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Mathematical model of determination of optimal modes of oil extraction process with electrical impulse processing of seed pulp

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ABSTRACT

The article is devoted to the study of methods for accelerating the process of oil extraction from industrial seeds using the method of completely squeezing the oil by pressing. As part of the study, parameters such as the moisture level of the product, capacitance of the capacitor and the number of pulses in the device for electric pulse processing were considered. The degree of damage to seed cells and tissues caused by exposure to discharge voltage was also studied. The article presents the functional relationships between these parameters of electric pulse processing, the increase in the volume of extracted oil and its overall yield.

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Chigit yanchilmasiga elektr impulsli ishlov berish bilan moy olish jarayoni optimal rejimlarini aniqlashning matematik modeli

Kalit so‘zlar:
texnik chigit,

ANNOTATSIYA

Ushbu maqolada texnik chigitdan moy olish jarayonini jadallashtirish, presslash usuli yordamida moyni to‘liq siqib

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elektr impulsli ishlov berish,
mahsulotning namlik darajasi,
chigit yanchilmasi,
harorat,
namlik,
impulslar soni,
razryad kuchlanishi.

olish haqida ma’lumotlar berilgan. Bunda mahsulotning namlik darajasi, elektr impulsli ishlov berish qurilmasining kondensatori sig‘imi va impulslari soni, razryad kuchlanishi ta’sirida chigit hujayralari va to‘qimalarining shikastlanish darajasi tadqiq qilingan. Moy miqdorini oshirish uchun chigit yanchilmasiga elektr impulsli ishlov beradigan qurilma parametrlari va moy chiqish miqdori orasidagi funksional bog‘liqliklar keltirilgan.

Математическая модель определения оптимальных режимов процесса маслоэкстракции при электроимпульсной обработке семенной пульпы

Ключевые слова:
технические семена,
электроимпульсная обработка,
уровень влажности продукта,
разложение семян,
температура,
влажность,
количество импульсов,
напряжение разряда.

АННОТАЦИЯ

Статья посвящена изучению методов ускорения процесса экстракции масла из технических семян с использованием метода полного отжима масла путем прессования. В рамках исследования были рассмотрены такие параметры, как уровень влажности продукта, емкость конденсатора и количество импульсов в устройстве для электроимпульсной обработки. Также была изучена степень повреждения семенных клеток и тканей, вызванная воздействием разрядного напряжения. В статье представлены функциональные зависимости между этими параметрами электроимпульсной обработки, увеличением объема извлекаемого масла и его общим выходом.

KIRISH

Paxta moyi iste’mol qilinishi jihatidan dunyoda sakkizinchi o‘rinni egallaydi. Paxta moyi tarkibida turli foydali moddalar, fosfolipidlar, efir moylari va foydali omega-3 yog‘ kislotalari hamda vitamin E ham mavjudligi tufayli boshqa o‘simlik moylariga qaraganda inson salomatligi uchun foydaliroq hisoblanadi.

Moyli ekin mahsulotlaridan moyni ajratib olishda birlamchi ishlov berishning asosiy turlari, mexanik ishlov berish (mahsulotni maydalash va siqish), kimyoviy ishlov berish (suv, qutbli va qutbsiz erituvchi fermentlar va pereparatlar) va elektrofizik ta’sirlar bilan ishlov berish (elektr toki, elektromagnitli maydon va boshqalar) hisoblanadi.

Elektr impulsli ishlov berish usuli ekologik toza va yuqori sifatli oziq-ovqat mahsulotlarini olish imkonini beruvchi energiyani tejaydigan texnologiya hisoblanadi. Ushbu usul impulsli elektr razryadning ishlov berilayotgan mahsulotga ta’siriga asoslangan. Ishlov berilayotgan mahsulot ikkita elektrodlar o‘rtasida joylashgan bo‘lib, hujayra membranalari yuzasida yoriqlar paydo bo‘lishiga olib keladi. Bu esa o‘simlik moddasi tarkibidan hujayra ichidagi moyni tezroq va osonroq chiqishini ta’minlaydi.

ADABIYOTLAR TAHLILI VA METODOLOGIYA

Ma’lumki bugungi kunda o‘simliklarga, shu jumladan meva va poliz mahsulotlarga elektr ta’sirlar orqali birlamchi ishlov berish energiya samaradorligiga erishishning eng

maqbul usuli hisoblanib, moy olish jarayonini jadallashtiradi va energiya sarfini kamaytiradi.

