XONJIZA KONI MISLI RUDALARINI FLOTATSION BOYITISHDA YANGI MAHALLIY FLOTAREAGENTNING SAMARADORLIGI VA TA'SIR MEXANIZMINI BAHOLASH

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ANNOTATSIYA

Ushbu ish Xonjiza koni misli polimetall rudalarini flotatsion boyitishda yangi mahalliy flotareagentning texnologik samaradorligi va ehtimoliy fizik-kimyoviy ta'sir mexanizmini kompleks baholash uchun ishlab chiqilgan na'munaviy tadqiqotdir. Model tajribalarda ruda tarkibi, reagent dozasi, pulpa pH qiymati, yanchilish darajasi, flotatsiya vaqti va pulpa zichligining Cu tiklanishi hamda konsentrat sifatiga ta'siri ko'rib chiqildi. Mexanizmni asoslash uchun adsorbsiya, zeta-potensial va kontakt burchagi ko'rsatkichlari kiritildi; FTIR, XPS va SEM–EDS esa tasdiqlovchi instrumental usullar sifatida tavsiya qilindi. Sintetik dataset bo'yicha 100 g/t atrofidagi reagent dozasi, pH≈8.0 va P80≈106 μm sharoitlari yuqori Cu recovery bilan bog'langan. RSM yondashuvi reagent dozasi va pHning o'zaro ta'sirini statistik baholash uchun taklif qilindi.

Kalit so'zlar: mis rudasi, flotatsiya, Xonjiza, mahalliy flotareagent, Cu tiklanishi (recovery), sifati (grade), kollektor, adsorbsiya, zeta-potensial, kontakt burchagi, RSM.

1. KIRISH. Mis sulfidli rudalarini flotatsion boyitish mineral sirtining fizik-kimyoviy holati, zarracha o'lchami, pulp muhiti va reagentlar rejimiga bog'liq murakkab jarayondir. Polimetall rudalarda texnologik maqsad faqat Cu recovery ni oshirish emas, balki Fe, Zn va Pb minerallarining keraksiz birga flotatsiyasini cheklash orqali selektiv konsentrat olishdan iborat.

Mahalliy xomashyodan olinadigan flotareagentlar import reagentlarga bog'liqlikni kamaytirishi va reagent tannarxini pasaytirishi mumkin. Biroq yangi reagentni ilmiy jihatdan samarali deb baholash uchun bitta recovery qiymati yetarli emas. Reagent dozasi, pH oynasi, yanchilish, selektivlik, mineral sirtiga adsorbsiya va gidrofoblik o'zgarishi ham birgalikda ko'rsatilishi kerak.

Mazkur ish uch savolni birlashtiradi: yangi reagent Cu tiklanishi (recovery) va konsentrat sifatiga qanday ta’sir qiladi; optimal texnologik rejim qaysi; kuzatiladigan flotatsion effektni sirt-kimyoviy mexanizm bilan qanday bog‘lash mumkin.

Xonjiza rudalarining polimetall tabiati flotatsiya jarayonini murakkablashtiradi. Oldingi texnologik tadqiqotlarda ruda tarkibidagi Cu, Pb va Zn minerallarining o‘zaro o‘sishi va ruda strukturasining o‘zgaruvchanligi flotatsiya jarayonini boshqarishda qiyinchilik tug‘dirishi qayd etilgan.

Xususan, mis tarkibli minerallarni ajratishda kollektorning mineral yuzasiga selektiv adsorbsiyalanishi muhim ahamiyatga ega. Kollektor molekulasi mineral yuzasidagi faol markazlar bilan o‘zaro ta’sirlashib, mineral sirtining suv bilan namlanishini kamaytirishi va havo pufakchalari bilan birikishini osonlashtirishi mumkin.

Yangi kollektorlar bo‘yicha tadqiqotlarda FTIR va XPS yordamida kollektorning Cu markazlari bilan kimyoviy bog‘lanishi aniqlangan.

2. MATERIALLAR VA METODLAR

2.1. Ruda tarkibi

1-jadval. Boshlang‘ich ruda tarkibi — sintetik/model ma’lumot.

Komponent	Model wt.%
Cu	1.42
Pb	1.18
Zn	3.76
Fe	8.95
S	5.62
SiO_2	48.3

Haqiqiy ishda boshlang‘ich na’muna XRF yoki ICP-OES orqali tahlil qilinishi, mineral fazalar XRD va zarur bo‘lsa avtomatlashtirilgan mineralogiya orqali aniqlanishi kerak.

