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Tashkent state transport university

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Investigation of the desulfurization process for 20GL grade steel

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Abstract: This article examines the influence of sulfur on the properties of 20GL grade steel. The desulfurization process was studied under real production conditions, investigating the relationship between the sulfur content in the metal and the duration of its retention under slag. Additionally, the microstructure of 20GL grade steel after the desulfurization process was analyzed.

Keywords: sulfur, steel, microstructure, 20GL steel, slag, holding time

20GL markali po‘latning desulfuratsiyalash jarayonini tadqiq qilish

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Annotatsiya: Ushbu maqolada oltingugurtning 20GL markali po‘latning xossalariga ta’siri o‘rganilgan. Real ishlab chiqarish sharoitlarida desulfuratsiyalash jarayoni o‘rganilib metal takibidagi oltingugurtning shlak ostida ushlab turish davomiyligiga bog’liqligi tadqiq qilingan. Bundan tashqari desulfuratsiyalash jarayonidan keying 20GL markali po‘latni mikrostrukturasi tahlil qilingan.

Kalit so‘zlar: oltingugurt, po‘lat, mikrostruktura, 20GL markali po‘lat, shlak, ushlab turish davomiyligi

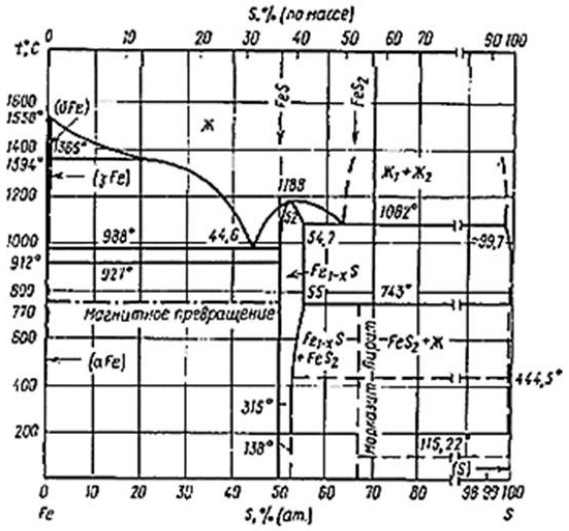
1. Kirish

Temir yo‘l transporti tarmog‘i uchun mas’uliyati yuqori bo‘lgan quyma detallarni kimyoviy tarkibi hamda mexanik xossalariga qo‘yiladigan talablar kundan-kunga oshib bormoqda. Shu sababli ularni ishlab chiqarish uchun zarur tarkiblarni tanlash, eritish, termik va kimyoviy ishlov berish hamda zararli kimyoviy elementlardan rafinirlashga alohida e’tibor qaratilmoqda. Bunday zararli kimyoviy elementlar sirasiga kislorod, vodorod, azot, oltingugurt, fosfor va boshqalar kiradi.

D.I. Mendeleyev kimyoviy elementlar davriy jadvalida oltingugurt - 16-kimyoviy element bo‘lib, xalqaro nomi lotincha “sulfur” so‘zidan olingan. Oltingugurtning kimyoviy belgisi - S. U oltinchi guruh asosiy guruhining uchinchi davrida joylashgan, p-elementlar, xalkogenlar, ya’ni «ruda hosil qiluvchilar» guruhiga mansub. Elektronlar, proton va neytronlar soni 16 ta. Atom tuzilishining sxemasi - $1s^2 2s^2 2p^6 3s^2 3p^4$ ko‘rinishga ega. Oltingugurt metallmas, yuqori oksidi SO_3 (oltingugurt (VI) oksid), uchuvchan vodorodli birikmasi H_2S. Oltingugurtning nisbiy atom massasi 32,066 ga teng.

Metall tarkibidagi oltingugurtni kamaytirish - po‘latning yuqori sifatliligа erishishni ta’minlovchi eng muhim metallurgik jarayonlardan biri hisoblanadi [1].

Oltingugurtning po‘lat xossalariga salbiy ta’siri uning temir bilan fizik-kimyoviy o‘zaro ta’sirining tabiati, yani metal eritmasida yuqori eruvchanligi va qattiq temirda juda kam eruvchanligi bilan belgilanadi [2]. Temir-oltingugurt (Fe-S) diagrammasiga ko‘ra evtektikaning erish harorati 975°C ni tashkil etadi. Bu esa kristallanish jarayonida dendritlar orasidagi eritma oltingugurt bilan boyiydi (1-rasm).



