at room temperature in accordance with GOST (Russian state standard) 1497-84 «Metals. Methods of tension test» [11] were carried out on a tensile testing machine SSI MTSInsight 100.

3. EXPERIMENTAL PART

Cold deformation was carried out in the mode of sequential increase in the compression value. Photographs of Appearance of samples after testing are shown in Figure 2 Photographs of specimens rolled with varying degrees of deformation are shown in Figure 3.

The degree of deformation ε was calculated using the following formula:

$$\varepsilon = \frac{F_0 - F_1}{F_0} \cdot 100\%$$

where, ε is degree of deformation, F_0 is the area of an undeformed bar, F_1 is the area of the deformed bar.

Figure 2. Tensile samples after testing

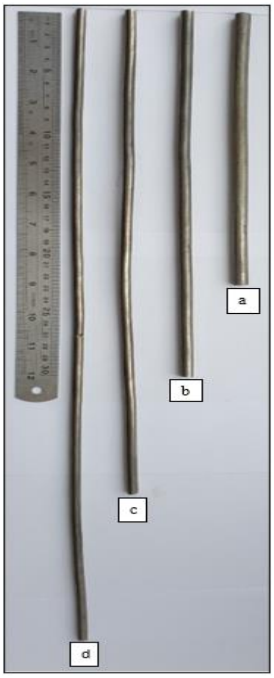

Figure 3. Rolled samples with varying degrees of deformation ε: a – ε=9.75%; b – ε=31.11%; c – ε=48.16%; d– ε=61.56%

4. RESULT PROCESSING

Tables 1 and 2 show the tensile test results. Figures 4 and 5 show the empirical curves of the change in temporary resistance, yield point, and relative elongation versus the degree of deformation.

Table 1. Results of mechanical tests of samples

№	⌀ Mm	$\sigma_{в}$ N/mm^2	$\sigma_{0,2}$ N/mm^2	δ %	ε %
1-1	6.09	833	481	45.0	0
1-2	6.12	846	481	47.3	
2-1	5.16	943	764	30.4	9.75
2-2	5.15	918	729	29.2	
3-1	5.12	1267	1153	8.1	31.11
3-2	5.18	1250	1150	8.8	
4-1	4.09	1400	1153	7.3	48.16
4-2	4.09	1393	1282	45.0	
5-1	4.11	1522	1408	47.3	61.56
5-2	4.09	1517	1395	30.4	

where, ⌀ is diameter of the sample, $\sigma_{в}$ is temporary resistance, $\sigma_{0,2}$ is yeld point, δ is relative extension, ε degree of deformation.

Table 2. Mechanical properties of the researched samples, depending on the degree of deformation

degree of deformation, %	temporary resistance $\sigma_{в}$, N/mm^2	yield point $\sigma_{0,2}$, N/mm^2	relative extension δ, %
0	839	481	46.2
9.75	931	746	29.8
31.11	1258	1152	8.4
48.16	1396	1218	7.1
61.56	1520	1401	6.5

Thus, the change in the mechanical properties of the CrNi60WT alloy depending on the degree of cold deformation can be represented by the following functions:
for temporary resistance:

$$\sigma_{в}(\varepsilon) = 846{,}1 + 11{,}379\ \varepsilon;$$

for yield point:

$$\sigma_{0,2}(\varepsilon) = 14{,}219\varepsilon + 571{,}37;$$

for relative extension:

$$\delta\ (\varepsilon) = 0{,}0176\varepsilon^2 - 1{,}695\ \varepsilon + 45{,}44;$$

where, ϵ is the degree of deformation, %.

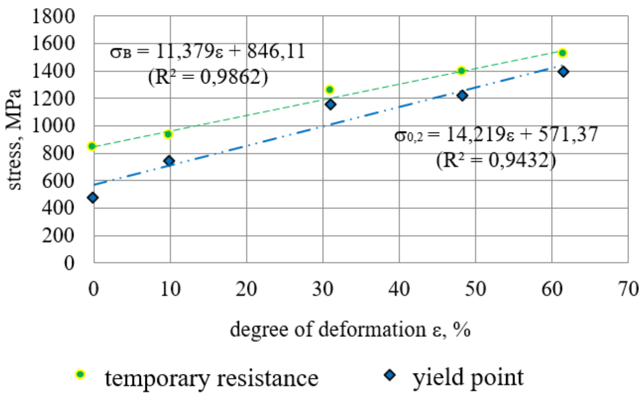

Figure 4. Dependence of temporary resistance and yield point on the degree of cold deformation

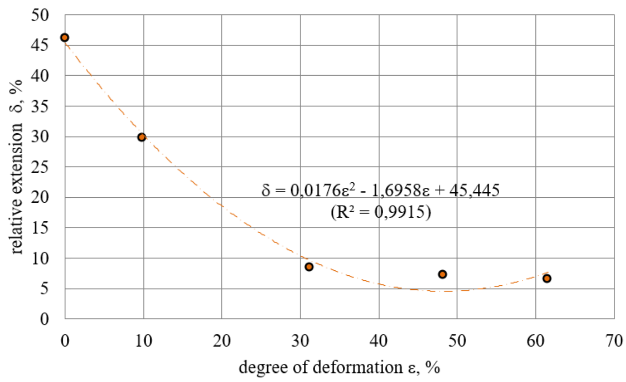

Figure 5. Dependence of the relative elongation on the degree of deformation

5. CONCLUSION

Alloy CrNi60WT has high ductility with high strength properties. Analysis of the surface of the rods after cold deformation showed that even with a degree of deformation of more than 60%, failure is not observed.

An experimental study of the effect of cold plastic deformation on the mechanical properties of the CrNi60WT alloy was carried out. Empirical dependences of the yield point, ultimate strength, and relative elongation on the degree of deformation were calculated.

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