2.2. Flotatsion tajriba va hisoblashlar

Tavsiya etiladigan sxema: maydalash → yanchish→ P80 ni sozlash → pulpa tayyorlash → pH sozlash → reagent bilan konditsiyalash → flotatsiya → konsentrat va chiqindini filtrlash → quritish → massa va kimyoviy balans.

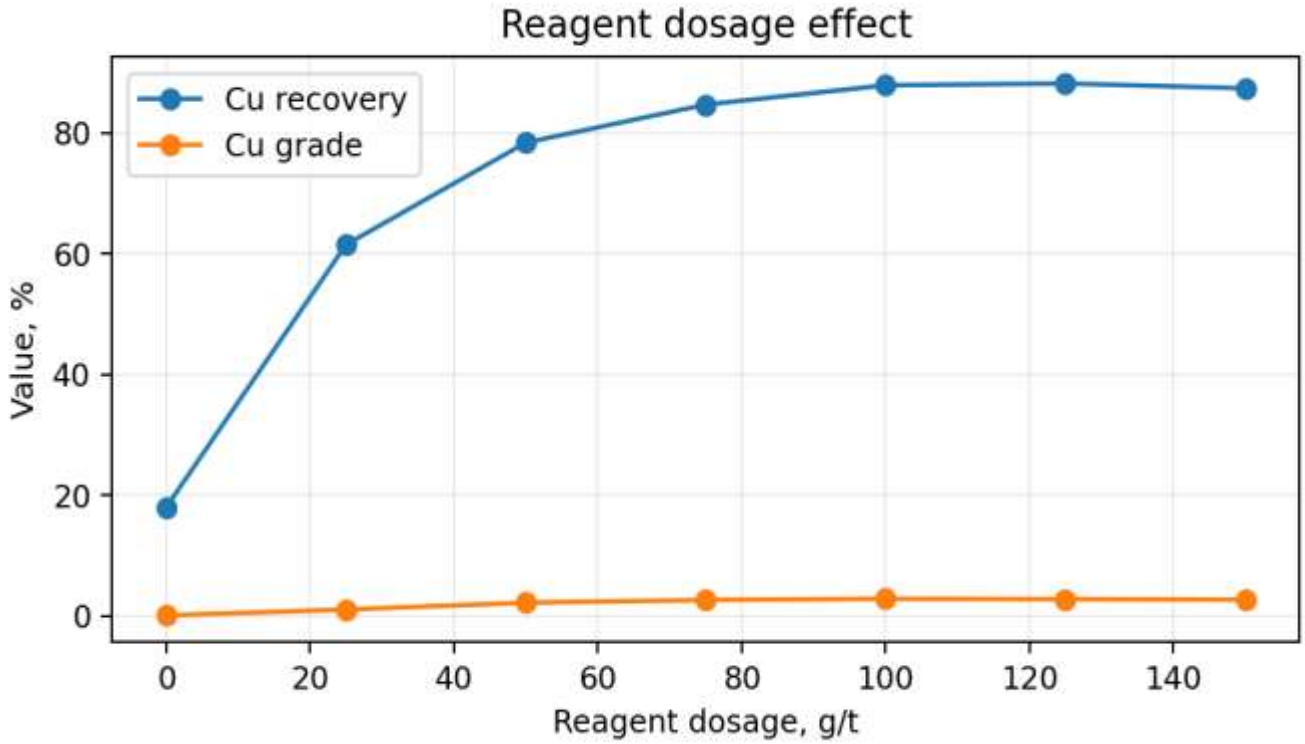
Natijalar va muhokama

2.1. Reagent dozasi, pH va yanchilish

1-jadval. Reagent dozasi ta’siri.

