

Analysis and Calculation of Contact Stresses Rolling and Roll Strength Assessment

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Annotation

The article analyzes the current state of the production of hot-pressed bimetallic seamless pipes, considers the technological features of pressing bimetals, identifies the main problems and presents ways to improve the process of pressing bimetallic pipes.

Keywords: pressing, bimetallic pipes, seamless pipes, assortment of pipes, hot-pressed pipes, technological features, bimetal pressing.



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Introduction:

In world practice, the production of seamless bimetallic pipes is carried out in various ways: hot deformation (on hydraulic presses, continuous, pilgrim , piercing and drawing mills), cold deformation, thermal diffusion welding, casting, explosion welding, electrolytic deposition, etc.

Bimetallic seamless pipes include products made of carbon and alloy steels, plated with copper, nickel, titanium, aluminum, corrosion-resistant steel and various alloys. When using pipes in particularly critical conditions, corrosion-resistant steels and heat-resistant alloys, niobium, tantalum, molybdenum, refractory metals are used as the main layer. Table 1 shows the main range of manufactured seamless bimetallic pipes.

Table 1. Range of hot - deformed bimetallic pipes

Layer material		Pipe size, mm		Technological scheme of production
main	cladding	diameter	total wall thickness	
Steel 10, 10XH1M	08X18H10T	114.0 - 116.0	9.0 – 12.0	Hot pressing - HPT
Steel 10	Copper M3r	57.0	4.5	Continuous rolling mill
	Nickel NP2			
	Copper M3r	168.0 – 273.0	5.0 – 9.0	Pilgrim Mill Rolling
	Copper M3r	66.0	6 – 7.25	Hot pressing
Steel	Nickel	68.0	5.0	-/-
Nickel	08X18H10T	59.0	7.0	-/-
Nickel NP2	08X18H10T, 12X1MF	68.0	5.0	-/-
10G2B	Heat-resistant steels based on Fe - Ni	63.0	3.0 - 5.0	-/-
10GN2MFA	08X18H10T	351.0 - 426.0	36.0 – 40.0	Continuous rolling mill
12XГМФ (12XH3A)	Copper	36.0	6.0	Hot pressing
Nickel	08X18H10T	35.0	2.0 – 3.0	-/-
Steel	08X18H10T	82.0 – 125.0	9.0 – 24.0	Pushing on a rack mill in a hot state

The blanks for the production of seamless bimetallic pipes are hollow two-layer sleeves obtained by mechanically joining two pipes using casting methods and vacuum - arc remelting, piercing with pressing in of the cladding layer.

The technological processes of pressing bimetallic and monometallic pipes are practically identical. However, during deformation of bimetallic blanks there are some characteristic features, as a result of which specific problems and limitations arise that are not typical for pressing monometallic pipes.

The paper describes examples of pressing bimetallic pipes that differ in the combination of pressed bimetallics and alloys, the shape of the blank and the design of the tooling. The results of the study of pressing three-layer pipes made of alloys TsAM 9-1.5 (outer and inner layer) and D1 (middle layer) showed:

1. Noticeable unevenness in the thickness of individual layers across cross sections, as well as along the length of the finished pipe (Fig. 1).
2. The influence of the matrix channel shape on this unevenness, which is evident from a comparison of the graphs shown in Fig. 1, photographs of samples (Fig. 1), and also the graph in Fig. 1, which relates the unevenness of the layer thicknesses along the length of the pipe with the angle α of the conical matrix. The value A, %, is taken as an indicator of this unevenness:

$$A = \frac{L_{об} - L_{павн}}{L_{об}} 100. \quad (1)$$

where $L_{об}$ is the length of the extruded pipe;

L_{equal} – the length of the middle part of the pipe, on which no noticeable changes in the thickness of the layers are observed.

The least unevenness is obtained at $\alpha = (40 \div 50)^\circ$.

