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Influence of carbon-containing materials and furan oligomers on the technological and performance characteristics of rubber compositions

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Abstract: The paper presents methods for investigating the physicochemical, technological, and performance properties of compositions based on butadiene–nitrile elastomers and their ingredients. The studies were carried out using GOST standards, modern instrumental analysis methods, and laboratory mixers and extruders. The physicochemical characteristics of carbon-containing materials, the technological parameters of rubber compounds, as well as the extrudability and plasto-elastic properties of filled compositions were determined. Special attention was paid to the influence of local raw materials and furan oligomers on the formation of specific properties of rubber compounds.

Keywords: butadiene–nitrile elastomers; rubber compositions; carbon-containing materials; furan oligomers; technological properties; performance characteristics; vulcanization

Rezina kompozitsiyalarining texnologik va ekspluatatsion xarakteristikalariga uglerod saqlovchi materiallar va furan oligomerlarining ta'siri

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Annotatsiya: Ishda butadiyen-nitril elastomerlari va ularning ingrediyentlari asosidagi kompozitsiyalarning fizik-kimyoviy, texnologik va ekspluatatsion xossalarini tadqiq qilish usullari keltirilgan. Tadqiqotlar GOST standartlari, zamonaviy instrumental tahlil usullari, laboratoriya aralashtirgichlari va ekstruderlardan foydalangan holda amalga oshirildi. Uglerodli materiallarning fizik-kimyoviy xususiyatlari, rezina aralashmalarining texnologik parametrlari, to'ldirilgan kompozitsiyalarning shpritslanuvchanligi va qatlam-elastik xususiyatlari aniqlangan. Mahalliy xomashyolar va furan oligomerlarining rezina aralashmalarining maxsus xossalarini shakllantirishga ta'siriga alohida e'tibor qaratilgan

Kalit so'zlar: butadiyen-nitril elastomerlari; rezina kompozitsiyalari; uglerodli materiallar; furan oligomerlari; texnologik xususiyatlar; foydalanish xususiyatlari; vulkanizatsiya

1. Kirish

Butadien-nitril elastomerlari asosida kompozitsion materiallar yaratishda xom ashyo komponentlarining xususiyatlarini chuqur tahlil qilish muhim ahamiyatga ega. Bunda ingrediyentlarning fizik-kimyoviy ko'rsatkichlari, ularning aralashtirish va plastikatsiya jarayonlariga ta'siri, shuningdek, tayyor vulkanizatlarining mexanik va dinamik xossalari kompleks ravishda o'rganiladi [1].

So'nggi yillarda furan oligomerlari hamda mahalliy uglerodli xom ashyodan foydalanish rezina kompozitsiyalarining ekspluatatsion ko'rsatkichlarini yaxshilash imkonini bermoqda. Bunday modifikatorlar rezinalarning mustahkamligi, elastikligi va qayta ishlashdagi texnologik qulayligini oshirishga xizmat qiladi. Ushbu ishning maqsadi butadien-nitril kauchuklari asosida tayyorlangan rezina aralashmalarida furan oligomerlari va uglerodli to'ldirgichlarning texnologik hamda ekspluatatsion xususiyatlarga ta'sirini baholashdan iborat [2].

2. Tadqiqot metodologiyasi

Rezina aralashmalarini tayyorlash jarayonining texnologik xususiyatlari rotorli turdagi «Brabender» plastikorderi yordamida o'rganildi. Tajribalar sanoat sharoitiga yaqin bo'lgan tezliklarida ($1-250 \text{ s}^{-1}$) va 473 K gacha bo'lgan haroratlarda amalga oshirildi. Model tarkibi kauchuk va to'ldirgichdan tashkil topgan [3-5].

Eksperimental sharoitlar:

rotorlar aylanish tezligi — 30 ayl/min;
kamera harorati — 353 K;
kamera hajmi — $7 \cdot 10^{-5} \text{ m}^3$.