1-rasm. Fe-S holat diagrammasi

Oltingugurt bilan boyitilgan teng o‘qli kristallar, dendritlar va likvatsion zonalar quymalarni turli sohalaridagi kristallanish haroratlaridagi farq 400-500°C gacha yetadi. Natijada yuzaga keladigan termik kuchlanishlar tufayli quymada kristallanish yoriqlari paydo bo‘ladi.

Temir sulfidning oson eriydigan plyonkalari donalar chegarasi bo‘ylab ajralib chiqadi. Sulfidli evtektikalar quymalarni prokatlash uchun qizdirilganda eriydi, bu esa deformatsiya paytida don chegaralarining yorilishiga, yani issiq mo‘rtlikka olib keladi (2-rasm).

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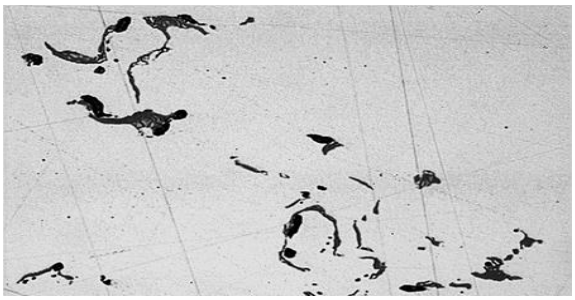
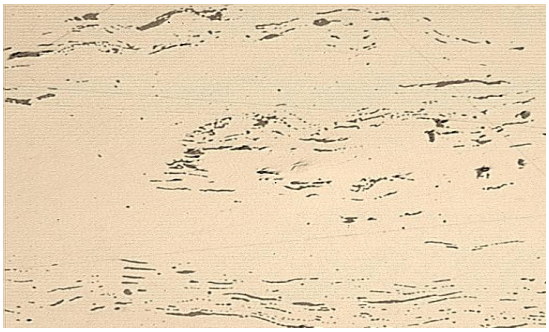


2-rasm. Po‘lat strukturasidagi sulfidlar (x100)

Sulfidlar quymalarda sinuvchanlik (qizil sinuvchanlik) va mo‘rtlikka sabab bo‘ladi. Ular prokatlash jarayonida deformatsiyalanib, qo‘shilmalar zanjirini hosil qiladi [3]. Prokatlashdagi sulfidli qo‘shilmalar po‘latni anizotrop (parallel yo‘nalish bo‘yicha bir xil, qolgan yo‘nalishlarda boshqa xossalarga ega bo‘lgan) xususiyatli bo‘lishiga olib keladi. Temir va marganesni cho‘zinchog’ sulfidlari vodorod sulfid muhitida ishlaydigan po‘lat konstruksiyalarda vodorod ta’sirida yorilish markazlai hisoblanadi (3 va 4 rasmlar).

3-rasm. Po‘lat stukturasidagi marganes sulfidlari (1-tip Sims bo‘yicha)



4-rasm. Po‘lat strukturasidagi ikkinchi turdagi plyonkali sulfidlar

2. Tadqiqot metodologiyasi

Induksion tigel pechida 20GL markali po‘lat ertishda desulfuratsiyalash jarayoni tadqiq qilindi. Tadqiqot obyekti sifatida 20GL markali po‘lat tanlandi. 20GL markali po‘lat kimyoviy tarkibi ГОСТ 32400-2013 bo‘yicha olindi (1-jadval) [4].

1-jadval

20GL markali po‘latni kimyoviy tarkibi, % (mass.)

[C]	[Si]	[Mn]	[P]	[S]	Fe
0,17 - 0,25	0,30 - 0,50	1,10 – 1,40	≤0,020	≤0,020	qolg.

Bunda 20GL markali po‘lat olish uchun, shixta o‘rta chastotali 6 tonna sig‘imli induksion tigel pechida eritildi va harorat 1550°C oksidlovchi shlak to‘liq to‘kib tashlandi. Shundan so‘ng metaldan namuna olindi (2-jadval).

2- jadval

Eritish jarayonidan keying namunaning kimyoviy tarkibi, % (mass.)

[C]	[Si]	[Mn]	[P]	[S]	Fe
0,185	0,067	0,62	0,019	0,035	qolg.

