ISNN 3030-3907

2026/4
VOLUME 7

DEVELOPMENT OF SCIENCE

ILMIY JURNAL



Development of science

Ilmiy jurnal

2026/4 VOLUME 7

ISSN 3030 -3907

Ilmiy jurnal OAK rayosatining 2024 yil 27 sentabrdagi 361-son qaroriga asosan 02.00.00 kimyo fanlari hamda 2025 yil 12 fevral 367- son qaroriga asosan 05.00.00 texnika fanlari bo‘yicha falsafa doktori (PhD) va fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiya ishlari yuzasidan dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxatiga kiritilgan.

BOSH MUHARRIR:
Temirov Alisher Hoshim o‘g‘li – texnika fanlari falsafa doktori (PhD),Dotsent.
TAHRIRIYAT KENGASH RAISI:
Fozilov Sadriddin Fayzullayevich – texnika fanlari doktori, professor
TAHRIRIYAT KENGASH A’ZOLARI

TEXNIKA FANLARI/ TECHNICAL SCIENCES/ ТЕХНИЧЕСКИЕ НАУКИ

Bozorov G‘ayrat Rashidovich
Buxoro Davlat Texnika Universiteti, professor
Abdurahmonov Olim Rustamovich
Buxoro Davlat Texnika Universiteti, professor
Adizov Bobur Zamirovich
O‘zbekiston Respublikasi Fanlar akademiyasi Umumiy va noorganik kimyo instituti, professor
Hayitov Ruslan Rustamjonovich
Buxoro Davlat Texnika Universiteti, professor
Jumayev Qayum Karimovich
Buxoro Davlat Texnika Universiteti, professor.
Berdiyev Dorob Murodovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor
Maxmudov Rafiq Amonovich
Buxoro Davlat Texnika Universiteti, professor.
Tilloyev Lochin Ismatilloyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Raxmonov Qahramon Sanakulovich
Buxoro Davlat Texnika Universiteti, dotsent.
Barakayev Nusratullo Rajabovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor.
Jo‘rayev Xayrullo Fayziyevich
Buxoro Davlat Texnika Universiteti, professor.
Panoyev Erali Rajabboyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Ataullayev Sherzod Nabiullyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Malik Negmurodovich
Buxoro Davlat Texnika Universiteti, dotsent.
Axmedova Ozoda Bahronovna
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti.
Safarov Bahri Jumayevich
Buxoro Davlat Texnika Universiteti, dotsent.
Xaydarov Axtam Amonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Safarov Jasur Alijon o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Асадова Раъно Дилмуратовна
Тошкент Давлат техника университети доценти

KIMYO FANLARI/ CHEMICAL SCIENCES/ ХИМИЧЕСКИЕ НАУКИ

Axmedov Voxid Nizomovich
Buxoro Davlat Texnika Universiteti, professor
Umarov Baqo Bafoyevich
Buxoro Davlat Universiteti, professor
Kodirov Abduaxad Abduraximovich
Qarshi davlat Universiteti, professor
Qurbonov Mingniqul Jumagulovich
Qarshi davlat Universiteti, dotsent
Turemuratov Sharibay Naurizbaevich
O‘zbekiston Respublikasi Fanlar akademiyasi Qoraqalpog‘iston bo‘limi Bosh ilmiy kotibi, professor
Tursunov Kaxor Shonazarovich
Qarshi davlat Universiteti, professor
Do‘stov Hamro
Buxoro Davlat Texnika Universiteti, professor
Panoyev Nodir Shavkatovich
Buxoro Davlat Texnika Universiteti, dotsent.
Olimov Bobur Bahodir o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Kasimov Sherzod Abduazimovich
Termiz Davlat Universiteti, professor.
Aliqulov Rustam Valiyevich
Termiz Davlat Universiteti, professor
Tropov Xamza Tursunovich
Samarqand Davlat Universiteti, professor

