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Determination of the Optimum Conditions at the Processing of High-Strength Corrosion-Proof Pipelines

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Abstract: It was carried out an evaluation of influence of thermomechanical parameters of rotary rolling-off on mechanical characteristics of a titanium alloy BT1-0 and corrosion-resistant steel AISI 304. It is established the law of variations of characteristics of strength and plasticity depending on growth of strain intensity. It was defined the optimum condition of processing of pipeline elements of high-responsible products of engineering products.

Key words: Rotary rolling-off, pipe shell, precision, thin-walled, titanium alloy, stainless steel, life cycle

INTRODUCTION

At production of products of chemical and oil and gas mechanical engineering the longitudinally welded pipes are used in the absence of seamless drill pipe. However, the welded seam is the concentrator of stress that reduces operational characteristics. It is necessary to use rotary rolling-off for elimination of negative influence of a welded seam (Davydov, 2015).

Rotary rolling-off of a longitudinal welded seam of cylindrical components is carried out on the universal equipment, where instead of a toolholder there is installed the device for rolling-off of pipe shell (Fig. 1) which is connected to pumped storage plant (Yakovlev, 2009).

Now, operation of rotary rolling-off (drawing) of cylindrical shells with thinning of a wall is well studied by both domestic and foreign researchers (Yudin, 1984). Rotary rolling-off is represented by processing of hollow axisymmetric element which is rotated together with horse cock of pipe shell, deformed by pressing elements and it is used at processing of pipe shells with wall thickness <1 mm with diameters from 40-300 mm.

Fig. 1: Equipment for rotary rolling-off

However, the question of influence of extent of deformation at rolling-off on mechanical characteristics of strength and plasticity of material of thin-walled pipes is not studied in full.

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OBJECTS AND METHODS OF RESEARCH

Object of research is the thin-walled corrosion-proof pipeline. Research methods are experiment on a rotary drawing with various extent of deformation, test for stretching.

The purpose of the given research is an evaluation of change of characteristics of strength and plasticity of welded connections depending on the reached strain intensity at rotary rolling-off.

For carrying out of experimental researches for determination of ultimate tensile strength and elongation at the gaps of welded connections after rotary rolling-off, the samples from corrosion-resistant

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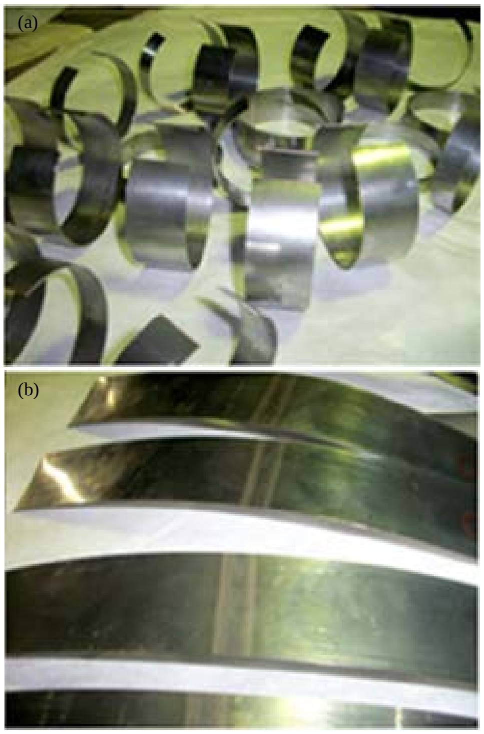

Fig. 2: a, b) Main stages of receiving experimental samples from the rolled pipe shells for carrying out of experimental researches

steel AISI 304 (ASTM A240) and a titanium alloy of BT1-0 (State Standard 19807-91) were made in the following sequence.

From plate stock with thickness in 1 mm there were twisted the thin shells and straight-line-seam pipe shells for rolling-off were made with use of automatic argon-arc welding. It was made the rolling-off of cylindrical samples to thickness of 0.9, 0.8, 0.7 and 0.6 mm.

