ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ
Satbayev University

ХАБАРЛАРЫ

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

NEWS

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Satbayev University

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

3 (447)

MAY – JUNE 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

Clarivate
Analytics

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

Бас редактор

ЖҰРЫНОВ Мұрат Жұрынұлы, химия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, Қазақстан Республикасы Ұлттық Ғылым академиясының президенті, АҚ «Д.В. Сокольский атындағы отын, катализ және электрохимия институтының» бас директоры (Алматы, Қазақстан) Н = 4

Редакциялық алқа:

ӘБСАМЕТОВ Мәліс Құдысұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, «У.М. Ахмедсафина атындағы гидрогеология және геоэкология институтының» директоры (Алматы, Қазақстан) Н = 2

ЖОЛТАЕВ Герой Жолтайұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, Қ.И. Сатпаев атындағы геология ғылымдары институтының директоры (Алматы, Қазақстан) Н=2

СНОУ Дэниел, Ph.D, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры (Небраска штаты, АҚШ) Н = 32

ЗЕЛЬТМАН Реймар, Ph.D, табиғи тарих мұражайының Жер туралы ғылымдар бөлімінде петрология және пайдалы қазбалар кен орындары саласындағы зерттеулердің жетекшісі (Лондон, Англия) Н = 37

ПАНФИЛОВ Михаил Борисович, техника ғылымдарының докторы, Нанси университетінің профессоры (Нанси, Франция) Н=15

ШЕН Пин, Ph.D, Қытай геологиялық қоғамының тау геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі (Пекин, Қытай) Н = 25

ФИШЕР Аксель, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) Н = 6

КОНТОРОВИЧ Алексей Эмильевич, геология-минералогия ғылымдарының докторы, профессор, РҒА академигі, А.А. Трофимука атындағы мұнай-газ геологиясы және геофизика институты (Новосибирск, Ресей) Н = 19

АБСАДЫКОВ Бахыт Нарикбайұлы, техника ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, А.Б. Бектұров атындағы химия ғылымдары институты (Алматы, Қазақстан) Н = 5

АГАБЕКОВ Владимир Енокович, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры (Минск, Беларусь) Н = 13

КАТАЛИН Стефан, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) Н = 20

СЕЙТМҰРАТОВА Элеонора Юсуповна, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, Қ.И. Сатпаев атындағы Геология ғылымдары институты зертханасының меңгерушісі (Алматы, Қазақстан) Н=11

САҒЫНТАЕВ Жанай, Ph.D, қауымдастырылған профессор, Назарбаев университеті (Нұр-Сұлтан, Қазақстан) Н = 11

ФРАТТИНИ Паоло, Ph.D, Бикокк Милан университеті қауымдастырылған профессоры (Милан, Италия) Н = 28

«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген **№ KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.
Тақырыптық бағыты: *геология және техникалық ғылымдар бойынша мақалалар жариялау.*
Мерзімділігі: жылына 6 рет.
Тиражы: 211 дана.
Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19, 272-13-18
http://www.geolog-technical.kz/index.php/en/

© Қазақстан Республикасының Ұлттық ғылым академиясы, 2021

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

Главный редактор

ЖУРИНОВ Мурат Журинович, доктор химических наук, профессор, академик НАН РК, президент Национальной академии наук Республики Казахстан, генеральный директор АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского» (Алматы, Казахстан) H = 4

Редакционная коллегия:

АБСАМЕТОВ Малис Кудысович, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан) H = 2

ЖОЛТАЕВ Герой Жолтаевич, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, директор Института геологических наук им. К.И.Сатпаева (Алматы, Казахстан) H=2

СНОУ Дэниел, Ph.D, ассоциированный профессор, директор Лаборатории водных наук университета Небраски (штат Небраска, США) H = 32

ЗЕЛЬТМАН Реймар, Ph.D, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Англия) H = 37

ПАНФИЛОВ Михаил Борисович, доктор технических наук, профессор Университета Нанси (Нанси, Франция) H=15

ШЕН Пин, Ph.D, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай) H = 25

ФИШЕР Аксель, ассоциированный профессор, Ph.D, технический университет Дрезден (Дрезден, Берлин) H = 6

КОНТОРОВИЧ Алексей Эмильевич, доктор геолого-минералогических наук, профессор, академик РАН, Институт нефтегазовой геологии и геофизики им. А.А. Трофимука СО РАН (Новосибирск, Россия) H = 19

АБСАДЫКОВ Бахыт Нарикбаевич, доктор технических наук, профессор, член-корреспондент НАН РК, Институт химических наук им. А.Б. Бектурова (Алматы, Казахстан) H = 5

АГАБЕКОВ Владимир Енокович, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь) H = 13

КАТАЛИН Стефан, Ph.D, ассоциированный профессор, Технический университет (Дрезден, Берлин) H = 20

СЕЙТМУРАТОВА Элеонора Юсуповна, доктор геолого-минералогических наук, профессор, член-корреспондент НАН РК, заведующая лаборатории Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) H=11

САГИНТАЕВ Жанай, Ph.D, ассоциированный профессор, Назарбаев университет (Нурсултан, Казахстан) H = 11

ФРАТТИНИ Паоло, Ph.D, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия) H = 28

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).
Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан **№ KZ39VPY00025420,** выданное 29.07.2020 г.
Тематическая направленность: *публикация статей по геологии и техническим наукам.*
Периодичность: 6 раз в год.
Тираж: 211 экземпляров.
Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19, 272-13-18
http://www.geolog-technical.kz/index.php/en/

© Национальная академия наук Республики Казахстан, 2021

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

Editor in chief

ZHURINOV Murat Zhurinovich, doctor of chemistry, professor, academician of NAS RK, president of the National Academy of Sciences of the Republic of Kazakhstan, general director of JSC "Institute of fuel, catalysis and electrochemistry named after D.V. Sokolsky» (Almaty, Kazakhstan) H = 4

Editorial board:

ABSAMETOV Malis Kudysovich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, academician of NAS RK, director of the Akhmedsafin Institute of hydrogeology and hydrophysics (Almaty, Kazakhstan) H = 2

