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THE SCIENTIFIC RESEARCHES DIRECTED ON RECEIVING PREPARATIONS FROM THE TEXTURED METAL SHEET WITH THE SET PROPERTIES

Abstract. The process of metal forming is widely used in metallurgy, machine-building and other industries of production of semi-finished and finished products made of ferrous and nonferrous metals and their alloys. From this standpoint, the important value obtains scientific research aimed at designing the properties of metallurgical blank of the machine-building complex. In work short results of a technique of development of laboratory schemes of obtaining the textured metal sheet with anisotropy of physicomechanical properties, on the basis of the principle of symmetrization-dissymmetrization of Shubnikov-Curie method of the differential longitudinal rolling drawing developed are presented.The method is based on the symmetry approach for modeling processes on the basis of the identified relationships between the kinematic factor and the impact that allows to predict the result of processing, and conversely, setting the result, it is possible to design technology.

Keywords: anisotropy, systemmade element, the generating element of symmetry of an elementary field of influence, symmetry texture, quasi-isotropic preform microplastic deformation.

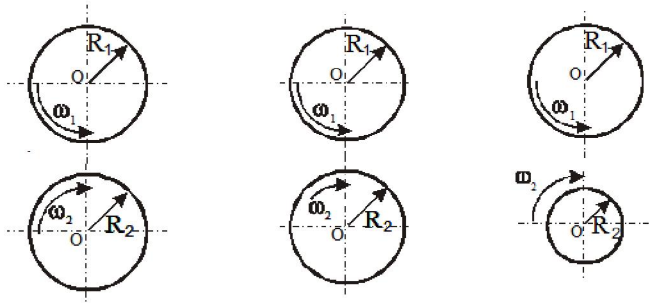
Introduction. In technological processing of preparations by pressure, in particular at the first hot rolling of industrial ingots, results of processes of transcrystallization have essential impact on macro- and a preparation microstructure, and, therefore, and on its quality indicators.

Ways of receiving preparations with the directed crystal structure (texture) are based on management of a ratio of macrostructural zones in system: a peripheral fine-grained zone – column crystals – equal crystals.

On the basis of the principle of symmetrization-dissimmetrization of Shubnikov–Curie [1] authors experimentally, with use of technologies of longitudinal rolling, is reasonable the system method allowing to solve effectively the problems connected as with receiving materials with various on symmetry and size of anisotropy of their physicomechanical properties, and with production of products from them with necessary operational properties [2-6].

Discussed in [2-4] laboratory rolling longitudinal differential scheme do not exhaust all the possible technology for sheet metal with different symmetry of the anisotropy of physical and mechanical properties for this type of treatment. It was considered the most general case of a longitudinal rolling when the work rolls are rotated in opposite directions at the same speed (figure 1a). [2].

In continuation of [3, 5, 6] and the development of the principle of symmetrization-dissymmetrization Shubnikov-Curie [1, 3], the simulation laboratory processing circuitry materials legitimate question becomes the link between the characteristics of the kinematic factor, impact and response, by which is meant any geometric structural, physical and mechanical properties that are sensitive to the effects of rolling.



a) $\omega_1 = \omega_2$, $R_1 = R_2$ b) $\omega_1 \neq \omega_2$, $R_1 = R_2$ c) $\omega_1 = \omega_2$, $R_1 \neq R_2$

Figure 1 – The geometric interpretation of possible kinematic parameters of laboratory processing circuit materials based on longitudinal rolling

The most interesting from the point of view of the principle of symmetrization-dissymmetrization Shubnikov-Curie, in the development of technologies for the production of sheet metal with different symmetry of the anisotropy of physical and mechanical properties, is rolling, drawing, kinematic parameters of which are presented in figure 1 (b, c).

That's way, in the present study we solve the following problem - find all the laboratory scheme longitudinal differential rolling-drawing, which allow to obtain metal sheets with different symmetries of anisotropy of physical and mechanical properties.

Problem statement and the physical nature of the process. The fundamental difference of rolling-drawing from conventional longitudinal rolling is in the structure of the stress field and, consequently, in the processes occurring in the deformation, which is caused by the kinematic parameters of the working tool and the characteristics of deformation of polycrystalline materials in the area of microplastic deformation [6-15].

We will not consider in detail the processes occurring in the deformation, we note only that the kinematics of the metal flow during rolling, drawing differs from the usual longitudinal rolling in that field strain rates is not symmetrical with respect to a plane lying parallel to the axes of the rolls and equidistant from them.

Determining influence on the symmetry characteristics of the kinematics of rolling provides a working tool – a laboratory rolling mill rolls. Geometrically work roll in a static state is displayed as a resting cylinder and is characterized by symmetry group ∞ / mmm.