Metalni legirlash va normativ hujjatga mos keladigan kimyoviy tarkibga erishish uchun ferroqotishmalardan foydalanildi. Metal tarkibidagi kremniy va marganes miqdorini ko‘tarish uchun ФС65 hamda ФМн78А markali ferroqotishmalardan foydalanildi. ФМн78А markali ferroqotishmadan foydalanishga sabab, tarkibidagi fosforni miqdorini 0,1% gacha tashkil etganidadir. Legirlovchi elementlarni hisoblash uchun 1- formuladan foydalanildi.

$$Q_F = \frac{m_0 \cdot (E^G - E^N)}{A \cdot B}; \quad (1)$$

bu yerda: m_0 =6000 kg, pechdagi metal massasi;

E^G – normativ hujjat bo‘yicha talab qilingan element miqdori, %;

E^N – namunadagi element miqdori, %;

A – ferroqotishma takibidagi legirlovchi elementning miqdori, %;

B – ferroqotishmaning singish koeffietsenti.

Bunda normativ hujjat bo‘yicha kremniy miqdori 0,35%, kremniyni ferroqotishmadan singish koeffietsentini 0,9, marganes miqdorini 1,15% hamda singish koeffitsentini 0,95 deb qabul qilindi. 1-formuladan foydalanib legirlovchi elementlarning miqdori hisoblandi. Natijada metalni legirlash uchun pechga 29 kg ФС65 hamda 43 kg ФМн78А solindi. Legirlash jarayonidan keyingi metalni kimyoviy tarkibi 3-jadvalda keltirilgan.

3- jadval

Legirlash jarayonidan keyingi namunaning kimyoviy tarkibi, % (mass.)

[C]	[Si]	[Mn]	[P]	[S]	Fe
0,232	0,35	1,15	0,020	0,035	qolg.

Metal legirlangandan keyin desulfuratsiyalash jarayoni boshlandi. Desulfuratsiyalash jarayonini amalga oshirish uchun qattiq shlak aralashmalaridan foydalanildi. Qattiq shlak aralashmalari tarkibi: 70 kg miqdorda yangi kuydirilgan ohak, 20 kg ФК-75 markali dala shpati hamda 10 kg ikkilamchi alyumiydan foydalanildi. Pechga 10 kg miqdordagi alyuminiy solingandan keyin porsiyalab ohak hamda dala shpati solindi. Pechda harakatlanuvchi suyuq shlak hosil bo‘lgandan so‘ng metal harorati o‘lchandi. Harorat 1600 °C ni tashkil qilganda pech termostat rejimiga o‘tkazilib desulfuratsiya jarayoni boshlandi.

Ma‘lumki, real texnologik jarayonlarda desulfuratsiya jarayonini muvaffaqiyatli amalga oshirish uchun quyidagi asosiy texnologik parametrlarni ta’minlash zarur: shlakning yuqori asosliligi; metallning past oksidlanganligi; jarayon kinetikasini amalga oshirishni ta’minlaydigan harorat, vaqt va boshqalar. Bunda real sanoat sharoitida jarayonning tugallanganligi uning kinetik parametrlariga bog‘liq bo‘ladi. Ushbu parametrlarni bilgan holda, termodinamik imkoniyatlar bilan oldindan belgilangan qiymatlarga maksimal erishishni ta’minlash mumkin.

Metalni desulfuratsiyalash jarayonini ko‘rib chiqishda uni cheklovchi bosqichlar asosiy o‘rinni egallaydi. Desulfuratsiya jarayonining cheklovchi bosqichi haqidagi fikrlari bir xil emas, ayniqsa, eritish induksion tigel pechida amalga oshirilsa. Amaliyotda tasdiqlangan tadqiqotlar shuni ko‘rsatadiki, desulfuratsiya jarayoni ba’zi hollarda shlakdagi dastlabki moddalar va reaksiya mahsulotlarining diffuziyasi bilan cheklanadi. Shlakdagi diffuzion jarayonlarning tezligi ularning qovushqoqligi kamayishi va haroratning ko‘tarilishi bilan ortadi.

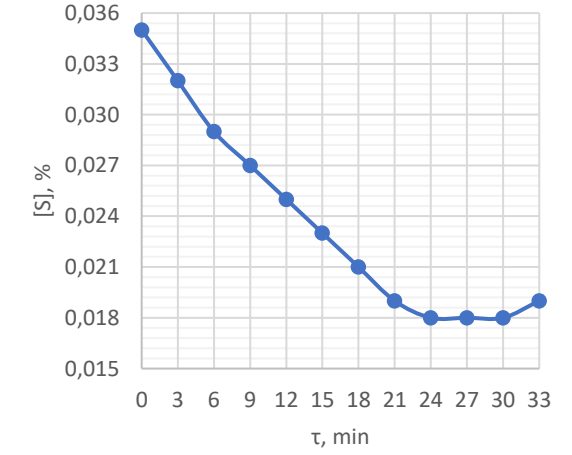
Shuning uchun zararli aralashmalarni, shu jumladan oltingugurtni kamaytirish bo‘yicha kinetik parametrlarni, desulfuratsiya jarayonining tezligini o‘rganish asosiy hal qiluvchi omillarni aniqlash juda muhimdir.

