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**AMUDARYO DARYOSI SUV OQIMI TARKIBIDAGI LOYQA OQIZIQLAR
DINAMIKASINING IMITATSION MODEL****Murodov Navruz Qurbonovich-** tadqiqotchi, e-mail: navrozmurodov99@gmail.com

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***Annotasiya.** Maqolada suv oqimidagi muallaq va tub oqiziqqlarining deformasiyalanuvchi o‘zanga nisbatan dinamikasini o‘rganish borasida amalga oshirilgan tadqiqot natijalari keltirilgan. Loyqa cho‘kindilar zarrachalarining gidravlik karakteristikalarini ifodalovchi imitasion model kanalda loyqa cho‘kindilar rejimini boshqarish hamda zemsnaryadlarni samarali ishlashini ta‘minlash imkoniyatini yaratadi.*

***Kalit so‘zlar:** fizik model, oqimning gidravlik parametrlari, o‘zan morfologiyasi dinamikasi, imitasion model.*

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**ИМИТАЦИОННАЯ МОДЕЛЬ ДИНАМИКИ НАНОСОВ В СОСТАВЕ ВОДЫ РЕКИ
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***Аннотация.** В статье представлены результаты исследования динамики взвешенных и придонных жидкостей в потоке воды по отношению к деформирующемуся телу. Имитационная модель, отображающая гидравлические характеристики частиц мутных осадков, создает возможность управлять режимом мутных осадков в канале и обеспечивать эффективную работу земснарядов.*

***Ключевые слова:** физическая модель, гидравлические параметры потока, динамика морфологии пласта, имитационная модель.*

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SIMULATION MODEL OF SEDIMENT DYNAMICS IN AMUDARYA RIVER WATER**Murodov Navruz Kurbanovich-** researcher, navrozmurodov99@gmail.com

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***Abstract.** The article presents the results of a study of the dynamics of suspended and bottom liquids in a water flow in relation to a deforming body. A simulation model that displays the hydraulic characteristics of turbid sediment particles makes it possible to control the turbidity regime in the channel and ensure the efficient operation of dredgers.*

***Keywords:** physical model, hydraulic flow parameters, reservoir morphology dynamics, simulation model.*

Kirish

O‘zbekiston Respublikasi iqtisodiyoti va suv xo‘jaligi xavfsizligi uchun o‘ta muhim ahamiyatga ega bo‘lgan Markaziy Osiyoda eng yirik hisoblangan transchegaraviy Amudaryo daryosidan suv olish inshootlari XX asrning 60-yillarida shakllantirilgan to‘g‘onsiz suv olish inshootlari bo‘lib ularning ishonchlilik holati yirik suv omborli gidroenergetik inshootlar ta‘sirida keskin pasayib bormoqda. Shu bilan birgalikda transchegaraviy daryolardagi suv olish inshootlaridagi noqulay gidravlik vaziyatlar tufayli suv oluvchi kanallarni loyqa-cho‘kindilar bilan to‘lib borishi ularning suv o‘tkazish qobiliyatiga jiddiy salbiy ta‘sir ko‘rsatmoqda. Shu sababli ushbu tadqiqot ishida yirik daryolarda tub va muallaq loyqa oqiziqqlarining harakatlanish dinamikasi tadqiq qilindi [1-5].

Uslub va materiallar

Tadqiqot maqsadiga erishish uchun Irrigasiya va suv muammolari ilmiy-tadqiqot instituti bazasida shakllantirilgan Qarshi magistral kanalining bosh suv olish qismi - Amudaryo daryosining fizik modelida o'tkazilgan eksperiment tadqiqotlari natijalariga ko'ra, yirik daryolarda tub va muallaq loyqa oqizqlarining harakatlanish mexanizmlari tadqiq qilindi.

Eksperiment natijalari shuni ko'rsatdiki, oqim bilan harakatlanayotgan tub va muallaq oqizqlar oqimning bo'linish stvorlarida turli tezliklarga ega bo'lib, gidravlik qarshilik koeffitsiyenti qiymatlari katta bo'lgan uchastkada ularning tezliklari kamayib o'zan tubiga o'tirishi sodir bo'ladi. Tajribalarga ko'ra, yuqorida qayd etilgan uchastkalarda muallaq va tub oqizqlarni to'planishi oqibatida kundalang valiklar hosil bo'lib, o'zanda qavariq qiyalikka ega rifellar shakllana boshlaydi [6-7].