IQTISODIYOT FANLARI/ ECONOMICS/ ЭКОНОМИЧЕСКИЕ НАУКИ

Nizamov Aslitdin Badreddinovich
Buxoro Davlat Texnika Universiteti, professor.
Boboyev Akmal Choriyevich
Buxoro Davlat Texnika Universiteti, professor.
Ergashxojayeva Shaxnoza Djasurovna
Toshkent davlat iqtisodiyot universiteti, professor
Saidaxmedova Nodira Ilxomovna
Toshkent davlat iqtisodiyot universiteti, professor
Muxsinov Bekzod Toxirovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shakarov Qulmat Ashirovich
Renessans ta'lim universiteti,dotsent.
Jumaeva Zulfiya Qayumovna
Buxoro Davlat Texnika Universiteti, dotsent.
Norova Salomat Yusupovna
Buxoro Davlat Texnika Universiteti, dotsent.
Avezova Shaxnoza Maxmudjonovna
Buxoro Davlat Texnika Universiteti, dotsent.
Jalilov Jamshid G‘anijonovich
Toshkent davlat iqtisodiyot universiteti, dotsent
Xasanova Gulruh Djumanazarovna
Buxoro Davlat Texnika Universiteti, dotsent.

PEDAGOGIKA FANLARI/ PEDAGOGICAL SCIENCES / ПЕДАГОГИЧЕСКИЕ НАУКИ

Siddiqova Sadoqat G‘afforovna
Buxoro Davlat Texnika Universiteti, dotsent.
Zoyirov Erkin Xalilovich
Buxoro Davlat Texnika Universiteti, DSc, professor
Gaffarov Feruz Hasanovich
Puchon Universiteti, *professor*
Ruziyev Davron Yuldashevich
Buxoro Davlat Universiteti, professor
Muradova Firuza Rashidovna
Buxoro Davlat Texnika Universiteti, professor.
Yunusova Gulandon Samiyevna
Buxoro Davlat Texnika Universiteti, professor.
To‘xtayeva Zebo Sharifovna
Buxoro Davlat Texnika Universiteti, professor.
Navro‘zova Gulchixra Nigmatovna
Buxoro Davlat Texnika Universiteti, dotsent.
Uzoqova Laylo Polvonovna
Buxoro muhandislik – texnologiya instituti, dotsent.
To‘raqulova Marjona Qiyom qizi
Buxoro Davlat Texnika Universiteti, dotsent.
Muradova Zarina Rashidovna
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Sanjar Aslonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shodiyev Jahongir Jo‘raqulovich
Buxoro Davlat Texnika Universiteti, dotsent
Gaffarov Laziz Hasanovich
Buxoro muhandislik – texnologiya instituti, dotsent.

Tahririyat a’zolarning to‘liq ro‘yxati jurnalning www.devos.uz saytida keltirilgan.

Tahririyat hay’ati a’zolarining tarkibini o‘zgartirish hamda qo‘shimcha kiritish yoki tahririyat a’zoligidan chiqarish bosh muharrir tomonidan amalga oshiriladi.

ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

To‘plam elektron ko‘rinishda (pdf formatida) mualliflarga taqdim etiladi. To‘plamga kiritiladigan maqolalarning mazmuni, ulardagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligiga hamda har qanday fikr - mulohazalarga mualliflarning o‘zlari mas’ul hisoblanadilar. Talablarga javob bermaydigan maqolalar to‘plamga kiritilmaydi. Tashkiliy qo‘mita maqola matnini qisqartirish, qisman tuzatish kiritish, seksiyalarga joylashtirish huquqiga ega.

ISSN 3030-3907

IMPROVED DESIGN OF A LIQUID MIXING DEVICE WITH INCLINED DISC BLADES HAVING WAVY SURFACES

Djuraev Anvar
Tashkent Institute of Textile and Light Industry, Doctor of Technical Sciences, Professor
Dustova Mekhriniso
Navoi Innovation University, Assistant
Oripov Dostonjon
Navoi State University of Mining and Technologies, Master's student.