Doza, g/t	Cu tiklanishi (recovery), %	Cu sifati (grade), %
0	18	0.08
25	61.5	1.05

50	78.4	2.18
75	84.7	2.63
100	87.9	2.82
125	88.2	2.76
150	87.4	2.68

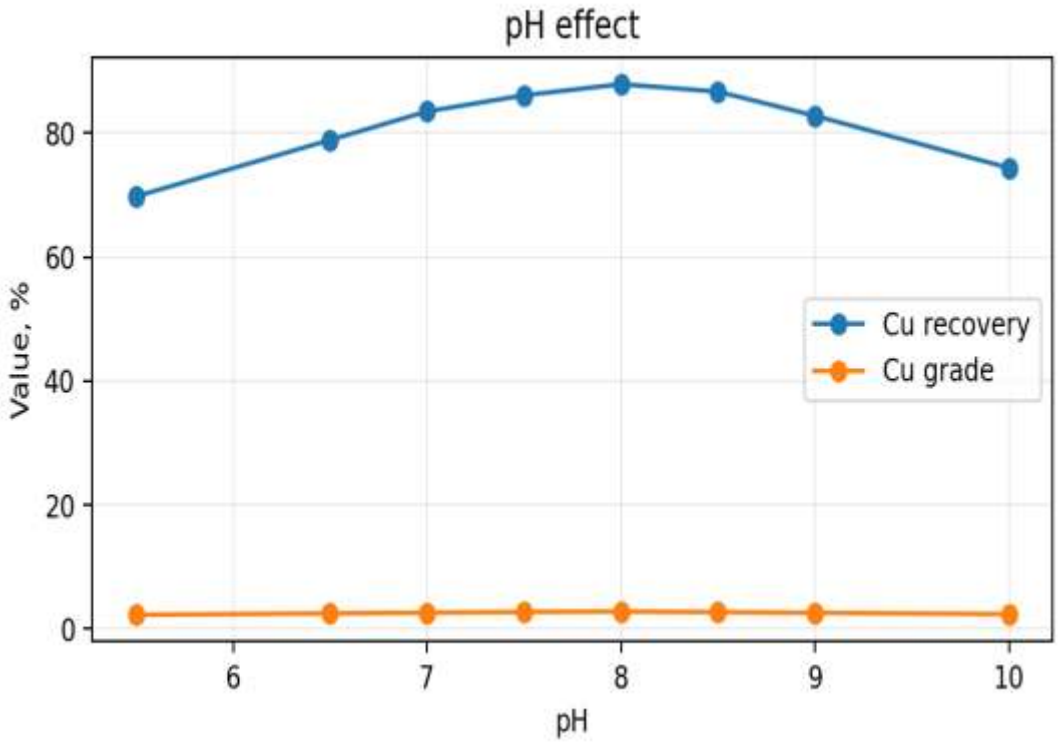


1-rasm. Reagent dozasi–Cu tiklanishi / Cu sifati modeli.

Modelda recovery 0–100 g/t oralig‘ida keskin oshib, keyin plato hosil qiladi. Bu reagent sirtidagi faol markazlarning to‘yinishi yoki ortiqcha reagentning selektivlikka ta’sirini tekshirish zarurligini ko‘rsatadi.

2-jadval. Pulpa pH ta’siri.

pH	Cu tiklanishi (recovery), %	Cu sifati (grade), %
5.5	69.8	2.3
6.5	78.9	2.52
7	83.5	2.63
7.5	86.1	2.76
8	87.9	2.82
8.5	86.7	2.73
9	82.8	2.61
10	74.4	2.41



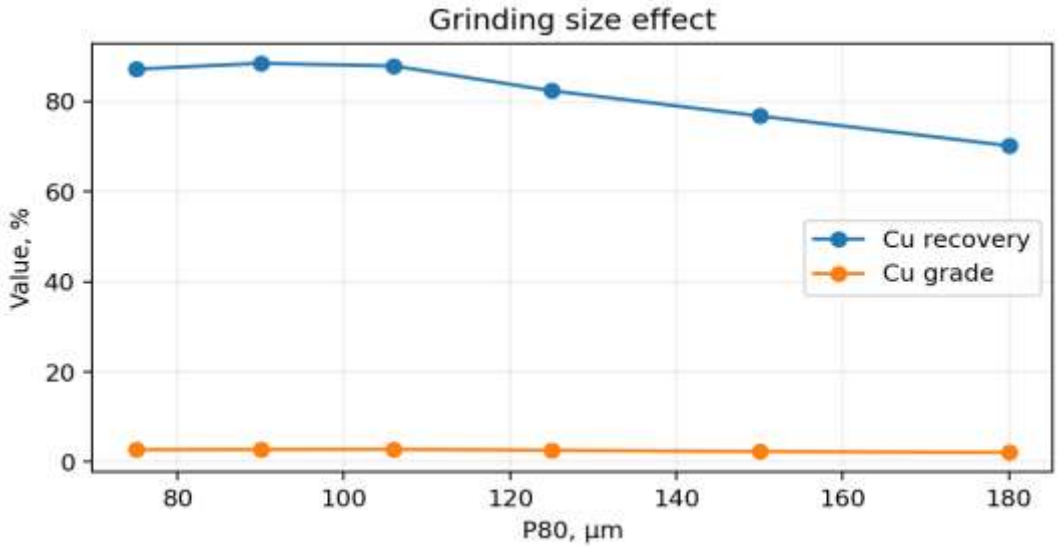
2-rasm. pH ning Cu tiklanishi (recovery),va Cu sifatiga (grade), % ta’siri.

