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PREDICTION BY RESIDUAL STRESSES OF THE QUALITY OF THIN ROLLED AFTER TEMPER ROLLING IN WARM DEFORMATION MODE

ПРОГНОЗУВАННЯ ЗА ЗАЛИШКОВИМИ НАПРУЖЕННЯМИ ЯКОСТІ ТОНКОГО ПРОКАТУ ПІСЛЯ ДРЕСИРУВАННЯ В РЕЖИМІ ТЕПЛОГО ДЕФОРМУВАННЯ

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Operational improvement is an important factor in maintaining and increasing a company's competitiveness. It provides world-class of product quality, process performance and customer satisfaction. With today's marketplace dominated by new technologies, outsourcing, online business transactions and global competition, the pursuit of operational excellence is so important. The desire to use modern production technologies that provide a predictable level of quality becomes necessary to achieve positive results. The introduction of operational improvement principles makes the ability to predict and manage quality indicators of finished products very important. It is worth noting that it is considered unacceptable to set quality limits, because improvement must be systemic. Improvement must be an integral part of the management system: optimization of technology and equipment to improve quality begins at the design stage and is repeated cyclically. This allows for continuous product improvement. That is why to develop mathematical models that are able to predict the quality of finished products, and then use them to develop technological production modes is so important.

If we talk about the production of thin rolled products, then its final quality strongly depends on the properties that the sheet steel will receive after temper rolling (rolling sheets with small reductions). This is because the process of tempering the strip shapes its final mechanical properties and, most importantly, its formability. The ability of rolled products to be formed is influenced, among other factors, by residual stresses. The use of technology, when the strip is heated to the temperature of warm deformation during the rolling process, makes it possible to regulate the final values of residual stresses. Especially if you use a temperature field that is uneven in height. The use of technological schemes with heating of the surface layers of strips to warm deformation temperatures, for example, due to contact with preheated work rolls, makes it possible to control the levels of resistance to plastic deformation of the metal and the nature of their distribution. This means that it allows you to control the resulting distribution of residual stresses.

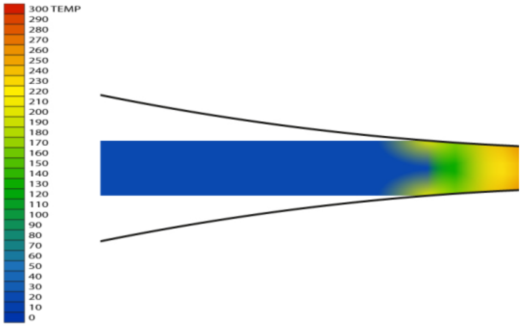

Fig. 1. Temperature field of a thin strip, which obtained as a result of tempering in rolls preheated to warm temperatures

The methodology for calculating the residual stresses of materials that are strengthened during plastic deformation is based on a power-law function taking into account the intensity of strain hardening of a given material. This function describes the relationship between stress and strain and is adapted to take into account the temperature field. It looks like this:

$$\sigma_j^* = C^* \cdot \varepsilon_j^{n^*}, \tag{1}$$

where C^* is the regression coefficient, which is determined taking into account the degree of deformation and temperature of the metal at a certain point in the field; n^* is a power exponent, which is also determined taking into account the degree of deformation and temperature of the metal at a certain point in the field.

On the other side, $\sigma_j^* = \sigma_j \cdot n_{tj}$, where n_{tj} is a thermo-mechanical coefficient that takes into account the difference in metal temperature during temper rolling from the temperature of standard stress tests σ_j. That is:

$$\sigma_j \cdot n_{tj} = C^* \cdot \varepsilon_j^{n^*}. \tag{2}$$

Taking into taking the logarithm of the left and right sides, equation 2 is reduced to the form:

$$\ln \sigma_j + \ln n_{tj} = \ln C^* + n^* \ln \varepsilon_j, \tag{3}$$

from where, taking into account the known, at least two, ($j = 1$; $j = 2$) values of the degree of deformation $\varepsilon_j\big|_{j=1}$, $\varepsilon_j\big|_{j=2}$ stress $\sigma_j\big|_{j=1}$, $\sigma_j\big|_{j=2}$, temperature $t_j\big|_{j=1}$, $t_j\big|_{j=2}$ and the corresponding thermo-mechanical coefficients $n_{tj}\big|_{j=1}$, $n_{tj}\big|_{j=2}$, the values of the regression coefficient C^* and the power exponent n^* can be calculated.

Taking into account the functional relationship between the power exponent and the thermo-mechanical coefficient $n^* = F(n_{tj})$, the influence of this coefficient on the nature of the distribution of relative value $\sigma^*_{x\,res\,j}/\sigma^*_{j\,m}$ (relative value of normal residual stress and normal stress on the axis) over the thickness of the strip is shown in Figure 2.

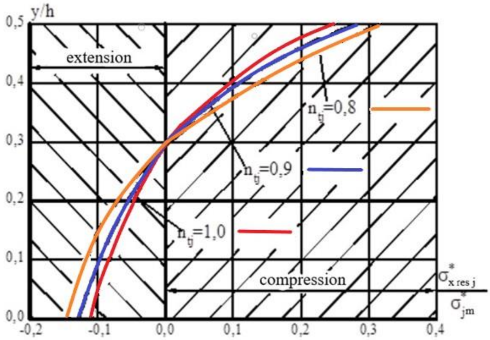

Fig. 2. Calculated distributions of the ratio of normal residual stress $\sigma^*_{x\,res\,j}$ and stress on the axis of the deformation zone $\sigma^*_{j\,m}$ for different levels of metal flow (y/h). The distribution depends on the thermo-mechanical coefficient n_{tj}, which characterizes the influence of temperature of the warm temper rolling process (steel AISI 321 / 1.4541, $\varepsilon = 0,03$)

Thus, the mathematical model of the mechanism for the formation of residual stresses can be improved if we take into account the influence of real temperature conditions of the process. Analysis of the results of modeling the temper rolling of thin sheets in a warm temperature range shows that the use of a non-uniform temperature distribution along the height of the deformation zone increases the level of residual compressive stress in the surface layers. In turn, this makes it effective to use preheated rollers for warm temper rolling to improve the consumer properties of the rolled. Rolled, which will then be used in the implementation of various technological schemes for sheet stamping. Altogether, this helps to ensure operational improvement of the rolling and stamping industries at the enterprise.

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IMPLEMENTATION OF PREVENTIVE QUALITY MANAGEMENT SYSTEM FOR PRODUCTION OF TMCP PROCESSED 10MN2VNBAL STEEL HEAVY PLATES

ВПРОВАДЖЕННЯ ПРЕВЕНТИВНОЇ СИСТЕМИ УПРАВЛІННЯ ЯКІСТЮ ДЛЯ ВИРОБНИЦТВА ТОВСТОЛИСТОВОГО ПРОКАТУ ЗІ СТАЛІ 10MN2VNBAL, ОБРОБЛЕНОГО TMCP

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The quality of hot-rolled steel products is formed by technological means as a set of mechanical, environmental, surface and other operational properties of rolled products that determine their suitability to meet certain customer needs [1, 2]. To obtain an increased level of mechanical properties of rolled plates, a number of effective but energy-intensive heat treatment schemes are used with preliminary modification of the composition of alloying elements and the formation of multiphase structures [3]: ART treatment of steels with