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DYNAMICS OF THE MACHINE UNIT OF A DEVICE FOR MIXING LIQUIDS

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Аннотация: Мақолада фазовий кривошип-шатун узатмали аралаштиргич қурилма ҳақида сўз боради. Бу қурилманинг ишчи органи, яъни парраги резервуар ичида айланма ҳаракат билан биргаликда ўзгарувчан илгариланма қайтма ҳаракатни амалга оширишга мўлжалланган. Бунинг натижасида, мазкур қурилмада парракнинг айланма ҳаракат қилаётган ҳолатидан бирданига уни пастга ва юқорига симметрик ўзгарувчан илгариланма қайта ҳаракат билан айланма ҳаракат қилиши, суюқ муҳитни аралаштиришга сарфланадиган энергия сарфи камайишига ва қурилманинг ишлаш муддатини оширишга олиб келади.

Калит сўзлар: механик аралаштиргич қурилма, фазовий кривошип-шатун узатма, паррак, айланма ҳаракат, ўзгарувчан илгариланма қайта ҳаракат.

Аннотация: В статье рассматривается устройство смесителя с пространственной кривошипно-шатунной передачей. Рабочий орган этого устройства, то есть лопасть, наряду с вращательным движением предназначен для выполнения переменного возвратно-поступательного движения внутри резервуара. В результате в этом устройстве резкое перемещение лопасти из вращающегося положения с симметричным переменным движением вперед и назад приводит к снижению энергозатрат на перемешивание жидкой среды и увеличению срока службы устройства.

Ключевые слова: механическое перемешивающее устройство, удлинение стержня пространственной кривизны, лопасть, вращательное движение, переменное поступательное движение.

Annotation: The article discusses the device of a mixer with a spatial crank drive. The working body of this device, that is, the blade, along with the rotational movement is designed to perform a variable reciprocating movement inside the tank. As a result, in this device, a sharp movement of the blade from a rotating position with symmetrical alternating motion forward and backward leads to a

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decrease in energy consumption for mixing a liquid medium and an increase in the service life of the device.

Key words: mechanical mixing device, spatial elongation of the crankshaft, blade, rotary motion, alternating translational motion.

Introduction

Mixing is one of the most common processes in various industries and agriculture, and devices with mixing devices are the most common type of equipment used to carry out various physical and chemical processes. As a rule, most existing mixers operate in a stationary mode, and the working element of the mixer consists of a rotating blade with a constant angular velocity. The rotating blades of the mixer act on the mixed medium (liquid + solid particles), the liquid moves, the intensity of mixing increases above the working element of the mixer and decreases as it moves away from it, but there are areas of the tank in which the liquid velocity is too low or equal to zero, in which the mixing process does not occur.

As a result, the homogeneity of the prepared mixture is lost, the time for preparing the mixture in the required concentration increases, and a lot of energy is consumed. In addition, after a certain time, the speed of the mixed medium coincides with the speed of the working element, the relative movement between them disappears, as a result of which the liquid moves rhythmically, separating the particles that make up the mixture, sedimentation is observed. The operating mode used in mixing liquids, which is stationary, has been carefully studied by local and foreign scientists [1].

Currently, mixing devices are widely used in various industries. For example, in agricultural production, mixing is used to prepare fertilizers and feed mixtures; in the construction industry to obtain various materials and solutions; in food technology to prepare oils, confectionery and dairy products, products from chopped meat and fish semi-finished products, chopped boiled vegetables; in the petrochemical industry to obtain various petroleum products (fuel oil, oils, gasoline, etc.); in the mechanical engineering industry, mixing devices are used to manufacture various process fluids. The mixing process is also used to prevent sedimentation and for uniform heat distribution during food storage. [2,3].

In general, the mixing process can be divided into two types - mixing of liquid and solid media. The main processes for which apparatus with mixers are used are usually carried out in a liquid medium .

There are various methods of energy supply to the medium being processed: mechanical, circulation, jet, pulsating-jet, bubbling, gas-lift and magnetic-vortex. In industry, the most common is the mechanical method of mixing liquid media, which is carried out in reactors with mixing devices. This is explained by the high

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efficiency of such machines. Therefore, mechanical mixing devices are currently the most common [4].

