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Research Article

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ORIGINAL RESEARCH

THE USE OF A NEURAL NETWORK CLASSIFIER OF MATERIAL FACTURE CRITERIA FOR THE RATIONAL CHOICE OF THE METHOD FOR CUTTING OF ROLLED STOCKS

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Abstract

To select a rational method for cutting of rolled stocks made from materials with different physical and mathematical properties, an engineer must have the tools to make such a choice. For this, it is proposed to use the well-known synergistic material fracture criteria. In order to find the most informative system of synergetic criteria allowing to classify materials authentically by their fracture sensitivity, the software was developed. It allows to solve the clustering problem in a multidimensional space of parameters and present the obtained information in a visual form using self-organizing Kohonen maps. The cluster analysis of the synergetic criteria of fracture material was carried out. The most informative criterion among the ones characterizing the mechanical properties of steels is the «offset yield strength», among the synergistic ones – «scale criterion». At the same time, among the traditional mechanical features of steels, a set allowing to classify materials with a given integrity by their cutting sensitivity has not been found. It was established that the synergistic criteria: «crack propagation criterion» and «brittleness criterion» are basic informative features. When adding any of the remaining complex criteria («crack nucleation criterion» or «scale criterion»), they form the most informative sets of minimal power, providing the classification of materials by their cutting sensitivity with a given integrity. In order to obtain high quality billets at a minimum conversion cost, recommendations were developed for choice of the method for cutting of rolled stocks in magnitude of criteria values: «crack propagation criterion» and «brittleness criterion». To cut materials «in plastic state», the cutting with a shear should be used, specifically – a closed cut-off scheme or an incompletely closed cut-off scheme with an active transverse clamp or a cut-off scheme with a differentiated rolling clamp. If increased requirements are imposed on the geometric accuracy of the billets, it is recommended to use complex blanking and cutting processes. For cutting materials «in elastoplastic state» there are good reasons to use a cut with a shear, and in particular – an incompletely closed cut-off scheme with an active and passive transverse clamp. Closer to the class interval, it is possible to apply cold bend breaking with the application of an effective stress concentrator. Cold bend breaking should be used to cut «brittle» materials. The carried out experiments confirmed the adequacy of theoretical conclusions and recommendations on the choice of a rational method for cutting of the rolled stocks to obtain high quality billets.

Key words: clustering, Kohonen maps, mechanical properties, fracture criteria, synergetics, bend breaking, cutting by shear

Introduction.

Important trends to improve machine-building production are the development of ways to reduce the consumption of metal in billet production, increase the accuracy and productivity of cutting rolled products, since these factors significantly affect the technical and economic indicators of subsequent shaping treatment processes [1, 2]. Therefore, obtaining high-quality billets ensuring a low cost of their production is an urgent task. Since even a slight improvement in the cutting technology efficiency leads to a significant increase in production profitability [3, 4].

Analysis of the literature data and target setting.

In billet production, more than ten methods of rolled metal cutting are used. They are classified according to the number of features: according to the waste degree, to the rolling strain pattern, to the applied load type, etc. [3 – 10]. Each of the known methods has its own advantages and disadvantages.

The most promising of all cutting methods, in terms of productivity and waste, are cutting with a shear and bend breaking. Comprehensive studies of waste-free methods for cutting of the rolled stocks have been widely carried out [3-7, 11-18]. During this time, a large amount of information has been accumulated on the nature, mechanisms and criteria of fracture. The following scientists made a significant contribution to the development of this science: K. Kessler, O. Keller, T. Nakagawa, T. Ekobori, E. Orovan, G. V. Kolosov, M. I. Muskhelishvili, G. I. Barenblatt, M. Ya. Leonov, S. O. Khristianovich, G. P. Cherepanov, V. V. Panasyuk, O. I. Tselikov, K. M. Bogoyavlensky, V. G. Kononenko, V. M. Finkel,, V. T. Meshcherin, V. P. Romanovsky, S. S. Solovtsov, N. L. Lisunets, V. A. Timoshchenko and many others [3-18].

