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MATHEMATICAL CLASSIFICATION OF THE STRUCTURE OF FLOWS IN CONTROLLED DEVICES OF MULTIPLE PRODUCTION TECHNOLOGICAL PROCESSES

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Annotatsiya: Oqimning agregatga kirishida unga qandaydir vosita bilan indikator kiritilib, oqimning agregatdan chiqishida indikator konsentratsiyasini vaqt funksiyasi sifatida oʻlchashidan iborat. Bu chiqish egri chizigʻi oqim tarkibi boʻyicha namunaviy gʻalayonga tizimning javob funksiyasi deb ataladi. Indikatorlar sifatida boʻyoqlar, tuzlar va kislota eritmalari, izotoplar va boshqa moddalardan foydalanadilar.

**Kalit so`zlar:** agregat, indicator, ko`rsatkich, oqim, model, usul, taqiq, gidrodinamik

Аннотация: индикатор вводится в него каким-либо способом на входе потока в агрегат и заключается в измерении концентрации индикатора как функции времени на выходе потока из агрегата. Эта выходная кривая называется функцией отклика системы на стандартное отклонение по составу тока. В качестве индикаторов они используют красители, растворы солей и кислот, изотопы и другие вещества.

Ключевые слова: Агрегат, показатель, показатель, поток, модель, метод, запрет, гидродинамика.

Abstract: the indicator is introduced into it in some way at the inlet of the flow into the unit and consists in measuring the concentration of the indicator as a function of time at the outlet of the flow from the unit. This output curve is called the response function of the system to the standard deviation in the composition of the current. As indicators, they use dyes, solutions of salts and acids, isotopes and other substances.

Keywords: Aggregate, indicator, indicator, flow, model, method, prohibition, hydrodynamics.

Kirish:

Indikatorga (Kimyoda indiktor -ko'rsatkich (lotincha indikator - ko'rsatgich) - modda yoki komponent konsentratsiyasining o'zgarishini, masalan, titrlash paytida eritmada ko'rish yoki pH, eH va boshqa parametrlarni tezda aniqlash imkonini beruvchi ulanish.) qoʻyiladigan asosiy talab – agregatda indikator zarralarining xulqi oqim zarralarining xulqiga oʻxshashi shart. Bu nuqtai nazardan eng yaxshisi izotoplardir, chunki xossalari boʻyicha ular asosiy oqimdan kam farqlanadi. Amalda koʻpincha asosiy oqim bilan oʻzaro ta'sirga tushmaydigan va oson oʻlchanishi mumkin boʻlgan indikatorlar qoʻllaniladi. Bunday indikatorlarga tuz eritmalari tegishlidir. Agregatga indikator oqimning kirishidagi standart signallar koʻrinishida quyidagicha kiritiladi: impulsli, pogʻonali va siklik. Gʻalayonlovchi signalning koʻrinishiga muvofiq oqimlar strukturasini tadqiq qilishning quyidagi usullari farqlanadi: impulsli, pogʻonali va siklik. Odatda oxirgi signal amaliyotda sinusoida shakliga ega boʻladi.

Materiallar va uslublar. Impulsli usul. Bu usulga muvofiq oqimning agregatga kirishida amaliy bir onda indikatorning delta funksiya shaklidagi ma'lum miqdori kiritiladi. Faraz qilaylik, ixtiyoriy murakkablilik agregatga oqimni kirishiga amaliy bir onda indikator kiritdik va 1-rasmda tasvirlangan bu gʻalayonga javob funksiyasini aniqladik.

Agregatda boʻlish vaqti t dan t+dt gacha oʻzgaradigan indikatorning miqdori quyidagini tashkil etadi:

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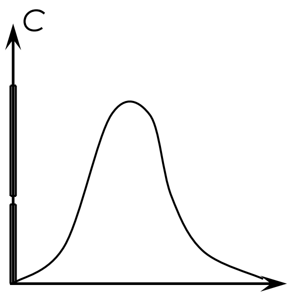
dg=νC_E (t)dt (1)

dg indikatorning umumiy miqdori g ga nisbati indikatorning agregatdan t dan t+dt vaqtda chiqqan ulushini ifodalaydi:

dρ=dg/g=(νC_E (t)dt)/g (2)

Asosiy oqim xulqi agregatdagi indikatorning xulqiga o‘xshash bo‘lganligi uchun, (1) tenglama t dan t+dt bo‘lgan vaqtda oqimning ulushini ifoda etadi..



