УДК 536.2

# ROTOR-PULSATING APPARATUS FOR THE PREPARATION OF LIQUID FEEDS ON THE GRAIN BASIS

***V. G. Gorobets, doctor of technical sciences, associate professor***

***A. M. Serdyuk, graduate student***

***National university of life and environmental sciences of Ukraine***

*e-mail: gorobetsv@ukr.net*

**Abstract.** *The principle of work and design of rotary-pulsating apparatus for preparation of liquid cereal forage mixtures is considered. The main advantages of new technologies in comparison with the existing technologies when applied at the agroindustrial complexes are given.*

**Keywords:** ***rotor-pulse apparatus, mass transfer, energy, grain feed mixture***

**Introduction.** Rotary-pulsating apparatus (RPA) is an effective equipment for multifactor impulse action on a heterogeneous fluid in order to obtain stable, highly dispersed emulsions and suspensions, intensification of processes of dissolution and extraction of substances, changes in physical and chemical parameters of a liquid, destruction of molecular compounds [1,2].

**Analysis of recent researches and publications**. RPA is used to process such systems as "liquid-liquid", "liquid – solid" and "gas – liquid" due to a wide range of factors of influence:

– mechanical action on particles of a heterogeneous medium;

– hydrodynamic effect, which is expressed in large shear stresses in the fluid, developed turbulence, pulsations of pressure and fluid flow velocity;

– hydroacoustic effects on the liquid due to small-scale pressure fluctuations, intense cavitation, shock waves and nonlinear acoustic effects.

The developed designs of RPA are used for the preparation of food mixtures for baby food, medical preparations, soy paste, etc. [3,4]. It is promising to use rotor-pulsating technologies for the preparation of liquid cereal forage mixtures, since these technologies have several advantages over traditional methods used in cattle feed machines for farms.

**The purpose of research.** Consideration of the principle of operation of the rotary-impulse apparatus for the preparation of liquid grain fodder, the description of the design of such devices and the advantages of their application in the production of agro-industrial complex.

**Materials and methods of research.** Rotary-pulsating apparatus (RPA) is an effective equipment for the preparation of feed using different types of cereals – wheat, rye, oats, corn and other crops. The operation of such machines differs significantly from those used in existing prototypes, for example, hammer crushers, where the main mechanism of grinding grain is mechanical shock loads using hammer devices.

RIA is used to process such systems "liquid – solid" due to a wide range of factors of influence:

– mechanical action on particles of a heterogeneous environment consisting of shock, cutting and erosion loads and contacts with the working parts of the RPA;

– hydrodynamic effect, which is expressed in large displacement stresses in fluid, developed turbulence, pulsations of pressure and fluid flow velocity;

–hydroacoustic effect on the liquid is carried out due to small-scale pressure fluctuations, intense cavitation, shock waves and nonlinear acoustic effects.

For RPA for the preparation of liquid grain feeds, one rotor and one stator – with a gap of 0.1-0.5 mm and a large step of the arrangement of the channels in the rotor and stator on the side walls of the rotor and stator – are characteristic of one stator. The most active working area in the RPA is the gap between the rotor and the stator, in the RPA stator channels. The standard RPA design of the radial type is shown in Fig. 1.

The principle of the apparatus is as follows. The treated liquid is fed under pressure or gravity through the inlet pipe 7 to the rotor cavity 1, passes through the channels of the rotor 2, the stator 4 channels, the working chamber formed by the housing 5 and the lid 6, and leaves the apparatus through the outlet 8. During rotation of the rotor, its channels periodically combined with stator channels. Based on the stator ducts, the fluid is collected in the working chamber and output through the outlet pipe. During the time when the rotor's channels are covered with a stator's wall, the pressure in the rotor's cavity increases, and when the rotor channel is combined with the stator channel, the pressure in a short

period of time is reset and as a result, a pressure pulse propagates into the stator's channel. The flow rate of the fluid in the stator channel isvariable value. In the spreading of the stator pulse of excess pressure, a short-term impulse of the lowered ("negative") pressure arises after it, since the combination of the rotor and stator channels is complete, and the flow of fluid into the stator can only occur due to the "transit" flow from the radial gap between rotor and stator. The volume of fluid entering the stator channel tends to flow out of the channel, and inertial forces create tensile stress in the fluid causing cavitation. Cavitation bubbles grow when pressure is reduced to the pressure of saturated vapors of the treated liquid at a given temperature, and burst or pulsate with increasing pressure in the stator duct. Part of the cavitation bubble is put into the working chamber.