Munozara

Olib borilgan eksperimental tadqiqot natijalariga ko'ra, o'zan uzunligi bo'ylab oqim tezligini pulsasiyalanishi oqibatida tub oqizqlarining tezliklari qiymatlari ba'zi bir uchastkalarda kamayishi, boshqa uchastkalarda esa ko'payishi ro'y beradi (1-rasm).



1-rasm. Fizik modelda suv oqimidagi tub va muallaq oqizqlar harakatining eksperimental tadqiqotlari

Suv oqimi uyurma sohasini to'sishi bilan o'zan rifeli sirti bilan tutashib, rifel grebeni sirtidan tub oqiziq zarrachalarini yuvib ketadi. Suv oqimi bilan yuvib ketilgan tub oqiziq zarrachalari, uyurma oqimi ta'sirida rifel qiyaligiga yopishadi. Natijada o'zan tubi rifelini o'zgarishi yoki rifelni ko'chishi sodir bo'ladi. Rifelni ko'chish tezligi uning sirtidan yuvilgan zarrachalar miqdoriga va suv oqimi tezligiga bog'liq bo'ladi. Undan tashqari uning shakli o'lchamlariga ham bog'liq bo'ladi, rifelning o'lchamlari qancha katta bo'lsa uning ko'chish tezligi shuncha kichik bo'ladi.

1-jadval

Fizik modeldagi suv oqimining gidravlik va o'zanning morfologik parametrlarining eksperimental qiymatlari

Hisobiy stvorlar	Rifel			Oqim chuqurligi, h, sm	v_{oq} , m/sek	v_{mo} , m/sek	v_{to} , m/sek
	$h_{o'r}$, sm	$L_{o'r}$, sm	Ko'chish tezligi, m/soat				
1-1	1,21	41,2	0,09	4,8	0,76	0,36	0,17
2-2	1,24	36,2	0,084	4,7	0,73	0,30	0,14
3-3	1,28	39,3	0,072	4,6	0,60	0,24	0,12
4-4	1,31	41,2	0,077	4,9	0,56	0,21	0,09

Bu yerda: v_{oq} – suv oqimining o'rtacha tezligi, v_{mo} – muallaq oqiziq zarrachalari tezligi, v_{to} – tub oqiziq zarrachalari tezligi.

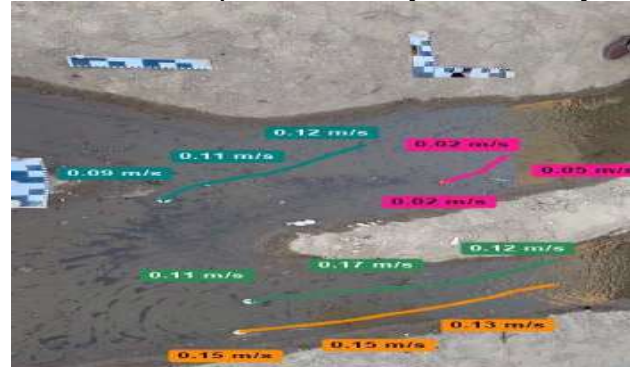
Tajribalarga ko'ra, turli jinsli rifellarni ko'chishi jarayonida ularni kichik o'lchamdagi shakllarga bo'linishi ro'y beradi. Agarda rifellar bir jinsli bo'lsa u holda ularning bo'linishi deyarli sodir bo'lmaydi.

1-jadvalda fizik modeldagi oqimning gidravlik parametrlari va rifellarning o‘lchamlarini va ko‘chishini xarakterlovchi eksperimental natijalar keltirilgan.

Eksperiment natijalari shuni ko‘rsatmoqdaki, oqimning o‘rtacha tezligi ortishi bilan muallaq va tub oqiziq zarrachalari tezliklari qiymati kattalashadi. Shu bilan bir qatorda rifellar yuvila boshlaydi.



2-rasm. Fizik modelda $v_{oq} = 0,60 \frac{m}{s}$ bo‘lganda tub va muallaq oqiziqqlarning kinematik xarakteristikasi.



3-rasm. Fizik modelda $v_{oq} = 0,56 \frac{m}{s}$ bo‘lganda tub va muallaq oqiziqqlarning kinematik xarakteristikasi.

Laboratoriya va dala tadqiqotlari natijalariga ko‘ra, tub loyqa oqiziqqlar avval rifel ko‘rinishida keyin gryadlar shaklida oqim yo‘nalishiga nisbatan qavarik ko‘rinishida shakllanadi. Keyinchalik tub loyqalar qirg‘oq oldi yirik cho‘kindilar shakliga o‘tadi.