1-rasm. Impulsli g‘alayonga tizimning tipik javob funksiyasi

Agregat hajmini V deb va oqimning hajmli tezligini – ν deb belgilaymiz.
C(θ) o‘lchamsiz konsentratsiyani quyidagi formula bo‘yicha kiritamiz:

$$C(\theta) = \frac{C_E(t)}{C_0^E} \quad (3)$$

bunda C_0^e - oqimdagi boshlang‘ich konsentratsiya:

$$C_0^E = \frac{g}{V} \quad (4)$$

Shu vaqtning o‘zida θ o‘lchamsiz vaqtni quyidagi formula bo‘yicha kiritamiz:

$$\theta = \frac{t}{\bar{t}} \quad (5)$$

bunda $\bar{t}$ - oqim zarralarining agregatda o‘rtacha bo‘lish vaqti:

$$\bar{t} = \frac{V}{\nu} \quad (6)$$

Endi (2) tenglamani quyidagi ko‘rinishga keltirish mumkin:

$$d\rho = \frac{\nu C_E(t)dt}{g} = \nu \frac{C_0^E C_E(t)}{C_0^E} \cdot \frac{1}{g} \cdot \frac{tdt}{\bar{t}} = \nu \frac{C_0^E \bar{t}}{g} C(\theta)d\theta == \frac{\nu C_0^E \frac{V}{\nu}}{g} C(\theta)d\theta$$
$$= C(\theta)d\theta \quad (2.7)$$

Kiritilgan indikatorning umumiy miqdori quyidagi ifoda bilan aniqlanadi

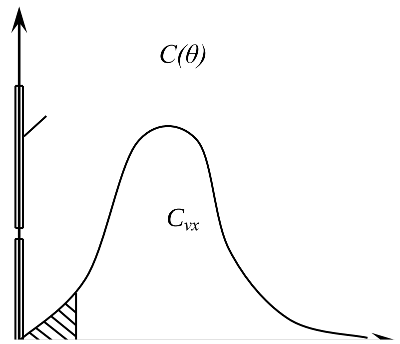
$$g = \nu \int_0^\infty C_E\,(t)dt \quad (8)$$

U vaqtda (2), (7) tenglamalardan quyidagi ifoda kelib chiqadi:

$$C(\theta) = \frac{\nu C(t)dt}{gd\theta} = \frac{\nu C_e(t)}{g}\bar{t} = \frac{C_E(t)}{\int_0^\infty C_E\,(t)dt}\bar{t} = C(t)\bar{t} \quad (9)$$

$$C(t) = \frac{C_E(t)}{\int_0^\infty C_E\,(t)dt} \quad (10)$$

unda ifoda me’yorlangan S-egri chiziqni beradi.



2-pasm. Tipik C – egri chiziq

C(θ) koordinatalarda tajriba egri chizig‘ini quramiz (2-rasm.). Bunday egri chiziq C-egri chiziq deb ataladi. Uni ostidagi shtrixlangan maydon quyidagiga teng

$$\int_0^\infty C(\theta)\,d\theta \qquad (11)$$

va 0 dan θ gacha o‘zgarish vaqtida agregatdagi oqim ulushini belgilaydi. Tabiiyki

$$\int_0^\infty C(\theta)\,d = 1 \qquad (12)$$

Shunday qilib, S- egri chiziq agregatda vaqt bo‘yicha oqim elementlarining taqsimlanishining tavsifidir.

Oqimning agregatda o‘rtacha bo‘lish vaqti quyidagini tashkil etadi

$$\bar{t} = \int_0^\infty t d\rho \qquad (13)$$

Bu tenglamaga (3) tenglamadagi dρ ni qo‘yamiz va (8)

$g = \nu \int_0^\infty C_e\,(t)dt$ dan foydalansak, unda quyidagi ifoda kelib chiqadi:

$$t = \frac{\nu \int_0^\infty tC_E\,(t)dt}{\nu \int_0^\infty C_E\,(t)dt} = \frac{\int_0^\infty tC_E\,(t)dt}{\nu \int_0^\infty C_E\,(t)dt} \qquad (14)$$

Natijalar va tahlil. Agregatdagi oqimlarning gidrodinamikasini tadqiq qilishda impulsli usul qo‘llaniladi. Impulsli g‘alayonni berish (indikatorni impuls shaklida kiritish) natijasida agregat chiqishidagi indikatorning quyidagi konsentratsiya qiymatlari olinadi (formalin konsentrasiyasi misolida) (1-jadval).