ZHOLTAEV Geroy Zholtaevich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, director of the institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) H=2

SNOW Daniel, Ph.D, associate professor, director of the labotatory of water sciences, Nebraska University (Nebraska, USA) H = 32

Zeltman Reymar, Ph.D, head of research department in petrology and mineral deposits in the Earth sciences section of the museum of natural history (London, England) H = 37

PANFILOV Mikhail Borisovich, doctor of technical sciences, professor at the Nancy University (Nancy, France) H=15

SHEN Ping, Ph.D, deputy director of the Committee for Mining geology of the China geological Society, Fellow of the American association of economic geologists (Beijing, China) H = 25

FISCHER Axel, Ph.D, associate professor, Dresden University of technology (Dresden, Germany) H = 6

KONTOROVICH Aleksey Emilievich, doctor of geological and mineralogical sciences, professor, academician of RAS, Trofimuk Institute of petroleum geology and geophysics SB RAS (Novosibirsk, Russia) H = 19

ABSADYKOV Bakhyt Narikbaevich, doctor of technical sciences, professor, corresponding member of NAS RK, Bekturov Institute of chemical sciences (Almaty, Kazakhstan) H = 5

AGABEKOV Vladimir Enokovich, doctor of chemistry, academician of NAS of Belarus, honorary director of the Institute of chemistry of new materials (Minsk, Belarus) H = 13

KATALIN Stephan, Ph.D, associate professor, Technical university (Dresden, Berlin) H = 20

SEITMURATOVA Eleonora Yusupovna, doctor of geological and mineralogical sciences, professor, corresponding member of NAS RK, head of the laboratory of the Institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) H=11

SAGINTAYEV Zhanay, Ph.D, associate professor, Nazarbayev University (Nursultan, Kazakhstan) H = 11

FRATTINI Paolo, Ph.D, associate professor, university of Milano-Bicocca (Milan, Italy) H = 28

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).
The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420,** issued 29.07.2020.
Thematic scope: *publication of papers on geology and technical sciences.*
Periodicity: 6 times a year.
Circulation: 211 copies.
Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

© National Academy of Sciences of the Republic of Kazakhstan, 2021

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN **SERIES OF GEOLOGY AND TECHNICAL SCIENCES**
ISSN 2224-5278
Volume 3, Number 447 (2021), 65-71 **https://doi.org/10.32014/2021.2518-170X.64**

UDC 669.018.2
IRSTI29.19.13

A.T. Kanayev, M.A. Jaxymbetova, I.M. Kossanova
S.Seifullin Kazakh agrotechnical University, Nur-Sultan, Kazakhstan,
E-mail: aman-kanaev2012@yandex.ru

QUANTITATIVE ASSESSMENT OF THE YIELD STRESS OF FERRITE-PEARLITIC STEELS BY STRUCTURE PARAMETERS

Abstract. In various sectors of the economy, requirements are imposed on the quality of metallurgical products. The event that improves the quality of metallurgical products - thermomechanical treatment (TMT). TMT allows reducing the specific consumption of steel, increasing the service life, reliability and durability of products, which is tantamount to an increase in the volume of finished metal products.

The problem of applied materials science is the establishment of a quantitative relationship between the structure and properties of steels and alloys, it underlies the development and creation of new effective ways to improve the operational characteristics of metal products. In the production of long products, (TMT) is increasingly used, which is a combination of two methods of strengthening steels: deformational by plastic deformation and thermal by phase transformations.

Revealing the features of the properties of heat-treated steels makes it possible to approach the solution of this problem. The main mechanisms of hardening are solid solution hardening by alloying with relatively cheap alloying elements (Mn, Si) and dislocation and precipitation hardening using hardening heat treatment and microalloying of steel with carbide and nitride-forming elements V (C, N).

The article quantifies the approximate contribution of various strengthening mechanisms to the yield stress of carbon and low-alloy steels. For St5ps steel (hot-rolled state), the yield stress is given by solid-solution and grain-boundary hardening (37.4.0% and 28.6%), in low-alloy steel 16G2AF (36.7% and 27.1%), the role of dispersion hardening (28.0%).Thermomechanical treatment of steel grade St.5ps leads to an increase in the value of dislocation hardening up to 27.6% due to an increase in the density of dislocations and the retention of most of the dislocations in the rolled stock during accelerated cooling of hot-deformed austenite.

Key words: hardening mechanisms, yield stress, thermomechanical treatment, accelerated cooling, plasma hardening, phase components, grain size.

Introduction. As is known, the establishment of a quantitative relationship between the structure and properties of metallic materials is one of the main problems of applied materials science, since it underlies the development and creation of new effective ways to improve the performance of products. So, at present, thermomechanical treatment (TMT) is increasinglyused in the production of long products, which is a combination of two effective methods of hardening: deformation from plastic deformation and thermal from phase transformations. The attention of researchers is also drawn to the fact that when using TMT according to the interrupted quenching mode, a layered structure is formed in the surface layers of rolled products, which can be classified as structural composites with their advantages.

Revealing the features of the formation of the structure and properties at the yield point of steels subjected to different heat treatment allows one to approach the solution of this problem [1].

The purpose of this work is to quantify the yield stress of low-carbon and low-alloy steels in terms of chemical composition and structure parameters, to compare the calculated values with the data of the corresponding GOST to obtain information about the existing strengthening mechanisms after one or another treatment and alloying [2,3].

Models description and parameter estimation. The initial data for calculating the yield point of steel used data on the chemical composition, the distribution of constant and alloying impurities between the phases and quantitative parameters of the structure: grain size, the ratio of phase and structural components, their distribution, distance between strengthening particles, dislocation density, etc [4,5].

Note that such estimates of the yield stress are rather not quantitative, but semi-quantitative, since a number of simplifications and assumptions in the theory of the hardening mechanisms themselves are adopted in the calculation, which do not allow a rigorous quantitative assessment of the yield stress of steel. Thus, in the theory of dislocation hardening, an important role is played by the precise determination of the dislocation density; however, the calculations neglect a decrease in the dislocation density in the process of foil thinning in transmission electron microscopy, or the distribution of dislocations over the volume of the material is assumed to be homogeneous and isotropic, although in fact this does not correspond to reality. For deformation-thermally hardened steels, the dislocation density (according to literature data) is approximately$\rho=109cm^{-2}$ [6,7].