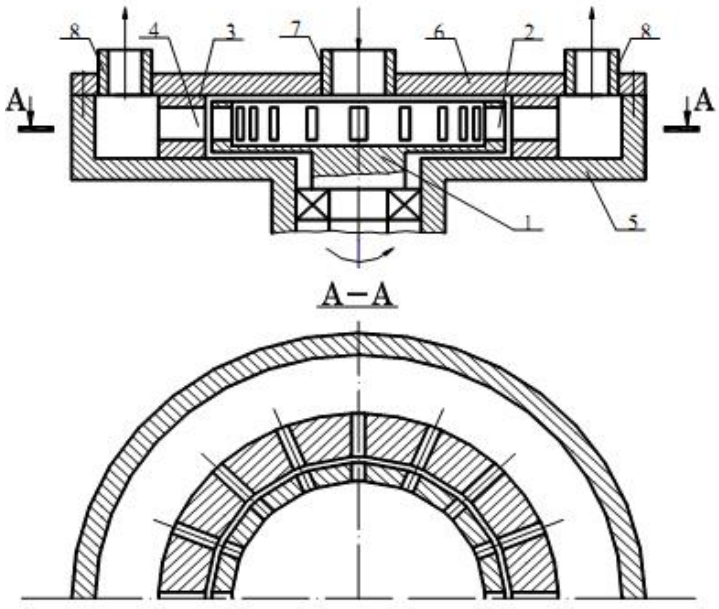


**Fig. 1 Scheme of rotary-impulse apparatus:**

1 – rotor, 2 – rotor ducts, 3 – stator, 4 – stator ducts, 5 – housing, 6 – lid, 7 – inlet duct; 8 – outlet pipe.

Due to the fact that the flow rate of the fluid in the stator channel is large and has fluctuations, the flow has a developed turbulence. When rotor rotation in the gap between the rotor and stator there are large shear stresses. The working surfaces of the rotor and stator influence the liquid heterogeneous medium through mechanical contact, creating large cutting and shear forces.

When constructing RPA for the preparation of liquid feed on a grain basis, it is necessary to calculate the hydromechanical and heat-mass exchange processes in heterogeneous environments for a particular technological process.

Universal RPAs are commonly used in small-tonnage production with a wide range of product range. In the large industrial production, and also, when justified use of the device for carrying out only one technological process, the most effective is the use of specially designed RIA for this technological process.

When designing RIA the task of choosing the main optimal criterion. Most often, RIA counts on the criterion of the greatest impact on the processed medium at the lowest cost of consumed energy at a given performance.

The scheme of classification of technological processes implemented in RIA, is shown in Fig. 2