1-jadval

Vaqt, min	1:35	6:30	10:20	15:10	18:20	22:30
Indekator-ning konsentra-tsiyasi, g/m^3	39,23	39,93	39,37	39,8	39,08	39,9

S- egri chiziqning taqsimlanishini qurish kerak.

Yechim. C(θ) funksiyani aniqlash uchun dastlab (9) tenglamadagi C(t) qiymatlarni topamiz. Buning uchun probalar (tahlil uchun namuna) olish vaqtining intervalini amaldagi (taxlil natijalari asosida) Δt=4 soat deb taxminiy faraz qilib, $\sum C_e(t)\,\Delta t$ Δt qiymatlar yig‘indisini hisoblaymiz:

$$\int_0^\infty C_E(t)\,dt \approx \sum v \int_0^\infty C_i^E\,(t)\Delta t = (39{,}23 + 39{,}93 + 39{,}37 + 39{,}8 + 39{,}08 + 39{,}9)\cdot 4 = 100\,\frac{g\cdot daq.}{m^3}$$

$C(t) = C_i^E(t)/\sum C_i^E(t)\,\Delta t$ me'yorlangan funksiyani vaqtga bog'liq qiymatlarini 2-jadval shakliga keltiramiz.

2-jadval

C (t) me'yorlangan funksiyaning qiymatlari

t, daq.	1:35	6:30	10:20	15:10	18:20	22:30
$C(t)\ min^{-1}$	0,03	0,05	0,05	0,04	0,02	0,01

C(θ) funksiyani olish uchun, vaqt θ va C ni o'lchamsiz ko'rinishga keltiramiz – ya'ni C(θ) ko'rinishga. Buning uchun agregatda o'rtacha bo'lish vaqtini (14) tenglamadan topamiz.

O'lchamsiz vaqt quyidagini tashkil etadi:

$$\theta = \frac{t}{\bar{t}} = \frac{t}{15}$$

(9) tenglamadan foydalanib, quyidagiga ega bo'lamiz:

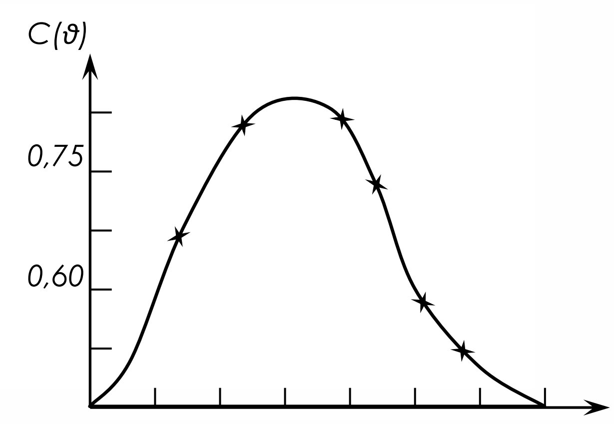
va t_i,C_i^E qiymatlarni qo'ygandan keyin, C(θ) muvofiq qiymatlarini olamiz (3-jadval)

3-jadval

C(θ)o'lchamsiz funksiyaning qiymatlari

θ	0	1/3	2/3	1	4/3	5/3	2	7/3
C (θ)	0	0,45	0,75	0,75	0,60	0,03	0,15	0

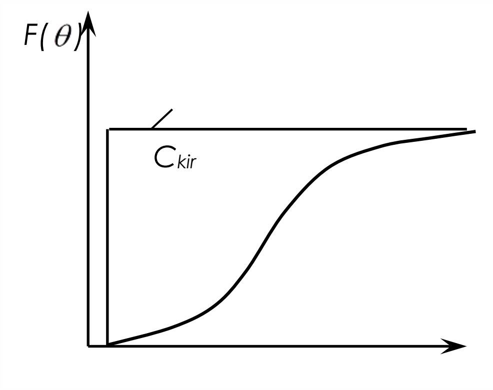
Bu ma'lumotlar bo'yicha taqsimlanishning C-egri chizig'ini quramiz.