The reliability of the calculated dispersion hardening is largely determined by the reliability of the determination of the interparticle distance - λ, since it is precisely this that is included in the Orowan calculation equation $-\Delta\sigma=(9,8*103/\lambda)\ \ln 2\lambda$. The difficulty lies in the fact that it is practically impossible to measure the interparticle distance -λ in the images, therefore it can be calculated through other measured parameters: the volume fraction - f and the diameter of the strengthening particles - D; $\lambda = D * (\pi/6f)1/2$ [8,9].

The determination of the volume fraction of phases by the method of point analysis is based on the proposition that the fraction of randomly applied points on the micrograph falling on the image of the phase under study is equal to the volume fraction of this phase. $f_\alpha = n_\alpha / n_0$, where n_α –is the number of points that fall on the sections of phase α; n0 – is the total number of points plotted on the microstructure image. A comparative analysis of the role and contribution of various mechanisms of hardening to the total yield stress of carbon and low-alloy steels was carried out according to the methodology proposed in [4]. The investigated steels differ not only in chemical composition, but also in the hardening heat treatment used.The magnitude of the individual components of hardening and their contribution to the total yield stress of these steels were determined using the known empirical formulas given below. The coefficients required for the calculation are taken from the specified literature data. In this case, the calculated values of the yield stress of the studied steels were compared with the data of GOST 5781, GOST 10884, and GOST 19282 to obtain information on the applicability of the method for assessing the yield stress by structural parameters. Determination of structure parameters (pearlite content in steel, inter-plate spacing, ferrite grain diameter, size and volume fraction of the carbonitride phase, etc.) to assess the yield stress was performed by quantitative metallography methods using a Neophot 21 optical microscope and an UEMV-100 electron microscope [10].

The calculation is based on the principle of additivity of hardening mechanisms, which has been confirmed by many researchers in many steels. The essence of this principle is that the contribution of individual hardening mechanisms to the total yield stress of a polycrystalline material is summed up.

As you know, the yield point of steel is determined by the Hall-Petch ratio, which for tensile conditions has the form:

$$\sigma_T = \sigma_i + k_y * d^{-1/2} \qquad (1)$$

where σ_{i}- the frictional stress of the crystal lattice during the movement of dislocations inside grains, i.e. intragranular hardening without taking into account the contribution of grain boundaries (such as a single crystal) to the yield stress;

$k_y d^{-1/2}$ - grain boundary hardening, where, ky - coefficient characterizing the contribution of grain boundaries to hardening, which are barriers to the advancement of dislocations from one grain to another; according to the literature data, this coefficient is within wide limits, affecting the calculation results (0,57-0,73MPa√м), influencing the calculation results, therefore, the proportion of grain boundary hardening was estimated from the nomogram, d - grain diameter [11,12,13].

This expression is applicable with sufficient accuracy to ferritic steels with grains ranging in size from 0,3 to 400 mkm (literature data), from which it follows that the yield stress of the material increases with decreasing grain size.

Intragrain hardening from relation (1) can be represented as:

$$\sigma_i = \sigma_0 + \Delta\sigma_{SS} + \Delta\sigma_P + \Delta\sigma_{SH} + \Delta\sigma_{PH} \ (2)$$

where irepresents the amount:

1) σ_0 - lattice friction stresses to the motion of free dislocations, taking into account defects in the crystal structure and taking into account a certain amount of interstitial impurities (C + N) in a solid solution for iron-based steels with bcc. lattice $\sigma0_{\sim 30MPa.}$

Calculated hardening formula: $\sigma_0 = 2 * 10^{-4}\ G$, Modulus of elasticity for iron G = 84000 MPa.

2) $\Delta\sigma_{ss}$-solid solution hardening with alloying impurities, calculation formula

$\Delta\sigma_т p = \sum Ki*C_i$

whereKi – hardening coefficient determined in special studies on the influence of alloying elements on the hardening of ferrite,

C_i – the concentration of the alloying element in the solid solution (ferrite). In this work, the following (literary)

Ki values are taken to calculate тр:

Element	C+ N	P	Si	Mn	V
K_iMPa/%,	4670	690	86	33	3

As can be seen, interstitial atoms (C + N) strongly strengthen ferrite than substitutional atoms.

3) p - hardening due to the formation of a pearlite component, p=2,4P, where 2,4-empirical coefficient MPa/P%, share of pearlite component in structure,%; depends on the composition of the steel (primarily on the carbon content), the cooling rate during heat treatment. The degree of dispersion of pearlite is determined by the inter-plate distance - Δ., which is the sum of the thicknesses of two adjacent ferrite and cementite plates in pearlite structures (perlite, sorbitite, troostite). Δ changes depending on the cooling rate.Thus, the measured values of the

inter-plate distance for the hot-rolled state of St5Ps Δ= 0,6 mkm, after HTTT (in the unreinforced zone) decreases and amounts to 0,4 mkm [14,15].

4) $\Delta\sigma_{SH}$ - hardening due to the resistance of a gliding dislocation to other dislocations (strain hardening), SH = αM G b ρ1|2 , whereα – коэффициент, is a coefficient depending on the nature of the distribution and interaction of dislocations, is in the range 0,1-0,3. For the considered steels (with a ferritic base), the parameters included in the above equation, according to the literature, are:M=2,75; G = 84000 MPa; vector Burgers b = 0,25nm[16,17].

5) $\Delta\sigma_{PH}$ - hardening caused by dispersed particles of the second phase (dispersion hardening) Calculation formulas: PH = (9,8 *103/$^{\lambda}$) ln 2 λ, where, λ - is the interparticle distance; λ = D * (π/6f)$^{1/2}$

Results obtained and their discussion.