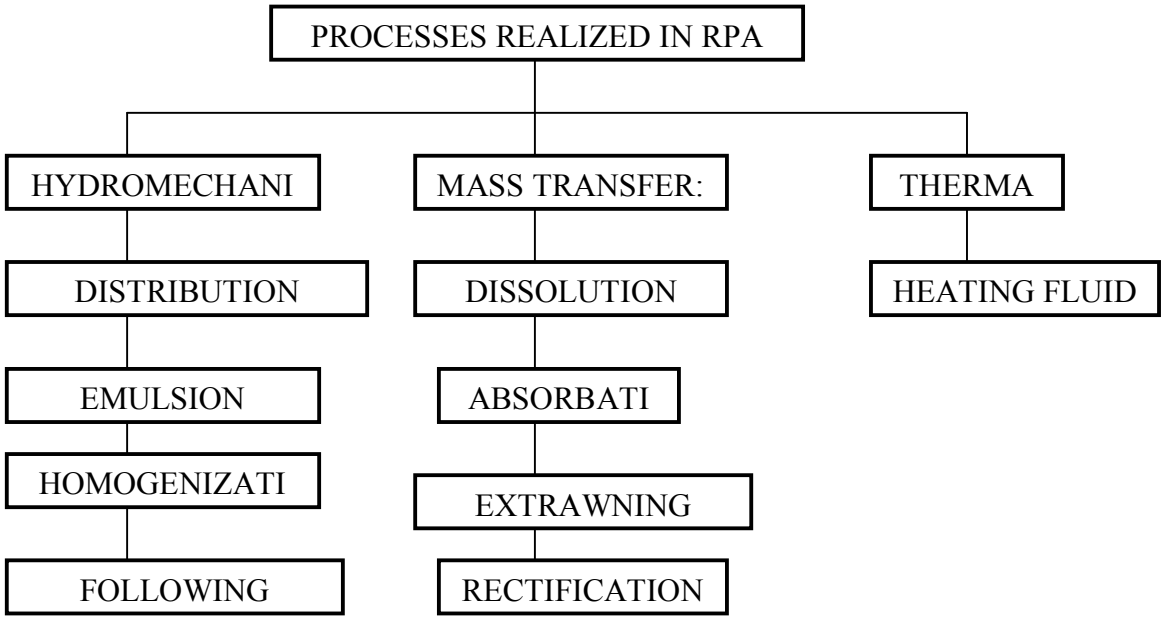


**Fig. 2. Scheme of classification of technological processes implemented in RPA**

Technologies and technological complexes on the basis of RPA allow to receive high-quality technological, homogeneous forage grain mixtures. In technological complexes in addition to RPA includes standard equipment for the dispensing, injection and supply of liquids and components of the product, the capacity of premixing and temporary storage of components.

**Fig. 3 General view of the rotary-pulsating apparatus for the preparation of liquid cereal mixtures**

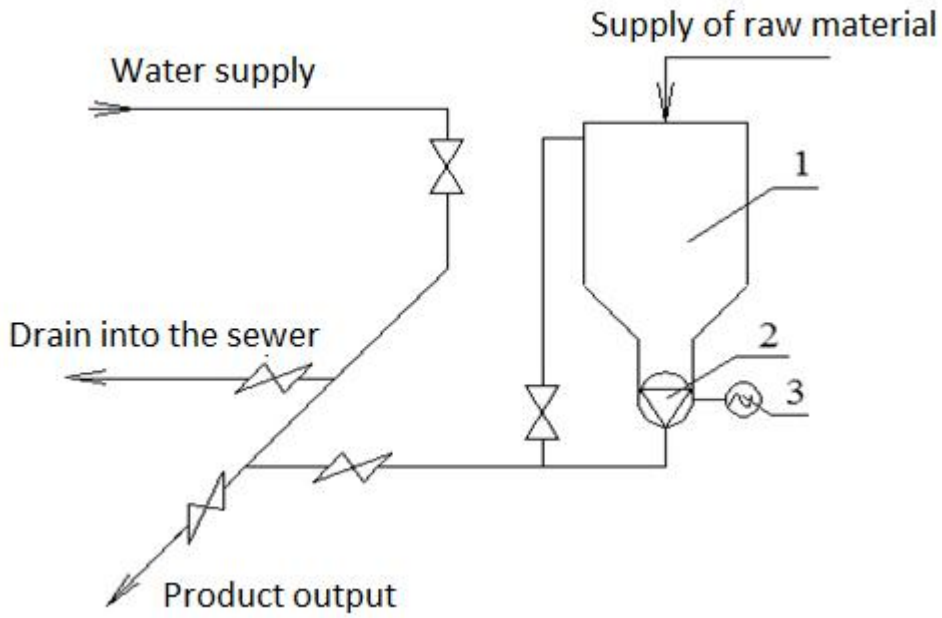


**Fig. 4 Technological scheme for grain feed preparation:**

1 – bunker; 2 – rotor-stator system; 3 – an electric motor

Developed RPA for the preparation of grain feed is presented in Fig. 3. The scheme of such a device is shown in Fig. 4. Feed preparation technologywith the use of grain material is as follows – in the bunker is fed a mixture of water and grain mass, which enters the rotor-stator system with a slot. When grains ofparticles fall into the channels, when coincident with the openings, their mechanical grinding is accompanied by complex