Plastikorderda olingan kinetik egri chiziqlar asosida vaqt davomida burovchi momentning o'zgarishi tahlil qilindi va quyidagi texnologik ko'rsatkichlar hisoblab chiqildi:


Burovchi momentning nisbiy o'zgarishi:

$$\lambda = \frac{M_{MAX} - M_{MIN}}{M_{OIRT}} \quad (1)$$

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Bu yerda:

M_{MAX} — eng katta burovchi moment;

M_{MIN} — eng kichik burovchi moment;

M_{SR} — o'rtacha burovchi moment qiymati.

Plastiklanuvchanlik ko'rsatkichi maksimal va minimal momentlar nisbati orqali aniqlanib, rezina massasining qayta ishlash qobiliyatini ifodalaydi:

$$P = \frac{M_{MIN}}{M_{MAX}} \quad (2)$$

To'ldirgich kiritilgandan keyin maksimal burovchi momentning nisbiy ortishi quyidagi ifoda orqali hisoblandi:

$$M_{otn} = \frac{M_{MAX} - M_{KR}}{M_{KR}} \cdot 100\% \quad (3)$$

Bu yerda:

M_{MAX} — eng katta burovchi moment;

M_{KR} — kauchuk 3 daqiqa plastikatsiya qilingandan keyingi burovchi moment.

16 daqiqalik aralashtirishdan keyingi shartli plastikatsiya tezligi:

$$V_{Plast} = \frac{M_{MAX} - M_{OIRT}}{t \cdot 60} \quad (4)$$

Bu yerda:

M_{OIRT} — tebranish amplitudasining o'rtacha qiymati (15 daqiqada);

M_{MAX} — to'ldiruvchi kiritilgandan keyingi maksimal burovchi moment;

τ — V_{Plast} qatlamni aniqlash mos keladigan vaqti.

Barcha natijalar kamida uch marta takrorlangan tajribalar asosida olinib, ularning qayta ishlanuvchanligi ta'minlandi.

Rezina aralashmalarining shprislanadigan xususiyatlari laboratoriya jihozi hisoblangan chervyakli uzatmaga ega bo'lgan mashinaga ulangan shprislovchi pristavka yordamida baholandi. Ekstruziya jarayoni diametri 3 mm bo'lgan filera va «Garvey» mundshtugi orqali 20–50 ayl/min tezlikda hamda 293–363 K harorat oralig'ida amalga oshirildi [6].

Ekstrudat usadkasi quyidagi nisbat orqali aniqlandi:

$$\theta = \frac{P_E}{P_T} \quad (5)$$

Bu yerda:

P_E — aniqlangan l uzunlikdagi ekstrudat massasi, kg;

P_T — uzunligi l bo'lgan cho'kmaydigan ekstrudatning nazariy massasi, kg.

$$P_T = F_0 \cdot \gamma \cdot l \quad (6)$$

Bu yerda:

F_0 — fileraning ko'ndalang kesim yuzasi, m^2 ;

γ — aralashma zichligi, kg/m^3 ;

l — ekstrudatning uzunligi, m.

Doiraviy kesimli filera orqali shpritslash unumdorligi (N/s) quyidagi formula yordamida aniqlanadi:

$$Q = \frac{\pi \cdot d_1^2 \cdot l}{4 \cdot \tau} \cdot \gamma \cdot 10 \quad (7)$$

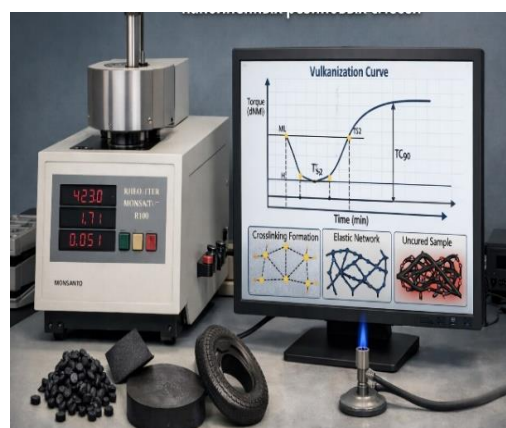
Bu yerda:

$d_1 = \sqrt{\frac{4 \cdot Re}{l \cdot \gamma \cdot \pi}}$ — ekstrudatning o'rtacha diametri;

l — ekstrudatning uzunligi, m;

τ — shpritslash uchun ketgan vaqt, s.