With unequal resistance to deformation of individual layers of a polymetallic pipe in a pressing state, the possibility of the occurrence of longitudinal tensile stresses, and with them the formation of transverse cracks - external and internal - can either increase or decrease depending on the arrangement of the layers.

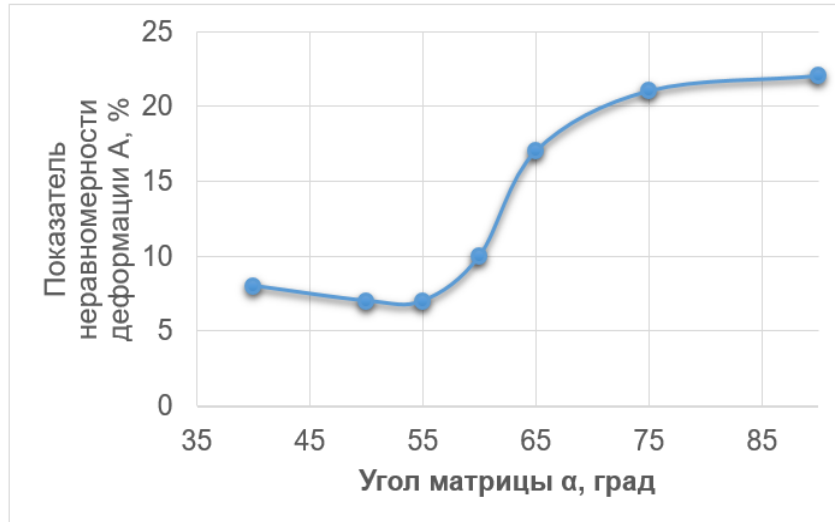


Fig. 1 Samples of trimetallic pipes extruded through conical dies with different angles

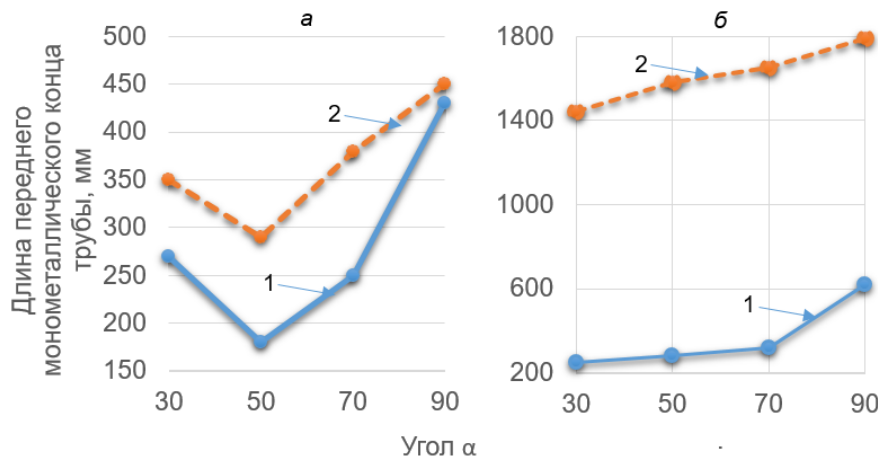


Fig. 2. The influence of pressing conditions of bimetallic pipes D16 – AD1 with external (a) and internal (b) arrangement of AD1 alloy on the size of the front monometallic end of the pipe
1 – pressing with lubrication; 2 – without lubrication.

In Fig. 1 and 2 The results of a study of the influence of the mutual arrangement of metal layers in the workpiece, the angle of the matrix α and the value of external contact friction (pressing with and without lubrication of the container) on the value of the front monometallic end of the pipe made of the metal of the inner layer are presented.

Comparison of the monometallic front ends of each of these pressed specimens under identical conditions at a temperature of about 750°C , shows that the brass end is approximately 3 times longer than the copper one. This in turn indicates a reduced mutual longitudinal displacement of the layers and, consequently, the occurrence of reduced longitudinal additional stresses when the inner layer (in this experiment - copper) has increased strength properties compared to the outer (brass), and vice versa.

