

ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ  
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ  
ТОРАЙҒЫРОВ УНИВЕРСИТЕТА

---

**ҚАЗАҚСТАН ҒЫЛЫМЫ  
МЕН ТЕХНИКАСЫ**

2001 ЖЫЛДАН БАСТАП ШЫҒАДЫ



**НАУКА И ТЕХНИКА  
КАЗАХСТАНА**

ИЗДАЕТСЯ С 2001 ГОДА

ISSN 2788-8770

№ 3 (2025)

---

ПАВЛОДАР

**Тусупова С. О., Кузьминова Н. Ю., Янюшкин А. С.,  
Исабек З. Р., Сулейменов А. Д.**

Жоғары жылдамдықты фрезерлеу кезінде қиын өңделетін материалдардың беткі қасиеттеріне әсерін зерттеу

**Чукенова Э. С., Нұрман Е. З., Мустафа А. Қ.,  
Хошнау Ф., Дюсебаев И. М.**

Белсенді және инертті газдардың WAAM технологиясы арқылы өндірілген болаттың микроқұрылымына әсері

**Шеров К. Т., Бердімұратова Д. И., Сағитов А. А.,  
Мусаев М. М., Турусбекова А.**

3D-принтерде FDM әдісімен жасалған гидравликалық машинаның «Білік-тістегеріш» бөлігінің беріктігін зерттеу

**МЕТАЛЛУРГИЯ  
МЕТАЛЛУРГИЯ  
METALLURGY**

**Abildina A. R.**

Study of the effect of molybdenum on the properties of the Co-Cr-Fe-Ni-Mn-Nb QHEA

**Акбердин А. А., Ким А. С., Султангазиев Р. Б.,  
Орлов А. С., Адамова Г. Х.**

Математическая модель диаграммы фазового состава системы Ni-B-Si

**Богомоллов А. В., Жунусов А. К., Кажмухамбетов Ж. Б.,  
Спанов С. С., Жунусова А. К.**

Совершенствование технологии прокатного передела помольных шаров диаметром 125 мм

**Burumbayev A., Akhmetov A., Zhakan A.,  
Myngzhassar Ye., Yucel O.**

Research of the electrical resistance of charge materials for the synthesis of silicon carbide

**Yerzhan A., Issagulova D. A., Okishev K. Yu., Kovaleva T. V.**

Application of ferroalloy production waste as deoxidising agent in steel production

**Kassymova D. B., Sapinov R. V., Adilkanova M. A.**

Selection of optimal cyanide leaching modes for gold from ore deposits in the Republic of Kazakhstan

**Kulikov V. Yu., Baiseitova Y. A., Tulegenova Sh. N., Kovalev P. V.**

Study of energy aspects of cold briquetting for SHH15 steel dust under varying press conditions

**Қызатова Е. А., Қызатов А. С., Айдарова М. Т.,  
Курбанбеков Ш. Р., Баятанова Л. Б.**

Исследование влияния механоактивации на структуру композитов WC-Fe и WC-Ni

**Лопатин В. Ю., Жолдубаева Ж. Д., Арыстанова Д. М.**

Темір тотығы қабыршағының қалпына келтіру әдістерінің салыстырмалы талдауы: кептіргеннен кейінгі және тотықтырылғаннан кейінгі

**Omarov Zh. M., Zhakanov A. N., Yelmuratova A. F.,  
Kaliyeva O. K., Dashzeveg D.**

Use of waste from metallurgical enterprises for the production  
of dry construction mixtures

**Сариев О. Р., Алмагамбетов М. С., Нургали Н. З.,  
Келаманов Б. С., Әбдірашит А. М.**

Отработка способов брикетирования пыли от дробления  
высокоуглеродистого феррохрома

**Туганбаева А. А., Аринова С. К., Квон Св. С., Исагулов А. З.**

Термодинамическое моделирование фазовых превращений  
в стали 40ХНЗМФ при различной модификации

