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Studying The Importance Of Processes Performing A Useful Function Due To Movement-Based Vibratory Movement

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Abstract: This article studies the physical and mathematical models of technological processes based on induced vibrational motions and their significance in industrial sectors. The influence of vibrational (vibrational) action on mass transfer, energy distribution and structure stabilization in liquid, solid and mixed media is analyzed. Also, the energy-saving and eco-technological advantages of using vibrating systems in chemical and building materials production processes are shown.

Keywords: Vibrating motion, vibration, energy saving, mass transfer, hydrodynamic stability, technological process, modeling.

INTRODUCTION:

In engineering and chemical technology, processes based on vibrational motion have attracted great interest in recent years. Systems under the influence of vibration significantly activate the processes of energy distribution and mass transfer. This is especially important in highly viscous liquid media and in processes with strong interaction between solid and liquid phases [1-3].

The introduction of vibrating equipment in the building materials, chemical, petrochemical and food industries improves the quality of the process, allows for the efficient use of energy resources. For example, vibrating separators and extractors increase the efficiency of processing cement, gypsum, wood dust [4-7].

In industry, vibration processes and devices have a wide range of applications, including: construction, production of building materials and many other industries. Currently, general-purpose vibration generating devices are widely used and are manufactured by machine-building enterprises in a wide range. For example, in the production of building structures, the first place is occupied by the vibration compaction and molding of reinforced concrete products and unreinforced concrete products. Vibrating screening machines are used in many construction, quarries and similar enterprises. Vibrating screening machines are used in many construction, quarries and similar enterprises. Machines used for compacting road bases and pavements, soil are also widely used. Compaction and crushing, mixing and separation, loosening and excavating wells, unloading stuck materials from vehicles, processing frozen soils, loading bulk materials, washing sand and gravel - these are the processes that can be performed with vibrating machines, and many such examples can be given [8-11].

Problem statement

The main task of the research is to determine the physical model of energy and mass transfer in technological processes under the influence of induced vibrational motion, to develop methods for their optimization, and to assess the possibilities of their application on an industrial scale.

The development and expansion of the scope of application of vibration techniques is hampered by the lack of knowledge among most engineers about the principles of operation, design, and process dynamics of these machines. Although most vibration machines have a simple design, their operation and the dynamics of vibration processes are extremely complex.

Therefore, in order to successfully work in the field of vibration engineering and technology, future engineers will need to study a certain set of theoretical methods of analysis, practical data, and recommendations from a single perspective [12-15].

Solution method

Mathematical modeling and Computational Fluid Dynamics methods were used to find the solution. The energy distribution and mass transfer coefficient values were calculated depending on the amplitude, frequency, and type of vibrational motion.

METHODS

1. Experimental methods: liquid flow rate and temperature changes were determined in a shaking reactor under laboratory conditions.

2. Computational modeling: carried out in the ANSYS Fluent program.

3. Analysis method: the results were compared in terms of energy consumption and mass transfer efficiency.

One of the most remarkable features of the world around us is that it is constantly undergoing a large number of changes, movements, and changes in appearance. All variable properties, parameters, and indicators that can be measured directly or indirectly are considered variable quantities from a mathematical point of view. A quantity whose value is determined by 1 number at any given moment is called a scalar. For example, the temperature at some point in our body, the pressure at some point in a volume of gas, etc. Despite the fact that the changes in scalar quantities are infinitely diverse, they are all divided into 2 classes: oscillatory and non-oscillating changes [16-21].

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RESULTS AND DISCUSSION

Mechanical vibrations are encountered in nature or in artificial devices created by man. For example, the vibration of the earth's crust when it moves, the vibration of branches and leaves in the wind, the flapping of wings, the opening and closing of a lid, the heartbeat, the movement of an engine piston, the vibration of a clock pendulum, the vibration of window frames in buses due to poor sealing, etc [22-26].

Among oscillatory movements, it is important to distinguish periodic vibrations, that is, after a certain time, the vibration is completely restored.

A function f(t) representing a process is called periodic if there is a constant quantity T, called the period, for which:

$$f(t)=f(t\ T)=f(t\ 2T)=...\ =f(t\ nT) \qquad (1)$$

where:, n is a positive integer.

In the two-dimensional or three-dimensional motion of a point along a solid surface, it may occur that it passes through each of the state's several times along a closed trajectory in one direction. Such a motion of a point is called a circular motion. Circular motions can also be periodic. The projections of a circularly moving point oscillate about the axis of a rectilinear coordinate system.

Due to the similarity of the laws and mathematical expressions of oscillatory and circular motions, the terms "conical pendulum", "rotational", and "elliptical oscillations" have been studied in physics and engineering [27-32].

Among the many types of oscillations, sinusoidal or harmonic oscillations occupy a special place. In this case, the oscillating quantity is represented by a sinusoidal function of time, for example:

$$u=a\sin\left(\frac{2\pi}{T}t+\phi\right) \qquad (2)$$

where: u is the coordinate of the oscillating point from the middle position, a is the amplitude of the oscillation, T is the period of oscillation, t is the current value of time, ϕ is the initial phase of the oscillations [33-37].