The advantages of bend breaking include high productivity and low energy-power parameters of cutting. The disadvantages are additional time spent on preliminary marking and the cutting machine scratch – applying a stress concentrator and, in some cases, low quality of the cutting surface (cutting obliquity, breakaways, shields) [3, 4].

The cut with a shear benefits in terms of process performance. The disadvantages of this method include higher energy consumption for cutting and, in some cases, the low quality of the cutted billets [4]. To improve the quality of cutting billets, complex blanking and cutting processes are used, in which the shear cut is combined with the operations of metal pressure processing: calibration, extrusion, shortening, etc. [5, 6].

The difficult choice of the method for cutting of the rolled stocks into billets is caused by the fact that often the solution to this problem is multioptional, the choice of one option is not obvious and is often based on engineering intuition and practical experience. Besides, decisions are made in the context of capacity constraints, limited material resources, economic opportunities, energy resources, availability of qualified personnel, transportation costs, cooperation opportunities, preproduction time [19-22].

The existing recommendations for choosing a method for cutting of the rolled stocks are associated with traditional mechanical features of the material: hardness, yield strength, and hardness limit. However, the use of traditional mechanical features of the material does not always allow to make the right choice of the cutting method for delivered materials, subjected to different modes of thermal or chemical-thermal treatment [23-25].

At the same time, for a comprehensive assessment of the brittle fracture sensitivity, scientists began to use synergistic fracture criteria: the ultimate specific strain energy (metal viscosity index) – W_c, crack nucleation criterion – K_{ci}, crack propagation criterion – K_{cp} brittleness criterion – P_{fr} and «scale criterion» – M [26-29].

The most important feature of the structural-energy state of a polycrystal is the ultimate specific energy (work) spent on deformation of a unit of its volume before the fracture moment W_c (i.e. ultimate specific strain energy). The value W_c was determined in tensile test cylinders as the area under the curve in the «true stress – true strain» diagram and was calculated by the formula [26]:

$$W_c = 0{,}5 \cdot (\sigma_{02} + \sigma_K) \cdot \varepsilon^{lim}, \tag{1}$$

where σ_{02} – offset yield strength;

σ_K – true resistivity to fracture, equal to $\sigma_B \cdot (1 + \delta)$;

δ – percent elongation;

ε^{lim} – true reduction of the cross-sectional area of the sample by the time of fracture, equal to $ln \cdot [1/(1 - \psi)]$;

ψ – relative reduction.

W_c – metal viscosity index: the greater the specific work of deformation, the more difficult the fracture becomes, so, it is more difficult for cracks to nucleate and propagate. Unlike other material indicators (impact hardness, impact work), calculated for one specific type of deformation and having an applied value, W_c is valid for any type of load and serves to determine other fracture criteria. Hereinafter W_c will be denoted as «metal viscosity index».

«Crack nucleation criterion» numerically defines the ability of material to resist cracking during deformation (the higher K_{ci}, the harder for cracks to nucleate) [26]:

$$K_{ci} = W_c/\sigma_{02}. \tag{2}$$

«Crack propagation criterion» numerically defines the ability of material to resist free movement of cracks during deformation under conditions of reaching a critical stress state (the higher K_{cp}, the harder for cracks to propagate) [24]:

$$K_{cp} = W_{c_{cr}} \cdot \sigma_{02}, \tag{3}$$

where $W_{c_{cr}}$ — critical ultimate specific strain energy, determined at a critical stress state (triaxial tension), when the deformation energy spent on plastic deformation is equal to the energy spent on elastic volume distortion. $W_{c_{cr}} \cong 0{,}75 \cdot W_c$.

«Brittleness criterion» numerically defines the concept of «brittleness» by the ratio of the previous criteria (the higher P_{fr}, the more the criterion of crack propagation exceeds the criterion of crack nucleation and the metal resists brittleness) [26-29]:

$$P_{fr} = K_{cp}^2/(K_{ci} \cdot \sigma_{02}). \tag{4}$$

«Scale criterion» (dimensionless value) takes into account the interrelation between the billet and sample dimensions and the fracture sensitivity of steels (according to elasticity features) [29]:

$$M = e_{xx}/P_{fr}, \tag{5}$$

where $e_{xx} = \left(E \cdot W_{c_{cr}}^2\right)/\left((1+\mu)\cdot(1-2\cdot\mu)\right)$;

E – Young's module; μ – Poison's ratio of material.