Shu nuqtai nazardan, induksion tigel pechida 1600 °C haroratda desulfuratsiya jarayoni tahlil qilindi. Pechdan har 3 minut vaqt mobaynida namuna olinib metal tarkibi o‘rganildi (4-jadval, 4-rasm).

4-jadval

Metal takibidagi oltingugurtning shlak ostida ushlab turish davomiyligiga bog’liqligi

τ, min	0	3	6	9
[S], %	0,035	0,032	0,029	0,027
τ, min	12	15	18	21
[S], %	0,025	0,023	0,021	0,019
τ, min	24	27	30	33
[S], %	0,018	0,018	0,018	0,019

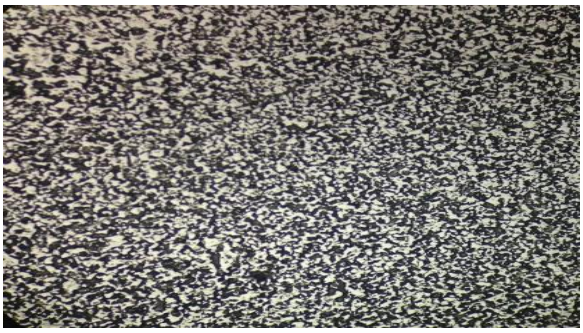


4-rasm. Metal takibidagi oltingugurtning shlak ostida ushlab turish davomiyligiga bog’liqligi

4-rasmdan ko‘rinib turibdiki metal tarkibidagi oltingugurt miqdori shlak ostida ushlab turish davomiyligiga ham bog‘liqdir. Dastlabki vaqt mobaynida metalldagi oltingugurt miqdori intensive pasayadi. Eng yaxshi natjalar 21-24 minut oralig’ida kuzatildi, keyingi 6 minutda o‘zgarmadi so‘ngra resulfuratsiya (shlakdagi oltingugurt metalga o‘tishi) jarayoni kuzatildi. Bunga sabab, shlakning reaksiyaga kirish qobilitani pasayishi hamda metalning oksidlanishi pasayishidadir.

Shundan so‘ng seriyali desulfuratsiyalash jarayoni o‘tkazildi hamda desulfuratsiyalash shlagi 25 minutdan kechiktirmagan vaqtda to‘kila boshlandi. Bunda metalni oltingugurtsizlantirish darajasi 45-60 % gacha yetdi.

Desulfuratsiyalash jarayonidan keyin metal pechda 1640 °C ga qizdirilib formaga quyish uchun po‘lat quyish kovshiga quyiladi. Kovshdan formaga quyish harorati 1585±5 °C ni tashkil qiladi. Jami sakkizta formaga quyiladi. Formalarga quyiladigan detallar asosan temir yo‘l transporti yuk vagonlarining yon ramalari va avtoulagichlari hisoblanadi hamda bir metal eritishda sakkizta opokalarga quyiladi. To‘rtinchi va beshinchi opokalar oralig‘ida metallarni mexanik hamda strukturasini tekshirish uchun mahsus formaga metal quyiladi. Bu quyilgan metalni kesib, termik ishlov berilib undan namuna mikrostrukturani tekshirish uchun shlif yasaldi. Mikrostruktura tahlili natijalari 5-rasmda keltirilgan.



5-rasm- 20GL markali po‘latni mikrostrukturasi

Yuqorida keltirilgan rasmdan ko‘rinib turibdiki 20GL markali po‘latda oltingugurt kam bo‘lsa marganes va plyonkali sulfidlar hosil bo‘lmaydi.

3. Xulosa

Maqolada oltingugurtning metal xossalari va tuzilishiga salbiy ta’siri, uning temir bilan fizik-kimyoviy o‘zaro ta’sirining tabiati, po‘latda hosil bo‘ladigan sulfidlar o‘rganildi hamda ishlab chiqarish sharoitlarida 20GL markali po‘latning desulfuratsiyalash jarayonini tadqiq qilindi. Metal takibidagi oltingugurtning shlak ostida ushlab turish davomiyligiga bog’liqligi ko‘rsatildi. Ushbu texnologiya natijasida metalni oltingugurtsizlantirish darajasi 45-60 % gacha yetdi.

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