The moment of force **F**, acting on the work roll, and its geometrical interpretation, represented an axial vector, identical in terms of the group transformations, and describe the same symmetry group ∞ **/ m**. Due to the fact that the geometric figures form a heterogeneous system, based on the principle of Curie symmetry kinematic factor of the roll is determined by the intersection of the symmetry groups ∞ **/ mmm** and ∞ **/ m:**

$$\mathbf{G_k = \infty/mmm \cap \infty/m = \infty/m.} \quad (1)$$

The system of rolls in a static state is established is described **mmm** symmetry group, i.e. system is symmetrical relative to the three planes of symmetry.

The symmetry group describing said system in a dynamic state is determined based on the generalized principle of symmetry and will look like:

$$\mathbf{G_c = \infty/m \cap \infty/m = m.} \quad (2)$$

As seen from the expression, the common element of symmetry is the plane of symmetry **m**, perpendicular to the roll axes and which will determine the symmetry of the system band. Thus, the velocity field of the deformation is not symmetrical about a plane lying parallel to and equidistant from the axes of the rolls.

However, the kinematic factor, in terms of symmetry, only the structural features characteristic of the working body and completely covers the symmetry of impact, which ultimately determines the physical and mechanical properties of the rolled product.

The authors found an association between the kinematic factor and a factor of influence on the basis of the symmetry approach to this kind of treatment [4].

It is known that the influence on the symmetry properties of the crystals can be analyzed: firstly - in crystal symmetry; Second - symmetry of external forces; thirdly - symmetry offset; and fourthly - the symmetry of the physical properties [7, 11-13, 19].

For the polycrystalline materials symmetry analysis it looks not so clear, because of the structural features of the structure of the latter.

The authors of the impact of external forces on the symmetry of the physical properties of polycrystalline materials during their processing is investigated through various schemes of stress-strain state, symmetry-related generating elements of symmetry of the elementary field exposure (*GSEFE*).

Symmetry approach for modeling processes on the basis of the identified relationships between the kinematic factor allows to predict and influence the result of processing [5]. Conversely, setting the result, it is possible to design technology.

Experimental study and discussion of the results. For the production of the original billet was developed [17, 18, 20] technique to obtain quasi-isotropic samples by pressing powders of copper, followed by sintering. We investigated the dependence of the density pycnometric pressing and sintering parameters for sieve № 035-025. The results are shown in figure 2.

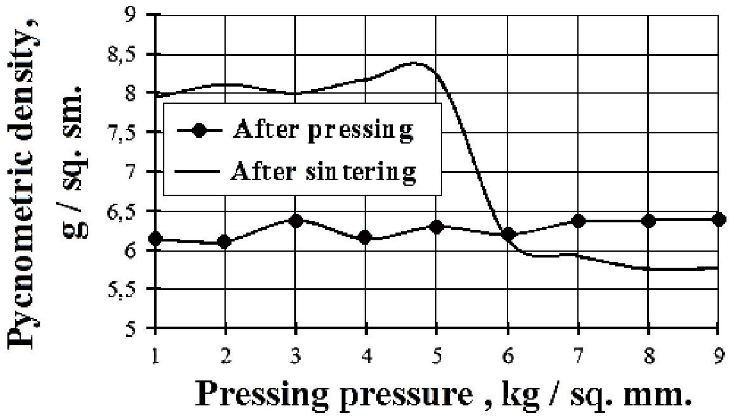


Figure 2 – Depending pycnometric density of modes pressing and sintering copper powder (sieve № 035-025)

As can be seen from the graph, pressing pressure significantly affects the density of the powder, which is explained by the influence of particle shape and external friction of the particles against each other and on the mold surface. However, this small difference of density (less than 10%), strongly influences the subsequent processing. Sintering powders compacted under a pressure of 1 to 5 kg/mm^2, considerably increases Pycnometric density (about 30%).

At higher pressures, the effect of compression on pycnometric sintering density drops sharply. In powder compacted pressure of about 6 kg/mm^2, the sintering density does not change substantially. At compaction pressures greater than 6 kg/mm^2 sinter powder, on the contrary, reduces Pycnometric density. We believe the main reason for this change in the current process of open porosity. As is known, the larger the porosity, the less Pycnometric density of the metal powder. During sintering there is intense release of gases from the fusion of the powder particles and particles in the contact areas. At low compaction pressures many open pores through which gases are emitted to the outside, there is shrinkage of the sample. With increasing pressure, the number of contact points of the particles increases, the gases can not be as freely as before, to come out [16]. Shrinkage decreases Pycnometric density becomes smaller.

