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Articles are published in Uzbek, Russian, and English, ensuring a wide-reaching audience and fostering cross-cultural academic exchange. As a beacon of academic excellence, the "Journal of Transport" continues to serve as a vital conduit for knowledge dissemination, collaboration, and innovation in the transport sector and related fields.

Development of a technology for producing coarse-grained tungsten carbide powders

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Abstract:

This paper investigates the technology for manufacturing hard-alloy cutting teeth intended for mining excavation machines. The main objective of the study is to develop a coarse-grained tungsten carbide-based hard alloy with enhanced wear resistance and operational performance for efficient cutting of potash salt rocks. The macrostructure and microstructure of the obtained alloys were examined using metallographic microscopy, while phase composition was determined by X-ray diffraction analysis. Mechanical properties were evaluated using standard hardness and strength testing methods. As a result, a technology for producing hard-alloy tool materials of various shapes and dimensions based on coarse-grained tungsten carbide was developed. An optimal composition of a cobalt–nickel bonded hard alloy for RS-14 type cutting tools was proposed. The obtained results demonstrated that the developed material possesses high wear resistance and improved operational efficiency during the cutting of potash salt formations, making it suitable for application in mining equipment operating under severe abrasive conditions.

Keywords:

tungsten carbide, hard alloy, cobalt–nickel binder, carburization, synthesis, microstructure, wear resistance, mining cutters, potash salt rocks, cutting tools

Yirik donadorli volfram karbid kukunlarini olish texnologiyasini ishlab chiqish

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Annotatsiya:

Ushbu maqolada konchilik sanoatida qo‘llaniladigan qazish mashinalari keskichlari uchun mo‘ljallangan qattiq qotishmali tishlarni tayyorlash texnologiyasi tadqiq etilgan. Tadqiqotning asosiy maqsadi kaliyli tuz jinslarini samarali parchalash imkonini beruvchi, yuqori yeyilishga chidamli va ekspluatatsion xossalarga ega bo‘lgan yirik donadorli volfram karbidi asosidagi qattiq qotishma tarkibini ishlab chiqishdan iborat. Tadqiqot jarayonida qotishmalarning makro va mikrostrukturasi metallografik mikroskoplar yordamida o‘rganildi, fazaviy tarkibi rentgenostruktura tahlili orqali aniqlandi hamda mexanik xossalari standart sinov usullari asosida baholandi. Natijada yirik donadorli volfram karbidi asosida turli geometrik shakl va o‘lchamdagi qattiq qotishmali asbob materiallarini olish texnologiyasi ishlab chiqildi. Tadqiqotlar asosida RS-14 turdagi keskichlar uchun kobalt-nikel bog‘lovchili qattiq qotishmaning optimal tarkibi tavsiya etildi. Olingan natijalar ishlab chiqilgan materialning kaliyli tuz jinslarini kesish jarayonida yuqori yeyilishga chidamlilik va ekspluatatsion samaradorlikka ega ekanligini ko‘rsatdi.

Kalit so‘zlar:

volfram karbidi, qattiq qotishma, kobalt-nikel bog‘lovchi, karbidlash, sintezlash, mikrostruktura, yeyilish, kon mashinalari keskichlari, kaliyli tuz jinslari

1. Kirish

Bugungi kunda dunyo miqyosida tog‘-kon sanoatida qo‘llaniladigan qazish mashinalarining keskichlarini qattiq qotishmalar asosida ishlab chiqarish, keskichlarning ishlash muddatini oshirish, fizik-mexanik va ekspluatatsion ko‘rsatkichlarini yaxshilash ustida olib borilayotgan tadqiqotlar mavzuning dolzarbligini ko‘rsatadi. Bu borada kaliyli tuz jinslarini samarali parchalovchi qattiq qotishmali

tishlarni volfram karbidi asosida ishlab chiqarish va ularni sohaga qo‘llash muhim ahamiyat kasb etadi.