Eksperimental tadqiqot oldiga tashqi ta'sirlar va ob'yekt parametrlarini ishlov berish sifati bilan bog'lovchi jarayonning matematik modelini qurish vazifasi qo'yiladi [1, 2].

Tajribalar sonini kamaytirish va aniqligini oshirish, jarayonning matematik tavsifini olish, tadqiqotning optimal rejim parametrlarini o'rnatish uchun tajribalarni rejalashtirish bo'yicha matematik nazariyadan foydalanildi. [3-5].

Eksperimentlarni rejalashtirish matritsasini qurish uchun faktorlarning haqiqiy kattaliklaridan kodlangan qiymatiga o'tishi quyidagi ifoda yordamida bajarildi.

$$x_i = \frac{X_i - X_{i0}}{\varepsilon} \qquad (1)$$

Bu yerda: x_i - *i* – faktorning kodlangan qiymati;

X_i - *i* –faktorning kontrol qiymati;

X_{io}- *i* – faktorning nol darajadagi kontrol qiymati;

ε - shu faktorning o'zgarish intervali.

Quyidagi ko'rinishdagi matematik modelni tanlaymiz:

$$y = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{i<j}^{n} b_{ij} x_i x_j + \sum_{n=1}^{n} b_{ij} x_i^2 \qquad (2)$$

Dastlabki ekperimentlardan chigit yanchilmasidagi moy tutib turuvchi to'qimalarning shikastlanish darajasiga ta'sir qiluvchi asosiy parametrlar deb quyidagilar belgilab olindi:

X_1 – razryad kuchlanishi, kV;

X_2 –impulslar soni, dona;

X_3 – kondensator sig'imi, mkF;

X_4 – yanchilmaning namligi, %

X_5 - Ishlov beriladigan yanchilmaning qalinligi, mm.

NATIJALAR

O'tkazilgan n ta tajriba natijalarning o'rtacha qiymatlari va dispersiyalar quyidagi formulalar orqali hisoblanadi:

$$\overline{y}_g = \frac{1}{m}\sum_{i=1}^{m} y_{gi} \qquad (3)$$

$$S_g^2 = \frac{1}{m-1}\sum_{i=1}^{m}\left(y_{gi} - \overline{y}_g\right)^2$$

Eksperiment ifodalanishini $q = 0{,}05$ uchun Koxren kriteriyasi bo'yicha tekshiramiz[6]:

$$G = 0{,}8563 < G_{1-q}\left(v_1 = 2,\ v_2 = 42\right) = 0{,}1131\ ,$$

Dispersiya ifodalanish darajasini quyidagi formula yordamida hisoblaymiz:

$$S^2\{y\} = \frac{1}{N}\sum_{g=1}^{N} S_g^2 = \frac{1}{N_1 + 2n + N_0}\sum_{g=1}^{N} S_g^2 = \frac{142{,}07}{42} = 3{,}38 \qquad (4)$$

O'rtacha dispersiyani quyidagicha hisoblaymiz:

$$S^2\{\overline{y}\} = \frac{S^2\{y\}}{m} = \frac{3{,}38}{3} = 1{,}127 \qquad (5)$$

Regretsiya koeffitsiyentlarini aniqlash uchun quyidagi summani hisoblaymiz[7]:

$$z_j = \sum_{g=1}^{N} f_{gj}\bar{y}_g, j = 0\ldots20. \quad (6)$$

Bu yerda, $j = 0$ uchun $f_{g0} = 1$; $j = 1\ldots5$ uchun $f_{gj} = (x_i)_g$; $j = 6\ldots15$ uchun $f_{gj} = (x_i x_j)_g, (ij = 1\ldots5, i = f)$; $j = 16\ldots20$ uchun $f_{gj} = (x_i^2)_g, (i = 1\ldots5)$.

