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Influence of the Wall Thickness Value on the Cross Wall Thickness Deviation of Tubes Rolled on the Tube Rolling Plant with the Continuous Mill

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Abstract. The high requirements as to accuracy of the wall thickness are due not only to necessity of assuring the reliability and serviceability of equipment, but also to the trend towards the continuous decrease of metal capacity. In this situation assuring observing of the given parameter is the most difficult affair. The cross wall thickness deviation can be presented in the form of two components: eccentric and symmetric deviation. In the given work authors present the research of the influence of the tube wall thickness on the share of eccentric component of the wall thickness deviation of the tubes rolled on the TRP with the continuous mill. Analysis of research results allowed concluding that with increase of the tube wall thickness the share of wall thickness deviation induced with the eccentricity decreases. On the whole, it is to be noted that for the giving plant, characteristically the influence of methods of longitudinal flaring (in continuous mill with mandrel and multistand mills of rolling without mandrel) on the tube accuracy is greater. In two first cases while reducing tubes to the finish dimension, the share of the number of faces, which depends on the summary reduction through the diameter and the value of tension, increases substantially.

Keywords: tube rolling plant with continuous mill, wall thickness, cross wall thickness deviation, eccentric component.

1 Introduction

Accuracy of the tube wall thickness is one of the most important characteristics of the given kind of metal products. The value of this characteristic's scattering is strictly regulated by the up-to-date standards. The high requirements as to precision of the wall thickness are conditioned not only by the necessity of assuring the reliability and efficiency of equipment, but also by the trend of continuous decreasing the metal capacity (content) [2, 3]. In these conditions the most complicated task is to ensure the maintenance of the mentioned parameter of the tube accuracy [1, 2].

2 Literature Review

Precision of finished tubes is a result of shaping (changing the shape) of a tube on all the stages of deforming the latter. In this situation the special attention should be given to the aggregate (mill), where the proper geometrical sign is formed [1]. In the general form the cross wall thickness deviation can be presented as two components [1, 4]: eccentric wall thickness deviation and deviation occasioned by the "cut" of internal and external surfaces. The "eccentricity" of tubes rolled on the TRA with continuous mill averages 55 %; tubes rolled on the TRP with plug automatic mill have the average value of wall thickness deviation within the limits of 26 % [1]. From the practice of the pipe and tube production it is known that for all the tubes, which were not subjected to considerable degree of reducing, independently of method of production, the share of eccentricity makes the greater part in the scattering of the wall thickness in the cross tube section [4].

The wall thickness is formed in the process of piercing and decreases in the course of rolling out (Figures 1, 2) [1, 2], but the main influence on accuracy of the wall is exerted exactly by the process of piercing [1].

As a whole, the relative wall thickness deviation of tubes rolled on TRA with continuous mill decreases with increase of the tube wall thickness [1] (Figure 3).

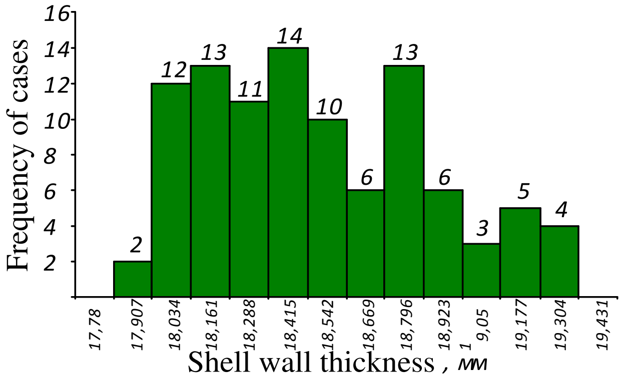


Figure 1 – The statistic distribution of the shell wall thickness [2]

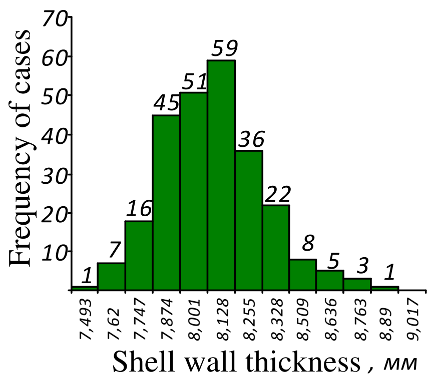
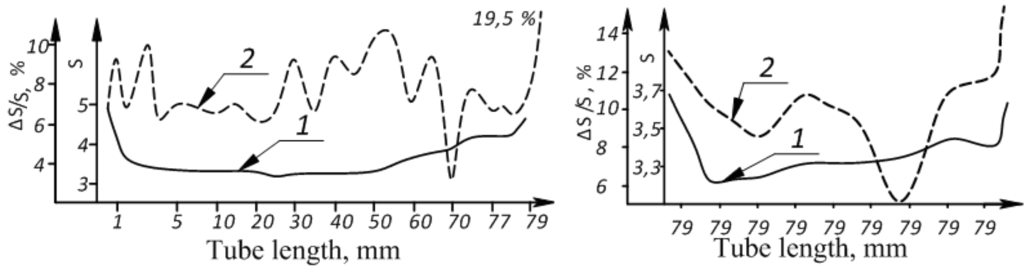