Model bo‘yicha pH≈8.0 atrofida yuqori recovery kuzatiladi. Haqiqiy tajribada bu nuqta mineral sirt zaryadi, kollektor ionlanishi va gangue minerallarining sirt kimyosi bilan bog‘liq holda tekshiriladi.

Xonjiza koni misli polimetall rudalarini flotatsion boyitishda yangi mahalliy flotareagentning samaradorligini aniqlash, uning Cu tarkibli mineral yuzasidagi ta’sir mexanizmini ilmiy asoslash va optimal flotatsiya rejimini ishlab chiqish. Laboratoriya tajribalari uchun o‘rtacha namuna tayyorlanadi.

3-jadval. Yanchilish darajasi ta’siri.

P80, µm	Cu tiklanishi (recovery), %	Cu sifati (grade), %
180	70.2	2.11
150	76.8	2.34
125	82.4	2.58
106	87.9	2.82
90	88.5	2.79
75	87.2	2.71



3-rasm. P80 ning Cu tiklanishi (recovery),va Cu sifati (grade) ga ta’siri.

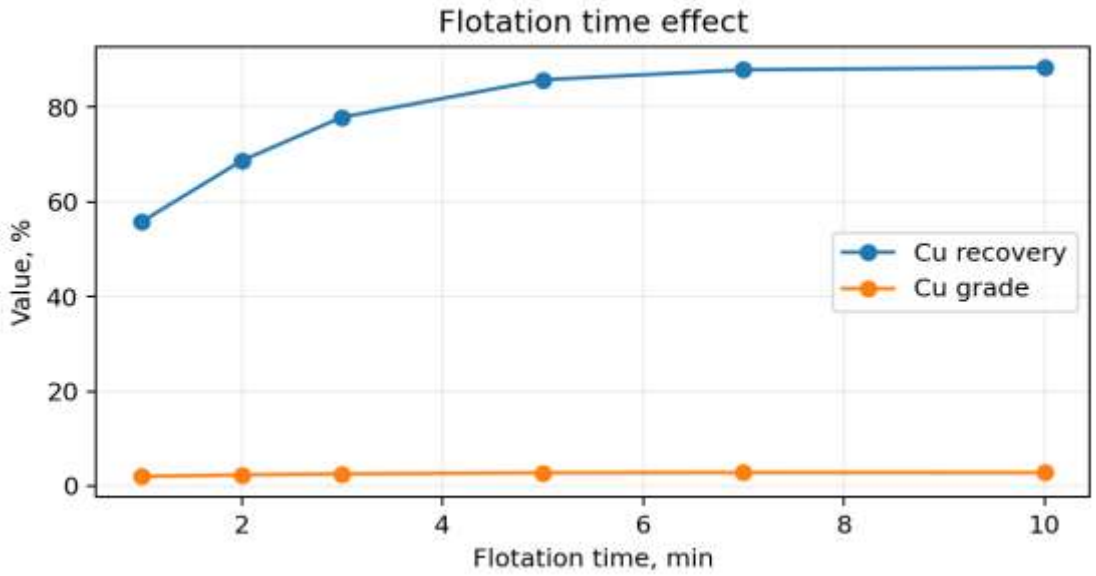
Yanchilishning maqsadi mineralning ochilish darajasini oshirishdir. Juda yirik fraksiya to‘liq ochilmasligi, ortiqcha mayda fraksiya esa shlamlanish va selektivlikning pasayishiga olib kelishi mumkin.