Depending on the nature of the processes occurring in the reactor, various design versions of the apparatus are used. Steel, aluminum, titanium and their alloys are used as body materials. The inner surface of the apparatus, designed to work with acidic, alkaline or acid-alkaline environments, is enameled. The bottom and cover of the apparatus can be flat and elliptical. An electric motor connected to the stirrer shaft by direct and reduced transmission is usually used as a drive. To enhance the circulation of the liquid, the apparatus can be equipped with baffles. The mixing device can be equipped with heat exchange devices (coil or jacket) [5,6].

In addition to classic rotary mixing devices, there are many non-standard designs of devices. They can be divided into three types:

1) devices with complex spatial movement of working elements and planetary mixing devices;

2) vibratory mixing devices with reciprocating movement of working elements;

3) mixing devices with reciprocating rotational movement of working elements. [7].

EXPERIMENTAL AND METHODS

In addition to the well-known classification, the authors of this article have filed an application for the proposed invention of a mixing device with a drive in the form of a spatial crank mechanism (Fig.1).

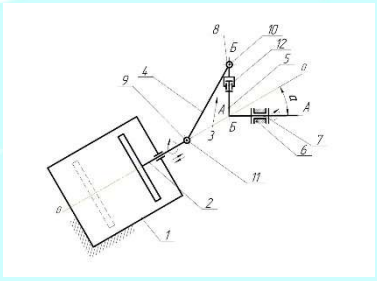


Fig.1. The mass output from the volume of the extracted brine
1. Reactor. 2. Shaft with working element. 3. Drive. 4. Connecting rod. 5. Crank.

Let's start the study by studying the movement of the fork around the loop. If we place the shaft of the mechanism at an angle a in the XOY plane relative to the O-O axis and turn the plug from the initial position, it will turn to some angle θ around the hook. In the vertical position of the mechanism (=0), if we move the shaft along the XOY plane to an angle α from the O-O axis, the plug turns around the loop to an angle θ, that is, the lever (3), and the loop (2) is at an angle α with the fork shaft (1) lie on different planes. In this case, the oscillating turn of the fork is equal to the angle θ, that is, θ = a.

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In the horizontal position of the mechanism (=90), the lever (3), hook (2) and fork shaft (1) lie in the XOY plane(Fig.2). Therefore, the oscillating angle θ of the plug is equal to zero, that is, θ=0.

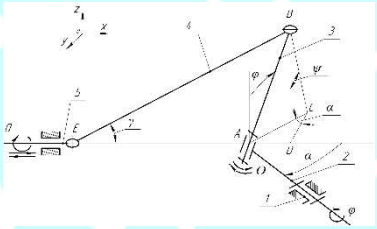


Fig 2. State of movement of the mixing device relative to the 0-0 axis

We use the following condition to find the connection between the angle of the fork's oscillating turn θ and the angle α. It is known that in the upright position of the mechanism (=90) θ = a or $\frac{\sin\theta}{\sin\alpha}=1$

If we turn the fork shaft from a vertical position to an angle, its initial position is found as follows

R·cos φ=R yoki cos φ=1

Here, the length of the R-loop is compared to the expressions (1) and (2) above, and we find the angle θ.

$$\theta = arcsin(sin\alpha \cdot cos\varphi)$$

$$L_{EP} = \sqrt{L_{EQ}^2 + L_{PQ}^2} = R \cdot \sqrt{1 - sin^2\alpha \cdot sin^2\varphi}$$

$$cos\psi = \frac{L_{EQ}}{L_{EP}} = \frac{cos\varphi}{\sqrt{1 - sin^2\alpha \cdot sin^2\varphi}}$$

$$\psi = arccos\frac{cos\varphi}{\sqrt{1 - sin^2\alpha \cdot sin^2\varphi}}$$

$$cos\gamma = \frac{L_{DK}}{L_{DE}} = \frac{L_{DN} + L_{NK}}{L_{DE}} = \frac{L_{TF} + L_{FP}}{L_{DE}} = \frac{1 + sin\alpha \cdot sin\varphi}{2}$$