Abstract. This article presents an improved design of a mechanical device intended to intensify the liquid mixing process. The device consists of a reservoir, a drive, a coupling, a working shaft, and three rigidly fixed inclined disc blades with wavy surfaces mounted on the shaft. In the proposed design, liquid components are mixed under the simultaneous action of rotational motion and reciprocating oscillatory motion along the shaft axis. The inclination angles of the upper, middle, and lower blades were selected as 30°, 20°, and 10°, respectively. The amplitudes and frequencies of the blade surface waviness were determined differentially and accepted in the following ratios: $A_3 = 3A_1$, $A_2 = 2A_1$, $f_1 = 3f_3$, and $f_2 = 2f_3$. Such a parametric solution takes into account the variation in liquid resistance along the depth of the reservoir and ensures effective mixing throughout the entire volume. During rotation, the surface points of the blades produce sinusoidal displacement along the axis, resulting in the formation of axial and radial force components. Therefore, liquid particles acquire complex spatial motion, which increases the mixing intensity. The study analyzes the structural design, operating mechanism, and physical nature of the mixing process. As a result, the proposed construction was substantiated as a promising technical solution for improving mixing efficiency on the basis of a simplified drive system.

Keywords: mixing device, liquid, blade, wavy surface, inclined disc, oscillatory motion, axial displacement, radial flow, mixing intensity.

Annotatsiya. Ushbu maqolada suyuqliklarni aralashtirish jarayonini intensivlashtirishga mo'ljallangan mexanik qurilmaning takomillashtirilgan konstruksiyasi taqdim etilgan. Qurilma rezervuar, yuritma, mufta, ishchi val va valga qattiq mahkamlangan, to'lqinsimon yuzaga ega bo'lgan uchta qiya disk pichoqlardan iborat. Taklif etilgan konstruksiyada suyuqlik komponentlari valning aylanish harakati bilan bir vaqtda o'q bo'ylab tebranuvchi ilgarilanma-qaytma harakat ta'sirida aralashtiriladi. Yuqori, o'rta va pastki pichoqlarning qiyalik burchaklari mos ravishda 30°, 20° va 10° qilib tanlangan. Pichoqlar yuzasidagi to'lqin amplitudalari va chastotalari differensial tarzda aniqlanib, quyidagi

ISSN 3030-3907

nisbatlarda qabul qilingan: $A_3 = 3A_1$, $A_2 = 2A_1$, $f_1 = 3f_3$ va $f_2 = 2f_3$. Bunday parametrik yechim rezervuar chuqurligi bo‘yicha suyuqlik qarshiligining o‘zgarishini hisobga oladi hamda butun hajm bo‘ylab samarali aralashtirishni ta’minlaydi. Aylanish jarayonida pichoqlar yuzasining nuqtalari o‘q bo‘ylab sinusoidal siljish hosil qilib, o‘qiy va radial kuch komponentlarini yuzaga keltiradi. Natijada suyuqlik zarralari murakkab fazoviy harakatga ega bo‘lib, aralashtirish intensivligi ortadi. Tadqiqotda qurilmaning konstruktiv tuzilishi, ishlash mexanizmi hamda aralashtirish jarayonining fizik mohiyati tahlil qilingan. Natijada taklif etilgan konstruksiya soddalashtirilgan yuritma tizimi asosida aralashtirish samaradorligini oshirish uchun istiqbolli texnik yechim sifatida asoslab berilgan.

Kalit so‘zlar: aralashtirish qurilmasi, suyuqlik, pichoq, to‘lqinsimon yuza, qiya disk, tebranuvchi harakat, o‘q bo‘ylab siljish, radial oqim, aralashtirish intensivligi.