3-rasm. O'lchamsiz C-egri chiziq

Pog'onali g'alayon usuli. Bu usuldan foydalanishda agregatga kirayotgan va indikator bo'lmagan suyuqlik oqimiga indikatorning ma'lum miqdori Shunday kiritiladiki, kirayotgan oqimda uning konsentratsiyasi noldan sakrab C_0 ning ma'lum qiymatigacha o'zgaradi va shu sathda ushlab turiladi.

Signalning pog'onali shakliga mos keluvchi javob egri chizig'i 4-rasmda tasvirlangan ko'rinishga ega. Agar vaqt o'lchamsiz birliklarda ifodalangan bo'lsa, unda agregatdan chiqayotgan oqimdagi indikator konsentratsiyasining vaqt bo'yicha o'zgarish bog'liqligi F-egri chiziq deb ataladi. Kirayotgan oqimdagi F/F(∞) nisbatga teng miqdor 0 dan 1 gacha o'zgaradi.



4-rasm. Tipik tajribaviy F – egri chiziq

Oqim elementlarining agregatda bo‘lish vaqti θ dan θ+dθ gacha oraliqda bo‘lsa, oqim elementlarining ulushi quyidagiga teng bo‘ladi:

$$dF(\theta) = C(\theta)d\theta \qquad (15)$$

Oqim elementlarining agregatda bo‘lish vaqti θ dan kichik bo‘lsa, oqim elementlarining ulushi quyidagicha aniqlanadi:

$$F(\theta) = \int_0^{\theta} C(\theta)d\theta \quad (16)$$

Agregatdagi suyuqlikning barcha ulushlarini yg‘indisi 1 ga teng bo‘lganligi uchun C-egri chiziq ostidagi maydon 1 ga teng va $\theta \longrightarrow \infty \; da \; f(\theta) \longrightarrow \infty$ ya’ni

$$\int_0^1 \theta dF(\theta) = \int_0^{\theta} \theta C(\theta)d\theta = 1 \qquad (17)$$

Oqimning agregatda o‘rtacha bo‘lish vaqti quyidagini tashkil etadi:

$$\bar{t} = \frac{\int_0^{\infty} tC_E(t)dt}{\int_0^{\infty} C_E(t)dt} == \int_0^{\infty} tC_E(t)dt = \int_0^{\infty} tdF = -\int_0^{\infty} td(1-F) \qquad (18)$$

(18) ifodada oxirgi integralni topish uchun bo‘laklab integrallashdan foydalanamiz:

$$\int_0^{\infty} td(1-F) = t(1-F) - \int_0^{\infty}(1-F)td \qquad (19)$$

(19) tenglamadagi birinchi qo‘shiluvchi nolga teng. Bunda oqimning agregatda o‘rtacha bo‘lish vaqti agregatdan chiqishdagi oqim elementlarining taqsimlanish funksiyasi qiymatlari $F(t) = F_E(t)/F_E(\infty)$orqali quyidagicha ifodalanadi:

$$\bar{t} = \int_0^{\infty}(1-F)\, td \qquad (20)$$

Quyidagi funksiyani kiritib

$$I(t) = 1 - F(t) \qquad (21)$$

o‘rtacha bo‘lish vaqtini quyidagicha ifodalash mumkin:

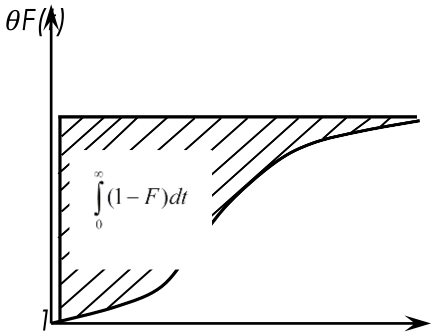
$$\bar{t} = \int_0^{\infty} I(t)dt \qquad (22)$$

Geometrik jihatdan o‘rtacha bo‘lish vaqti F(t) egri chiziq ustidagi maydonga mos keladi (5-rasm).