Here $L_{EQ} = R \cdot cos\alpha$ is the organizer of the loop along the Z axis

Here $L_{PQ} = R \cdot cos\alpha \cdot sin\varphi$ - organizer of the loop along the Y axis

$$L_{GM} = L_{DT} = 2 \cdot R \cdot \left[\sin\left(arccos\frac{1 + sin\alpha \cdot sin\varphi}{2}\right) - \sqrt{1 - sin^2\alpha \cdot sin^2\varphi}\right]$$

$$\gamma = arccos\frac{1 + sin\alpha \cdot sin\varphi}{2}$$

$$S = R\,sin\alpha{\cdot}sin\varphi$$

Here: S- is the variable movement path of the bladed shaft; R- is the length of the curve; a - deviation of the crankshaft axis from the 0-0 axis; φ is the turning angle of the curved shaftUnlike existing designs of mixing devices, due to the fact that the mixer tank is installed with an inclination relative to the horizontal axis of the drive, the mixer simultaneously performs a rotational movement around the 0-0 axis and a reciprocating movement along the same axis. The mixing device

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consists of a reactor 1, a bladed working shaft 2 and a drive 3. The drive 3 includes a connecting rod 4 and a crank 5. The connecting rod 4 and the crank 5 are connected to each other by a hinge 8. The bladed working shaft 2 is connected by a hinge 9 to the end of the connecting rod 4. The axes 10, 11 of the hinges 8, 9 of the connecting rod 4 with the crank 5 and the bladed working shaft 2 are parallel to each other and at the same time perpendicular to the axis A-A of the shaft of the crank 5. The shaft of the crank 5 is connected to the housing 6 by means of a hinge 7. The hinge 8 connecting the crank 5 with the connecting rod 4 are connected to each other by an additional hinge 12 mounted on the upper part of the crank 5. The axis of the additional hinge 12 is located along the axis B-B of the crank 5. The housings of the hinges 8, 12 are made as a single unit[8-10].

The device operates as follows. When the A-A axis of the crank shaft 5 coincides with the 0-0 axis ($\alpha = 0^{\circ}$), the rotational movement of the crank 5 around the 0-0 axis of the crank shaft 5 is transmitted by the crank 5 through the connecting rod 3 to the bladed working shaft 2.As a result, the bladed working shaft 2 inside the reactor performs only rotational motion.

When the axis A-A of the crank shaft 5 is deflected from the axis 0-0 by an angle α with a numerical value greater than 0° to 90°, the crank 5, rotating around the axis A-A of the crank shaft 5, due to the hinge 9, simultaneously performs rotational motion around the axis 0-0 and rectilinear reciprocating motion along the same axis. This occurs due to the rotational-oscillatory motion of the crank 4 around the axis B-B along the body of the additional hinge 12. Subsequently, the rotation of the crank 5 around the axis 0-0 and the rectilinear reciprocating motion along the same axis perceived by the connecting rod 4 are transmitted to the bladed working shaft 2. As a result, the bladed working shaft 2 simultaneously performs a rotational motion around the 0-0 axis and a rectilinear reciprocating motion along the same axis. In this case, to regulate the magnitude of the rectilinear reciprocating motion of the bladed working shaft (2), it is necessary to change the value of the angle α by a value greater than 0° to 90° [11].

The use of a simplified drive design allows for increased efficiency in mixing liquids by introducing both rotary and adjustable linear reciprocating motion into the mechanism. In addition, a patent was obtained for a device for mixing liquids (Fig.3) [12].

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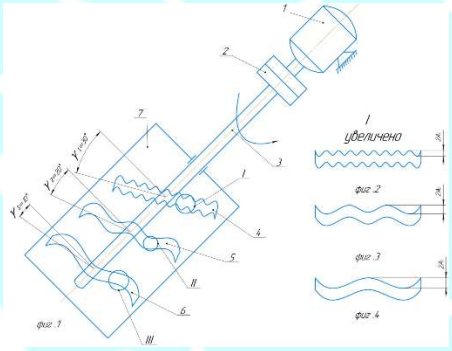


Fig 3. A device for mixing materials in a liquid environment 1. Drive. 2. Coupling. 3 Working shaft. 4. I blades. 5. II blades. 6. III blades. 7. Reservoir

The device consists of an electric drive 1, a clutch 2, a working shaft 3, disks rigidly mounted at an angle on it, blades 4,5,6 with a wavy surface. Blades 4,5,6 are located in a reservoir 7 with a liquid not mixed with the components.