Аннотация. В данной статье представлена усовершенствованная конструкция механического устройства, предназначенного для интенсификации процесса перемешивания жидкостей. Устройство включает резервуар, привод, муфту, рабочий вал и три жёстко закреплённые на валу наклонные дисковые лопасти с волнистой поверхностью. В предложенной конструкции компоненты жидкости перемешиваются под одновременным воздействием вращательного движения и возвратно-поступательных колебаний вдоль оси вала. Углы наклона верхней, средней и нижней лопастей выбраны соответственно 30°, 20° и 10°. Амплитуды и частоты волнистости поверхности лопастей определены дифференцированно и приняты в следующих соотношениях: $A_3 = 3A_1$, $A_2 = 2A_1$, $f_1 = 3f_3$ и $f_2 = 2f_3$. Такое параметрическое решение учитывает изменение сопротивления жидкости по глубине резервуара и обеспечивает эффективное перемешивание по всему объёму. В процессе вращения точки поверхности лопастей совершают синусоидальное перемещение вдоль оси, формируя осевые и радиальные составляющие сил. В результате частицы жидкости приобретают сложное пространственное движение, что приводит к повышению интенсивности перемешивания. В работе проанализированы конструктивная схема, принцип действия и физическая природа процесса перемешивания. В итоге предложенная конструкция обоснована как перспективное техническое решение для повышения эффективности перемешивания на основе упрощённой системы привода.

Ключевые слова: устройство перемешивания, жидкость, лопасть, волнистая поверхность, наклонный диск, колебательное движение, осевое перемещение, радиальный поток, интенсивность перемешивания.

ISSN 3030-3907

INTRODUCTION.

Liquid mixing is one of the most important stages in many technological processes. Mixing devices are widely used in chemical, food, pharmaceutical, mining, and other industries where it is necessary to obtain homogeneous solutions, emulsions, suspensions, and other multicomponent liquid systems. The efficiency of heat transfer, mass transfer, dissolution, dispersion, and homogenization processes largely depends on the quality and intensity of mixing. For this reason, the improvement of mixing equipment remains one of the relevant engineering tasks in modern industrial practice.

Conventional mechanical mixers usually operate by transmitting rotational motion to the working element. In many cases, such a principle provides acceptable results; however, in a number of technological applications it does not ensure sufficiently intensive redistribution of liquid particles throughout the entire vessel volume. This limitation becomes especially significant when it is necessary to intensify mixing not only in the circumferential direction, but also along the axial direction of the shaft. Therefore, the search for improved structural solutions capable of generating more complex hydrodynamic motion is of considerable scientific and practical interest.[1]

A review of existing designs shows that some devices use rather complicated drive systems based on spatial cranks and connecting rods in order to create additional motion of the working shaft or blades. Although such systems can increase the complexity of particle movement in the liquid, they are often characterized by structural complexity, reduced manufacturability, and insufficient efficiency in providing simultaneous rotational and axial mixing effects. In some known solutions, the transmission of rotational motion and controlled reciprocating movement to the working shaft is not fully achieved, which limits the overall intensification of the mixing process. As a result, the effectiveness of mixing remains insufficient, especially when a more uniform distribution of components throughout the vessel depth is required.

In this regard, the development of an improved mixing device capable of intensifying the motion of liquid components by simpler mechanical means is an important task. One promising approach is to modify the geometry and spatial arrangement of the working blades in such a way that their rotation creates not only circumferential flow, but also periodic axial displacement of liquid particles. This can be achieved through the use of inclined blades combined with a wavy working surface. Such a combination makes it possible to form more complex trajectories of particle motion and to increase the active interaction between the working element and the liquid medium.[2]

ISSN 3030-3907

The proposed design is based on a working shaft carrying three rigidly fixed inclined disc blades with wavy surfaces. In this configuration, the upper, middle, and lower blades differ in their inclination angles, as well as in the amplitudes and frequencies of surface waviness. This differential arrangement is intended to take into account the variation of liquid resistance along the depth of the reservoir. Since the hydrodynamic resistance in the upper part of the vessel is lower than in the deeper layers, the inclination angles and waviness parameters are selected differently for each blade. As a result, the mixing action can be distributed more effectively throughout the entire volume of liquid.[3]

During shaft rotation, each point on the blade surface performs a sinusoidal displacement along the shaft axis. The magnitude of this displacement depends on the radial position of the point and reaches its maximum near the outer circumference of the blade. At the same time, the forces acting normally to the blade surface are resolved into axial and radial components. Owing to this, the liquid particles are subjected simultaneously to rotational, axial, and radial influences, which leads to complex spatial motion. Such a mechanism creates favorable conditions for intensifying the mixing process and for improving the distribution of components within the reservoir.