Table 1: Initial data for quantitative assessment of the yield strength of the investigated steel

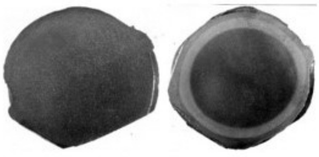
№	Characteristics of steeltype	The grade of the investigated steels and their heat treatment		
1	Alloying element content in α-Fe, %: Mn Si P V (C+ N)	St5ps	St5ps	16G2AF
		0,55 0,11 0,04 - 0,015	0,58 0,15 0,04 - 0,015	1,5 0,3 0,035 0,11 0,015
2	Strengtheningphase (dispersed particle)	-	-	V(C,N)
3	The proportion of pearlite structures (%) with different-Δ, (for steel after HTTT without taking into account the hardened surface zone)	35 0,6 mkm	43 0,4 mkm	17 0,11 mkm
4	Grain size: (number according to GOST 5639-82) d, mm	6 0,051	9 0,012	9 0,014
5	Volume fraction of dispersed particles, f,%	-	-	0,096
6	Dispersed particle size, D, nm	-	-	30
7	Interparticle distance, λ, nm	-	-	765
8	The nature of the dislocation structure, ρ, sm^{-2}	10^8	10^9	10^8

Note. 1. Based on the experimental data, it is assumed that ~ 0.015 (C + N) is dissolved in the ferrite, the rest of the carbon and nitrogen are bound into carbonitrides

2. According to the literature data for deformation-thermally hardened steels, the dislocation density is approximately ρ=10 9sm-2.

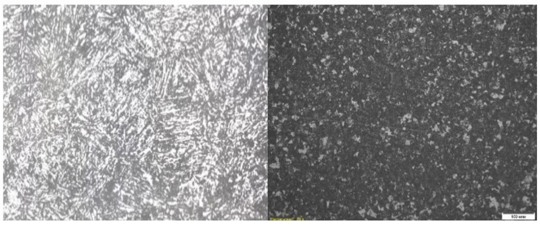
As can be seen from the data presented (Tables 1 and 2), the yield stress of steels to which the studied grades belong can be considered as the sum of terms in equation (1). The share of the contribution of individual hardening factors to the total yield strength of steel is not the same and depends on the content of alloying elements and the degree of alloying, the presence and dispersion of the hardening phases, applied thermal, thermomechanical treatment and other factors [18].

In carbon steel grade St5ps (hot rolled state), the main components of hardening are solid solution and grain boundary hardening, the proportion of which is ~ 66%. In absolute terms, the proportion of these terms is equal to 125,3 MPa and 95,7 MPa. In steel St5ps, subjected to HTTT, a significant contribution to the overall hardening is made by strain (dislocation) hardening. Note that HTTT of reinforcing steel St.5ps with a diameter of 14 mm was carried out according to the scheme of interrupted quenching with self-tempering: the temperature of the end of rolling is 1050^0C, the pause between the end of rolling and the beginning of intensive cooling is 2 s, and the self-tempering temperature is ~500°C. When hardening according to this scheme, the transformation of most of the austenite occurs after the cessation of water cooling; therefore, the main factor determining the obtained properties will be the temperature level after its leveling over the cross section of the reinforcement being hardened. This temperature is usually called the self-tempering temperature. However, this definition is valid only for the surface layers, which, upon cooling in water, underwent a martensitic transformation and are tempered at the leveling temperature, which has a tempering sorbitol structure with a globular shape of cementite particles. For the inner layers, which make up the main part of the section, this temperature (~450-500^0C) is the temperature of austenite decomposition by the diffusion mechanism. Metallographic studies show that at HTTT the structure of the surface layer (~ 3 mm thick) of reinforcement with a diameter of 14 mm is formed as a result of the martensitic γ→α transformation, and the structure of the axial central zone is formed as a result of the diffusion γ→α transformation, figure 1,2,3 [19,20].



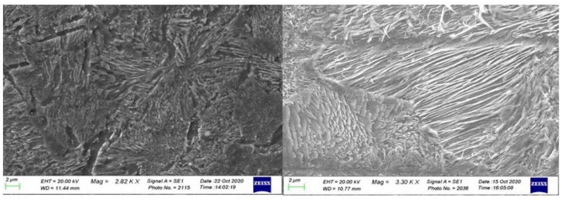
a) b)

Figure 1: Macrostructure (x25) of hot-rolled (a) and heat-strengthened (b) reinforcing steel



a) b)

Figure 2: Microstructure of heat-strengthened reinforcing steel after quenching (a-hardening martensite) and self-tempering at ~ 500^{0}C (b-tempered martensite-sorbitol tempering)



a) b)

Figure 3: Substructure of intermediate (a) and central (b) zones of reinforcing steel after surface hardening (at HTTT)

In steel thermomechanically treated according to the interrupted quenching scheme with subsequent self-tempering, the proportion of strain hardening is 27,6%, absolute value $\Delta\sigma_{SH}$=140MPa. This is apparently explained by an increase in the density of dislocations when hot rolling is combined with subsequent immediate quenching. In this case, intensive cooling suppresses recrystallization processes and fixes a significant part of the dislocations that arise during hot rolling of austenite; the dislocation structure of hot-deformed austenite is inherited by the martensite formed in the process of diffusion-free austenite-martensite transformation. In addition, the refinement of the austenite grain during thermomechanical treatment leads to the refinement of the formed martensite crystals [5-7]. Note that an increase in the yield stress after HTTT (in our case, 27,6%) is also noted in other works [4,10]. Noting the efficiency of the solid-solution hardening mechanism and its applicability, at the same time, it should be emphasized that there is probably some optimal degree of doping α-Fe, because saturation of α-Fe with impurity substitution and interstitial atoms can lead to dangerous elastic deformation of the lattice and fracture toughness of the alloy [21,22].