The amplitude of oscillations is the absolute value of the maximum deviation from the mean in sinusoidal oscillations. The amplitude of oscillations is equal to two amplitudes in sinusoidal oscillations and is the distance between two opposite extremes of the oscillating point. The term "amplitude" is used for non-sinusoidal oscillations. In such cases, we speak of the maximum value of the oscillating magnitude or the half-wavelength of oscillations. For sinusoidal oscillations, the terms amplitude, maximum value, and half-wavelength of oscillation are used as synonyms.

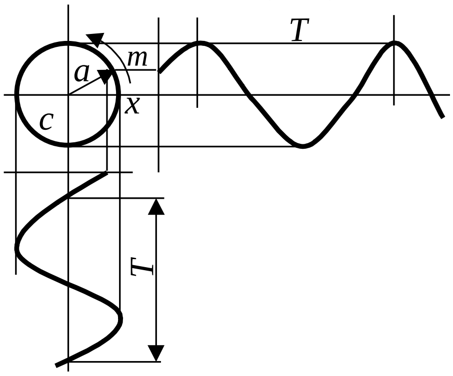

Figure 1. Vector representation of harmonic oscillations.

The oscillation phase is called the argument of the sinusoidal function $(2\ t/T)+\ \phi$, and the initial phase is the value of this argument at t=0, i.e. ϕ. The vector representation of harmonic oscillations can be expressed very precisely [38-42].

If a radius vector of constant length a=SM (Fig. 1) rotates uniformly around its origin S and forms a circle at its other end M, then the projection of the vector will produce sinusoidal oscillations on any one of the diameters of the fixed circle. If the angles are between the right horizontal radius and the radius vector SM, and the initial value of this angle is equal to ϕ. at t=0, then the oscillations of the projection of the rotating radius vector on the vertical axis are expressed by equation (2). The oscillogram - the time-dependent oscillations of these oscillations is shown on the right side of Fig. 1. The oscillations of the radius vector on the vertical axis are expressed by the following equation [1,2,3,18,19,20,21].:

$$u=a\cos\left(\frac{2\pi}{T}t+\phi\right) \qquad (1)$$

The frequency of oscillation is the inverse of the period T:

$$f=1/T \qquad (2)$$

The unit of measurement for frequency is usually the hertz (one oscillation per second). It is more convenient to use the angular frequency in the study of vibrations [1,2,3,22,23,24,25].:

$$\varpi=2\ f=2\ /T \qquad (3)$$

This frequency is equal to the angular velocity of the radius-vector SM in Figure 1. Based on expression (5), the oscillation phase can be written as:

$$(2\ t/T)+\phi=2\ ft+\phi=\varpi\ t+\phi \qquad (4)$$

Oscillations with the same frequency occurring at the same time are called synchronous oscillations. Synchronous oscillations with the same phase are called in-phase oscillations [1,2,3,4,26,27,28,29]. Two synchronous oscillations that differ in π are called antiphase oscillations.

If the coordinate of the oscillating point

$$x = x_a \cos(\varpi\ t-\phi) \qquad (5)$$

X_a is the displacement amplitude; φ- is the initial phase - then, differentiating with respect to time, we obtain the following vibrational velocity [43-45]:

$$dx/dt=x=-x_{av}\sin(vt-\phi)=x_{av}\cos\left(vt-\phi+\frac{\pi}{2}\right) \qquad (6)$$

where: x_{av} - is the velocity amplitude, after second differentiation we obtain the vibration acceleration as follows:

$$d^2x/dt^2=x=-x_{av}^2\cos(vt-\phi)=x_{av}^2\cos(vt-\phi+\pi) \qquad (7)$$

where: x_{av}^2 is the acceleration amplitude.

Vibration machines belong to the field of vibration engineering, which was formed and developed during the second half of the 20th century [49-51]. Vibration engineering includes: machines, stands, devices, instruments, and tools that perform a useful function due to a deliberately induced vibrating motion; apparatus and devices for measuring, monitoring, and controlling vibration; and devices for preventing, suppressing, damping, and isolating harmful vibrations [52-53].

A vibrating machine is characterized by the fact that its working body transmits the vibrational motion necessary to carry out or intensify a process. The schematization method is used when it is necessary to study the properties of complex objects, for example, the operation of a vibrating machine in a controlled manner. The complex object is replaced by a simplified scheme. This scheme can be studied for a limited time using convenient mathematical tools. One of the important factors in schematization is the nature and purpose of the problem to be solved. Schematization can only bring a close result to the sought-after solution if the adopted scheme corresponds to the problem being solved.

An overly simplified or otherwise inadequate model (scheme) may be fundamentally unsuitable for solving a problem, because an overly simplified model may lack the desired effects inherent in a real model [2,3,4,39,49,50,51].

The study found that when the vibrating frequency was in the range of 15–25 Gs, the mass transfer coefficient increased to 0.0028–0.0041 m/s. When the amplitude was increased from 2.5 mm to 4 mm, the energy distribution in the vibrating system became uniform, and the turbulent flows in the liquid stabilized.

CONCLUSIONS

1. The induced vibrational motion is an important factor in accelerating technological processes and saving energy.

2. It is recommended that the optimal frequency range be 15–25 Gs, and the amplitude be 3–4 mm.

3. When introduced into the chemical, food, and building materials industries, vibrational systems can increase product quality by 10–20%.

4. In the future, it is advisable to develop optimal models of vibrational motion based on analysis.

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