### **КӨЛІК ТРАНСПОРТ TRANSPORT**

**Мухаметжанова А. В., Жандарбекова А. М., Мурзабекова К. А.,  
Қуанышбекова Қ. Қ., Искаков Д. С.**

Көлік саласының технологиялық трансформациясы:  
жасанды интеллектінің мүмкіндіктері

**Rakisheva A. A., Kokin S. B., Yessaulkov V. S.,  
Petr Bouchner, Abishev K. K.**

On the problem of designing a vehicle with hybrid propulsion

**Сауханов Н. С., Имагамбетов М. Б., Ордабаева Г. М.,  
Жаманбаев Б. У., Мырзабеков Н. М.**

Реттелетін қиылыста адаптивті басқару макеті

**Тулепбек Н. Т., Оралбекова А. О., Ахметов Б. С.**

Темір жол көлігіндегі маршал станцияларын басқаруды компьютерлендіру

**Шукаманов Ж. Е., Сүлейменова Г. А., Павлов С.**

Пойыздар қозғалысын интервалды реттеудің әртүрлі жүйелерінде  
аралықтың өткізу қабілетін модельдеу

### **ҚҰРЫЛЫС СТРОИТЕЛЬСТВО CONSTRUCTION**

**Никитин В. А., Саканов К. Т., Макашев К. Т.**

Трещиностойкость и деформативность балок  
из тяжелого бетона и сталефибробетона

**Свидерская Д. С., Мазина Ю. И., Лебедева М. С.**

Архитектура как искусство создания общественных пространств  
с точки зрения эстетики и функциональности

SRSTI 53.37.31

DOI

**\*A. R. Abildina<sup>1</sup>**<sup>1</sup>Abylkas Saginov Karaganda Technical University,  
Republic of Kazakhstan, Karaganda<sup>1</sup>ORCID: <https://orcid.org/0009-0001-1705-1352>\*e-mail: [aizhan--1984@mail.ru](mailto:aizhan--1984@mail.ru)**STUDY OF THE EFFECT OF MOLYBDENUM  
ON THE PROPERTIES OF THE CO-CR-FE-NI-MN-NB QHEA**

*This study investigates the effects of varying molybdenum concentrations (5%, 10 %, and 15 %) on the microstructural features, hardness, and melt fluidity of quasi-high-entropy alloys (QHEAs) within the Co-Cr-Fe-Ni-Mn-Nb system. The primary objective is to reduce production costs of advanced alloys by partially replacing pure elemental constituents with ferroalloys. Experimental ingots were synthesized via induction melting, followed by characterization through scanning electron microscopy (SEM), Brinell hardness testing, and spiral fluidity assessments. Results indicate that increasing Mo content markedly enhances hardness – approaching a threefold increase at 15 % Mo – attributable to solid-solution strengthening and probable intermetallic phase formation. However, elevated molybdenum levels negatively affect melt fluidity, with a reduction of approximately 12 % observed at Mo contents between 10 % and 15 %, leading to casting defects. These findings emphasize the importance of optimizing molybdenum concentration to achieve an optimal balance between mechanical performance and castability. For components with complex geometries, maintaining Mo content below 10 % is advisable. This work contributes to the development of cost-effective QHEAs suitable for precision casting using locally sourced materials.*

*Keywords: quasi-high-entropy alloy, melt fluidity, molybdenum, hardness, microstructure, casting, ferroalloy.*

**Introduction**

Since the early 2000s, the field of alloy development has increasingly emphasized multicomponent systems based on the high-entropy alloy (HEA) concept, establishing HEAs as a novel class of advanced metallic materials. Among these, the equiatomic five-element Cantor alloy (Co-Cr-Fe-Ni-Mn) [1; 3] stands out as one of the most extensively studied, exhibiting remarkable mechanical properties, including an ultimate tensile strength of 491 MPa, yield strength of 292 MPa, and ductility reaching elongations up to 50 %. Such a unique combination of strength and ductility is uncommon in conventional alloy systems.

Despite these advantages, the practical application of HEAs is frequently constrained by high production costs, largely attributed to the necessity of using high-purity elemental feedstock. Strategies aimed at cost reduction involve streamlining manufacturing processes or substituting expensive raw materials with more economical alternatives.