Gidravlik modellashtrish. O‘zan deformatsiyasini va loyqa cho‘kindilar harakatini hisoblash usulini takomillashtirishni o‘z oldimizga maqsad qilib olamiz. Gidravlika kursidan ma’lumki, suyuqlik harakatini ifodalovchi ikkita usuli mavjud:

1. Lagranj usuli.
2. Eyler usuli.

Gidrotexnikadagi aksariyat ilmiy-texnik masalalar asosan Eyler usuli bilan yechiladi. Maqolada suv oqimidagi muallaq va tub oqiziqqlar harakatini ifodalash maqsadida Lagranj usulidan foydalaniladi.

Fizik modelda muallaq oqiziqqlarni oq rangli sharlar bilan, tub oqiziqqlarni esa qizg‘ich rangli sharlar orqali ifodalanadi. Suv oqimining turli tezliklarida suv oqimidagi muallaq va tub oqiziqqlarning kinematik parametrlar, jumladan tezliklari va trayektoriyalari tadqiq qilindi (2-3 rasmlar). Eksperimental tadqiqot natijalari asosida gidravlik modellashtrish amalga oshirildi. Buning uchun o‘zan tubi sirti buylab “oxy” tekislik belgilandi.

Suv oqimidagi muallaq va tub oqiziqqlar nafaqat ilgarilanma balki o‘z o‘qi atrofidagi va koordinatalar tekisligiga nisbatan aylanma harakatda bo‘ladi. Shu sababli, har bir vaqt intervalida muallaq va tub oqiziq zarrachalari holati 5 ta koordinatalar orqali ifodalanadi. Chizilgan 2 ta x,y dekart va ψ, ϕ, θ lar Lagranj koordinatalari orqali aniqlanadi. Ya’ni bunda suv oqishidagi oqiziq zarrachalarining ixtiyoriy vaqt momentidagi holatida x, y, ψ , ϕ , θ va θ koordinatalar mos ravishda qandaydir qiymatlarni qabul qilishi mumkin. “oxy” koordinata tekisligi belgilangan sirt silliq sirt deb faraz qilamiz. U holda suvdagi loyqa zarrachasi x, y, ψ , ϕ , θ koordinatalar bilan aniqlanadigan holatdan $x+dx$, $y+dy$, $\psi+d\psi$, $\phi+d\phi$ va $\theta+d\theta$ cheksiz kesim masofadagi holatga uzluksiz ko‘chadi [8-9].

Amudaryo daryosining to‘g‘onsiz suv olish inshooti Qarshi magistral kanalining I nasos stansiyasiga suv keltiruvchi kanalining suv olish uchastkasida suvni loyqaligini aniqlash bo‘yicha olingan namunalarni laboratoriya tahlillariga ko‘ra suv oqimi fraksiyasi 0,05-0,01 mm bo‘lgan oqiziq zarrachalari o‘rtacha 70,3 foizni, <0,01mm-14,3 foizni, <0,001mm-3,73 foizni, 0,10-0,05mm-5 foizni, 0,01-0,005 mm-5,6 foizni tashkil etadi. Shu sababli oqimdagi oqiziq zarrachalarini funksiyalar bo‘yicha tizimlarga ajratamiz. Demak suv oqimi uzluksiz muxit sifatida qaralib turli tizimlardan tashkil topgan deb faraz qilamiz [10]. Ushbu tizimlar mos ravishda q_1, q_2, \dots, q_n koordintalar bilan aniqlanadi. Ya’ni tizimlarning ixtiyoriy vaqt t momentidagi konfiguratsiyasi yuqorida qayd etilgan koordinatalar orqali ifodalanadi. Har bir tizimdagi m_i massaga ega loyqa

cho‘kindi zarrachasi holatining mos ravishda $x_i y_i z_i$ koordinatalar orqali aniqlanadi. U holda $x_i y_i$ va z_i koordinatalar q_1, q_2, \dots, q_n kattaliklarini va t vaqtning funksiyasi hisoblanadi va quyidagicha ifodalanadi;

$$\begin{cases} x_i = \vartheta_i(q_1, q_2, \dots, q_n, t) \\ y_i = \varphi_i(q_1, q_2, \dots, q_n, t) , \\ z_i = \psi_i(q_1, q_2, \dots, q_n, t) \end{cases} \quad (1)$$