Rezina aralashmalarining zichligi 293 K haroratda ma'lum zichlikdagi suyuqlik miqdorini aniqlashga asoslangan piknometrik usul bilan aniqlandi (1-rasm).

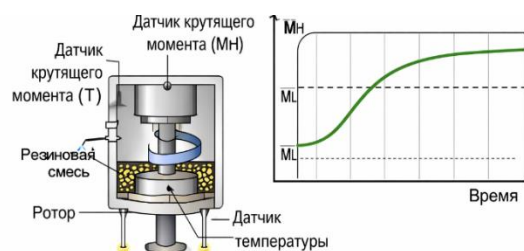


1-rasm. To'ldirilgan rezina aralashmalarining qatlam-elastik xususiyatlarini aniqlash

O'rganilgan SKI-3, nairit KR-50, SKIS-30, ARKM-15 va SKN-18M kauchuklari va to'ldirilgan aralashmalarining plast-elastik xususiyatlari GOST bo'yicha aniqlandi:

— Qattqlik va elastik tiklanish - GOST 10201-75; Plastiklik - GOST 415-95;

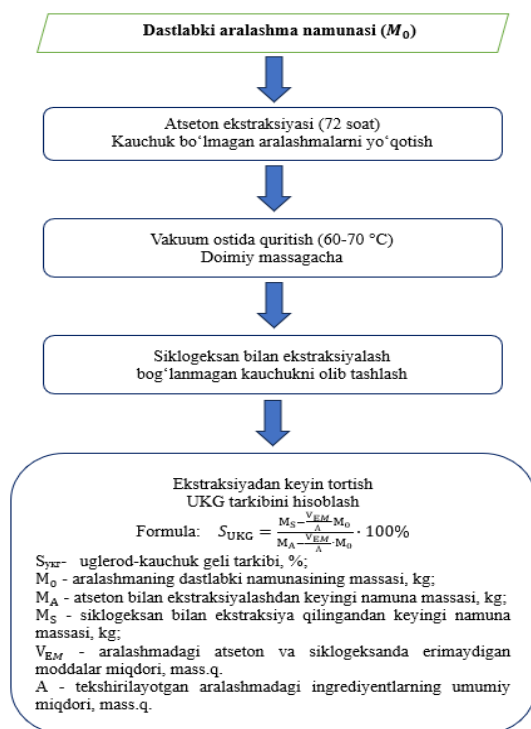
— Muni bo'yicha qovushqoqlik - GOST 10722-96. Qovushqoqlik 373 va 408 K haroratlarda "Monsanto" Muni viskozimetrida aniqlandi.



2-rasm. To'ldirilgan rezina aralashmalarining vulkanizatsiya xususiyatlarini aniqlash

To'ldirilgan va to'ldirilgan rezina aralashmalarini vulkanlash jarayonlarini o'rganish "Monsanto" firmasining vibratsion REOMETR-100 da quyidagi sharoitlarda amalga oshirildi.





3-rasm. Uglerod-kauchuk gelining kattaligini aniqlash sxemasi

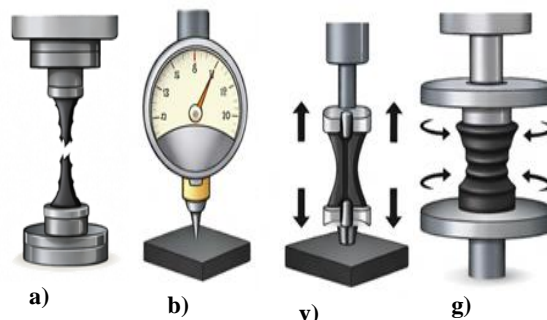
Uglerod - kauchuk gelining kattaligiga qarab, kauchuklarning uglerodli to'ldiruvchi bilan o'zaro ta'siri haqida bilvosita fikr yuritildi. O'rganilayotgan aralashma namunasi Sokslet apparatiga joylashtiriladi va kauchuk bo'lmagan aralashmalarni yo'qotish uchun 72 soat davomida issiq atseton bilan ekstraksiyalanadi [7-9]. Shundan so'ng aralashma 60-70oS haroratda vakuum ostida doimiy massagacha quritiladi. So'ngra bog'lanmagan kauchukni yo'qotish maqsadida aralashma issiq siklogeksan bilan 72 soat davomida ekstraksiya qilinadi. JK miqdori [10] formula bo'yicha hisoblandi. Quyida uglerod-kauchuk gelining qiymatini aniqlash sxemasi keltirilgan (3-rasm).