Within this context, the emergence of quasi-high-entropy alloys (QHEAs) has garnered significant attention [2; 3; 4].

Previous studies [4; 5] have validated the feasibility of synthesizing QHEAs through partial replacement of pure elements with ferroalloys. Additionally, alloying with elements such as niobium (Nb) has demonstrated marked improvements in both strength and wear resistance relative to the baseline Cantor alloy. Investigations detailed in [6, p. 3] have further explored the impact of processing conditions on the fluidity of QHEAs in the Co-Cr-Fe-Ni-Mn-Nb system, revealing that Nb additions tend to diminish melt fluidity, likely due to the formation of secondary phases.

The influence of molybdenum (Mo) as an additional alloying constituent in Cantor-type systems has been examined in prior research [7; 8]. Due to its comparatively large atomic radius, Mo induces significant lattice distortions, thereby enhancing hardness. Acting as an effective solid-solution strengthener, molybdenum impedes dislocation motion, which translates into improved resistance to plastic deformation and increased mechanical strength.

However, these mechanical enhancements are often accompanied by a reduction in casting fluidity, since materials with elevated strength typically exhibit lower melt flowability. For the production of precision cast components, achieving an optimal balance between mechanical properties and castability necessitates meticulous control of Mo content, taking into account its effects on melt viscosity and phase stability.

#### Materials and methods

The present study focuses on examining how different molybdenum concentrations (5 %, 10 %, and 15 %) influence the hardness, microstructure, and melt fluidity of quasi-high-entropy alloys (QHEAs) based on the Co-Cr-Fe-Ni-Mn-Nb system.

For alloy synthesis, the charge mixture comprised ferromanganese (FeMn80C05), ferrochrome (grade FK005), electrolytic nickel (N1 grade), metallic cobalt (K1AU grade), ferroniobium (FNb60 grade), and ferromolybdenum (FМо60 grade). The chemical composition of each input component was determined using a NITON XL2-100G (USA) portable X-ray fluorescence analyzer and a SPAS-05 spectrometer (Russia). The obtained elemental compositions are summarized in Table 1.

Table 1 – Chemical analysis of the charge component composition

Element, wt.%	Mn	Nb	Fe	Cr	Ni	Co	Mo	C	Si	P	S
FeMn80C05	75,1	-	25,2	-	-	-		0,1	1,85	up to 0,3	up to 0,03
ФХ001А	-	-	32,04	68,2	-	-		0,01	0,82	up to 0,02	up to 0,02
ФН660	-	62	35,5	-	-	-		0,3	1,8	0,04	0,05
Ni H-1y	-	-	-	-	99,95			0,01	0,002	0,001	0,001
Co K1Ay	0,03	-	0,2	-	-	99,3		0,02		0,003	0,004
ФМо60	-	-	38,8	-	-	-	60,2	0,08	0,8	0,05	0,01

The charge formulation was designed to obtain target molybdenum concentrations of 5%, 10%, and 15%, while keeping the contents of the remaining alloying elements approximately balanced. The majority of the raw materials (about 90%) had a particle size in the range of 2-3 mm. The particle size distribution was assessed using an AS 200 control analytical sieve shaker (Retsch, Germany). Following sieving, the charge components were uniformly mixed for 15 minutes in a Schatz laboratory mixer to ensure compositional homogeneity.

The alloy ingots were fabricated via double remelting in an induction furnace under ambient atmospheric conditions. The second melting stage was conducted specifically to improve structural uniformity and minimize chemical segregation within the ingot.

To evaluate melt fluidity, a spiral casting test was performed (Figure 1). The spiral mold featured a triangular cross-section measuring 15 mm in height and 10 mm in width, resulting in a cross-sectional area of 75 mm<sup>2</sup>. The experimental setup consisted of the following elements: 1 – gating cup, 2 – mesh filter, 3 – riser, 4 – sump, 5 – spiral channels, and 6 – calibration protrusions. In order to accurately determine the flow length, notches were pre-machined into the mold at 50 mm intervals along the spiral, which subsequently formed raised markers on the castings, simplifying length measurement.