$Z_j\left(j = 0...14\right)$ qiymatlar yordamida regressiya koeffitsiyentlarini quyidagi formulalar orqali hisoblaymiz[8]:

$$b_0 = \frac{a}{N}\sum_{i=1}^{N}\bar{y}_g - \frac{b}{N}\sum_{i=1}^{n}\cdot\sum_{g=1}^{N}(x_i^2)_g\bar{y}_g ; \quad (7)$$

$$b_i = \frac{1}{\lambda_2 \cdot N}\cdot\sum_{g=1}^{N}(x_i\ )_g\,\bar{y}_g ; \quad (8)$$

$$b_{ij} = \frac{1}{\lambda_3 \cdot N}\cdot\sum_{g=1}^{N}(x_i x_j\ )\bar{y}_g ; \quad (9)$$

$$b_{ij} = \frac{C}{N}\cdot\sum_{i=1}^{N}(x_i^2\ )\bar{y}_g - \frac{d}{N}\cdot\sum_{i=1}^{n}\cdot\sum_{g=1}^{N}(x_i^2\ )\bar{y}_g - \frac{b}{N}\cdot\sum_{g=1}^{N}\bar{y}_g ; \quad (10)$$

Bu yerda, a,b,c,d, $(\lambda_{.2}\cdot N)^{-1}, (\lambda_3\cdot N)^{-1}$ - konstantalar, model koeffitisiyentlarini hisoblash uchun yordamchi konstruksiyalar.

n=5 da konstantalar qiymati quyidagicha bo‘ladi:

a = 4,1642; b= 0,91416; c= 13; d= 2,33584; $(\lambda_{.2}\cdot N)^{-1} = 0{,}05556$; $\left(\lambda_3 N\right)^{-1} = 0{,}0625$.

Koeffitsiyentlar dispersiyalari quyidagi ifodalar orqali hisoblanadi:

$S^2(b_0) = \frac{a}{N}S^2\{\bar{y}\};$ (11)

$S^2\{b_i\} = (\lambda_2\cdot N)^{-1}S^2\{\bar{y}\};$ (12)

$S^2\{b_{ij}\} = (\lambda_3\cdot N)^{-1}S^2\{\bar{y}\};$ (13)

$S^2\{b_{ii}\} = \frac{C-OC}{N}S^2\{\bar{y}\};$ (14)

t_j -kriteriya qiymatlarini quyidagi ifoda orqali hisoblaymiz:

$$t_i = \frac{\left|b_j\right|}{S\{b_j\}} \quad (15)$$

Bu yerda, $S\{b_j\} = \sqrt{S^2\{b_j\}}$ tanlama o‘rtacha kvadrat og‘ishi.

Regressiya koeffitsiyentlarini baholashni tekshirish uchun nolinchi gipotezani Styudent t-kriteriyasining alternativ qiymati bilan taqqoslab, quyidagi tengsizlik orqali amalga oshiramiz[9]:

$$t_j > t_{1-\frac{g}{2}}(v = N(m-1)) \quad (16)$$

Bu yerda, $t_{1-\frac{g}{2}}(v)$ - V = N (m-1) erkinlik darajasi soni uchun Styudentning $(1-\frac{g}{2})$ % kvantil taqsimoti. Natijada matematik model quyidagi ko‘rinishda yoziladi:

$$Y = 43{,}65 + 3{,}21x_1^2 + 8{,}26x_2^2 + 7{,}11x_3^2 + 6{,}52x_4^2 + 8{,}91x_5^2 + 4{,}22x_1 + 3{,}73x_2 + 1{,}32x_3 + 1{,}01x_4 + 4{,}07x_5 - -0{,}64x_1x_2 - 1{,}53x_1x_3 - 0{,}69x_1x_4 - 0{,}16x_1x_5 + 3{,}83x_2x_3 + 1{,}91x_2x_4 - 3{,}44x_2x_5 + +1{,}70x_3x_4 + 2{,}75x_3x_5 - 0{,}54x_4x_5$$

MUHOKAMA

Eksperiment natijalariga ishlov berishning navbatdagi bosqichi matematik model va javob funksiyasining adekvatligi haqidagi gipotezani tekshirib ko‘rishdir. Regression tahlil usulidan so‘ng ushbu tanlanma dispersiya va adekvatlik dispersiyasini taqqoslash orqali amalga oshiriladi. Belgilangan ikkala dispersiyaning bir xilligi haqidagi gipotezaning adekvatligini tekshirish Fisher kriteriyasi yordamida amalga oshiriladi:

$$F = \frac{S_{OTK}^2}{S^2\{\bar{y}\}} \qquad (17)$$

Tanlangan dispersiya S_{OTK}^2 quyidagi formula yordamida topiladi:

$$S_{OTK}^2 = \frac{\sum_{g=1}^{N}(\bar{y}_g - \hat{y}_g)^2}{N-d} = \frac{1875{,}9}{21} = 89{,}32 \qquad (18)$$