3. Natija va muhokamalar

Vulkanizatlarining fizik-mexanik va dinamik ko'rsatkichlarini aniqlash Davlat standartlariga muvofiq amalga oshirildi: 262-03- parchalanishga chidamlilik (Ra); 263-03- Shor-A bo'yicha qattqlik; 270-95- cho'zilishdagi elastik-mustahkamlik xossalari: shartli mustahkamlik (fp), nisbiy cho'zilish (Ye-nisb) va qoldiq cho'zilish (Yeost) [11].

O'zgarmas deformatsiya sharoitida siqilishdagi qoldiq deformatsiyani aniqlash SEVI217-78 standarti; rezinalarni o'zgarmas deformatsiyada ko'p karrali cho'zilishga sinash GOST 26I-94.

Issiqlik hosil bo'lishi, qoldiq deformatsiya va ko'p marta siqilishdagi toliqishga chidamlilik GOST 2048-95 bo'yicha baholandi; sakrash bo'yicha elastiklik GOST 6950-03 [11-15] Shoba tipidagi asbobda aniqlandi. Vulkanizatlarining fizik-mexanik va dinamik xususiyatlari quyidagi asboblardan foydalangan holda aniqlandi (4-rasm):



4-rasm. To'ldirilgan vulkanizatlarining texnik ko'rsatkichlarini aniqlash uchun asboblari:

a) Uzilish, asbob: IR-5 tipidagi uzish mashinasi
Standart: GOST 262-03 O'lchanadigan
xarakteristika: uzilishga qarshilik (Ra);

b) Qattqlik (Sho'r-A) Asbob: Sho'r-A qattqlik o'lchagichi Standart: TOST 263-03;

v) Ko'p karrali cho'zilish Asbob: IR-5080 tipidagi cho'zish mashinasi Standart: TOST 270-95 O'lchanadigan xarakteristikalar: shartli mustahkamlik (σ), nisbiy uzayish (ϵ_{nisb}), qoldiq uzayish (ϵ_{qol});

g) Toliqib siqilish. Asbob: nazorat yuklamali press. Standart: SEV 121-78

4. Xulosa

Ushbu tadqiqotda butadien-nitril elastomerlari asosida tayyorlangan rezina aralashmalarining texnologik, mexanik va dinamik xususiyatlari kompleks ravishda tahlil qilindi.

Aralashmalarining plastiklanuvchanlik, qayta ishlashga moyilligi va shprislanadigan ko'rsatkichlari aniqlanib, ularning sanoat sharoitida qo'llash imkoniyatlari baholandi. Ekstruziya jarayonidagi usadka va unumdorlik hisob-kitoblari kompozitsiyalarning texnologik barqarorligini ko'rsatdi.

Plasto-elastik va vulkanizatsiya xususiyatlarini o'rganish natijalari uglerodli to'ldirgichlar va furan oligomerlarining kauchuk matritsasi bilan samarali o'zaro ta'sirga kirishishini tasdiqladi. Bu esa rezinalarning mustahkamligi, elastikligi va ko'p martalik deformatsiyalarga chidamliligini oshirishga olib keldi.

Olingan natijalar mahalliy uglerod xom ashyosi va furan oligomerlaridan foydalangan holda yuqori ekspluatatsion ko'rsatkichlarga ega rezina kompozitsiyalari yaratish imkoniyatini ilmiy jihatdan asoslab beradi.

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