When rolling sheets in rolling mills there are vibrations which have impact on decline in quality of hire in the form of superficial defects and a deviation on hire thickness. Frequency of vibrations of rolls depends on the mode of rolling and a condition of the equipment. The schedule of vibration of a working roll when rolling is submitted on figure 3 [8]. As we see, the frequency of vibrations makes about 0,3 Hz with the greatest amplitude of 0,2 mm.

Graphically periodic defects caused by vibrations of rolls can be presented, as shown in figure 4.

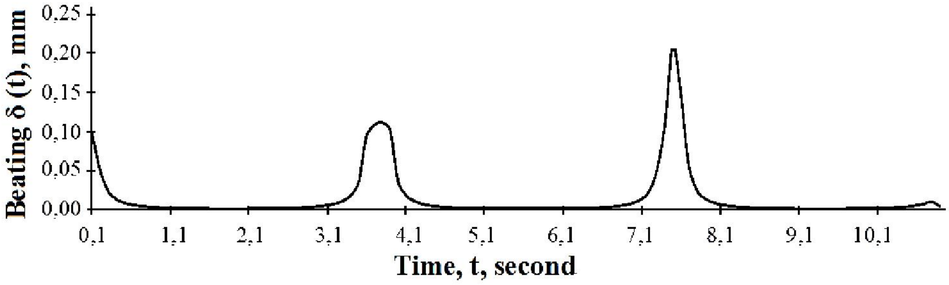


Figure 3 – The schedule of vibration of a working roll when rolling

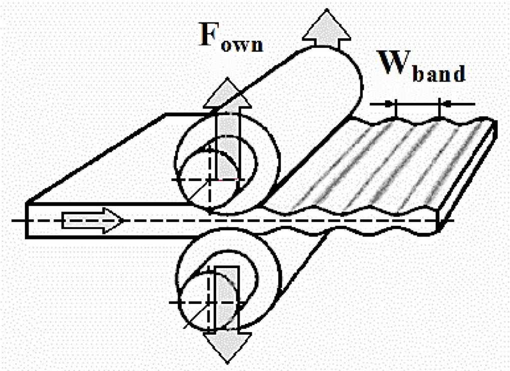


Figure 4 –
The scheme of emergence
of periodic defects of a leaf
as a result of own fluctuations of rolls

For decrease in influence of harmful vibrations on quality of a surface of hire, besides application of the standard actions, application of technologies of differential rolling in two mutually perpendicular directions with the minimum sinking for each tackle is possible, thus mutually perpendicular imposing of periodic defects minimizes their own influence on quality of a surface of a leaf.

Experiments on rolling of samples were made on the laboratory rolling mill of Mario Di Maio 20122 firm (Italy) (figure 5). Diameter of working rolls of 160 mm.

Figure 5 – Laboratory rolling mill

Initial material represented ingots section 60×6 mm and 60 mm long. After rolling the sample turned on 90° round a vertical axis and was repeatedly rolled with the same mode. Sinking of a sample for one tackle made no more than 5%. It is established that when rolling with sinking of 5% of vibration are practically not observed.

The received results of rolling of quasiisotropic preparation are presented in figure 6, 7. They can form the basis for development of laboratory schemes of receiving textures with anisotropy of physico-mechanical properties, various on symmetry, for other types of processing of metal materials.