Since the modules E and μ are considered structurally insensitive values, in the calculations for all steels we took $E = 2{,}1 \cdot 10^5 MPa$, $\mu = 0{,}28$.

However, the information content of the above mentioned criteria, concerning the cutting of the rolled stocks into billets, is still not known.

Goal and objectives of research.

The goal of the work is to find the most informative system of synergistic criteria that allow to classify materials authentically according to their fracture sensitivity. This will allow an engineer to make a rational choice of a method for cutting of the rolled stocks into billets made of materials with different physical and mathematical properties to obtain high quality billets at a minimum conversion cost.

Table 1 shows the calculations of the synergistic fracture criteria values for steels with different mechanical properties, which can be classified into one of three groups: «steel in plastic state», «steel in elastoplastic state» and «steel in brittle state».

To assess the ability measure of the synergistic fracture criteria to characterize the cutting sensitivity of material, it is required to determine the information content of these criteria.

Methods to solve the problem of determining the information content for the fracture synergetic criteria.

Such a task can be solved in the form of the taxonomic task of finding in a features (criteria) multidimensional space a minimum power set that provides a classification of objects with a given integrity [30-33].

The search for a solution to such a problem consists of an iterative sequence of two operations: hypothesizing and verification. Hypothesizing is performed according to features selection algorithms [30, 31]. In particular, according to the algorithm of sequential features addition, when at first the one-dimensional space of N features is considered, after that, based on the features with the best estimate, the space of $(N-1)$ features is considered, etc. Verification of the information content for the obtained features set is carried out by performing on its basis the classifying objects operation and the following comparing result with the standard.

Table 1. Calculation results

Cluster	Steel / Criterion number	σ_{02}, MPa	σ_B, MPa	δ, %	ψ, %	Hardness HB	W_c, MJ/m^3	K_{ci}	K_{cp}, $(MJ/m^3)^2$	P_{fr}, $(MJ/m^3)^3$	M
		1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
1	$2C10$	200	330	33	60	131	293	1,5	43906	6585954	4851
1	$C10$	210	340	31	55	143	262	1,2	41213	6491076	3933
1	$C15$	230	380	27	55	149	285	1,2	49078	8465900	3565
1	$C20$	250	420	25	55	163	309	1,2	58017	10878108	3282
2	$C30$	300	500	21	50	179	314	1,0	70571	15878486	2310
2	$C40$	340	580	19	45	187	308	0,9	78526	20024178	1766
2	$C45$	360	610	16	40	197	273	0,8	73623	19878279	1395
2	$37Cr4$	324	588	14	50	168	345	1,1	83739	20348584	2176
3	$65G$	785	980	8	30	285	329	0,4	193550	113952545	354
3	$60Si7$	1175	1270	6	25	269	363	0,3	319587	281636126	174
3	$C80W$	1230	1420	10	37	470	645	0,5	595014	548900309	283
3	$100Cr6$	1030	1270	8	34	400	499	0,5	385440	297752095	312

In this case, the most difficult task is the classification of objects in a multidimensional space of features. This problem is solved by the methods of cluster analysis, designed to divide the initial set of objects into a given (or unknown) number of classes – clusters based on certain criteria.

Clustering of objects is performed in a multidimensional space formed from vectors whose components represent the parameters of objects. Then a cluster will be a group of vectors, the distance between which within this group is less than the distance to neighboring groups.

Due to the large-scale problems clustering, one of the most effective tools used to solve these tasks are neural networks, which are a universal approximation tool [30-33].