The scientific novelty of the study lies in the use of inclined disc blades with wavy surfaces and different geometric parameters to generate combined rotational and axial mixing effects without the use of excessively complicated drive mechanisms. The proposed approach makes it possible not only to simplify the mechanical structure of the mixer, but also to strengthen the mixing process in two principal directions. In this way, the design combines structural simplicity with functional effectiveness.

The purpose of this study is to analyze the improved design of a liquid-mixing device and to substantiate the physical mechanism of its operation. Particular attention is given to the structural configuration of the mixer, the geometric parameters of the blades, and the formation of axial and radial force components during rotation. The general structural scheme of the device is presented in Figure 1, while the force interaction patterns corresponding to different shaft positions are shown in Figures 2 and 3.

MATERIALS AND METHODS.

The structural configuration, main geometric parameters, and operating principle of the proposed device were analyzed on the basis of a mechanical system intended for liquid mixing. The study mainly focused on the structural scheme of the device, the geometric arrangement of the blades, and the physical nature of force distribution during operation.[4]

ISSN 3030-3907

Structurally, the device consists of an electric drive, a coupling, a working shaft, a reservoir, and three disc blades rigidly fixed on the working shaft. The blades are mounted on the shaft at an inclination, and each of them has a wavy surface. The upper, middle, and lower blades are positioned inside the reservoir at different inclination angles. The general structural scheme of the device is presented in Figure 1.

The main design parameters were selected as follows: for the upper blade, $\alpha_1 = 30°$; for the middle blade, $\alpha_2 = 20°$; and for the lower blade, $\alpha_3 = 10°$. The amplitudes and frequencies of the surface waviness were assigned different values and selected according to the ratios $A_3 = 3A_1$, $A_2 = 2A_1$, $f_1 = 3f_3$, and $f_2 = 2f_3$. Such a parametric solution takes into account the variation of liquid resistance along the depth of the reservoir. For this reason, the lower blade was designed with a smaller inclination angle but a greater waviness amplitude.

Methodologically, the analysis was carried out in several stages. First, the structural arrangement of the device and the interrelation of its main elements were described. At the next stage, the geometric shape of the blades, their inclination angles, and the ratios of amplitudes and frequencies were analyzed. Then, the sinusoidal displacement of the points on the blade surface along the shaft axis during rotation was considered. At the final stage, the axial and radial components of the mixing process were explained on the basis of the force diagrams corresponding to the shaft positions $\varphi = 0°$ and $\varphi = 180°$