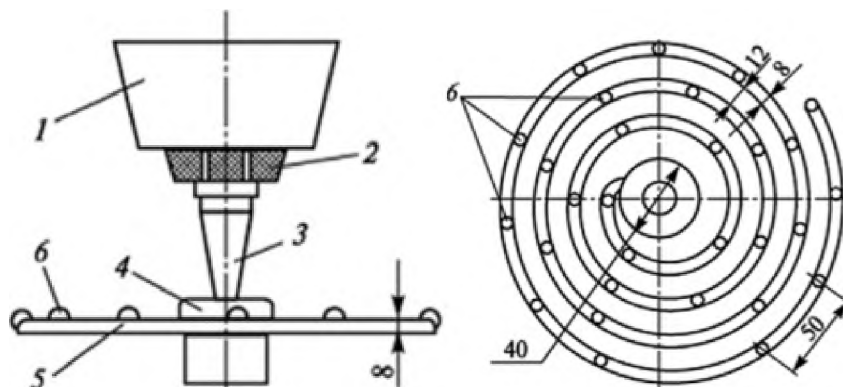


Figure 1 – Spiral test for determining the fluidity of the alloy [9]

The chemical compositions of the experimental alloys are summarized in Table 2. Sample № 0, which does not contain molybdenum, served as the reference material for comparative analysis.

Table 2 – Chemical composition of the studied samples

Sample	Co	Cr	Fe	Ni	Mn	Nb	C	Mo	Si	P	S
0	16.94	16.82	18.50	16.73	16.53	14.23	0.23	-	0,002	trace	trace
1	15.64	15.67	18.02	16.02	15.28	14.20	0.28	4.86	0,003	trace	trace
2	14.12	14.84	17.95	14.28	15.15	14.33	0.28	9.05	0,002	trace	trace
3	13.29	13.127	17.42	13.08	14.52	14.02	0.29	14.25	0,003	trace	trace

### Results and discussion

Figure 1 illustrates the microstructural features of the investigated alloy samples. Metallographic preparation was conducted in accordance with standard procedures. The specimens were sectioned using a Struers Discotom precision cutter, followed by mounting, grinding, and polishing carried out on a Struers Planopol system, employing a series of abrasive papers with decreasing grit size to achieve a mirror-like surface finish.

Subsequent to mechanical preparation, the samples were degreased and subjected to chemical etching at ambient temperature (20–25 °C) for periods ranging from 10 to 60 seconds, enabling clear visualization of microstructural details. The etched surfaces were examined using a scanning electron microscope (SEM), model S-3400N.