Agarda m_i massali loyqa oqiziq zarrachasiga ta’sir etuvchi (tashqi va ichki) kuchlarning teng ta’sir etuvchi komponentlari F_i^1, F_i^2 va F_i^3 bo‘lsa, u holda m_i massasi loyqa oqiziqning harakat tenglamasi quyidagi ko‘rinishga ega bo‘ladi:

$$\begin{cases} F_i^1 = m_i \frac{\partial^2 x_i}{t^2} \\ F_i^2 = m_i \frac{\partial^2 y_i}{t^2} , \\ F_i^3 = m_i \frac{\partial^2 z_i}{t^2} \end{cases} \quad (2)$$

(2) tenglamalar tuzishni mos ravishda $\frac{\partial \vartheta_i}{\partial q_r}, \frac{\partial \varphi_i}{\partial q_r}$ va $\frac{\partial \psi_i}{\partial q_r}$ hollarga ko‘paytirib, tizimning barcha zarralari bo‘yicha yozamiz. Natijada quyidagi tenglamaga ega bo‘lamiz:

$$\sum_i m_i \left(\frac{\partial^2 x_i}{\partial t^2} \frac{\partial \vartheta_i}{\partial q_r} + \frac{\partial^2 y_i}{\partial t^2} \frac{\partial \varphi_i}{\partial q_r} + \frac{\partial^2 z_i}{\partial t^2} \frac{\partial \psi_i}{\partial q_r} \right) = \sum \left(F_i^1 \frac{\partial \vartheta_i}{\partial q_r} + F_i^2 \frac{\partial \varphi_i}{\partial q_r} + F_i^3 \frac{\partial \psi_i}{\partial q_r} \right) \quad (3)$$

Quyidagi ifodani e’tiborga olsak:

$$\frac{\partial x_i}{\partial q_r} = \frac{\partial}{\partial q_r} \left(\frac{\partial \vartheta_i}{\partial q_1} \dot{q}_1 + \frac{\partial \vartheta_i}{\partial q_2} \dot{q}_2 + \dots + \frac{\partial \vartheta_i}{\partial q_n} \dot{q}_n + \frac{\partial \vartheta_i}{\partial t} \right) = \frac{\partial \vartheta_i}{\partial q_r} \quad (4)$$

U holda

$$\frac{\partial^2 x_i}{\partial t^2} \frac{\partial \vartheta_i}{\partial q_r} = \frac{\partial^2 x_i}{\partial t^2} \frac{\partial \dot{x}_i}{\partial q_r} = \frac{d}{dt} \left(\frac{\partial x_i}{\partial t} \frac{\partial \dot{x}_i}{\partial q_r} \right) - \frac{\partial x_i}{\partial t} \frac{d}{dt} \left(\frac{\partial x_i}{\partial q_r} \right) = \frac{d}{dt} \left(\frac{\partial x_i}{\partial t} \frac{\partial \dot{x}_i}{\partial q_r} \right) - \frac{\partial x_i}{\partial t} \left(\frac{\partial^2 \vartheta_i}{\partial q_1 \partial q_r} * \dot{q}_1 + \frac{\partial^2 \vartheta_i}{\partial q_2 \partial q_r} * \dot{q}_2 + \dots + \frac{\partial^2 \vartheta_i}{\partial q_n \partial q_r} * \dot{q}_n + \frac{\partial^2 \vartheta_i}{\partial t \partial q_r} \right) = \frac{d}{dt} \left(\frac{\partial x_i}{\partial t} * \frac{\partial \dot{x}_i}{\partial q_r} \right) - \frac{\partial x_i}{\partial t} * \frac{\partial \dot{x}_i}{\partial q_r} = \frac{d}{dt} \left(\frac{\partial}{\partial q_r} \left(\frac{1}{2} \dot{x}_i^2 \right) \right) - \frac{\partial}{\partial q_r} \left(\frac{1}{2} \dot{x}_i^2 \right). \quad (5)$$

Natijada quyidagi tenglamalar tizimiga ega bo‘lamiz:

$$\sum_i m_i \left(\frac{\partial^2 x_i}{\partial t^2} \frac{\partial \vartheta_i}{\partial q_r} + \frac{\partial^2 y_i}{\partial t^2} \frac{\partial \varphi_i}{\partial q_r} + \frac{\partial^2 z_i}{\partial t^2} \frac{\partial \psi_i}{\partial q_r} \right) = \frac{1}{2} \sum m_i \frac{d}{dt} \left(\frac{\partial}{\partial q_r} \left(\dot{x}_i^2 + \dot{y}_i^2 + \dot{z}_i^2 \right) \right) - \frac{1}{2} \sum m_i \frac{\partial}{\partial q_r} \left(\dot{x}_i^2 + \dot{y}_i^2 + \dot{z}_i^2 \right) \quad (6)$$