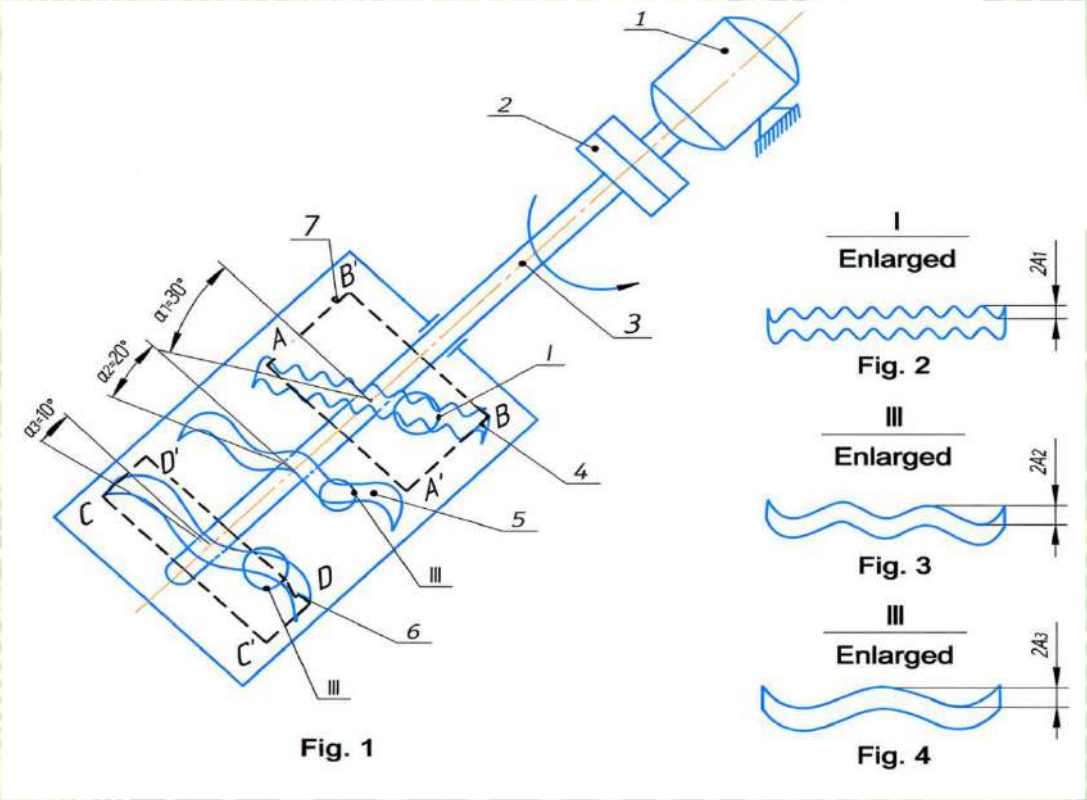


Figure 1,2,3,4. General structural diagram of the liquid mixing device.

ISSN 3030-3907

RESULTS.

The analysis showed that the main structural advantage of the proposed device lies in the inclined arrangement of the blades and the wavy shape of their surfaces. As the shaft rotates, each point on the blade surface produces a sinusoidal displacement along the axis. The amplitude of this displacement increases from the center toward the periphery and reaches its maximum value at the outer circumference. As a result, the liquid is mixed not only by rotational motion, but also under the action of vertical oscillatory movement.[5]

The waviness of the blade surfaces ensures periodic variation of the acting forces. The forces directed perpendicular to the blade surface are resolved into axial and radial components. For this reason, liquid particles move along complex trajectories. As a consequence, the mixing process is intensified not only in one direction, but in two principal directions — along the shaft axis and along the cylinder radius.

The differential selection of blade parameters contributes to a more uniform distribution of the mixing effect throughout the reservoir volume. The larger inclination angle and relatively finer waviness of the upper blade provide frequent and lighter action in the upper layer. The middle blade creates an additional mixing effect in the intermediate zone. The lower blade, due to its greater waviness amplitude, exerts a stronger influence in the deeper layers of the liquid. In this way, gradual and balanced mixing is achieved throughout the entire reservoir volume.

The general structural scheme of the device is presented in Figure 1, where the relative arrangement of the electric drive, coupling, working shaft, and three inclined disc blades is shown. Figures 2 and 3 illustrate the directions of the acting forces for the positions $\varphi = 0°$ and $\varphi = 180°$, respectively. These graphical materials confirm the theoretical validity of the device operating mechanism and demonstrate that, due to the force components generated during mixing, liquid particles actively move in two directions.

The use of inclined disc blades with wavy surfaces not only improves the mixing efficiency, but also makes the mechanical design of the device more compact. As a result, the need for complex spatial mechanisms is reduced, and an effective mixing process is achieved on the basis of a simplified drive system.

DISCUSSION.

The proposed device design combines geometric form and kinematic action in order to intensify the mixing process. In conventional mixers with flat blades, the liquid mainly moves under the influence of rotational flow, whereas in this case axial displacement is additionally generated due to the inclined arrangement and wavy surface of the blades. As a result, the mixing zone is expanded and spatial

ISSN 3030-3907

flows are formed inside the reservoir. This mechanism is of particular importance for achieving a more uniform distribution of components throughout the volume.

The gradual decrease in blade inclination angles from top to bottom represents a structurally justified solution. Since the liquid resistance is relatively lower in the upper layers, assigning a larger angle to the upper blade strengthens its axial oscillatory effect. In the deeper layers, where the liquid resistance increases, the use of a smaller inclination angle together with a greater waviness amplitude becomes more appropriate. Thus, the design takes into account the variation of hydrodynamic conditions along the depth of the reservoir.