Table 2: Quantitative assessment of the yield strength of steels with different structural and phase states

№	Indicators	Steelgrade		
		St5ps	St5ps	16G2AF
1	Latticefrictionstress	30/8,9	30/5,9	30/5,6
2	Solidsolutionhardening	125,3 /37,4	129,7 /25,5	169,8 /36.7
3	Strengthening due to pearlite structures	84,0 /25,1	103,2 /20,3	40,8 /7.6
4	Dislocationhardening	-	140 /27,6	
5	Dispersionhardening	-		150 /28,0
6	Grainboundaryhardening	95,7 /28,6	105 /20.7	145 /27.1
7	CalculatedYieldStrength	335	507.9	535.6
8	The value of the yield point according to GOST	285	440	440
9	Difference (in%) of data from GOST and calculated valuewe have the yield point	14,9	13.4	17,8

Note. 1. In the numerator - the absolute value of hardening (MPa), in the denominator - the proportion of hardening due to this mechanism, (in% of the value of the yield stress according to GOST). So, for hot-rolled reinforcing steel St.5ps according to GOST 5781 σ0,2 =285 N/mm^2, for the same steel after HTTT according to GOST 10884 (strength class AT 111C)σ0,2 =440 N/mm2, for steel 16G2AF according to GOST 19282 σ0,2 =440 N/mm^2.

If we take into account that solid solution hardening is caused by the difference between the atomic diameters of ferrite and alloying element and their elastic moduli, then a high proportion of this hardening can be explained by the resistance to moving dislocations from the side of dissolved atoms [23, 24].

In low-alloy steel 16G2AF, the role of precipitation hardening is noticeable – 28,0%, PH=150,0 MPa. As can be seen from table 1, in this steel a dispersed carbonitride phase V (C, N) is formed, which strengthens the ferrite by the Orowan mechanism. It is assumed that the V (C, N) carbonitride phase is incoherent with the (α-Fe) matrix and therefore the V (C, N) precipitates bend around the dislocations, thereby causing precipitation hardening.

The efficiency and prospects of precipitation hardening are also indicated by the effect of dispersed phases on the grain size. It follows from Table 1 that in steel 16G2AF, in the structure of which there is a dispersed carbonitride phase V (C, N), a finer grain d=0,014 mm is formed. This is explained by the embryonic influence of the V (C, N) particles when passing through the critical points Ac1 andAc3. In addition, the carbonitride phase inhibits the growth of austenite grain upon further heating up to the temperature of dissolution of these phases in austenite. These two circumstances lead to the fact that noticeable refinement of ferrite grains occurs in 16G2AF steel. Thus, dispersed particles of the carbonitride phase V (C, N) in steel cause additional grain boundary hardening [25].

In low-carbon and low-alloy steels, the main phase component is, as you know, ferrite, its share in these steels reaches 70-75%. When a load is applied, deformation begins to develop in ferrite, and pearlite colonies are "barriers" for the movement of dislocations that cause deformation. Therefore, hardening from the pearlite component also makes a certain contribution to the overall hardened state. The tables show that the proportion of hardening from the pearlite content is within wide limits from 7,6% for steel 16G2AF (only~0,16% of carbon) to 20,3% for the fine-lamellar state of pearlite in steel St.5ps due to general grinding structures after HTTT.

It should be noted that non-metallic inclusions can also affect the mechanical properties of these steels. However, their volume fraction in the steels under consideration does not exceed 0,1%, they do not have a hardening effect, and therefore, in this work, the behavior of non-metallic inclusions was not considered [26, 27].

Conclusion. 1. Analysis of the data for the quantitative assessment of the yield stress of carbon and low-alloy steels by structural parameters shows that the main mechanisms of their strengthening are solid solution strengthening by alloying with relatively cheap alloying elements (Mn, Si), as well as dislocation and precipitation hardening using hardening heat treatment and microalloying of steel with carbide and nitride-forming elements V (C, N).

2. The formation of a gradient structure in the surface layer of the product when hot deformation is combined with subsequent quenching in the rolling process flow (HTTT) leads to a significant increase in the yield strength (strength) of steel. In this case, the strengthening of the reinforcing profile is also facilitated by the refinement of the structure of the inner layers of steel. The gradient structure, as shown by numerous studies, excludes the formation of a sharp transition boundary from martensite structures to mixed structures of the pearlite type, which is one of the main factors that increase the contact-fatigue strength of steel.

3. Comparison of the calculated values of the yield point with its value in the corresponding GOST-ah shows a satisfactory difference in values: after normalization – 17,8% for steel 16G2AF and 14,9% for St5ps (Hot-rolled state). After HTTT, the difference between the calculated value of the yield stress and the value according to GOST 19282 is 13,4%. These data indicate the applicability of an approximate quantitative assessment of the yield strength of steel, based on the analysis of the parameters of the formed structure after certain treatments, taking into account the assumptions made.

А.Т. Қанаев, М.А. Джаксымбетова, И.М. Косанова
С. Сейфуллин атындағы Қазақ агротехникалық университеті
E-mail: aman-kanaev2012@yandex.ru

ФЕРРИТТІК-ПЕРЛИТТІК БОЛАТТАРДЫҢ АҚҚЫШТЫҚ ШЕГІН ҚҰРЫЛЫМЫНЫҢ ПАРАМЕТРЛЕРІ БОЙЫНША САНДЫҚ БАҒАЛАУ

Аннотация. Қарқынды инновациялық дамуына байланысты экономиканың әртүрлі салаларында үнемі жоғары талаптар металлургия өнімдерінің сапасына қойылады. Дайын металлургиялық өнімнің сапасын жақсарту жөніндегі шаралар арасында маңызды орын термиялық-механикалық өңдеу (ТМӨ) алады. Металдың беріктік сипаттамаларын арттыру арқылы ТМӨ болаттың меншікті шығынын азайтуға, бұйымдардың қызмет ету мерзімін, бөлшектер мен тораптардың сенімділігі мен беріктігін арттыруға мүмкіндік береді, бұл өз кезегінде дайын металл көлемінің ұлғаюына әсер етеді.

Қолданбалы материалтанудың негізгі мәселелерінің бірі болат пен қорытпалардың құрылымы мен қасиеттері арасындағы сандық байланысты орнату болып табылады, себебі ол металл бұйымдарының эксплуатациялық сипаттамаларын жақсартудың жаңа тиімді әдістерін жасау негізделген. Осылайша, қазіргі уақытта илемделген темір бұйым өндірісінде ол (ТМӨ) көбірек қолданылуда, бұл болаттарды беріктендірудің екі тиімді әдісін құрайды: пластикалық деформациядан деформацияланғанға дейін және фазалық түрлендіруден жылулық деформацияға дейін.