(6) tenglamalar tizimidagi $\frac{1}{2} \sum m_i \left(\left(\frac{\partial x_i}{\partial t} \right)^2 + \left(\frac{\partial y_i}{\partial t} \right)^2 + \left(\frac{\partial z_i}{\partial t} \right)^2 \right)$ ifoda har bir funksiyasi oqiziq zarrachalar massalarini, zarrachalar tezliklari kvadratlariga ko‘paytmasi yig‘indisining yarmi loyqa oqiziq harakatining kinetik energiyasini ifodalaydi.

Demak, tizimning harakat strukturasi aniq ko‘rinishga ega bo‘ldi. U holda suv oqimidagi muallaq va tub oqiziqning kinetik energiyasi quyidagi kattaliklarning funksiyasi sifatida ifodalash ya’ni,

$$q_1, q_2, \dots, q_n, \dot{q}_1, \dot{q}_2, \dots, \dot{q}_n, t$$

yoki

$$E_k(q_1, q_2, \dots, q_n, \dot{q}_1, \dot{q}_2, \dots, \dot{q}_n, t)$$

Ushbu funksiya quyidagi funksiya kabi, o‘zining argumentlariga nisbatan malum deb faraz qilamiz.

$$\frac{\partial x_i}{\partial t} = \frac{\partial \vartheta_i}{\partial q_1} \dot{q}_1 + \frac{\partial \vartheta_i}{\partial q_2} \dot{q}_2 + \dots + \frac{\partial \vartheta_i}{\partial q_n} \dot{q}_n + \frac{\partial \vartheta_i}{\partial t} \quad (7)$$

U holda harakat tenglamasidan quyidagi tenglamaga ega bo‘lamiz:

$$\frac{d}{dt} \left(\frac{\delta E_k}{\delta \dot{q}_r} \right) - \frac{\delta E_k}{\delta q_k} = \sum_i \left(F_i^1 \frac{\delta \vartheta_i}{\delta q_r} + F_i^2 \frac{\delta \varphi_i}{\delta q_r} + F_i^3 \frac{\delta \psi_i}{\delta q_r} \right) \quad (8)$$

(8) tenglamaning chap tarafidagi hadlar suv oqimidagi loyqa oqiziq zarrachalarining koordinatalariga bog‘liq emas, shu sababli mazkur tenglamani o‘ng qismidagi hadlarni chap qismiga o‘xshash shaklga keltirib olamiz. Shu maqsadda tizimlar harakatini umumlashtiramiz, unda q_r

koordinata $q_r + dq_r$ qiymatni qabul qilib, qolgan koordinatalar vaqtga nisbatan o'zgarmas deb faraz qilamiz. Ushbu farazni qabul qilsak tizim uzluksizligi taminlanadi. Shu tartibdagi ko'chishda m_i massasi loyqa oqiziq zarrachasining qiymati quyidagicha o'zgaradi:

$$x_i + \frac{\delta \vartheta_i}{\delta q_r} \delta q_r, \quad y_i + \frac{\delta \varphi_i}{\delta q_r} \delta q_r, \quad z_i + \frac{\delta \psi_i}{\delta q_i} \delta q_r$$

U holda suv oqimining turli tezliklarida daryo o'zani tubidagi rifelni ko'chirishdagi tashqi hadlar bajargan ishlar yig'indisi quyidagi ko'rinishga ega bo'ladi:

$$\sum_i \left(F_i^1 \frac{\delta \vartheta_i}{\delta q_r} + F_i^2 \frac{\delta \varphi_i}{\delta q_r} + F_i^3 \frac{\delta \psi_i}{\delta q_r} \right) \delta q_r \tag{9}$$

O'zan tubidagi rifel shaklini va holatini o'zgarishi quyidagi funksiya orqali ifodalaymiz:

$$W_r = W_r(q_1, q_2, \dots, q_n, t) \delta q_r$$

U holda quyidagi tenglamaga ega bo'lamiz:

$$\frac{d}{dt} \left(\frac{\delta E_k}{\delta \dot{q}_r} \right) - \frac{\delta E_k}{\delta q_k} = F_r, \quad r = \overline{1, n} \tag{10}$$

Natijada daryo o'zani tubidagi rifel harakatini ifodalovchi (10) tenglamaga ega bo'ldik.