Currently, there are several types of special neural networks designed to solve clustering problems. The most widespread are the so-called self-organizing structures, in particular, Kohonen's self-organizing maps (SOM). SOM can be considered one of the multidimensional space projection methods into a space with a lower dimension (two-dimensional), while the vectors, similar in the original space are also nearby on the obtained map [32, 33]. The generalized algorithm of the SOM functioning can be presented in the following form [32].

1. First SOM initialization. The following parameters are set: grid configuration (rectangular or hexangular), the number of neurons in the network, the initial and final learning radii, the initial and final learning rates, the number of learning iterations. The neurons weighted coefficients are initialized (by small random values, examples from the learning sample, in linear fashion).

2. Presentation of the new input signal SOM. Input signals (vectors of parameters) are sequentially fed to the input layer of the network, and the signal can be in absolute or normalized form. The desired output signals are not defined.

3. Calculation of the distance to all neurons in the network. The distance between vectors, usually calculated in Euclidean space, is a measure of their similarity. The distance d_j from the input signal to each j – neuron is defined as:

$$d_j = \sum_{i=0}^{N-1} \left(x_i(t) - \omega_{ij}(t)\right)^2, \tag{6}$$

where x_i – i -input signal at each iteration t (discrete time),

$\omega_{ij}(t)$ – weight of i -input signal to j-neuron at each iteration t link.

4. Selecting a neuron with a minimum distance. A neuron (winner) is determined j^*, for it the distance d_j is the least, so, it is most similar to a vector of inputs.

5. Adjusting neuron weights. Weights are being adjusted for the neuron j^* and all neurons from its neighborhood zone. The new weight values are defined as:

$$\omega_{ij}(t+1) = \omega_{ij}(t) + h_{ij}(t) \cdot \left(x_i(t) - \omega_{ij}(t)\right), \tag{7}$$

where $h_{ij}(t) = h(d_j, t) \cdot a(t)$ – non-increasing neuron neighborhood function, in which $h(d_j, t) = e^{d_j^2/\left(2 \cdot r^2(t)\right)}$ – distance function defined as a Gaussian function, where $r(t)$ – learning radius (usually a linearly decreasing function);

$a(t) = A/(B + t)$ – learning rate function, where A and B – constants, providing the approximately equal contribution of all vectors from the training sample to the training result.

As a result of weight adjustment, the vector describing the winner neuron and vectors describing its neighbors in the grid move in the direction of the input vector.

Checking. The end of the training cycle is checked. It is performed according to the value of the neuron weights total correction or by the number of iterations. In the case of the training completion, the synaptic weights of the SOM output layer determine the clusters; besides, the weights are organized in such a way that topologically close nodes are sensitive to similar input signals. Otherwise, we go to the next iteration on the step 2.

7. Mapping. After the neurons are placed on the map, the ready map can be displayed. SOM allows information to be presented in two modes: direct mapping of clusters and component-wise mapping of parameter vectors.

The given generalized algorithm reports, that the SOM application area for clustering is limited by tasks in which the number of clusters is known in advance. At the same time, a fixed number of clusters, due to a rather slow modification of weights, makes this algorithm more stable as compared to analogs, capable of functioning in the conditions of bugs and data skipping [30-33].

Based on this algorithm, the software was developed to solve cluster analysis tasks. It was used to analyze the fracture criteria for the given types of materials (see Table 1).

As a standard, the materials clustering was taken, carried out on the Delphi method basis with the allocation of three classes, which corresponds to the traditional classification of materials into those that can be supplied in fragile, elastoplastic and plastic states [3, 4].