Термиялық өңделген болаттардың құрылымы мен қасиеттерінің қалыптасу ерекшеліктерін анықтау осы мәселені шешуге жақындауға мүмкіндік береді. Көміртекті және аз легирленген болаттардың аққыштық шегін құрылымдық параметрлер бойынша сандық бағалауға мүмкіндік беретін мәліметтерді зерттеу келесі ақпаратты көрсетеді: оларды беріктендірудің негізгі механизмдері қатты ерітіндіні салыстырмалы түрде арзан легирлеуші элементтермен (Mn, Si) легирлеу және дислокация арқылы беріктендіру, және V (C, N) карбидті және нитридті түзетін элементтермен де болатты легирлеу және термиялық өңдеуді қолдану арқылы беріктендіру екенін көрсетеді.

Мақалада әдебиет деректерін талдау және өзіміздің эксперименттік зерттеулер жүргізу негізінде көміртекті және аз легирленген болаттардың аққыштық шегіне әр түрлі беріктендіру механизмдерінің сандық түрде болжамды үлесі бағаланады. Б5ps болаты үшін (ыстықтай илектелген күйде) аққыштық шегіне қатты-ерітінді мен дәннің шектік-түйіршік беріктендіру (37,4,0% және 28,6%) едәуір әсер етеді, ал төмен легирленген 16G2AF болатты беріктендіруге әсері (36, 7% және 27,1%) дисперсиялық беріктендірудің рөлі айтарлықтай (28,0%). Б5ps маркалы болатты термомеханикалық өңдеу дислокациялық тығыздықтың ұлғаюына және жылытылған құрамдағы дислокациялардың көп бөлігінің жеделдетілген салқындатуына байланысты ыстық деформацияланған аустенит жағдайында дислокациялық беріктендіру мәнінің 27,6% дейін өсуіне әкелетіні көрсетілген.

Түйін сөздер: беріктендіру механизмдері, аққыштық шегі, термомеханикалық өңдеу, жылдам салқындату, фазалық компоненттер, астық мөлшері.

А.Т. Канаев, М.А. Джаксымбетова, И.М. Косанова
Казахский агротехнический университет им.С.Сейфуллина
E-mail: aman-kanaev2012@yandex.ru

КОЛИЧЕСТВЕННАЯ ОЦЕНКА ПРЕДЕЛА ТЕКУЧЕСТИ ФЕРРИТО-ПЕРЛИТНЫХ СТАЛЕЙ ПО ПАРАМЕТРАМ СТРУКТУРЫ

Аннотация. В связи с инновационным развитием в различных отраслях экономики все более высокие требования предъявляются к качеству металлургической продукции. Важное место среди мероприятий, улучшающих качество готовой металлургической продукции, принадлежит термомеханической обработке (ТМО). Благодаря повышению прочностных характеристик металла, ТМО позволяет сократить удельный расход стали, увеличить срок службы изделий, надежность и долговечность деталей и узлов, что равносильно увеличению объема готовой металлопродукции.

Одной из основных проблем прикладного материаловедения является установление количественной связи между структурой и свойствами сталей и сплавов, поскольку лежит в основе разработки и создания новых эффективных способов повышения эксплуатационных характеристик металлических изделий. Так, в настоящее время при производстве сортового проката все шире применяется (ТМО), представляющая собой совокупность двух эффективных способов упрочнения сталей: деформационного от пластической деформации и термического от фазовых превращений.

Выявление особенностей формирования структуры и свойств сталей, подвергнутых термической обработке, позволяет приблизиться к решению указанной проблемы. Исследование данных количественной оценки предела текучести углеродистых и низколегированных сталей по параметрам структуры показывает, что основными механизмами их упрочнения являются твердорастворное упрочнение путем легирования относительно дешевыми легирующими элементами (Mn, Si) и дислокационное и дисперсионное упрочнения с использованием упрочняющей термической обработки и микролегирования стали с карбидо- и нитридообразующими элементами V(C,N).

В статье на основе анализа литературных данных и собственных экспериментальных исследований количественно оценен ориентировочный вклад различных механизмов упрочнения в предел текучести углеродистой и низколегированной сталей. Установлено, что для стали Ст5пс (горячекатаное состояние) наибольший вклад в предел текучести дают твердо-растворное и зерно-граничное упрочнения (37,4,0% и 28,6%), а в низколегированной стали 16Г2АФ наряду с такими слагаемыми упрочнения (36,7% и 27,1%) заметна роль дисперсионного упрочнения (28,0%). Показано, что термомеханическая обработка стали марки Ст.5пс приводит к росту величины дислокационного упрочнения до 27,6 % за счет роста плотности дислокаций и сохранения большей части дислокаций в прокате при ускоренном охлаждении горячедеформированного аустенита.

Ключевые слова: механизмы упрочнения, предел текучести, термомеханическая обработка, ускоренное охлаждение, фазовые составляющие, размер зерна.

Information about the authors:

Kanayev Amangeldi Tokeshovich – doctor of technical sciences, professor of the department «Standardization, metrology and certification” of S.Seifullin Kazakh Agrotechnical University, Nur- Sultan, Kazakhstan, aman-kanaev2012@yandex.ru; https://orcid.org/0000-0002-2530-038X

Jaxymbetova Makpal Adlikanovna – PhD student of the department «Standardization, metrology and certification»ofS.Seifullin Kazakh Agrotechnical University, Nur-Sultan, Kazakhstan, dzhaksymbetov@list.ru, https://orcid.org/0000-0002-3345-4071

Kossanova Indira Muratovna – PhD student of the department «Standardization, metrology and certification» of S.Seifullin Kazakh Agrotechnical University, Nur-Sultan, Kazakhstan, ind_jm@mail.ru, https://orcid.org/0000-0002-9092-8982

REFERENCES

[1] Kanaev A.T., Bogomolov A.V., Kanaev A.A., Reshotkina E.N. (2018) Influence of Intermittent Quenching and Self-Tempering on the Mechanical Properties of Rebar Steel Journal “Steel in Translation”, Vol.48(2), pp.130-134, DOI: 10.3103/S0967091218020079.