Xususan, mis tarkibli minerallarni ajratishda kollektorning mineral yuzasiga selektiv adsorbsiyalanishi muhim ahamiyatga ega. Kollektor molekulasi mineral yuzasidagi faol markazlar bilan o‘zaro ta’sirlashib, mineral sirtining suv bilan namlanishini kamaytirishi va havo pufakchalari bilan birikishini osonlashtirishi mumkin.

Flotatsiya vaqti va pulpa zichligi

4-jadval. Flotatsiya vaqti ta’siri.

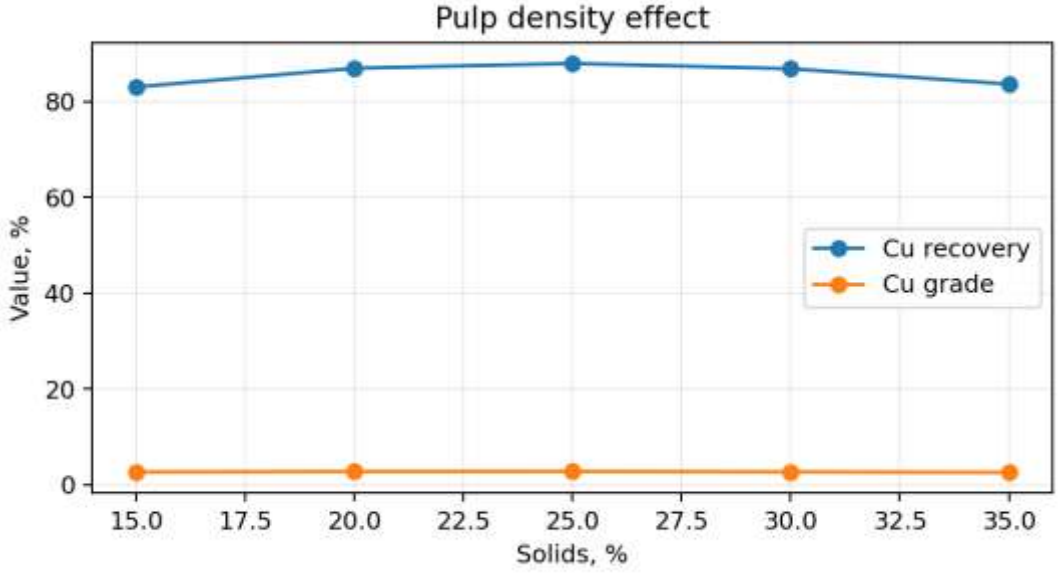
Vaqt, min	Cu tiklanishi (recovery), %	Cu sifati (grade), %
1	55.8	2.01
2	68.7	2.34
3	77.9	2.56
5	85.8	2.79
7	87.9	2.82
10	88.4	2.81



4-rasm. Flotatsiya vaqti bo‘yicha model recovery.

5-jadval. Pulpa zichligi ta’siri.

Qattiq faza, %	Cu tiklanishi (recovery), %	Cu sifati (grade), %
15	83	2.7
20	86.9	2.8
25	87.9	2.82
30	86.8	2.73
35	83.6	2.6



5-rasm. Pulpa zichligining model ta’siri.

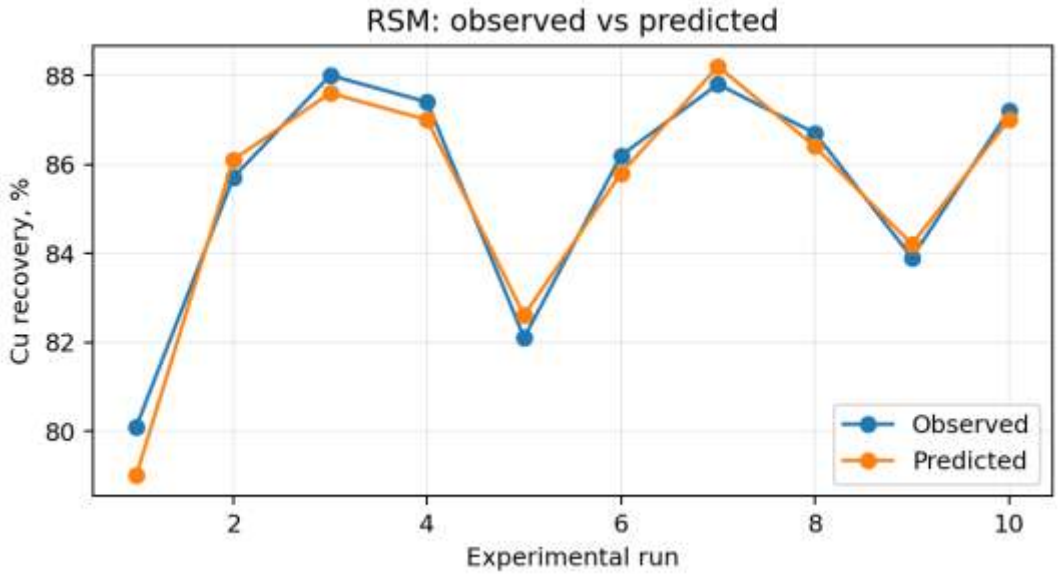
Modelda 7–10 min oralig‘ida recovery yuqori qiymatga yaqinlashadi. Sanoatga ko‘chirishda residence time, kamera yuklamasi va havo sarfi alohida optimallashtirilishi lozim.