Figure 2 – The statistic distribution of the rough tube wall thickness



a

b

Figure 3 – Change of the average values of the wall thickness (1) and the cross wall thickness deviation (2) along the length of a finished tube with dimensions: 45×3.5 mm (a); 76×3.5 mm (b) [1]

Tubes rolled on the TRA with continuous mill have strongly pronounced bulges on their ends (Figure 4). Wall thickness deviation of a tube on the thickened ends is on the average greater than the deviation in the middle part of a tube.

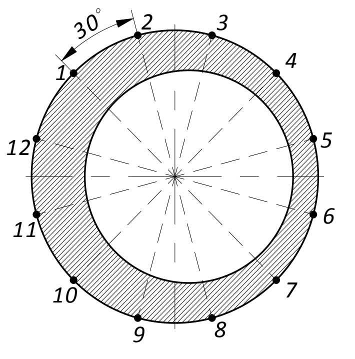


Figure 4 – The scheme of measurement of the wall thickness in the cross section of a tube

Precision of tubes as to wall thickness is an important and difficult to achieve factor of the quality of the given kind of rolled products. It depends on many factors. The degree of importance of majority of these factors is not completely specified. One of the questions, which are not enough taken up – is the investigation of the influence of the wall thickness on the eccentric wall thickness deviation of the cross section of tubes rolled on the TRP with continuous mill, and any investigations taking up this theme are actual.

3 Research Methodology

The following positions of assortment of the TRP with continuous mill have been chosen for investigation of the influence of the wall thickness on the eccentric wall thickness deviation of the cross tube section:

– 73×5.5 mm (D/S = 13.3);

– 32×3 mm (D/S = 10.7);

– 93×13 mm (D/S = 7.2).

After cutting the thickened ends, the pipe sockets have been cut from the tubes, marked and measured in 12 sections (Figure 4). Results of measurements are shown in the Table 1 and the Figure 5. The character of the change of the wall thickness deviation in cross section of the tubes rolled on TRP with continuous mill is shown in the Table 2.

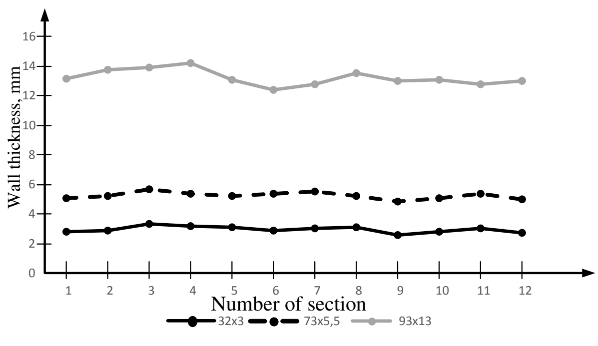


Figure 5 – Change of the wall thickness in the cross section of tubes rolled on the TRP with continuous mill

Table 1 – The change of the wall thickness in the cross section of tubes rolled on the TRP with continuous mill

Dt×St	Number of the point of measurement and value of the wall thickness deviation, mm											
	1	2	3	4	5	6	7	8	9	10	11	12
32×3	2.8	2.9	3.3	3.2	3.1	2.9	3	3.1	2.6	2.8	3	2.7
73×5.	5.1	5.25	5.65	5.4	5.25	5.35	5.55	5.2	4.8	5.1	5.35	5
93×13	13.15	13.75	13.9	14.2	13.1	12.4	12.75	13,55	13	13.1	12.8	13

Table 2 – Change of wall thickness deviation in the cross section of tubes rolled on the TRP with continuous mill

Dt×St	Number of the point of measurement and value of the wall thickness deviation, %											
	1	2	3	4	5	6	7	8	9	10	11	12
32×3	–5.08	–1.69	11.86	8.47	5.08	–1.69	1.69	5.08	–11.86	–5.08	1.69	–8.47
73×5.5	–2.86	0.00	7.62	2.86	0.00	1.90	5.71	–0.95	–8.57	–2.86	1.90	–4.76
93×13	–0.57	3.97	5.10	7.37	–0.95	–6.24	–3.59	2.46	–1.70	–0.95	–3.21	–1.70

As a whole, the cross wall thickness deviation can be presented as two components: eccentric and symmetric wall thickness deviation. To pick out these parts, let us use the approach, set forth in [1].