[2] GoldshteinM.I., Litvinov V.S., Bronfin B.M. Metal-physics of high-strength allpys. Moscow., Metallurgy,1986, p.312-326

[3] Kanaev A.T., Bogomolov A.V., Sarsembaeva T.E. (2012) Improving the wear resistance of wheel-pair rims by plasma quenching Journal “Steel in Translation”, Vol.42 (6), pp.544-547, DOI:10.3103/S0967091212060083.

[4] E.A. Khalid, M.Farooque, Anvar ul Haq, A.Q. Khan (1999) Role of ferrite-pearlite banded structure and segregation on mechanical properties of microalloyed hot rolled steel, Materials Science and Technology 15(10):1209-1215, DOI: 10.1179/026708399101505121

[5] Astafurova E.G., Zaharova G.G., Naidenkin E.V. (2011) Structure and mechanical properties of 10G2FT low-carbon ferrite-pearlite steel after severe plastic deformation and subsequent high-temperature annealing, 14(3-4): 195-203, https://doi.org/10.1016/j.physme.2011.08.011.

[6] Smirnov I., Belin P., Epelfeld A. (2011) Plasma-electrolytic modification of the surface of metals and alloys. “World of materials and technologies”Press, 194-211.

[7]Mchedlov S.G. (2004) Improving the technology of plasma coatings in the strengthening and restoration of machine parts. Journal “Bulletin of SSTU "Technology and materials", 2(3):86-92.

[8] Bykov E.G., Efimov O.YU., Ivanov YU.F.(2010) Evolution of structural and phase states during the operation of rolling rolls. Journal “Bulletin of universities, series Ferrous metallurgy, 12:35-37.

[9] Nechaev V.P., Ryazancev A.A. (2012) Research, development and substantiation of possibilities for increasing the reliability of large-modular gears by plasma hardening of their surfaces. Journal “Advanced technology and machine equipment system”. 43:227-232.

[10] Levchenko G.V., Vorobey S.A., Nogovitsky A.V. (2004) Prediction and stabilization of the structure and properties of heat-strengthened reinforcing steel. Fundamental and applied problems of ferrous metallurgy. Collection of scientific works, issue 7, pp.138-145

[11]B. E. Q'Donnelly, R. L. Reuben, T. N. Baker (2013) Quantitative assessment of strengthening parameters in ferrite-pearlite steels from microstructural measurements, 11:45-51. DOI: 10.1179/030716984803274837.

[12] Makarov A.V., Pozdeeva N.A., Savray R.A. (2012)Improving the wear resistance of hardened structural steel by nanostructural friction treatment, Friction and wear, 33(6): 444-455.

[13] Kozlov E.V., Popova N.A., Zhuleikin S.G., Kovalenko V.V. (2003) Gradient structures of non-equilibrium pearlite in deformed steel. Journal “Physical mesomechanics”. 5:73-79.

[14] Tushinskiy L.I. (2004) Problems of modern materials science of the XXI century. Fundamental and applied problems of ferrous metallurgy. Collection of scientific works, , issue 7, p.23-49

[15] E. Anelli, M. Tivelli, A. Izquierdo, H. Quintanilla (2006) Effect of reel-laying simulation on mechanical performance of flowlines. International Pipeline conference, Calgary, Alberta, Canada. – p.1–10.

[16] Weng Y. (2009) Ultra-fine grained steels. – Berlin: Metallurgical Industry Press, Beijing and Springer-Verlag GmbH, p.588

[17] Degtyarev M.V., Chashchuhina T.I., Voronova L.M., Kopylov V.I. (2013) The correlation between the strain, hardness and size of the structural elements of iron and structural steels under a large plastic deformation in different ways. Journal “Physical mesomechanics”, vol. 16, no. 6, pp. 71–80.

[18] Shin D.H., Park K.-T. (2005) Ultrafine grained steels processed by equal channel angular pressing. Materials Science and Engineering A, vol. 410–411, pp. 299–302.

[19] Hirsch P. (1987) Distribution of dislocations and the mechanism of hardening of metals. Translated from English-M: Metallurgy, pp. 42-47.

[20] H.I. Aaronson, M.Enomoto and J.K. Lee. (2001) Mechanisms of Diffusional Phase Transformations in Metall and Alloys. New York, CRC Press. p.575. DOI: 10.1080/14786435.2020.1808255.

[21] Rodionova I.G., Mishnev P.A., BykovaYu.S. (2012) Influence of impurities on the degree of solid solution hardening of rolled products from low-carbon steel. Steel, No. 6, p.62-66

[22] TyurinYu.N., Kolisnichenko O.V., Tishchenko O.V. (2013) The structure and properties of the modified layer on the working surface of knives for cutting rolled products in metallurgical production. Hardening technologies and coatings. Vol. 3, p.28-35

[23] Martin J. W. (1983) Micromechanisms of precipitation hardening of alloys. Per. from English Moscow: Metallurgy, 168 p.

[24] Sidorenko O. G., Fedorova I. P., Sukhov A. P. (2012) Formation of the structure of reinforcing bars, thermally hardened by interrupted and intermittent hardening. Steel, No.1, pp.61-64.