If the value of the front monometallic end is significant, this indicates a significant unevenness of the layer-by-layer deformation, which leads to a violation of the ratio of the layer thicknesses specified in the workpiece.

The results of the study of the initial stage of the pressing process of bimetallic pipes made of aluminum alloys D16 and AD1 show that the resistance to deformation of the D16 alloy is 4-5 times higher than that of AD1 aluminum.

The process of pressing bimetallic pipes through a conical matrix with low external friction proceeds with almost the same initial ratio of the cross-sectional areas of the layers, even if the ratio of the strength properties of the metals reaches 4-5. When pressing bimetallic pipes without lubrication of the container, a more uneven distribution of the thickness of the layers along the length of the pressed pipe occurs. This unevenness is greater, the more significantly the strength properties of the layers differ and the thicker the softer layer (especially when it is located internally).

3 as an example. The diagram graphically defines the region of maximum permissible relationships between the deformation resistance of the blank layers and their thickness during joint pressing of blanks in which the outer layer is less strong ($S_{T_1} < S_{T_2}$)

$$C = \frac{S_{T_1}(R_{H_1}^2 - R_{H_2}^2)}{S_{T_2}(R_{H_2}^2 - r_K^2)} \quad (2)$$

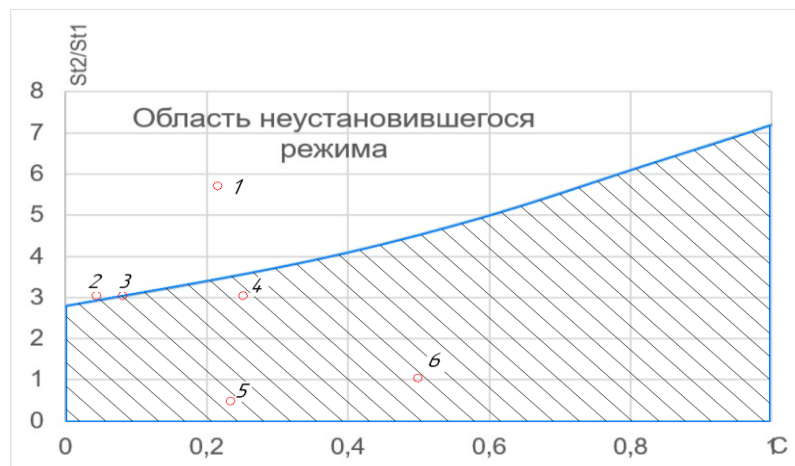


Fig. 3. Conditions of steady-state pressing mode of bimetallic pipes (the curve is constructed based on calculated data); experimental points are indicated by numbers: 1- aluminum + L62 ($D_{H_1} = 38$; $D_{H_2} = 28$; $d_K = 15$); 2- armco-iron + EI612 ($D_{H_1} = 38$; $D_{H_2} = 35.5$; $d_K = 14$); 3- armco - iron + EI612 ($D_{H_1} = 38$; $D_{H_2} = 35.5$; $d_K = 16$); 4- armco-iron + EI612 ($D_{H_1} = 38$; $d_K = 15$); 6- St.45 + EI612 ($D_{H_1} = 38$; $D_H = 28$; $d_K = 15$)

The diagram shows that the pressing conditions of a bimetallic pipe made of aluminum and brass L62 (point 1) correspond to a transient regime, while pipes made of Armco iron and steel 1X18N9T (point 5) correspond to a steady-state regime.

The current trends in the field of bimetallic pipe production are:

- increasing the accuracy of geometric dimensions of pipes;
- minimization of energy and force parameters of the deformation process.

Hollow non-circular profiles can also be obtained by pressing from longitudinally layered blanks. Pressing such profiles with two or more planes of symmetry causes fewer difficulties.

Conclusion

A practical solution to the problem of improving theory, technology and equipment for pipe-pressing systems in the field of manufacturing bimetallic pipes can be carried out by systematizing experimental data and developing a set of computer, mathematical and physical models of the process.

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