Jahonda tuz konlarida qo‘llaniladigan qazish mashinalari keskichlarining qattiq qotishmali tishlarining fizik-mexanik va ekspluatatsion xossalari oshirish hamda yangi qotishma tarkiblarini ishlab chiqish bo‘yicha keng ko‘lamda ilmiy-tadqiqot ishlari olib borilmoqda. Shu bilan bir qatorda qattiq qotishmali keskich materiallarining tarkibini ishlab chiqish va ularning mexanik xossalari oshirish, ularning fizik-mexanik va ekspluatatsion

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xossalarni yaxshilaydigan volfram karbidi bilan bog'lovchi komponentlarini ishlab chiqish texnologiyalarni yaratish muammosi dolzarb ahamiyat kasb etmoqda. Bu borada respublikada volfram karbidi asosida qattiq qotishmali tishlarni ishlab chiqarish, jumladan, konlarda qo'llaniladigan qazish mashinalari keskichlari uchun kaliyli tuz jinslarini samarali parchalaydigan, yuqori fizik-mexanik va ekspluatatsion xossalarga ega bo'lgan yirik donadorli volfram karbidi asosidagi qattiq qotishmali tishlarni ishlab chiqarish dolzarb masala bo'lib qolmoqda.

Respublikada ishlatilayotgan konlarda qo'llaniladigan qazish mashinasi keskichlarining mustahkamligi va yeyilishbardoshlilikini oshirishga qaratilgan chora-tadbirlarda, shuningdek 2017-2021 yillarda O'zbekiston Respublikasini yanada rivojlantirish bo'yicha Harakatlar strategiyasida, jumladan «makroiqtisodiy barqarorlikni mustahkamlash va yuqori iqtisodiy o'sish sur'atlarini saqlab qolish, milliy iqtisodiyotning raqobatbardoshligini oshirish, iqtisodiyotda energiya va resurslar sarfini kamaytirish, ishlab chiqarishga energiya tejaydigan texnologiyalarni keng joriy etish» kabi vazifalar belgilangan. Ushbu vazifalarni amalga oshirish, jumladan konlarda qo'llaniladigan qazish mashinalari keskich tishlari materiallarining yangi tarkibini volfram karbidi asosida ishlab chiqish va uni olish texnologiyasini ishlab chiqish asosiy vazifalardan biri hisoblanadi.

O'zbekiston Respublikasi Prezidentining 2017 yil 7 fevraldagi

PF-4947-son «O'zbekiston Respublikasini yanada rivojlantirish bo'yicha harakatlar strategiyasi to'g'risida»gi Farmoni, 2016 yil 26 dekabrda

PQ-2698-son «2017-2019 yillarda tayyor mahsulot turlari, butlovchi buyumlar va materiallar ishlab chiqarishni mahalliy lashtirishning istiqbolli loyihalarini amalga oshirishni davom ettirish chora-tadbirlari to'g'risida», 2018 yil 27 apreldagi PQ-3682-son «Innovatsion g'oyalar, texnologiyalar va loyihalarini amaliy joriy qilish tizimini yanada takomillashtirish chora-tadbirlari to'g'risida» gi Qarorlari hamda mazkur faoliyatga tegishli boshqa me'yoriy-huquqiy hujjatlarda belgilangan vazifalarni amalga oshirishga ushbu dissertatsiya tadqiqoti muayyan darajada xizmat qiladi [1,2,3].

2. Tadqiqot metodologiyasi

«Yirik donadorli volfram karbid kukunlarini olish texnologiyasini ishlab chiqish» deb nomlangan maqolamizda volfram kukunini uglerod kukuni bilan karbidlash nazariy asoslarining tahliliga, volfram va uglerod kukunlarining aralashmasidan sof elementlardan sintezlash usulida yirik donadorlikka ega bo'lgan volfram karbid kukunlarini olish texnologiyasini ishlab chiqish, texnologik jarayon haroratini, vaqt davomiyligini WC kukunining struktura-fazalar tarkibiga, donadorligiga, zarracha o'lchami va shakliga hamda tarkibidagi bog'langan va erkin uglerod miqdoriga ta'sirini tadqiq qilish natijalariga bag'ishlangan [4,5].