$S_{OTK}^2 < S_{\{\bar{y}\}}^2$ ni hisobga olib, quyidagicha hisoblaymiz:

$$F = \frac{S^2\{\bar{y}\}}{S_{OTK}^2} = \frac{1{,}127}{89{,}32} = 0{,}0126$$

V_1=Nd=42-21=21; V_2=N(h-1)=42(3-1)=84

q=0,05 da Fisher kriteriyasining jadval qiymati quyidagiga teng bo‘ladi:

F= 0,0126 <F_{1-q}(21,84) = 1,8425

Demak, matematik model va javob funksiyasining mosligi haqidagi gipoteza kuzatuv natijalariga zid kelmaydi.

Ahamiyatga ega emas koeffitsiyentlarni chiqarib tashlab, olingan ma’lumotlarning hisoblash natijalariga ko‘ra, matematik model kodlangan ko‘rinishda quyidagicha bo‘ladi:

$Y = 43{,}65 + 3{,}21x_1^2 + 8{,}26x_2^2 + 7{,}11x_3^2 + 6{,}52x_4^2 + 8{,}91x_5^2 + 4{,}22x_1 + 3{,}73x_2 + 1{,}32x_3 + 1{,}01x_4 + 4{,}07x_5 - -0{,}64x_1x_2 - 1{,}53x_1x_3 - 0{,}69x_1x_4 - 0{,}16x_1x_5 + 3{,}83x_2x_3 + 1{,}91x_2x_4 - 3{,}44x_2x_5 + +1{,}70x_3x_4 + 2{,}75x_3x_5 - 0{,}54x_4x_5$

O‘zgaruvchilarni kodlangan ko‘rinishdan natural qiymatlariga o‘tkazish quyidagi ifoda orqali bajariladi:

$$x_i = \frac{X_i - X_{i0}}{\varepsilon} \qquad (19)$$

(19) ifodaga asosan moy tutib turuvchi hujayra va to‘qimalar shikastlanish jarayonining tenglamasidagi o‘zgaruvchilar qiymati quyidagicha bo‘ladi:

$$x_1 = \frac{U-6}{2};\quad x_2 = \frac{n-18}{8};\quad x_3 = \frac{C-0{,}8}{0{,}2};\quad x_4 = \frac{f-9}{3};\quad x_5 = \frac{h-10}{5};$$

XULOSA

Kodlangan qiymatlarni natural qiymatlarga o‘tkazib, tegishli o‘zgarishlarni amalga oshirgandan keyin chigit yanchilmasiga elektr impulsli ishlov berganda, moy tutib turuvchi to‘qimalar shikastlanish jarayonining matematik modeli quyidagi ko‘rinishga keladi:

$$S = 35{,}78 + 1{,}6 \cdot U^2 + 1{,}03 \cdot n^2 + 35{,}55 \cdot C^2 + 2.15 \cdot f^2 + 1{,}78 \cdot h^2 - 2{,}84 \cdot U - 3{,}84 \cdot n - 297{,}7 \cdot C - 9{,}92 \cdot f +$$
$$+ 0{,}04 \cdot U \cdot n - 3{,}82 \cdot U \cdot C - 0{,}11 \cdot U \cdot f - 0{,}01 \cdot U \cdot h + 2{,}39 \cdot n \cdot C + 0{,}07 \cdot n \cdot f + 0{,}08 \cdot n \cdot h - 2{,}8 \cdot C \cdot f +$$
$$+ 2{,}75 \cdot C \cdot h + 0{,}03 \cdot f \cdot h$$

Tadqiqotlar natijasida elektr impulsli ishlov berib chigit hujayrasini shikastlash va moy olish jarayonining quyidagi optimal parametrlari aniqlandi: yanchilmaga ishlov beriladigan razryad kuchlanishi 6 kV, impulslar soni 18 ta, kondensator sig‘imi 0,8mkF, yanchilmaning namligi 9%; ishlov beriladigan yanchilma qalinligi 10 mm.

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