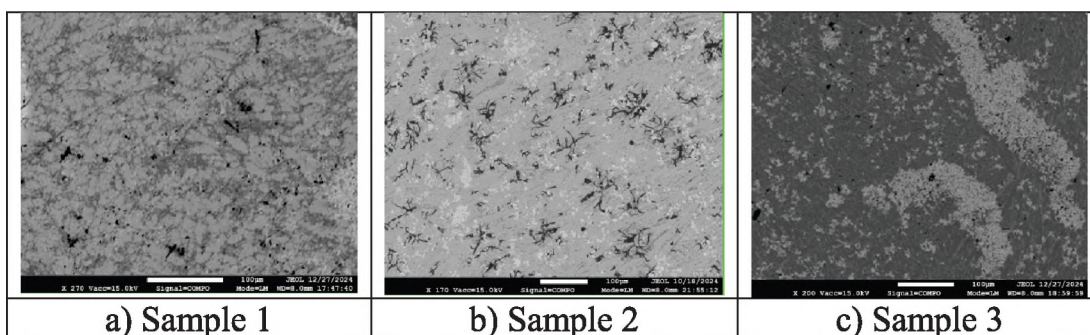


Figure 2 – Microstructures of the experimental samples

Microstructural analysis demonstrated that at a molybdenum concentration of 5 wt.% (Figure 2a), the alloy exhibits a relatively homogeneous structure characterized by fine, uniformly distributed grains, indicative of stable solidification conditions and limited elemental segregation. Upon increasing the Mo content to 10 wt.% (Figure 2b), microstructural heterogeneities begin to emerge, including the presence of darker inclusions and localized Mo enrichment, which may point to the formation of intermetallic phases or second-phase particles. At the highest investigated Mo level of 15 wt.% (Figure 2c), the alloy's microstructure becomes markedly inhomogeneous, with pronounced segregation phenomena, likely resulting from decreased solubility limits and incomplete diffusion during solidification. It is important to note that comprehensive phase analysis and crystallographic identification were not conducted within the scope of this investigation.

Hardness properties were evaluated using a Willson 1150 durometer under standard testing conditions. For each sample, a minimum of five indentations were performed, and the mean values were calculated to ensure statistical reliability. The hardness data are compiled in Table 3 and illustrate the influence of increasing Mo content on mechanical strength.

For fluidity assessment, specialized cast samples were prepared under controlled conditions. Alloys of designated compositions (Table 2) were melted and superheated to a processing temperature of 1700 °C, exceeding the liquidus temperature by approximately 100 °C to ensure complete dissolution and adequate fluidity. The molten

alloy was poured through the gating system (Figure 1) into a mold containing a spiral channel designed to quantify casting fluidity. After full solidification and cooling to ambient temperature, the spiral castings were extracted. The effective flow length was measured with a precision of  $\pm 0.5$  mm by summing the number of calibration marks (spaced every 50 mm) and the remaining distance beyond the final mark. The quantified fluidity lengths are presented in Table 3 and reflect the effect of molybdenum on melt flow behavior.

Table 3 – Obtained data on hardness and fluidity of the samples

Sample	Hardness, HV	Fluidity, mm
0	245	124
1	484	122
2	641	119
3	691	109

The data summarized in Table 3 clearly indicate that incorporating molybdenum within the examined concentration range exerts a significant strengthening effect on the experimental alloys, with hardness values increasing by over 2.5 times relative to the Mo-free reference. Conversely, this enhancement in mechanical strength is accompanied by a noticeable reduction in melt fluidity. Specifically, at Mo levels up to 10 %, the decrease in fluidity is marginal, approximately 4 %, which correlates with improved mold filling efficiency and a reduction in casting defects within the spiral channels. However, when the Mo content reaches 15 %, a more pronounced decline in fluidity – around 12 % – is observed, characterized by slower progression of the molten metal through the test channel and the emergence of porosity and voids. These phenomena suggest an increase in melt viscosity and impaired flow behavior at elevated molybdenum concentrations.

The observed deterioration in fluidity likely stems from either the nucleation of novel refractory intermetallic compounds not present at lower Mo levels or from the increased volume fraction of previously identified intermetallic phases. To comprehensively elucidate the mechanisms underlying the simultaneous increase in hardness and decrease in fluidity, further in-depth phase characterization employing techniques such as X-ray diffraction or transmission electron microscopy is warranted.

### Conclusions

The present study demonstrates that molybdenum exerts a pronounced influence on the properties of quasi-high-entropy alloys (QHEAs) within the Co-Cr-Fe-Ni-Mn-Nb system. Incorporation of Mo at levels ranging from 5 to 15 wt.% significantly alters the microstructure and leads to a considerable increase in alloy hardness, while concurrently causing a reduction in melt fluidity. Notably, fluidity degradation remains minimal – approximately 4 % – for Mo contents up to 10 %, whereas a more substantial decline of about 12 % is observed at 15 % Mo. This effect must be carefully considered during the optimization of casting parameters. For components featuring complex geometries,

it is recommended to restrict molybdenum content to 10% or alternatively adjust the pouring temperature to compensate for the reduced fluidity.

In summary, molybdenum additions provide beneficial mechanical strengthening to QHEAs; however, to maintain acceptable casting performance, the Mo concentration should ideally not exceed 15 %.