The vertical movement of the working shaft 3 with blades 4,5,6 is obtained from the electric power supply 1 through the coupling 2. In this case, the upper blade is installed at a large angle a1 = 30˚ at the working values with the blades the rotor rotates and the rotor rotates, so the vertical rotors. In this case, the small volumes on the surface of the blades 4 allow them to operate at high frequency on the fluid components, effectively mixing them.

Important mixing of liquid and their components of liquid, to some extent is transmitted and deep into the tank 7. In this case, the middle blade 5 changes the angle of inclination α2 = 20˚ additionally moves the components A2 of the liquid. In this case, the amplitude of the undulations allows mixing the components of the liquid with a large size. Further, this effect is enhanced by the greater amplitude of the undulations of the surface of the disk blade 6.

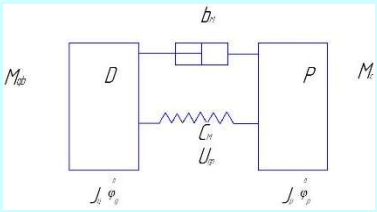


Fig 4. Calculation scheme of the machine unit

$$M_c = M_1 + M_{01}\,sin\,\omega\,t + M_{02}\,sin\,\omega\,t + M_{03}\,sin\,\omega\,t$$

The use of a simplified drive design allows for increased efficiency of liquid mixing by using inclined disc blades with wavy surfaces and simplifying the drive device [13].

The design of the spatial curve-rod gear mixer device allows the improved blade to rotate from the rotating position to the downward and upward symmetrical alternating advance and reverse movement, reducing the energy consumption for mixing the liquid medium and increasing the life of the device. Due to this, it was

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recommended to use the improved construction, which increases the product quality by 1.25% and efficiency by 2.5-3%, for production [14].

Graphical representation of the experimental results, determination of its mathematical expression allows to better understand the physical nature of the process under study. We used the Mathcad package for graphic representation of the experimental results and determination of the algebraic expression of the functional dependence of the positions of the input and output links of the mechanism on time.

RESULTS AND DISCUSSION

When calculating the economic efficiency achieved as a result of the industrial introduction of a mixing device designed to increase the intensity of mixing of liquid media, the increase in the effect of the mechanical mixing device on the liquid medium and the reduction of the time of the mixing process are taken into account.

In improving the design of the mixer of materials in a liquid environment, the following are proposed:

1. In this device, from the rotating state of the blade, it suddenly moves downwards and upwards by a symmetrical alternating advance, which reduces the energy consumption spent on mixing the liquid medium and increases the service life of the device.

2. The proposed mixing device is called ``Spatial Crankshaft Geared Mixer Device". As a result of the conducted researches, it has been scientifically and practically justified that by improving the construction of the mixing device, the liquid is mixed with high quality and intensively, and the efficiency and productivity of the device have increased. It also prevents sediment formation. Optimum parameters ensuring production efficiency have been determined

3. An efficient design of the proposed mixing device is developed. The noise level of the mixing device is quite low. According to the existing mixing device, the noise level of the recommended device was reduced by 4-8 dB, i.e. by 1.5 times.

4. The design of the spatial curve-rod gear mixer device allows the improved blade to rotate from the rotating position to the downward and upward symmetrical alternating advance and reverse movement, reducing the energy consumption for mixing the liquid medium and increasing the life of the device. Due to this, it was recommended to use the improved construction, which increases the product quality by 1.25% and efficiency by 2.5-3%, for production [15].

CONCLUSION

In the article, several devices were analyzed for the improvement of the design of the mixer of materials in the liquid medium and the dynamic analysis of the machine assembly with the working body mechanism, the implementation of

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experimental testing in the production conditions of the newly created mixing device, and the dynamic analysis of the machine assembly with the working body mechanism. mixed devices can be widely used in agriculture and mining. Different mixing techniques and methods are used to separate ores from inclusions. Advanced robust mixing equipment is used in mining, agriculture, manufacturing and many other industries.

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