Hisoblar shuni ko'rsatdiki, o'lchami 10 mkm bo'lgan volfram zarrachaga 1900oS haroratda gaz fazadan uglerodning statsionar diffuziyasida uglerodning diffuzion oqimi $6,01 \cdot 10^{-11}$ g/(sm²·s) tashkil etgan, haroratning 2500oS ga o'tishi uglerodning volframdagi diffuzion oqimini 1339 marta oshirgan va $4,15 \cdot 10^{-8}$ g/(sm²·s) tashkil etgan. Shuningdek, uglerodning 1900oS haroratda

volframga nostatsionar diffuziyasida o'lchami 10 mkm bo'lgan zarrachaning to'liq WC hosil bo'lib, karbidlanish vaqti 3,206 soniyani tashkil etishi ko'rsatib berilgan [6,7].

Uglerodning volframga statsionar diffuziyasi uchun uglerodning diffuzion oqimini hisoblashda Fik qonunining sharsimon yuzalar uchun mo'ljallangan formulasidan foydalanildi:

$$J = 4\pi D(C_A - C_B) \frac{r_B r_A}{r_B - r_A}$$

bunda J – diffuziya oqimi, g/(sm²·s);

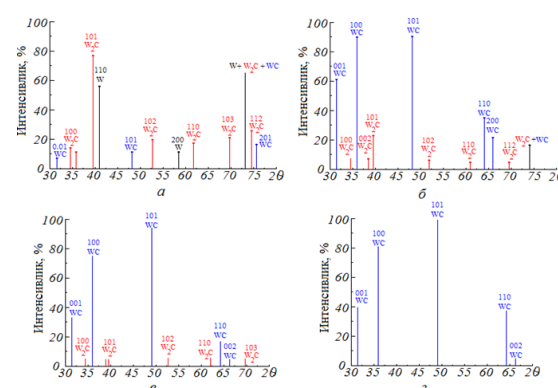
D – uglerodning volframga diffuziyasi koeffitsiyenti, sm²/s;

S_A – volfram zarrachasining tashqi yuzasidagi uglerod konsentratsiyasi, A nuqta, %;

S_V – volfram zarracha ichidagi uglerodning konsentratsiyasi, V nuqta, %;

r_A va r_B – mos ravishda volfram zarrachasidagi nuqtalar koordinatasi, sm.

3. Natijalar



a – 1900 oC; b – 2000 oC; c – 2100 oC; d – 2200 oC

1– rasm. Turli haroratlarda va 2 soat davomida karbidlangan namunalar difraktogrammasining shtrix-diagrammasi

Turli 1900, 2000, 2100, 2200 °C haroratlarda va bir xil vaqt davomida karbidlash jarayonidan o'tgan volfram va uglerod kukuni aralashma namunalarining sifatli rentgenostruktura-fazali tahlili natijalariga ko'ra 2200°C haroratda va 2 soat vaqt davomida karbidlash jarayonidan o'tgan namuna to'liq WC fazasidan tashkil topgan bo'lib, bunda WC – fazasining uglerod bilan 6,13% to'yinishiga jarayon davomiyligi vaqti yetmaganligi aniqlangan (1 – rasm).

Bir xil 2200oS harorat va turli 3,4,5,6 soat vaqt davomida karbidlash jarayonidan o'tgan volfram va uglerod kukun aralashma namunalarining rentgenostruktura-fazalar tahlili shuni ko'rsatdiki, 2200°C haroratda va 4 soat davomida WC – fazasida 6,12% uglerodga to'yinadi va karbidlash jarayonining keyingi 5, 6 soat davomida WC – fazadagi uglerod miqdori o'zgarmasdan qoladi (1 – jadval).