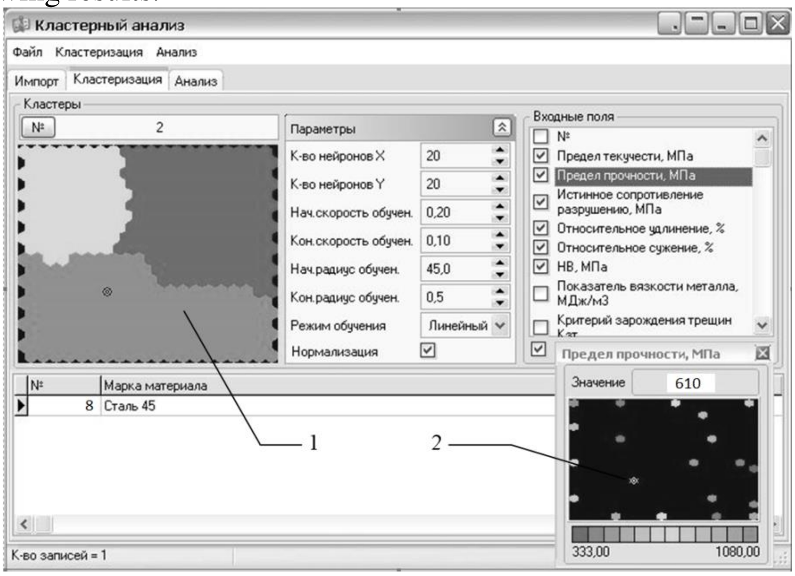
$2C10$, $C10$, $C15$, $C20$ were combined in the cluster of materials in the «plastic state».

$C30$, $C40$, $C45$, $37Cr4$ were combined in the cluster of materials in the «elastoplastic state».

$65G$, $60Si7$, $C80W$, $100Cr6$ were combined in the cluster of materials in the «brittle state».

The screen form of the developed program is shown in the Fig. 1.

The information content assessment for the classifying criteria set was carried out by counting the number of coincidences and non-coincidences of finding objects in the given clusters. The number of iterations in SOM constructing was 7000 for each simulation experiment, that ensured the stability of the classification with the total correction not exceeding 10^{-5}. Application of the sequential features addition method gave the following results.



1 – SOM of the clusters; 2 – SOM of the parameters

Fig. 1. The program for solving cluster analysis tasks using self-organizing Kohonen maps

At the first iteration, ten sets were obtained, consisting of one classifying criterion. The histogram of the information content assessment results is shown in the Fig. 2. The most informative one is the criterion 1 – «offset yield strength», among the complex ones there is the criterion 10 – «scale».

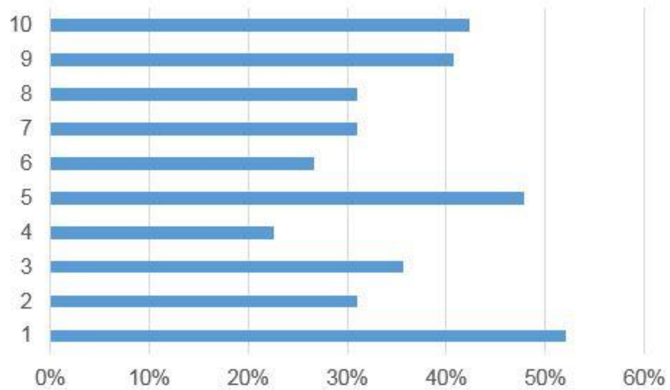


Fig. 2. The histogram for the information content assessment of each criterion

At the second iteration, nine sets of two criteria are obtained. The histogram of the information content assessment results is shown in the Fig. 3. The most informative ones are the sets of criteria 1-4 («offset yield strength» – «relative reduction») and 1-9 («offset yield strength» – «brittleness criterion»).