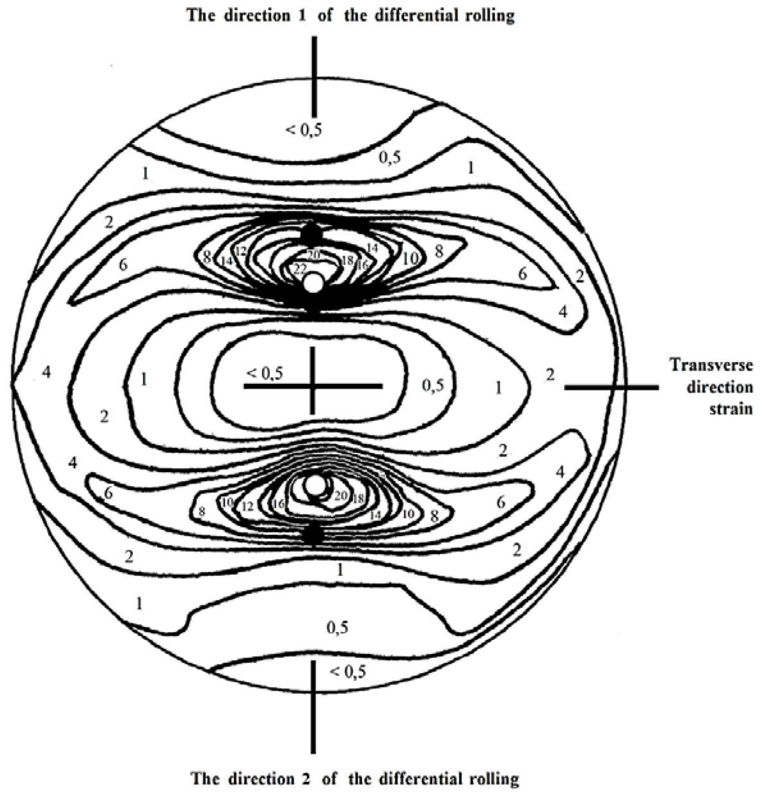


Figure 6 –
A polar figure {111} from the pressed copper powder after usual reversive longitudinal rolling in one direction

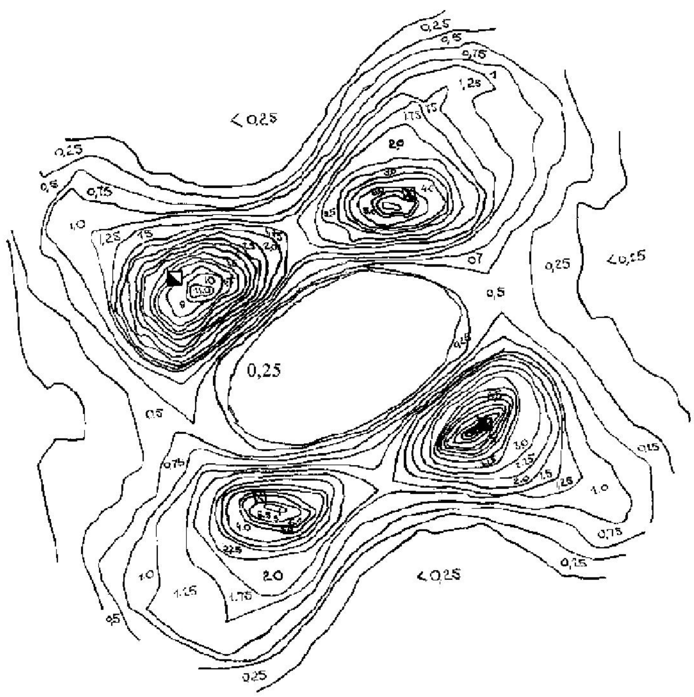


Figure 7 –
A polar figure {111} from the pressed copper powder after differential reversive longitudinal rolling in two mutual and perpendicular directions

Establishment of interrelation between a kinematic factor and a factor of influence was revealed through impact of elements of symmetry on orthogonal system of coordinates. The spatial arrangement initial (X_3 X_2 X_1) and shaded (X_3' X_1' X_2') systems of the coordinates connected among themselves by the plane of symmetry of m, perpendicular to a coordinate axis OX_1 is given in figure 8.

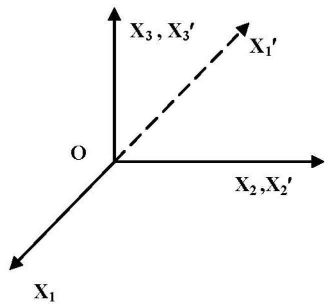


Figure 8 –
The systems of coordinates ($X_1X_2X_3$) and ($X_1'X_2'X_3'$), connected by one plane of symmetry, the perpendicular axis OX_1 coinciding with the coordinate plane (X_2OX_3)

According to the received results of interrelation of systems of coordinates through elements of symmetry identical mathematical images on the basis of tensors of the second rank were described [3].

On the basis of the established interrelations between a kinematic factor and a factor of influence laboratory schemes of processing of metal materials were simulated by the rolling drawing method.

As the instrument of modeling of laboratory schemes of processing of materials by authors the concept a *system creating element* (SKE) is entered.

The symmetry element which is basic at calculation of SKE, we will call *the generating element of symmetry of an elementary field of influence* (GESEFI). Then definition of SKE in a short form will have an appearance: - *it is system which is characterized by such set of elements of symmetry which contains the generating element of symmetry of an elementary field of influence, and their relative positioning determines its level.* Two rules follow from the last point in definition: 1) *each subsequent SKE level contains the previous;* 2) *derivative SKE of the current level can't be SKE of other levels.* We will easily be convinced of it when we analyse SKE of all possible levels and their derivatives for rolling drawing.