The differential selection of waviness amplitude and frequency also has a significant influence on the mixing efficiency. An increase in amplitude combined with a decrease in frequency enhances liquid displacement in the radial direction. For this reason, the larger amplitude selected for the lower blade contributes to stronger mixing in the deeper layers. At the same time, this effect is balanced by the smaller amplitude but higher frequency of the upper blade, which produces faster and more repetitive action in the upper zone.

The inclusion of force diagrams further strengthens the theoretical basis of the device. The diagrams corresponding to $\varphi = 0°$ and $\varphi = 180°$ show the decomposition of the forces acting normally to the blade surface into their components along the x and y axes. This makes it possible to explain the simultaneous radial and axial displacement of liquid elements. The direction and components of the forces in the initial position are shown in Figure 2, while the state corresponding to a shaft rotation of 180° is presented in Figure 3. This confirms the scientific validity of the proposed design concept for intensifying the mixing process.

ISSN 3030-3907

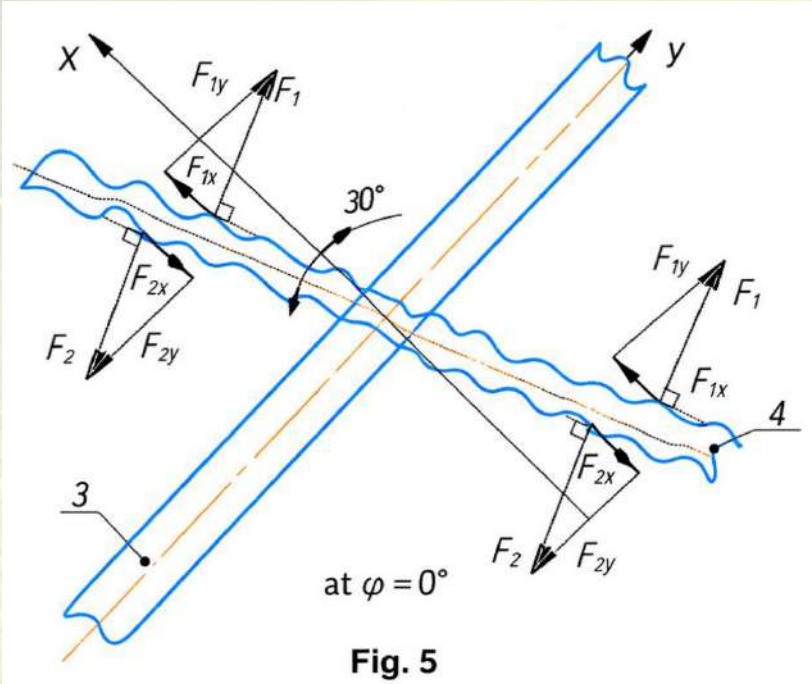


Fig. 5

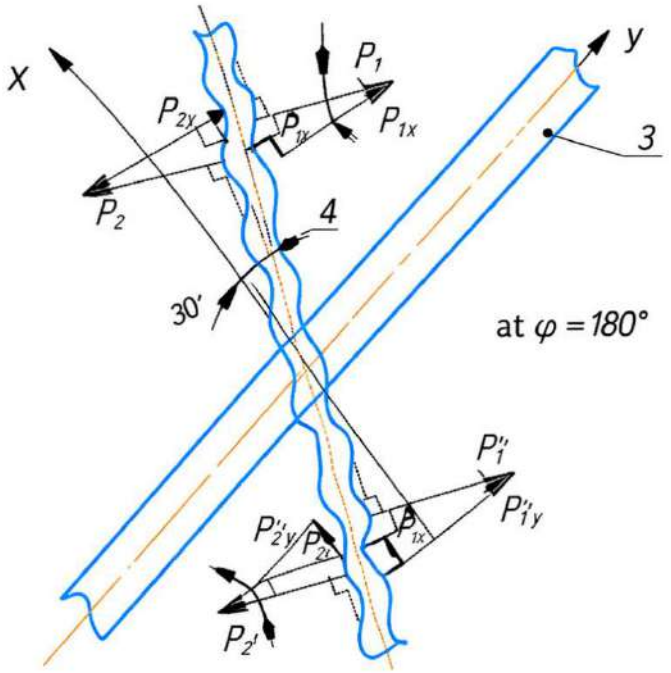


Fig. 6

Figure 5, 6. Force diagram acting on the inclined wavy blade at φ = 0°.