hydrodynamic processes (turbulization, cavitation, dispersion, emulsification, etc.). The indicated processes are accompanied by the heating of the grain mixture, which is due to the transformation of the mechanical energy of rotor rotation into thermal energy. The liquid grain mixture at the expense of centrifugal forces returns through the pipe channels to the hopper and again passes through the rotor-stator system. The process of cooking the grain mixture ends when the size of the crushed grain particles is optimal for animal consumption. The grain mix adds additives like premixes and other components that improve the consumer's quality of the feed received. As a result, a feed mixture will be obtained which, in terms of its consumer characteristics, exceeds the feed obtained in existing prototypes of feeding machines. At the same time, the energy costs in the RPA per unit weight of the fodder product are 1.5-2 times lower compared to the known designs of feeders.

**Conclusions and suggestions.** The principle of the discrete-pulse energy supply, on which the work of the rotary-pulsating apparatus is based, makes it possible to substantially intensify the processes of preparing liquid feeds using grain material of different types (wheat, rye, oats, corn, etc.) that are widely used for feeding livestock in agriculture with improved economic and energy performance compared to existing prototype feeders.

## References

1. Promtov, M. A. (2004). Mashinii apparati s impulsnimi energetichkimi vozdeistviiami na obrabativaiemi veshestva [Machines and apparatus with impulsive energy effects on processable substances]. Moskow: Mashinostroenie, 93.

2. Promtov, M. A. (2001). Pulsatsionnie apparati rotornogo tipa [Rotary-type pulsating apparatus]. Moskow: Mashinostroenie, 247.

3. Dolinskiy A. A., Basok B. I., Guliy I. S. and etc. (1996). Diskretno-impulsniy vvod energii v teplotehnologiyah [Discrete pulsed energy input in heat engineering]. Kyiv: ITTF NASU, 206.

4. Dolinskiy A. A. (1996). Ispolzovanie prinsipa diskretno-impulsnogo vvoda energii dlia sozdaniya effectivtih energosberegayushih tehnologiy [Implementation of the principle of discrete impulse input of energy to create effective energy consumption)] Inzhenerno-phizicheskiyzhurnal, 69 (6), 35-43.

## РОТОРНО-ПУЛЬСАЦІЙНІ АПАРАТИ ДЛЯ ПРИГОТУВАННЯ РІДКИХ КОРМІВ НА ЗЕРНОВІЙ ОСНОВІ

***В. Г. Горобець, А. М. Сердюк***

**Анотація.** *Розглянуто принцип роботи та конструкцію роторно-пульсаційного апарату для приготування рідких зернових кормових сумішей. Наведені основні переваги нових технологій порівняно з існуючими технологіями при їх застосуванні на виробництвах АПК.*

**Ключові слова:** ***роторно-імпульсний апарат, масообмін, енергія, зернова кормова суміш***

## РОТОРНО-ПУЛЬСАЦИОННОГО АППАРАТЫ ДЛЯ ПРИГОТОВЛЕНИЯ ЖИДКИХ КОРМОВ НА ЗЕРНОВОЙ ОСНОВЕ

***В. Г. Горобец, А. М. Сердюк***

**Аннотация.** *Рассмотрен принцип работы и конструкция роторно-пульсационного аппарата для приготовления жидки хзерновых кормових смесей. Приведены основные преимущества нових технологий по сравнению с существующими технологиями при их применении на производствах АПК.*

**Ключевые слова:** ***роторно-импульсный аппарат, массообмен, энергия, зерновая кормовая смесь***