#### **Information of funding**

The work was carried out within the framework of the implementation of the IRN Program BR21882240 «Developing a quasi-high-entropy alloy using Kazakhstani raw materials and technology of producing precision parts based on it» (agreement with the Committee of Science of the Ministry of Education and Science of the Republic of Kazakhstan No. 378-PTsF-23-25 dated November 15, 2023), funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan.

#### REFERENCES

- 1 **Cantor, B., Chang, I. T., Knight, P., Vincent, A. J. B.** Microstructural development in equiatomic multicomponent alloys // *Materials Science and Engineering*. – 2004. – Vol. 375–377. – P. 213–218. – <https://doi.org/10.1016/j.msea.2003.10.257>
- 2 **Bazlov, A., Stochko, I., Ubyivovk, E., Parkhomenko, M., Magomedova, D., Zanaeva, E.** Structure and Properties of Amorphous Quasi-High-Entropy Fe-Co-Ni-Cr-(Mo,V)-B Alloys with Various Boron Content // *Metals*. – 2023. – Vol. 13. – <https://doi.org/10.3390/met13081464>
- 3 **Yang, L., Li, Y., Wang, Z., Zhao, W., Qin, C.** Nanoporous Quasi-High-Entropy Alloy Microspheres // *Metals*. – 2019. – № 9. – P. 345. – <https://doi.org/10.3390/met9030345>
- 4 **Kvon, S., Issagulov, A., Kulikov, V., Arinova, S.** Niobium's Effect on the Properties of a Quasi-High-Entropy Alloy of the CoCrFeMnNi System // *Metals*. – 2024. – Vol. 14. – P. 564. – <https://doi.org/10.3390/met14050564>
- 5 **Kvon, S., Issagulov, A., Kulikov, V., Arinova, S.** The use of ferroalloys for the smelting of a quasi-high-entropy alloy // *CIS Iron and Steel Review*. – Moscow: Ore and Metals, 2024. – Vol. 26. – № 2. – P. 21–25. – <https://doi.org/10.17580/cisisr.2024.02.04>
- 6 **Issagulov, A. Z., Kulikov, V. Yu., Kvon, S. S., Tulegenova, Sh. N.** Influence of melting technological regimes on the mechanical properties of quasi-high-entropy alloys // *Foundry Production*. – Moscow: Publishing House «Foundry», 2024. – № 4. – P. 2–4.
- 7 **Liu, W., Lu, Z., He, J., Luan, J., Wang, Z., Liu, B., Liu, Y., Chen, M., Liu, C.** CoCrFeNiMox high entropy alloys strengthened by hard intermetallic phases // *Acta Materialia*. – 2016. – Vol. 111. – P. 332–342.
- 8 **Sanin, V. N., Ikornikov, D. M., Golosova, O. A., Andreev, D. E., Yuhvid, V. I.** Centrifugal SHS Metallurgy of Cast Co-Cr-Fe-Ni-Mn High-Entropy Alloys Strengthened by Precipitates Based on Mo and Nb Borides and Silicides // *Physical Mesomechanics*. – 2021. – Vol. 24. – № 6. – P. 692–700. – <https://doi.org/10.1134/S1029959921060072>

9 ГОСТ 16438–70. Формы песчаные и металлические для получения образцов для испытаний металлов на текучесть. – Введ. 1972-01-01. – М.: ИПК «Стандарты», – 1999. – С. 692.

10 Gludovatz, B., George, E. P., Ritchie, R. O. Processing, Microstructure and Mechanical Properties of the CrMnFeCoNi High-Entropy Alloy // JOM. – 2015. – Vol. 67. – № 10. – P. 2262–2270. – <https://doi.org/10.1007/s11837-015-1589-z>.

Received 07.08.25.

Received in revised form 07.08.25.

Accepted for publication 13.08.25.

\*А. Р. Абильдина<sup>1</sup>

<sup>1</sup>Әбілқас Сағынов атындағы Қарағанды техникалық университеті,  
Қазақстан Республикасы, Қарағанды қ.

07.08.25 ж. баспаға түсті.

07.08.25 ж. түзетулерімен түсті.

13.08.25 ж. басып шығаруға қабылданды.