The received samples of the rolled out pipes were cut on collars with width 25 mm and after they were cut in diametral place from a welded seam (Fig. 2a).

Samples from a titanium alloy BT1-0 were tested by annealing with duration in 1 h at a temperature of 550°C. Samples from corrosion-resistant steel AISI 304 weren't tested to heat treatment (Davydov, 2015).

The cut collars were straightened on rollers of the roll sheet bending machine, thus, there were made the welded pipe shells with perpendicular a longitudinal axis a welded seam (Fig. 2b) and they were bundled (before bundling on stated above condition, the samples from BT1-0 alloy were tested by stress-relieving annealing after the bending strain, made at extension of collars).

At the last stage from the flat bars there were milled samples for pulling tests in accordance with state standard 1497-84.

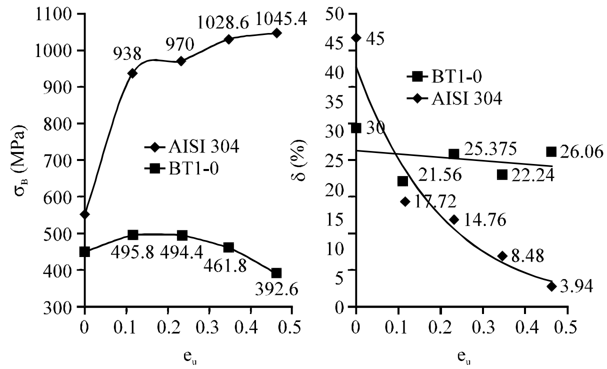

Fig. 3: Experimental plots of indicators of strength and plasticity of the investigated alloys from strain intensity e_u at rotary rolling-off with thinning of a wall

The axis of the main stresses from external loading in all cases was perpendicular to the direction of flats. The metalgraphic analysis was made by AxioScope A1 microscope.

Pulling tests with determination of temporary resistance to a gap (σ_B) were carried out on Inspekt 50 equipment.

At carrying out of experimental researches it was determined the maximum static load on stretching where there was a destruction of an experimental sample. As a result there were determined the plots (Fig. 3) of ultimate tensile strength σ_B material of welded connection and elongation at a gap δ depending on grade of material and strain intensity of e_u wall of a thin-walled pipe at rotary rolling-off. Thus, a magnitude e_u was determined by a equation:

$$e_u = \frac{2\sqrt{3}}{3}\frac{t_0-t}{t_0}$$

Where:

t_0 = Thickness of a wall of parent tube for rolling-off mm
t = Thickness of wall after rolling-off mm

DISCUSSION

Apparently from Fig. 3 that for BT1-0 alloy, the softening of the samples is begun at e_u = 0.35, strength is decreases ~ to 6%. At e_u = 0.46 the strength is fallen ~ to 20%. Thus, ultimate tensile strength of not rolled annealed welded samples (e_u = 0), made σ_B = 450 Mpa.

The revealed softening is connected with the beginning (at e_u = 0.35) and further development (at e_u = 0.46) of the processes of recrystallization in the process of annealing of the deformed titanium alloy. Thus,