Muvozanat holati usuli. Bu usul bilan agregatda oqimlar strukturasini tadqiq qilganda agregatdan chiqish oqimiga doimiy tezlik bilan indikator kiritiladi va indikator konsentratsiyasining oqim harakatining teskariga yo‘nalgandagi o‘zgarishi aniqlanadi. Indikator zarrachalari agregatga oqimning teskari aralashtirishi hisobiga tushadi.

Agregatning uzunligi bo‘yicha indikator konsentratsiyasining taqsimlanishi muvozanat rejimda aniqlanadi.

Diffuziyali model parametri - bo‘ylama aralashtirish koeffitsienti (D_l) ni baholash uchun muvozanat holati usullaridan foydalanish misolini ko‘rib chiqamiz.



5-rasm. O‘rtacha bo‘lish vaqtining geometrik talqini

Diffuziyali modelning tenglamasi quyidagi ko‘rinishda yoziladi:

$$\frac{d^2C}{dz^2} - Pe\frac{dC}{dz} = 0 \quad (23)$$

bunda z - o‘lchamsiz koordinata; C - konsentratsiya; Pe - Pekle soni. Quyidagi chegaraviy shartlarni yozamiz:

$$z = 1da\ C_{kr} = 0, C = \frac{1}{Pe}\frac{dC}{dz} \quad (24)$$

$$z = 1\ da\ C = C_k \quad (25)$$

(23) tenglamaning umumiy yechimi quyidagi ko‘rinishga ega:

$$C = A_1 + A_2e^{Pez} \quad (26)$$

bundan quyidagi ifoda kelib chiqadi:

$$\frac{dC}{dz} = A_2Pe \cdot e^{Pez} \quad (27)$$

z = 0 dagi chegaraviy shartdan foydalanib, A_x qiymatini topamiz:

$$A_1 + A_2e^0 = \frac{1}{Pe} \cdot A_2Pe \cdot e^0;\ A_1 = 0 \quad (28)$$

z =1 dagi shartdan esa quyidagiga ega bo‘lamiz:

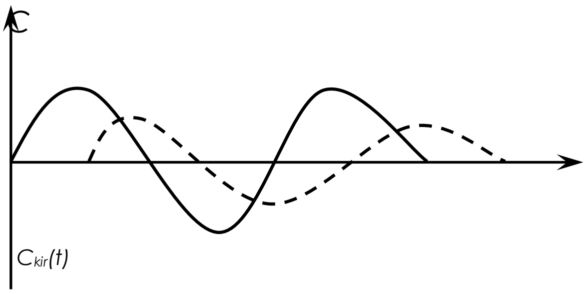
$$C_k = A_2e^{Pe};\ A_2 = C_ke^{-Pe} \quad (29)$$

Shuning uchun ushbu ko‘rilayotgan holda diffuziyali model tenglamasining yechimi quyidagicha bo‘ladi:

$$C = C_ke^{Pe(z-1)} \quad (30)$$

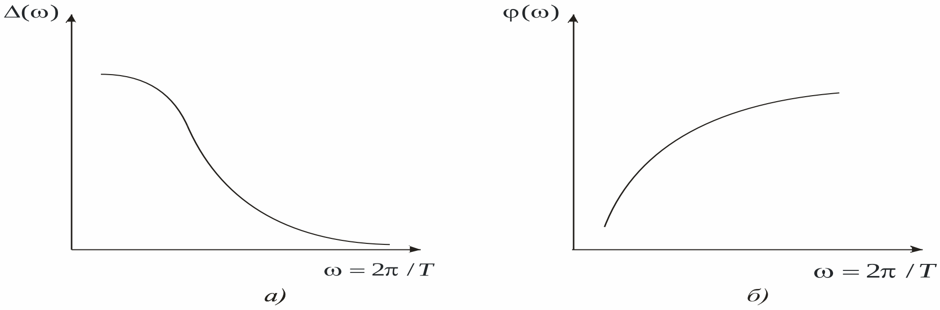
Agregatning qandaydir kesimida indikatorning konsentratsiyasini aniqlab, Pe ni topish mumkin va agregatning bir necha kesimlarida konsentratsiyani o‘lchab, model monandligini tekshirish uchun foydalanish mumkin bo‘lgan ma’lumotlarni olamiz. Agar oqimda bo‘ylama aralashtirish koeffitsienti agregatning uzunligi bo‘yicha bir xil bo‘lsa, unda turli nuqtalarda olingan Pe ning qiymatlari bir biriga mos keladi.