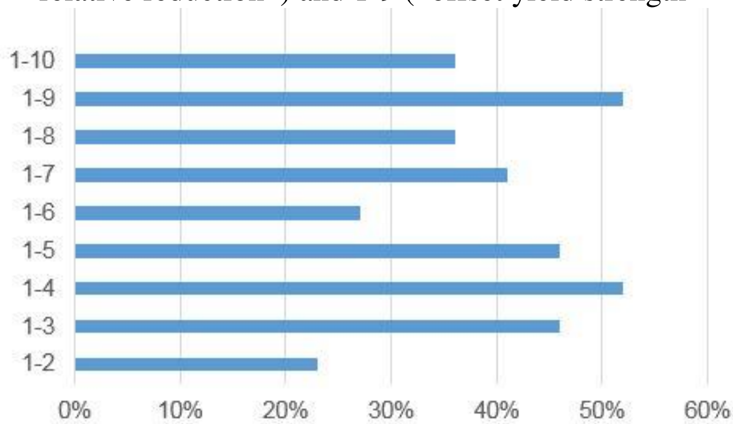


Fig. 3. The histogram for the information content assessment of criteria pairs

If the sets information content assessments are equal, the choice of the fundamental set of criteria of traditional mechanical properties 1-4 («offset yield strength» – «relative reduction») leads to obtaining the set 1-4-3-5-7-9-8 («offset yield strength» – «relative reduction» – «percent elongation» – «hardness» – «crack nucleation criterion» – «crack propagation criterion» – «brittleness criterion») at the seventh iteration, the information content of them is 100% (Fig. 4).

When choosing as the fundamental set of criteria 1-9 («offset yield strength» – «brittleness criterion»), at the fourth iteration, we get the set 1-9-6-8 («offset yield strength» – «brittleness criterion» – «metal viscosity index» – «crack propagation criterion»), that ensures complete identity of the obtained clusters with the standard ones (Fig. 5).

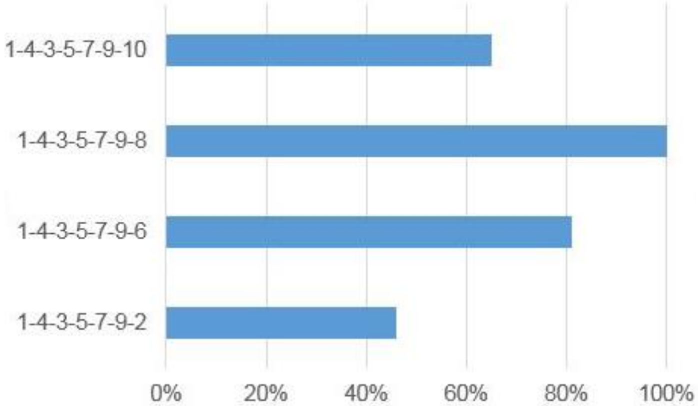


Fig. 4. The histogram for the information content assessment on the basis of 1-4-5-7-9 criteria

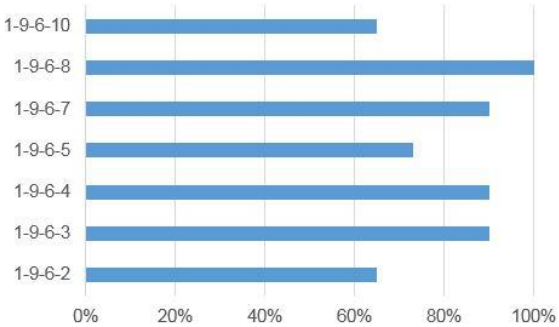


Fig. 5. The histogram for the information content assessment on the basis of 1-9-6 criteria

Applying the algorithm of features sequential removal, it was found that the set 1-9-6-8 can be reduced to the form 9-6-8 without reducing its information content. Further simulation experiments showed that the complex criteria 8-9 («crack propagation criterion» – «brittleness criterion») are basic informative features, and when adding any of the remaining complex criteria to them, they form the required informative sets of minimum power.

Discussion of research results.

Analysis of the obtained simulation results (see Table 1) gives the possibility to develop recommendations for classifying of the rolled stocks into one of three groups: «in plastic state», «in elastoplastic state» and «in brittle state» (Table 2).

Table 2

Steel group	K_{cp}, $(MJ/m^3)^2$	P_{fr}, $(MJ/m^3)^3$
«In plastic state»	to $7 \cdot 10^4$	до $15 \cdot 10^6$
«In elastoplastic state»	to $20 \cdot 10^4$	до $100 \cdot 10^6$
«In brittle state»	more than $20 \cdot 10^4$	more than $100 \cdot 10^6$

Recommendations for the choice of a method for cutting of the rolled stocks into billets were developed in order to obtain high quality billets at a minimum conversion cost.