МАЗМҰНЫ-СОДЕРЖАНИЕ-CONTENTS

Abishova A.S., Bokanova A.A., Kamardin A.I., Mataev U.M. , Meshcheryakova T.Y.
DEVELOPMENT OF OPTIMAL CONDITIONS FOR OBTAINING OZONE FOR DECONTAMINATION OF WAREHOUSE AIR..........6

Абсаметов Д.М., Рабат О.Ж., Байнатов Ж.Б., Жатканбаева Э.А., Тавшавадзе Б.Т.
МЕТОДЫ РАСЧЕТА НАДЕЖНОСТИ КОНСТРУКЦИИОГРАЖДЕНИИ ПОЛОС ВСТРЕЧНЫХ ДВИЖЕНИЙ ТРАНСПОРТА..........12

N. Dolzhenko, E Mailyanova, I.Assilbekova, Z.Konakbay
DESIGN FEATURES OF MODERN FLIGHT SIMULATION DEVICES, MOBILITY SYSTEMS AND VISUALIZATION SYSTEMS..........17

Donenbaev B.S., Sherov K.T., Sikhimbayev M.R., Absadykov B.N., Karsakova N.Zh.
USING ANSYS WB FOR OPTIMIZING PARAMETERS OF A TOOL FOR ROTARY FRICTION BORING..........22

Dzhalalov G.I., Kunayeva G.E. Moldabayev G.Zh.
FLUID INFLUX TO A BATTERY OF INCOMPLETE HORIZONTALLY BRANCHED WELLS IN DEFORMED FORMATION..........29

Elman Kh. Iskandarov
IMPROVING THE EFFICIENCY OF THE FUNCTIONING OF GAS PIPELINES, TAKING INTO ACCOUNT THE STRUCTURAL FEATURES OF GAS FLOWS..........34

Zhantayev Zh.Sh., Zholtayev G.Zh., Iskakov B., Gaipova A.
GEOMECHANICAL MODELING OF STRUCTURES OIL AND GAS FIELDS..........40

Faiz N.S., Satayev M.I., Azimov A.M., Shapalov Sh.K., Turguldinova S.A.
LOCAL MONITORING OF THE ENVIRONMENTAL SITUATION IN RESIDENTIAL AREAS WITH HIGH LEVELS OF ELECTROMAGNETIC RADIATION..........46

Fitryane Lihawa, Ahmad Zainuri, Indriati Martha Patuti, Aang Panji Permana, I Gusti N.Y. Pradana
THE ANALYSIS OF SLIDING SURFACE IN ALO WATERSHED, GORONTALO DISTRICT, INDONESIA..........53

Kaliyeva N.A., Akbassova A.D., Ali Ozler Mehmet, Sainova G.A.
ASSESSMENT OF LAND RESOURCE POTENTIAL AND SOLID WASTE RECYCLING METHODS..........59

Kanayev A.T., Jaxymbetova M.A., Kossanova I.M.
QUANTITATIVE ASSESSMENT OF THE YIELD STRESS OF FERRITE-PEARLITIC STEELS BY STRUCTURE PARAMETERS..........65

Kostenko V., Zavialova O., Pozdieiev S., Kostenko T., Vinyukov A.
SUBSTANTIATION OF DESIGN PARAMETERS OF COAL DUST EXPLOSION CONTAINMENT SYSTEM..........72

Космбаева Г.Т., Аубакиров Е.А., Тастанова Л.К., Орынбасар Р.О., Уразаков К.Р.
СИСТЕМЫ ОЦЕНКИ И УПРАВЛЕНИЯ РЕСУРСАМИ УГЛЕВОДОРОДОВ (PRMS)..........80

Kozbagarov R.A., Kamzanov N.S., Akhmetova Sh.D., Zhussupov K.A., Dainova Zh.Kh.
IMPROVING THE METHODS OF MILLING GAUGE ON HIGHWAYS..........87

Kozykeyeva A.T., Mustafayev Zh.S., Tastemirova B.E., Jozef Mosiej
SPECIFIC FEATURES OF FLOW FORMATION AND WATER USE IN THE
CATCHMENT AREAS IN THE TOBOL RIVER BASIN..........94

Khizirova M.A., Chezhimbayeva K.S., Mukhamejanova A.D., Manbetova Zh.D., Ongar B.
USING OF VIRTUAL PRIVATE NETWORK TECHNOLOGY FOR SIGNAL
TRANSMISSION IN CORPORATE NETWORKS..........100

Marynych I., Serdiuk O., Ruban S., Makarenko O.
PRESENTATION OF CRUSHING AND GRINDING COMPLEX AS
SYSTEM WITH DISTRIBUTED PARAMETERS FOR ADAPTIVE CONTROL
OF ORE DRESSING PROCESSES..........104

Novruzova S.G., Fariz Fikret Ahmed, E.V. Gadashova
CAUSES AND ANALYSIS OF WATER ENCROACHMENT OF SOME
OFFSHORE FIELDS PRODUCTS OF AZERBAIJAN..........112

Rakhadilov B.K., Buitkenov D.B., Kowalewski P.,
Stepanova O.A., Kakimzhanov D.
MODIFICATION OF COATINGS BASED ON Al2O3 WITH
CONCENTRATED ENERGY FLOWS..........118

Tergemes K.T., Karassayeva A. R., Sagyndikova A. Zh,
Orzhanova Zh.K., Shuvalova E
STABILITY OF ANONLINEAR SYSTEM «FREQUENCY
CONVERTER-ASYNCHRONOUS MOTOR»..........124

Chyrkun D., Levdanskiy A., Yarmolik S., Golubev V., Zhumadullayev D.
INTEGRATED STUDY OF THE EFFICIENCY OF GRINDING MATERIAL
IN AN IMPACT-CENTRIFUGAL MILL..........129

Publication Ethics and Publication Malpractice in the journals of the National Academy of Sciences of the Republic of Kazakhstan

For information on Ethics in publishing and Ethical guidelines for journal publication see http://www.elsevier.com/publishingethics and http://www.elsevier.com/journal-authors/ethics.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see http://www.elsevier.com/postingpolicy), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service http://www.elsevier.com/editors/plagdetect.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

Правила оформления статьи для публикации в журнале смотреть на сайтах:

www:nauka-nanrk.kz

http://www.geolog-technical.kz/index.php/en/

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Редакторы: *М. С. Ахметова, Р. Ж. Мрзабаева, Д. С. Аленов*
Верстка на компьютере *В.С. Зикирбаева*

Подписано в печать 15.06.2021.
Формат 60х881/8. Бумага офсетная. Печать – ризограф.
4,6 п.л. Тираж 211. Заказ 3.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-18, 272-13-19