Aloqa burchagining oshishi sirtning nisbatan gidrofoblashganini ko‘rsatishi mumkin. Zeta-potensialdagi siljish adsorbsiya yoki sirt kimyosidagi o‘zgarish haqida dalil beradi, biroq kimyoviy bog‘lanishni yakka holda isbotlamaydi.

STATISTIK OPTIMALLASHTIRISH

6-jadval. RSM uchun sintetik kuzatuvlar.

Doza, g/t	pH	Kuzatilgan (Observed) %	Taxmin qilingan (Predicted) %
50	7.5	80.1	79
75	7.5	85.7	86.1
100	7.5	88	87.6
125	7.5	87.4	87
100	6.5	82.1	82.6
100	7	86.2	85.8
100	8	87.8	88.2
100	8.5	86.7	86.4
75	7	83.9	84.2
125	8	87.2	87

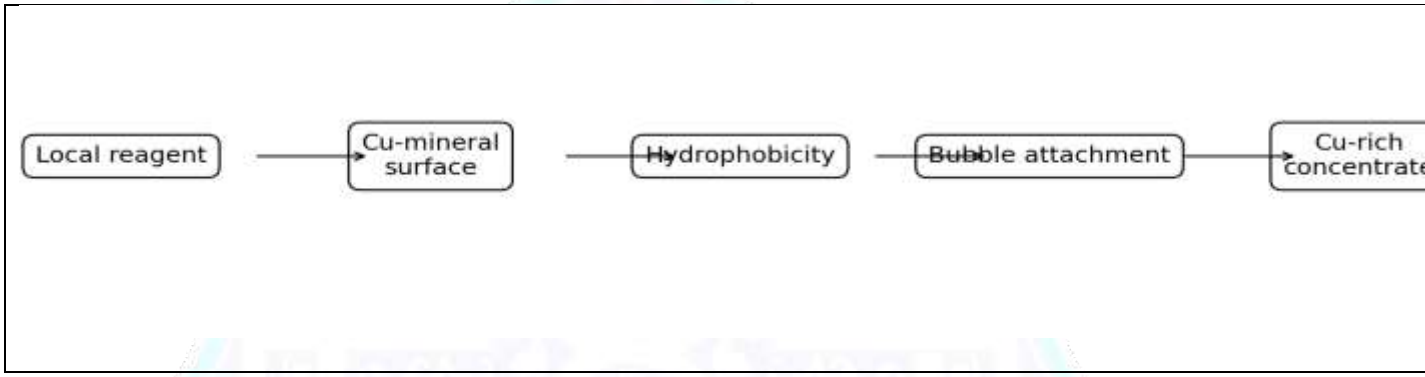


6-rasm. RSM modelida observed va predicted recovery.