To cut materials «in plastic state», the cut with a shear should be used, specifically – a closed cut-off scheme or an incompletely closed cut-off scheme with an active transverse clamp, or a cut-off scheme with a differentiated rolling clamp. If increased requirements are imposed on the geometric accuracy of the billets, it is recommended to use complex blanking and cutting processes.

For the cutting of materials «in elastoplastic state» it is also advisable to use the cut with a shear, and in particular – an incompletely closed cut-off scheme with an active and passive transverse clamp. For steels with the values of criteria 8-9, closer to the upper class interval, it is possible to use cold bend breaking with the application of an effective stress concentrator.

Cold bend breaking should be used to cutting "brittle" materials. Moreover, the higher the values K_{cp}, P_{fr}, the higher the tendency of the material to brittle fracture, the higher the quality of the obtained billets, when using simple schemes of cold bend breaking.

In order to check the correctness of the developed recommendations, experiments were carried out on the cutting of the rolled stocks into billets from steels belonged to different groups of materials. To carry out the experiments, we used a press-hammer of an original design Fig. 6, original equipment Fig. 7, including cylindrical samples from rolled products with a diameter of $16\,mm$ and a length of $160\,mm$. The samples were preliminarily applied to the same stress concentrators in the form of an annular groove of a triangular profile with a depth of 1.5 mm and a radius at the apex of 0.15 mm [34].

Fig.6. Photo of the press-hammer

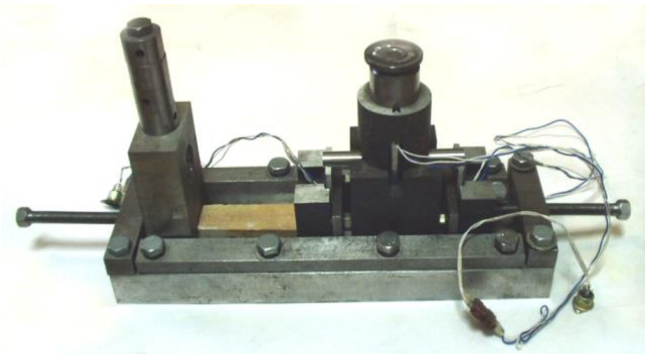


Fig. 7. Photo of equipment for cold breaking of rolled products by bending according to the three-point breaking scheme

The steels samples: $60Si7$, $100Cr6$, which are classified as «brittle state» materials, were cut by cold breaking by bending according to the three-point breaking scheme (Fig. 7). Photographs of the cutting billets are shown in Fig. 8, 9. The bending angle before failure was approximately 10^0. The crack crossed the sample exactly in the plane of the stress concentrator, orthogonal to the sample axis, the plastic deformation areas were not visually observed, the fracture surface was matt, fine-grained, the quality of the billet was high.

Fig. 8. Photo of $100Cr6$ steel billets

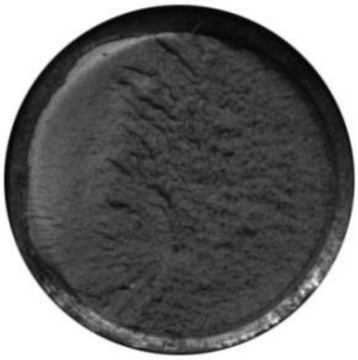


Fig. 9. Photo of $60Si7$ steel billets

Samples of $C30$, $C40$ steels, which are classified as materials «in the elastoplastic state», were also cutting by the method of cold breaking by bending according to the three-point breaking scheme. Obtained billets were of low quality (Fig. 10, 11). As a result of the crack branching (Fig. 10, a), a ledge was formed, on the surface of the fracture there were individual chips, metal breakouts, micro- and macrocracks. If for the $C40$ steel the quality of the obtained billets is acceptable (see Fig. 11), then rolled stocks made of the $C30$ steel should be cutting by shear. A photograph of the billet made of the $C30$ steel, obtained by cutting with shear according to the scheme of the incompletely closed cut with a passive transverse clamp, is shown in Fig. 10, b.

a

b

Fig. 10. Photo of $C30$ steel billets, obtained by cold bending break (a) and cutting by shear according to the scheme of incompletely closed cut with a passive transverse clamp (b)