The main point of the given method consists in the following. On the first stage it is necessary to put in order the experimental data as to measurements of the tube wall thickness in the cross section in the following way. Let us choose the greatest value of the wall thickness in the given cross section and confer the index “1” to it. The rest of values of the given excerpt will be numbered one after another from left to right.

For example, for a tube 73x5.5 mm we have the measurements in the form of a set of the wall thickness values, presented in the table 1. After putting in order the values of wall thickness, the massif will look as following: 5.65; 5.40; 5.25; 5.35; 5.55; 5.2; 4.8; 5.1; 5.35; 5.0; 5.1; 5.25

Further let us determine the average wall thickness of the tube S_{av} in the given cross section, eccentricity e, the part of dispersion σ_e^2, stipulated by eccentric component of the wall thickness deviation, the summary dispersion of the wall thickness σ_Σ^2. Let us find the share (part) a_e, brought into deviation of the tube wall thickness by eccentricity according to the formula:

$$a_э = \frac{\sigma_э^2}{\sigma_\Sigma^2}. \quad (1)$$

Let us calculate the value of the absolute cross wall thickness deviation ΔS_d, supposing that the probability of finding in the given cross section such value of ΔS_φ, which $\Delta S_\varphi > \Delta S_d$ for $P = 0.05$:

$$\Delta S_p = \psi \frac{n}{n-1} \sigma_\Sigma. \quad (2)$$

where n is the number of measurements of the wall thickness in given section; σ_Σ is the meansquare deviation; Ψ is the coefficient binding the share of wall thickness deviation a_e, caused by eccentricity in the total dispersion of the wall thickness:

$$\psi = 2\left(\sqrt{2a_э} + \sqrt{3(1-a_э)} - 0{,}82\sqrt[4]{a_э(1-a_э)}\right) \quad (3)$$

At the discrete measurements of the wall thickness the formula (2) allows calculating with more accuracy the value of the real swing (scattering) of the wall thickness values in the given section, since because of measurements discreteness there is the probability of finding the actual maximum (minimum) between the points of measurement.

Results of experimental data treatment are shown in the Table 3.

Table 3 – Results of treatment of the wall thickness experimental measurements in cross sections of a tube

Dt×St, mm	S_{av}, mm	e, mm	σ_Σ^2, mm²	Σ, mm²	a_e %	ΔS_r, mm	ΔS, mm
32×3	2.92	0.137	0.039	0.009	24.0	0.7	0.72
73×5.5	5.25	0.146	0.050	0.011	21.2	0.085	0.815
93×13	13.2	0.290	0.318	0.042	13.2	2.2	2.03

4 Conclusions

Analysis of data in the Table 3 allows making the following conclusions. The share of the tube wall thickness deviation caused by eccentricity is decreasing with increase of the tube wall thickness. As a whole, it is to note that the characteristic feature for given unit is the greater influence of the process of the lengthwise rolling-off on accuracy of tubes, namely, rolling-off in continuous rolling mill with mandrel and in multistand mills for rolling without mandrel. In the first two cases, while reducing tubes to the final dimension, the share of cutting depending on summary reduction as to diameter and the value of tension, is substantially increased.

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Дослідження впливу величини товщини стінки на поперечну різностінність труб, прокатаних на ТПА з безперервним станом

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Анотація. Високі вимоги до точності товщини стінки обумовлюються не тільки необхідністю забезпечення надійності і працездатності (роботоспроможності) обладнання, але й тенденцією до постійного зниження його металоємності. При цьому забезпечити дотримання даного параметра точності труби найбільш складно. Поперечну різностінність можна представити у вигляді двох складових: ексцентричної та симетричної різностінністі. У статті представлено дослідження впливу величини товщини стінки труби на частку ексцентричної складової поперечної різностінності труб, прокатаних на ТПА з безперервним станом. Аналіз результатів досліджень дозволив зробити висновки, що зі збільшенням товщини стінки труби знижується частка різностінності, викликаної ексцентричністю. В цілому, слід зазначити, що для даного агрегату є характерним більший вплив на точність труб способів поздовжньої розкатки: в безперервному оправочному стані і багатоклітьових станах безоправочної прокатки. У перших двох випадках, при редукуванні труб на готовий розмір, істотно зростає частка гранчастості, що залежить від сумарного обтиску по діаметру і величини натягу.

Ключові слова: ТПА з безперервним станом, товщина стінки, поперечна різностінність, екцентрична складова.