Karbidlash jarayonining davomiylik vaqtining WC donadorligiga va zarrachalar o'lchami hamda shakliga ta'sirini tadqiq qilish bo'yicha o'tkazilgan tadqiqot natijasiga ko'ra WC kukuni donadorligi boshlang'ich volfram kukuni donadorligiga va jarayon vaqtining davomiylikiga bog'liq holda quyida keltirilgan tartibda shakllanadi:

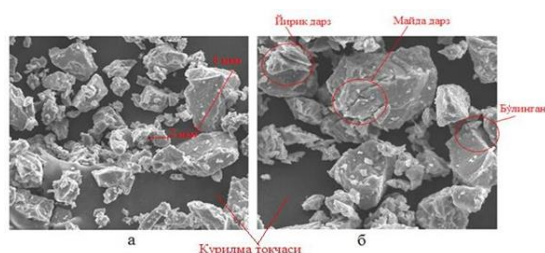
- karbidlash jarayonining 3...4 soatlarida volfram kukuni zarrachalarida sodir bo'ladigan kristall o'zgarishlar natijasida hosil bo'ladigan ichki zo'riqishlar yirik ($d \geq 8$



mkm) o'lchamli zarrachalarning o'lchami 1...6 mkm bo'lgan mayda zarrachalarga parchalanishiga olib kelgan (2 – rasm);

1 – jadval
2200 oS haroratda va turli vaqt davomida karbidlangan namunalardagi uglerod miqdorini aniqlash bo'yicha o'tkazilgan tahlil natijalari

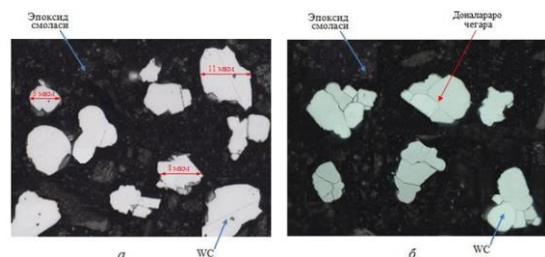
Uglerod, %	Karbidlash jarayoni vaqtining davomiyligi, soat			
	3	4	5	6
Bog'langan uglerod, S_{bg}	6,0	6,12	6,12	6,12
Erkin uglerod, S_{erk}	0,13	0,03	0,03	0,03
$S_{bog} + S_{erk}$	6,13	6,15	6,15	6,15



2– rasm. 2200 oC haroratda va 4 soat davomida karbidlangan namuna kukunining surati

- jarayonning 4...5 soatlarida o'lchami 7...8 mkm bo'lgan volfram zarrachalarni o'lchami

1...3 mkm bo'lgan mayda zarrachalar bilan birikadi va natijada o'lchami 9...12 mkm bo'lgan yirik zarrachalar hosil bo'ladi (3–rasm);



a – travitlanmagan; b - travitlangan

3– rasm. 2200 oC haroratda va 5 soat vaqt davomida karbidlangan zarrachalarning mikrostruktura surati

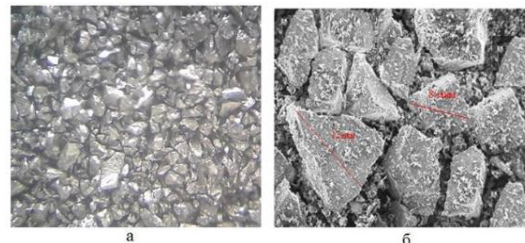
- karbidlash jarayonining 5...6 soatlari davomida volfram karbidi kukun zarrachalari bir-biri bilan to'liq qattiq fazali diffuzion pishib, volfram karbidi zarrachalaridan tashkil topgan g'ovakli bloklar hosil bo'ladi (4 – rasm);

- volfram karbidi kukuni zarrachalarining shakli karbidlash jarayoni vaqti davomiyligiga bog'liq holda, zarrachalar shakli qirralidan qirrasizgacha o'zgaradi (5 – rasm).