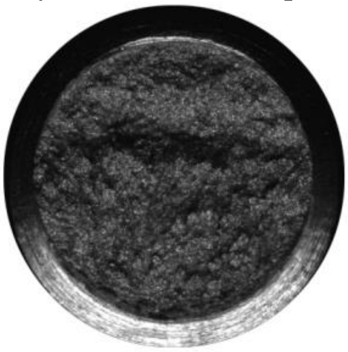


Fig. 11. Photo of $C40$ steel billets

Failure of samples made of steel $2C10$ («in the plastic state») occurred at large bending angles of the halves of the samples in the range $30^0...40^0$. Large bending angles cause plastic deformation to emerge on the sample surface. As a result, there were large contractions on the surface of the samples. The quality of the obtained billets is low (Fig. 12, a). At the same time, if for cutting the same samples we apply a cut by shear in a stamp with a differential clamp, we will obtain a high quality billets (Fig. 13, b).

a b

Fig. 12. Photo of $2C10$ steel billets, obtained by cold bending break (a) and cutting by shear in a stamp with a differential clamp (b)

Conclusions.

1. Software that allows to solve the clustering problem in a multidimensional space of parameters and presenting the obtained information in a visual form using self-organizing Kohonen maps, was developed.

2. Cluster analysis of the synergetic criteria of fracture material was carried out.

3. The most informative criterion among the ones characterizing the mechanical properties of steels is the «offset yield strength», among the synergistic ones it is «scale criterion». At the same time, among the traditional mechanical features of steels, a set allowing to classify materials with a given integrity according to their cutting sensitivity was not found.

4. It was established that the synergistic criteria: «crack propagation criterion» and «brittleness criterion» are basic informative features, and when adding any of the remaining complex criteria («crack nucleation criterion» or «scale»), they form the most informative sets of minimum power, providing, with a given integrity, the classification of materials according to their cutting sensitivity.

5. Recommendations were developed for choice of the method for cutting of the rolled stocks into billets in magnitude of criteria values: «crack propagation criterion» and «brittleness criterion».

With the values of the «crack propagation criterion» to $7 \cdot 10^4$ $(MJ/m^3)^2$, «brittleness criterion» to $15 \cdot 10^6$ $(MJ/m^3)^3$steel can be included into materials «in plastic state». To cut materials «in plastic state», a cut with a shear should be used, specifically – a closed cut-off scheme or an incompletely closed cut-off scheme with an active transverse clamp or a cut-off scheme with a differentiated rolling clamp. If increased requirements are imposed on the geometric accuracy of the billets, it is recommended to use complex blanking and cutting processes.

With the values of the «crack propagation criterion» to $20 \cdot 10^4$ $(MJ/m^3)^2$, «brittleness criterion» to $100 \cdot 10^6$ $(MJ/m^3)^3$ steel can be included into materials «in elastoplastic state». For cutting materials «in elastoplastic state» it is also advisable to use a cut with a shear, and in particular – an incompletely closed cut-off scheme with an active and passive transverse clamp. Closer to the class interval, it is possible to apply cold bend breaking with the application of an effective stress concentrator.

With values of the «crack propagation criterion» more than $20 \cdot 10^4$ $(MJ/m^3)^2$, «brittleness criterion» more than $100 \cdot 10^6$ $(MJ/m^3)^3$ steel can be included into materials «in brittle state». Cold bend breaking should be used to cutting “brittle” materials.

6. The carried out experiments confirmed the recommendations for choosing a rational method for cutting of the rolled stocks to obtain high quality billets.

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Conflicts of interest/Competing interests (include appropriate disclosures)

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Availability of data and material

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Ethics approval

This manuscript was submitted to only one journal. The submitted work is original and do not have been published elsewhere in any form or language (partially or in full). Results have been presented clearly, honestly, and without fabrication, falsification or inappropriate data manipulation (including image based manipulation). Authors adhered to rules for acquiring, selecting and processing data. Data, text and theories were the authors own. Proper acknowledgements to other works were be given and summarized.

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