As GESEFI for rolling drawing the plane of symmetry of **m** which also is also its group of symmetry is.

Results of calculation of SKE on levels, for longitudinal rolling drawing, are presented in table (without derivative transformations at each level).

Results of group transformation for SKE in a short form

SKE	SKE in a short form
SKE-1	$G_{c1} = m$
SKE-2	$G_{c2} = m \cap m = mm2$
SKE-3	$G_{c3} = m \cap m = 2$
SKE-4	$G_{c4} = 2 \cap m = 2/m$

The generalized results can be coordinated with the theory of classification of textures by simmetrition signs [9, 10]. Owing to lack recently of works on improvement of the system analysis, on the basis of the generalized principle of symmetry, this method didn't gain wide scientific circulation.

However, at development and addition of basic provisions of the system analysis on the basis of theoretical and experimental data, the last can be applied to the solution of tasks of design of special technologies of processing of materials.

Conclusions. At application of technologies of differential rolling mutually perpendicular imposing of periodic defects minimizes their own influence on quality of a surface of a leaf.

On the basis of the principle of symmetrization-dissimmetrization of Shubnikov-Curie groups of symmetry of initial (potential) fields of tension of processes of rolling drawing, by means of identical representation at the geometrical and mathematical levels of geometric-physical parameters of the working tool are found.

Schemes of processes of rolling drawing in which fields of tension of unilateral and reversed rolling act as backbone elements are developed.

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БЕРІЛГЕН ҚАСИЕТТЕРІМЕН ТЕКСТУРАЛАНЫЛҒАН МЕТАЛ ПАРАҚТАН ДАЙЫНДАМА АЛУҒА АРНАЛҒАН ҒЫЛЫМИ ЗЕРТТЕУЛЕР

Аннотация. Металлургияда, машина жасауда және өнеркәсіптің басқа салаларда қара және түсті металдар мен олардың қорытпаларынан жартылай өнімдер мен дайындамалар өндіру үшін металды қыыммен өңдеу процестері кең қолдануда. Бұл көзқараспен машина жасау кешені үшін металлургиялық дайындаманың қасиеттерін жобалауға бағытталған ғылыми зерттеулер зор маңыз алады. Жұмыста Шубников-Кюри симметриялау-диссимметриялау принципі негізінде зерттеп дайындалған дифференциалдық көлденең илемдеу-тарту әдісімен симметрия бойынша физика-механикалық қасиеттерінің анизотропиясы әртүрлі текстураланған металл парағын алу үшін зертханалық схемаларын жасау әдістемесінің қысқаша нәтижелері берілген. Кинематикалық фактор мен әрекеттің арасында анықталған өзара байланыстар негізінде технологиялық процестер үлгілегендегі симметийлық тәсілдемесі болып әдістеме негізі табылады. Сонымен, технологиялық өңдеудің нәтижесін болжауға мүмкіншілігі пайда болады және керісінше нәтижені белгілеп технологияны жобалау мүмкін.

Түйін сөздер: анизотропия, жүйе құрайтын элемент, әсердің қарапайым өрісі симметриясын тудыратын элемент, текстураның симметриясы, жалған изотропты дайындама, шаңын пластикалық деформациялар.

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НАУЧНЫЕ ИССЛЕДОВАНИЯ, НАПРАВЛЕННЫЕ НА ПОЛУЧЕНИЕ ЗАГОТОВОК ИЗ ТЕКСТУРИРОВАННОГО МЕТАЛЛИЧЕСКОГО ЛИСТА С ЗАДАННЫМИ СВОЙСТВАМИ

Аннотация. Процессы обработки металлов давлением широко используются в металлургии, машиностроении и других отраслях промышленности для производства полуфабрикатов и готовых изделий из черных и цветных металлов, а также и их сплавов. С этих позиций, принципиально важное значение приобретают научные исследования, направленные на проектирование свойств металлургической заготовки для машиностроительного комплекса. В работе представлены краткие результаты методики разработки лабораторных схем получения текстурированного металлического листа с различной по симметрии анизотропией физико-механических свойств, методом дифференциальной продольной прокатки волочением, разработанной на основе принципа симметризации-диссимметризации Шубникова-Кюри. В основе методики лежит симметрийный подход при моделировании технологических процессов на основе выявленных взаимосвязей между кинематическим фактором и воздействием, что позволяет прогнозировать результат технологической обработки, и наоборот, задавая результат, можно спроектировать технологию.

Ключевые слова: анизотропия, свойства, прокатка волочением; системообразующий элемент; порождающий элемент симметрии элементарного поля воздействия; симметрия текстур, квазиизотропная заготовка, микропластические деформации.

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