2200 °C harorat va turli vaqt davomida karbidlash jarayonidan o'tgan namunalarning kukunlarining donadorligi tadqiqoti natijasida olingan volfram karbidi kukunlari donadorligining shakllanish dinamikasi 6 – rasmda keltirilgan.

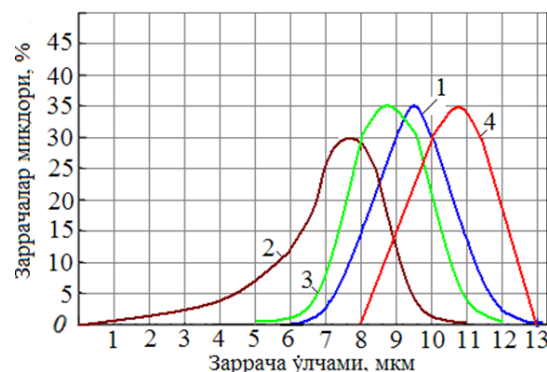


4– rasm. 2200 oC haroratda va 6 soat davomida karbidlangan namunalalar



a – x800; b – x3000

5– rasm. 2200 oC haroratda va 6 soat davomida karbidlangan namuna kukunining surati



1– volfram; 2 – 4 soat; 3 – 5 soat; 4 - 6 soat

6– rasm. 2200 oC haroratda va turli vaqt davomida karbidlangan namuna kukun donadorligining shakllanish dinamikasi

2200 °C harorat va turli vaqt davomida karbidlash jarayonidan o'tkazilgan kukun namunalari zarrachalarining mikroqattiqligi tahlili shuni ko'rsatdiki, 4 soat davomida karbidlangan kukun namuna zarrachasining mikroqattiqligi 5 va 6 soat davomida karbidlangan namuna kukun zarrachasining mikroqattiqligidan katta (2 – jadval).

O'tkazilgan tadqiqotlar natijalari asosida W9,5 markali volfram va uglerod kukunlari aralashmasidan sof elementlardan sintezlash usulida donadorligi o'rtacha 5...8, 7...10 va 9...12 mkm bo'lgan volfram karbidi kukunlarini olish texnologiyasi ishlab chiqilgan (3 – jadval).

2-jadval

2200 oC haroratda va turli vaqt davomida karbidlangan namunalarning kukuni zarrachalarining mikroqattiqligi

Zarracha o'lchami, mkm	Yuklama, gr	Karbidlash jarayonining vaqt davomiyligi, soat		
		4	5	6
		Mikroqattiqlik, GPa		
8...10	50	23,856	23,536	23,476



3– jadval
Sof elementlardan sintezlash usulida W9,5 markali
volfram va uglerod kukunlarini karbidlash
texnologiyasi

WC Donadorl i-gi, mkm	Jihozi	Har o-rati, °C	Muxit sarfi, m ³ /soat	Vaqt davomiyligi, soat	Unumdorligi, kg/sm ena
5...8	Grafitt nayli PGT -60/2	2200	N ₂ , 1	4	32
8...10				5	25
11...12				6	20

4. Xulosa

Olib borilgan izlanishlar natijasida quyidagicha xulosa qilish mumkin: Yirik donali volfram karbid kukunidan RS-14 turdagi keskichlar uchun kobalt-nikel bog'lovchili qattiq qotishmaning tarkibi, kaliyli tuz jinslarini kesish jarayonidagi yeyilish miqdoriga ko'ra ishlab chiqilgan. Yirik donali o'lchamdagi volfram karbidini olish texnologiyasi volfram karbid kukunlarini sof elementlardan sintezlash haroratiga, davomiyligiga va volfram kukunining donadorligiga ko'ra ishlab chiqilgan.

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