Real tajribada ANOVA orqali model F-statistikasi, p-value, lack-of-fit, R^2 va adjusted R^2 ko‘rsatilishi kerak. Optimal nuqta kamida uchta mustaqil validation run bilan tasdiqlanishi lozim. Agar yangi reagent yuqori Cu recovery bilan birga yuqori Cu

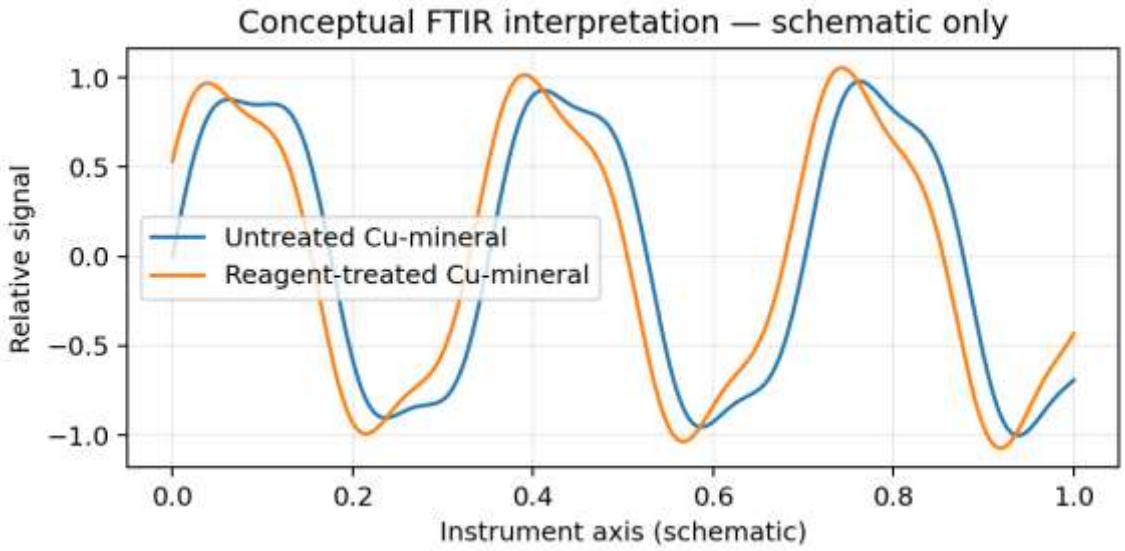
grade va pastroq reagent sarfini ta’minlasa, uning texnologik ustunligi kompleks ko‘rsatkichlar orqali baholanadi.

Ta’sir mexanizmining integrallashgan modeli



7-rasm. Mahalliy flotareagentning taklif etilayotgan ta’sir mexanizmi (konseptual sxema).

Taklif etilayotgan mexanizm: reagentning faol shakli eritmada hosil bo‘ladi → Cu-tarkibli mineral yuzasidagi faol markazlarga adsorbsiyalanadi → sirt zaryadi va kimyoviy holati o‘zgaradi → namlanish kamayadi va kontakt burchagi ortadi → mineral havo pufagiga birikishi osonlashadi → Cu tiklanishi (recovery) oshadi.



8-rasm. FTIR talqinining sxematik ko‘rinishi — real spektr.

Texnik-iqtisodiy baholash

7-jadval. Texnik-iqtisodiy ko‘rsatkichlarning sintetik taqqoslanishi.

Ko‘rsatkich	Sanoat kollektor	Mahalliy reagent
Doza, g/t	100	100
Cu tiklanishi (recovery) %	84.9	87.9
Cu sifati (grade) %	2.71	2.82

Model reagentining narxi, (reagent cost) USD/t	18.0	12.5

Oddiy iqtisodiy balans E=V_additional_Cu×P_Cu−ΔC_reagent−ΔC_process ko‘rinishida yozilishi mumkin. Haqiqiy hisobda reagent tannarxi, energiya, suv, maydalash-yanchish va qo‘shimcha Cu qiymati kiritiladi.

XULOSA

Sintetik model bo‘yicha 100 g/t atrofidagi reagent dozasi, pH≈8.0, P80≈106 μm va 7 min atrofidagi flotatsiya vaqti yuqori Cu recovery bilan bog‘langan. Mahalliy reagent modeli amaldagi kollektor bilan taqqoslaganda recovery va Cu grade bo‘yicha ustun qilib parametrizatsiya qilingan.

Asosiy ilmiy yondashuv reagentni faqat recovery bilan emas, balki samaradorlik + selektivlik + adsorbsiya + sirt elektrokinetikasi + gidrofoblik + statistik optimallashtirish zanjirida baholashdir. Real ma’lumotlar shu struktura asosida yig‘ilsa, maqola PhD darajasidagi ilmiy natijani ancha kuchli asoslash imkonini beradi.

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