ANALYSIS OF DESIGN FEATURES OF CIRCULATING ACTION MIXERS

M V Sevostyanov, V S Sevostyanov and I G Martakov

Department of Technological Complexes of Machines and Mechanisms, Belgorod State Technological University of V.G. Shukhov, Belgorod, 308012, RU

Abstract. This article considers the classification of the mixers of the circulation action. The analysis of their structural peculiarities and disadvantages was carried out. The need to create combined mixing devices has been identified. The design of a combined mixing apparatus is proposed.

One of the most important technological stages of most production is the process of mixing various bulk and viscous components. This is typical for various branches of industries such as the industry of building materials, food, metallurgy, pharmaceutical, agro chemistry and agriculture, chemical and etc. industries. The main purpose of the mixing process is to obtain a homogeneous mixture from separate components.

In the process of mixing bulk materials that differ in the density or particle size, the segregation, separation of particles by their size or density, affects the quality of the finished mixture negatively.

One of the effective methods of counteracting this process is the ordered loading of the components of the mixture and its homogenization in a circulating mixer [1, 2].

At the same time, segregation cannot prevent, but promote the production of high-quality mixtures. This is due to the fact that circulating mixers have an ordered nature of the motion of the components (the motion of material flows through a closed contour of varying complexity) and the zones of segregated state of the mixture are easily predictable.

The aim of this paper is to analyze the designs of the mixers of the circulation action and to develop a mixer design of the combined action.

Among circulating-type mixers, was planetary-screw, bladed, spinning centrifugal and screw with a central circulation pipe became more distributed in industry. They are recommended for mixing lightweight disconnected and cohesive bulk materials, as well as for mixing bulk materials with a small amount of liquid.

A mixer with a planetary-screw agitator [3] consists of the following main units (Figure 1): conical housing 1; transmission boxes 2; augers 3; drive 4.

Figure 1. Mixer planetary-screw:
1 - conical housing; 2 – transmission box; 3 - screws; 4 – drive
The disadvantages of such mixers are the complexity of the design, due to the large number of gears, and the presence of a stagnant zone in the central parts of the mixer.

Blade mixers [4] consist of the following main units (Figure 2): a vertical cylindrical body 1; unloading device 2; working body 3; drive 4.

Disadvantages of such mixers are increased energy costs and stagnant zones, depending on the type of working element.

![Figure 2. Blade mixer: 1 - vertical cylindrical body; 2 - unloading device; 3 - working body; 4 - drive](image2)

The spindle centrifugal mixer [5] consists of the following main units (Figure 3): cylinder-cone body 1; drive vertical shaft 2 with rotor 3; a hollow truncated cone 4 and a radial mixer 5; blade 6; drive 7.

The disadvantages of such mixers are increased energy costs and the complexity of the rotor design with blades.

A mixer with a central circulation pipe [6] consists of the following main parts (Fig. 4): a vertical body 1; with a vertical circulation pipe 2 installed in it; gas injection pipes 3; nozzles 4; unloading device 5; feed nozzle 6 and the air filter 7.

The disadvantages of such mixers are the complexity of the design, due to a gas supply and filtration system, and stagnant zones in the side parts of the mixer.

![Figure 3. Centrifugal spindle mixer: 1 - cylinder-cone body; 2 - drive vertical shaft; 3 - rotor; 4 - hollow truncated cone; 5 - radial stirrer; 6 - blades; 7 – drive](image3)

An analysis of the existing constructions has shown that the working bodies of the mixers creating the circulation movement are mixers made in the form of augers, radial blades, propellers or disks.

The implementation of the mixing process using these structures does not guarantee obtaining a qualitative mixture without providing certain operating modes.

The solution of this problem is the creation of combined mixing plants, which allow combining different modes of operation of mixers with different types of working bodies and also provide the possibility of creating various turbulent-laminar flows and obtaining qualitative homogenized mixtures with different physical and mechanical characteristics of the incoming components.
Figure 4. Mixer with central circulation pipe:
1 - vertical body; 2 - vertical circulation pipe; 3 - gas injection pipe; 4 - nozzle; 5 - unloading device; 6 - loading branch pipe; 7 - the air filter

Figure 5. Technological mixing module: 1 - vertical mixer; 2 - unidirectional double-threaded screw blades; 3 - a branch pipe; 4 - horizontal mixer; 5, 7 – screw blades; 6 - oppositely directed double-threaded screw blades; 8 - block for mechanical pre-compaction of the mixture

In the developed technological module [7] a combined mixing of materials is carried out (Fig. 5). The realization of mixing technogenic fibrous materials with various physical and mechanical characteristics is due to the stage-by-stage high-speed mixing of the mixture with the organization of internal recycling at each stage of their mixing, and the consequent increase in its density through mechanical pre-compacting and micro granulation. Due to the consequent, respectively installed vertical and horizontal mixers with blades, mixing takes place in two stages. Turbulent-gyratory mixing takes place in the first stage and in the second stage, recirculation is carried out with steam humidification. As a result of the analysis, it was found that the designs of the circulation mixers do not provide the required quality of the finished mixture. The use of the proposed mixer design combined action makes it possible to obtain ready-mixes of the required quality with different physical mechanical characteristics of the incoming components.

Acknowledgments
The article was prepared within development program of the Flagship Regional University on the basis of Belgorod State Technological University named after V.G. Shukhov.

References
[1] Selivanov Yu T, Pershin V F 2011 Some aspects of practical use of circulating mixers Chemical industry today 2 pp 51-56
[2] Glagolev S N, Sevostyanov V S, Gridchin A M and others 2013 Resource-energy-saving modules for the integrated utilization of technogenic materials Vestnik of the Belgorod State Technological University named after V. G. Shukhov 6 pp 102-106

[3] Orlov G I, Kupriyanov N A and Batashova Yu V Author's certificate of the USSR № 1011220, IPC B01F 7/02. Planetary- screw mixer (USSR) No 3 359369 / 23-26; claimed by 05.11.81; publ. 15.04.83 Bul 14 p 3

[4] Rastegaev P S, Burmaka V L and Manivchuk S D Author's certificate of the USSR No 1494957, IPC B01F 7/18 Centrifugal blade mixer / No 4116079 / 23-26; claimed by 01.07.86; publ. 23.07.89 Bul 27 p 2

[5] Borschchev V Ya The patent of the Russian Federation. No. 97935, IPC D03J 3/00. Spindle centrifugal mixer /; the applicant and the patent holder of Tambov State Technological University. No. 2010114959/05; claimed by 14.04.2010; publ. 27.09.2010 p 6

[6] Fiyalka M D Author's certificate of the USSR No. 1816490, IPC B01F 5/24. Pneumatic mixer / (USSR). No. 4921336/26; claimed by 01.02.91; publ. 23.05.93, Bul. No. 19. p 3

[7] Sevostyanov V S, Glagolev S N, Gridchin A M and others; The patent of the Russian Federation № 2624306, MIK B01F 7/04 (2006.01), B01F 7/18 (2006.01), B01F 13/10 (2006.01) 07/03/2017. Technological module and method of mixing technogenic fibrous materials the applicant and the patent holder Belgorod State Technological University. 2016140757; claimed by 10.17.2016; publ. 07.03.2017