At the same time, the present study mainly focused on the structural and theoretical aspects of the proposed device. Although the operating principle, structural scheme, and force distribution were sufficiently substantiated, it would be advisable to supplement the study in the future with experimental results, mixing time, energy consumption, and efficiency indicators in order to further strengthen its scientific and practical value. Nevertheless, the obtained results adequately reveal the scientific concept and structural advantages of the proposed device.

CONCLUSION.

ISSN 3030-3907

As a result of the analysis, the structural and functional advantages of the improved device intended for liquid mixing were identified. The device consists of inclined disc blades with wavy surfaces mounted on the working shaft, which makes it possible to mix liquid components simultaneously through rotational motion and oscillatory motion along the axis.

The selection of blade inclination angles $\alpha_1 = 30°$, $\alpha_2 = 20°$, and $\alpha_3 = 10°$, as well as the adoption of the parameter ratios $A_3 = 3A_1$, $A_2 = 2A_1$, $f_1 = 3f_3$, and $f_2 = 2f_3$, takes into account the variation of liquid resistance along the depth of the reservoir and ensures intensification of mixing throughout the entire volume.

During shaft rotation, the sinusoidal displacement of points on the blade surface, together with the decomposition of forces into axial and radial components, generates complex spatial motion of liquid particles. As a result, active mixing of the components and their more efficient distribution throughout the volume are achieved.

The use of inclined disc blades with wavy surfaces increases the mixing efficiency on the basis of a simplified drive system and demonstrates a structural advantage over existing analogues.

REFERENCES

1. Bakhtiyor Mardonov, Zayniddin Oripov, Rashid Muminov, Jamshed Ravshanov, and Nodirbek Jo‘rayev. Effect of dispersed particles of aluminum oxide on the degree of defects of the crystalline structure of the chromium coating. / E3S Web of Conferences 417, 06001 (2023) GEOTECH-2023 https://doi.org/10.1051/e3sconf/202341706001

2. M.G. Yarullin, M.R. Mingazov, Bulletin of Izhevsk State Technical University, **3**(63), pp 34-38 (2014).

3. R.O. Muminov, A.N. Ruzibaev, N.N. Juraev, J.R. Ravshanov, D.A. Kuziev. Development of measures to enhance the rotation and feed mechanism of a drill rig 2024 ISSN 0041-5790 (Print) • ISSN 2412-8333 (Online) • ugol’– russian Coal Journal, 2024, № 1, pp. 94-99 DOI: http://dx.doi.org/10.18796/0041-5790-2024-1-94-99

4. Rashid Muminov, Sherali Yakhshiev, Jamshid Ravshanov, Zayniddin Oripov, Nodirbek Juraev, and Mahbuba Maxmudova. // Development of technical solutions for modernization of the rotary feed mechanism of a quarry drilling rig / E3S Web of Conferences 486,AGRITECH-IX 2023 05007 (2024) https://doi.org/10.1051/e3sconf/202448605007

5. N.M. Obitov, A.N. Ruzibaev, AIP Conference Proceedings **2612**, 040004 (2023);

ISSN 3030-3907

6. Kuziev, D.A., Pyatova, I.Y., Klement'eva, I.N., Pikhtorinsky, D. Algorithm for the determination of maximum feed drive power of drilling rigs in open pit mining / Mining Informational and Analytical Bulletin, 2019, 2019(1), pp. 128–133. DOI: 10.25018/0236-1493-2019-01-0-128-133

ISSN 3030-3907