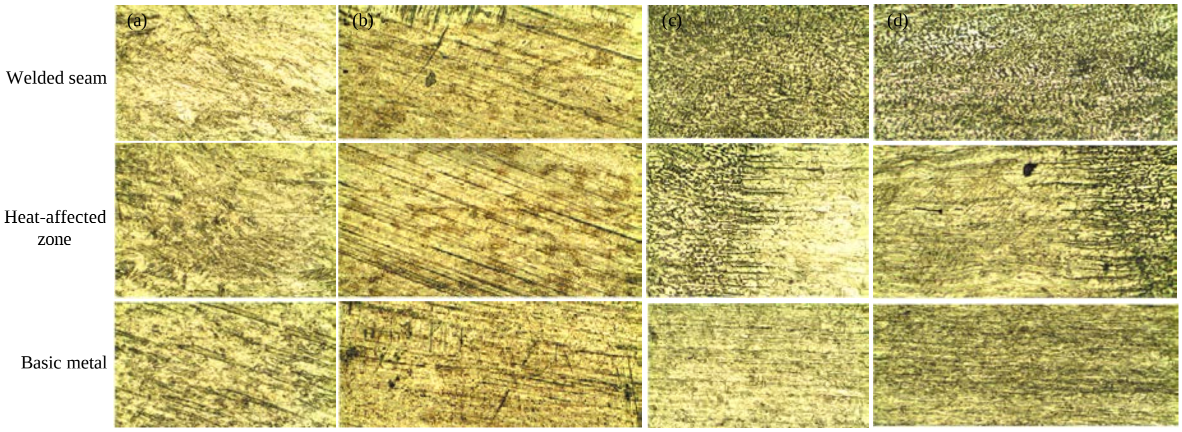

Fig. 4: a) Microstructure of welded connections of the titanium BT1-0. e_u = 0.23, x200; b) Microstructure of welded connections of the titanium BT1-0. e_u = 0.46, x200; c) Microstructure of welded connections of AISI 304 steel. e_u = 0.12, x200 and d) Microstructure of welded connections of AISI 304 steel. e_u = 0.35, x200

the critical strain intensity, causing the beginning the recrystallization processes is equal to e_u≈035 (Yudin, 1984).

For steel samples, there was noted the monotonous increase of strength from 938-1045.4 MPa in process of increase of strain intensity from 0.12-0.46, thus elongation at a gap is sharply fallen: from δ = 17.72% to δ = 3.92%.

It should be noted that in a condition of rolling-off the ultimate tensile strength of stainless steel AISI 304 makes >500 Mpa and $\delta \geq 40\%$. Thus, sharp hardening (~ in 1.8 times) with loss of plasticity (more than twice) has been already reached at initial degree of strain intensity e_u = 0.12 (Il'ina, 2010).

At metallographic researches of a microstructure on all samples there were revealed the slide curves, formed in the process of flow of metal at rolling-off (Fig. 4a-d).

These slide curves the most clear are revealed for steel samples on the main metal and in Heat-Affected Zone (HAZ) (Deryagin, 1946). The slide curves are practically not visible in a welded seam. Intensity of slide curves is increased in process of increase of deformation ratio.

Intensity of slide curves for titanic samples is significantly lower in photos with their microstructure, however slide curves are well looked through in all zones of welded connection including a seam.

CONCLUSION

It was revealed an essential influence of strain intensity at rotary rolling-off of pipes on mechanical characteristics of strength and plasticity of BT1-0 alloy and AISI 304 stainless steel.

The best mechanical characteristics σ_B and δ were received at strain intensity with e_u = 0.1...0.23 for welded connections of a titanium alloy BT1-0. Material has high strength at good indicators of plasticity. Strain intensity $e_u \geq 0.3$ leads to noticeable loss of strength owing to the beginning of development of processes of recrystallization at annealing.

There is characteristically monotonous increase of strength and strong decrease in plasticity in process of increase of strain intensity for corrosion-resistant steel AISI 304.

Thermomechanical conditions of processing of pipe shells at rotary rolling-off, received experimentally, can be recommended by production of pipe fittings of the high-responsible products of mechanical engineering.

REFERENCES

Davydov, O.Yu., 2015. Quality improvement of thin walled longitudinally welded pipes by the rotary rolling of weld seam. Weld. Eng., 2: 29-33.

Deryagin, B.V., 1946. Determination of specific surface of bodies by capillary impregnation rate. Colloidal J., 2: 27-30.

Il'ina, T.N., 2010. Methods of agglomeration of surface layer of polydisperse materials. Chem Oil Gas Eng. Ind., 4: 3-7.

Yakovlev, S.S., 2009. A Rotary Drawing with Wall Thinning of Axially Symmetrical Elements from Anisotropic Pipe Shells. Mechanical Engineering Publisher, Moscow, Russia, Pages: 256.

Yudin, L.G., 1984. Rotary Drawing of Cylindrical Shells. Mechanical Engineering Publisher, Moscow, Russia, Pages: 128.