#### СО-CR-FE-NI-MN-NB ЖҮЙЕСІНІҢ ҚЖЭҚ ҚАСИЕТТЕРІНЕ МОЛИБДЕННІҢ ӘСЕРІН ЗЕРТТЕУ

*Бұл жұмыста Со-Cr-Fe-Ni-Mn-Nb жүйесіндегі квазижогарыэнтропиялы қорытпаларға (ҚЖЭҚ) молибденнің (5 %, 10 % және 15 %) мөлшерінің микроқұрылымға, қаттылыққа және ағындылыққа әсері зерттелді. Зерттеу мақсаты - таза металдарды ферроқорытпалармен ішінара алмастыру арқылы жоғары тиімді қорытпаларды арзандату. Эксперименттік үлгілер индукциялық балқыту әдісімен алынған, олардың құрылымы сканерлеуші электронды микроскопия, қаттылықты өлшеу және спиральды арнада ағындылыққа сынау арқылы зерттелді. Нәтижелерге сәйкес, молибден қоспасы қорытпаның қаттылығын айтарлықтай арттырады – 15% Мо кезінде қаттылық шамамен үш есеге өсті, бұл қатты ерітіндінің беріктігінің артуымен және, мүмкін, интерметаллдық фазалардың түзілуімен түсіндіріледі. Алайда, молибденнің артық мөлшері қорытпаның ағындылығын төмендетеді: 10 % дейін ағындылық өзгерісі аз (4 %), ал 15 % Мо кезінде ағындылық 12 % төмендеп, құймада ақаулар байқалды. Сондықтан күрделі пішінді құймаларды жасау үшін Мо мөлшерін 10 % асырмаған жөн. Бұл жұмыс Қазақстандық шикізатты пайдалана отырып дәлме-дәл құюға арналған тиімді ҚЖЭҚ жасауда маңызды үлес қосады.*

*Кілтті сөздер: квазижогарыэнтропиялық қорытпа, ағындылық, молибден, қаттылық, микроқұрылым, құйма, ферроқорытпа.*

\*А. Р. Абильдина<sup>1</sup>

<sup>1</sup>Карагандинский технический университет имени Абылкаса Сагинова,  
Республика Казахстан, г. Караганда  
Поступило в редакцию 07.08.25.  
Поступило с исправлениями 07.08.25.  
Принято в печать 13.08.25.

## ИССЛЕДОВАНИЕ ВЛИЯНИЯ МОЛИБДЕНА НА СВОЙСТВА КВЭС СО-CR-FE-NI-MN-NB

*В данном исследовании изучается влияние различного содержания молибдена (5%, 10% и 15%) на микроструктуру, твердость и жидкотекучесть расплава квазивысокоэнтропийных сплавов (КВЭС) системы Co-Cr-Fe-Ni-Mn-Nb. Основная цель – снижение стоимости производства высокопрочных сплавов за счёт частичной замены чистых металлических компонентов ферросплавами. Экспериментальные слитки были получены методом индукционного плавления и охарактеризованы с помощью сканирующей электронной микроскопии (СЭМ), измерения твердости по методу Бринелля и тестов на текучесть по спиральной форме. Результаты показали, что увеличение содержания молибдена значительно повышает твердость – почти в три раза при 15 % Мо – что связано с упрочнением твёрдым раствором и вероятным образованием интерметаллических фаз. Вместе с тем, повышение содержания Мо отрицательно сказывается на текучести расплава: при содержании молибдена от 10 % до 15 % наблюдается снижение текучести примерно на 12 %, что приводит к появлению дефектов отливки. Полученные данные подчёркивают необходимость оптимизации концентрации молибдена для достижения баланса между механическими свойствами и литейными характеристиками. Для отливок сложной формы рекомендуется ограничивать содержание Мо уровнем не выше 10 %. Работа способствует разработке экономически эффективных КВЭС, пригодных для точного литья с использованием казахстанских сырьевых ресурсов.*

*Ключевые слова:* квазивысокоэнтропийный сплав, жидкотекучесть, молибден, твердость, микроструктура, отливка, ферросплав.