Endi (10) tenglamani sonli eksperimentini amalga oshiramiz. Buning uchun (10) tenglamani Lagranj-Liuvill dinamik masalasiga keltirib olamiz. Ya'ni, (10) tenglama faqat q koordinata uchun quyidagi ko'rinishga keladi [1]:

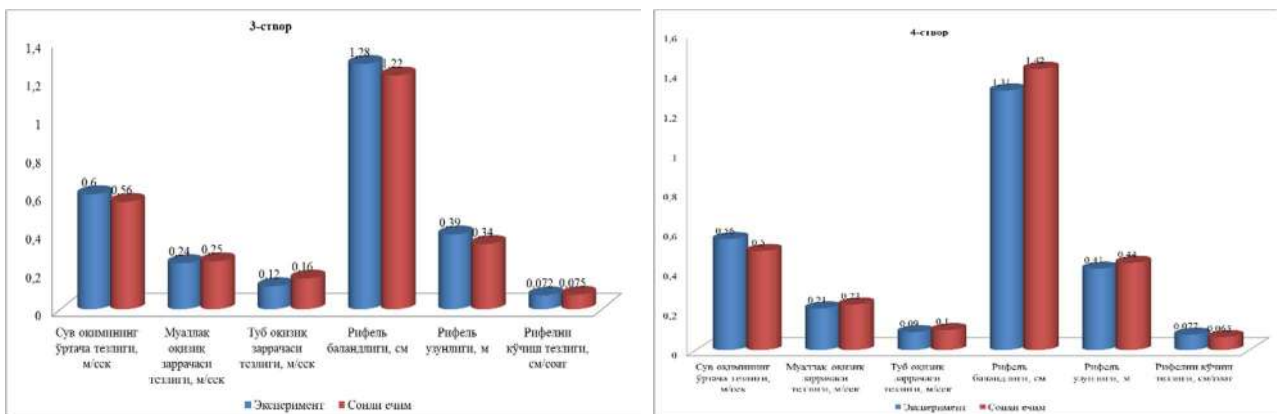
$$\frac{d}{dt} (u \dot{q}) - \frac{1}{2} \frac{\delta u}{\delta q} (\dot{q}_1^2 + \dot{q}_2^2 + \dots + \dot{q}_n^2) + Ar \cdot u_0^2 \frac{\delta u}{\delta q} \dot{q} \tag{11}$$

Tegishli matematik amallardan so'ng o'zan tubidagi rifellar harakati tezligini ifodalovchi tenglamaga ega bo'lamiz.

$$u = \sqrt{2 \cdot \frac{v \varrho + Ar \cdot u_0^3}{a u_1 + b u_2}} \tag{12}$$

bu yerda: u_1 – muallaq oqiziq zarrachalarining tezligi, u_2 – tub oqiziq zarrachalarining tezligi, a va b – eksperiment doimiysi.

Natura va eksperimental tadqiqot natijalari asosida (12) tenglamani sonli eksperimenti amalga oshirildi. Sonli eksperiment, fizik modelda va naturada o'tkazilgan tadqiqot natijalarini taqqoslash tahlillari 4-rasmدا keltirilgan. Taqqoslash natijalari xatoligi 4 % tashkil etadi.



4-rasm. Fizik modeldagi 3 va 4-stvorlarida suv oqimining va loyqa oqiziqqlarning kinematik parametrlarining eksperimental va sonli yechim natijalarining taqqoslash diagrammasi.

Xulosa

Eksperimental tadqiqotlar natijasida suv oqimining turbulent harakatida daryo o'zani tubidagi rifel harakat tezligini ifodalovchi gidravlik model ishlab chiqildi. Turli stvorlar bo'ylab suv oqimining va loyqa oqiziqqlarning kinematik parametrlarini eksperimental va sonli yechim natijalari bilan taqqoslashlar o'tkazildi. Taqqoslash natijalarining xatoligiga 4 % dan oshmasligi aniqlandi. Tadqiqot natijalarini amaliyotga tatbiq etish daryo, kanallarda loyqa cho'kindilar rejimini boshqarish hamda zemsaryadlarni samarali ishlashini ta'minlash imkoniyatini yaratadi.

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