Sinusoidal g‘alayonli usul. Kiruvchi oqimga sinusoidal g‘alayon ta’sir ettirilsa, chiqishda o‘zida sinusoidani ifodalaydigan, lekin boshqa amplitudaga ega va faza bo‘yicha siljigan javob funksiyasi olinadi. Kirishdagi sinusoidal g‘alayon A_0amplituda va chastota ω= 2p/T (rad/s) bilan aniqlanadi, bunda T – tebranishlar davri. Chiqish sinusoidada amplituda o‘zgaradi va φ faza siljis



6-rasm. Trasserni sinusoidal berishda kirish va chiqish signallarning ko‘rinishi

Bir ob'yekt uchun φ qiymat va amplitudaning o'zgarishi g'alayonlovchi signalning chastota funksiyalaridir. Kirish va chiqish sinusoidalarini solishtirish natijasida amplituda-chastota va faza-chastota tavsiflari olinadi (7-rasm).



7-rasm. Tizim javobining amplituda-chastota (a) va faza-chastota (b) tavsiflari

Amplitudalar nisbati kuchaytirish koeffitsienti $\Delta(\omega)$ deb ataladi.

Kirishga sinusoidal signal berilgandagi diffuziyali modelning bo'ylama aralashtirish koefffisienti D_l; $\frac{\partial C}{\partial t} = D_l \frac{\partial_2 C}{\partial x_2} - u \frac{\partial C}{\partial x}$ formulani aniqlanishini ko'rib chiqamiz. Chegaraviy shartlar quyidagi ko'rinishda ifodalanadi:

$$C(t,0) = C_0 A_0 sin\omega t \quad (31)$$

$$C(t,\infty) = C_0 \quad (32)$$

bunda C_0- indikatorning o'rtacha konsentratsiyasi; A_0 – z=0 dagi (agregatga kirishda) tebranishlar amplitudasi.

Xulosa. Diffuziyali model tenglamasi uchun Laplas o'zgartirishini qo'llab, (31), (32) chegaraviy shartlarni hisobga olgan holda agregat chiqishdagi indikator konsentratsiyasi uchun quyidagi ifodani olish mumkin:

$$C(t,l) = C_0 + A_0 e^{-B} sin(\omega t - \varphi) \quad (33)$$

bunda

$$B = \ln\frac{A_0}{A_1} = \frac{ul}{2D_l} = \left\{ \sqrt[4]{1 + \left(\frac{4\omega D_l}{u^2}\right)^2} \; cos\left[\frac{tg^{-1}\left(\frac{4\omega D_l}{u^2}\right)}{2}\right] \right\} - 1 \quad (34)$$

l —agregatning uzunligi; A_j— agregat chiqishdagi tebranishlar amplitudasi.

Ildiz ostidagi ifodani va trigonometrik funksiyani qatorga yoyib, yuqori darajali a'zolarini inobatga olmasak, (34) tenglama quyidagi ko'rinishga ega bo'lishi mumkin:

$$B = \frac{l\omega^2}{u^3} - \frac{5l\omega^2 D_l^3}{u^7} \quad (35)$$

(35) tenglamaning ikkinchi a'zosini inobatga olmasak, quyidagi ifodani olamiz:

$$B = \ln\frac{A_0}{A_1} = \frac{l\omega^2 D_l}{u^3} \quad (26)$$

Fazalar siljishini aniqlovchi tenglama quyidagi ko'rinishga ega:

$$\varphi = \frac{ul}{2D_l}\sqrt{\sqrt{\frac{1}{4} + \left(\frac{2D_l}{u^2}\right)^2} - \frac{1}{2}} \quad (37)$$

Qatorga yoyib, yuqori darajali a'zolarni chiqarib tashlagandan so'ng, oxirgi tenglama quyidagi sodda ko'rinishga ega bo'ladi:

$$\varphi = \frac{\omega L}{u} \quad (38)$$

Endi fazalar siljishining tajriba qiymati f va A_0/A_1amplitudalar nisbati bo'yicha (36), (37) tenglamalar asosida bo'ylama aralashtirish koeffitsienti D_l ning qiymatini baholash qiyin emas.

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