Int. J. Agricult. Stat. Sci. Vol. 16, Supplement 1, pp. 1769-1774, 2020 www.connectjournals.com/ijass
DocID: https://connectjournals.com/03899.2020.16.1769 ISSN : 0973-1903, e-ISSN : 0976-3392

REVIEW ARTICLE

MODELLING THE QUALITY OF THE MIXTURE IN A CONTINUOUS PADDLE MIXER

Ali A.H. Al-Maidi[1]*, Majed Salih Himoud[2], A. C. Kaliganov[3], V.P. Teryushkov[3], A.V. Chupschev[3], V.V. Konovalov[4] and Yu V. Rodionov[5]

[1]Department of Plant Protection, College of Agriculture, University of Misan, Misan, Iraq.
[2]Department of Agriculture Machinery, University of Basrah, Basrah, Iraq.
[3]Faculty of Engineering, Penza State Agrarian University, 30, Botanicheskaya St., Penza, Russia, 440014.
[4]Department of Machine Building Technology, Penza State Technological University, 1A/11, Proezd Baydukova / Gagarina St., Penza, Russia, 440039.
[5]Sciences FGBOU VO, Department of Technical Mechanics and Machine Parts, Tambov State Technical University, Russia.
E-mail: ali_abbas@uomisan.edu.iq

Abstract: The aim of the research was to establish the regression equation of the quality of the prepared mixture, depending on the influence of some technological and structural parameters of the continuous mixer. The research methodology provided for a statistical analysis of previously obtained results of experimental studies of identification the generalized effect of a number of factors on the quality of the mixture. A description of the design of a vertical continuous mixer with six-paddles is given. An adequate exponential regression model of the coefficient of variation was established depending on the rotation frequency of the working unit, the number of paddles, mixer performance and the proportion of the control (smallest) component. The mixing time is determined by the performance of the mixer and the number of paddles. The proportion of the control component hyperbolically affects the quality of the mixture. Good mixture quality is possible with a fraction of the smallest component of more than 15%. With increasing mixer performance, the quality of the mixture decreases slightly. An increase in the number of paddles significantly improves the quality of the mixture and should be at least 5. The rotation frequency (750-1500 rpm) does not significantly affect the quality of the mixture. At a speed of 1000-1500 rpm, the quality of the mixture remains almost unchanged.

***Key words*:** Paddle mixer, Mixture, The mixing tank, Nutrients, Circulation mixers.

Cite this article

Ali A.H. Al-Maidi, Majed Salih Himoud, A.C. Kaliganov, V.P. Teryushkov, A.V. Chupschev, V.V. Konovalov and Yu V. Rodionov (2020). Modelling the Quality of the Mixture in a Continuous Paddle Mixer. *International Journal of Agricultural and Statistical Sciences.* DocID: https://connectjournals.com/03899.2020.16.1769

1. Introduction

The rapid loss of these nutrients from some soils and high cost as well as the environmental pollution caused by unplanned applications led to the idea of adopting alternatives to improve soil fertility, reduce the cost of production and reduce the level of environmental pollution by moving towards an agricultural system such as the application of organic fertilizers of plant source (weeds), which is characterized by low economic cost, protecting the environment from pollution and improvement of the physical and chemical properties of the soil as well as representing the nutrients balance to provide the basic nutrient requirements of the plant during its various stages can be one of the best management practices [Al-Hasanie and Al-Maadhedi (2017), Hilfy and Flayyah (2017), Dhary and Al-Baldawi (2017)]. Diesel engines are one of the primary sources of energy for mobile vehicles and can also be used as stationary or mobile power sources [Al-Maidi *et al.* (2018)].

High productivity of poultry and animals requires providing their organisms with all the required set of nutrients. A complete set of nutrients in accordance

Author for correspondence ***Received** April 17, 2020* ***Revised** July 28, 2020* ***Accepted** August 22, 2020*

with the diet requires the preparation of feed mixtures according to a given recipe and the delivery of the finished mixture in the proper amount. Feed mixtures are made by dosing the initial components with the subsequent distribution of their particles in the entire volume of the prepared mixture. Mixers are used to distribute feed particles. They have a different design of both the mixing tank and the working units.

High mixing intensity is observed for circulation mixers [Habchi *et al.* (2019)], where the material moves along a given complex path of movement. In this case, the microvolumes are mixed, in the concentration of components they are averaged over the entire volume. However, these mixers are more applicable to liquid fluid mixtures. An example of rotary tank mixer is drum mixers [Li *et al.* (2017)]. Their main advantages are low energy consumption and short mixing time [Emeljanova *et al.* (2018)]. Unfortunately, to achieve high quality mixing using these mixers is difficult. Improving their design is aimed at optimizing the design of the blades to improve the quality of the mixture [Celik and Bonten (2019)].

For mixers with a fixed tank, high power costs are required. When using screws in them, the distribution of particles in the mixture occurs intensively [Kushnir *et al.* (2016)]. Paddle mixers have simpler working units. As a rule, they are faster, but at the same time evenly distribute the components in the mixture [Ebrahimi *et al.* (2018), Chupshev *et al.* (2018)]. In batch mixers, a horizontal drive working shaft is often used [Ebrahimi *et al.* (2018)].

At present, batch mixers are in most demand [Emeljanova *et al.* (2018), Chupshev *et al.* (2018), Chupshev *et al.* (2019)]. They provide the best quality mixture. However, high energy consumption for mixture formation is needed. Continuous mixers require significantly less energy, but unfortunately, require more complex and expensive dispensers and provide slightly lower mixture quality [Kushnir *et al.* (2016)].

The aim of the research was to establish a generalized regression equation for the change in the quality of the prepared mixture, depending on the influence of the number of technological and structural parameters of the continuous mixer.

2. Materials and Methods

The research methodology provided for a statistical analysis of previously conducted experimental studies in order to obtain a generalized regression model of the quality of the mixture depending on the design and technological parameters of the distribution process of the components in the volume of the mixture. The effect of the number of six-blade paddles rapidly rotating at different speeds, as well as the total productivity of a multicomponent continuous batcher (which together forms the performance of a continuous mixer) and the fraction of a smaller (control) component in the mixture were studied.

The studies were carried out in the form of two series of experiments. In the first series, the number of mixers (1; 3; 5) and their rotation frequencies (12.5;

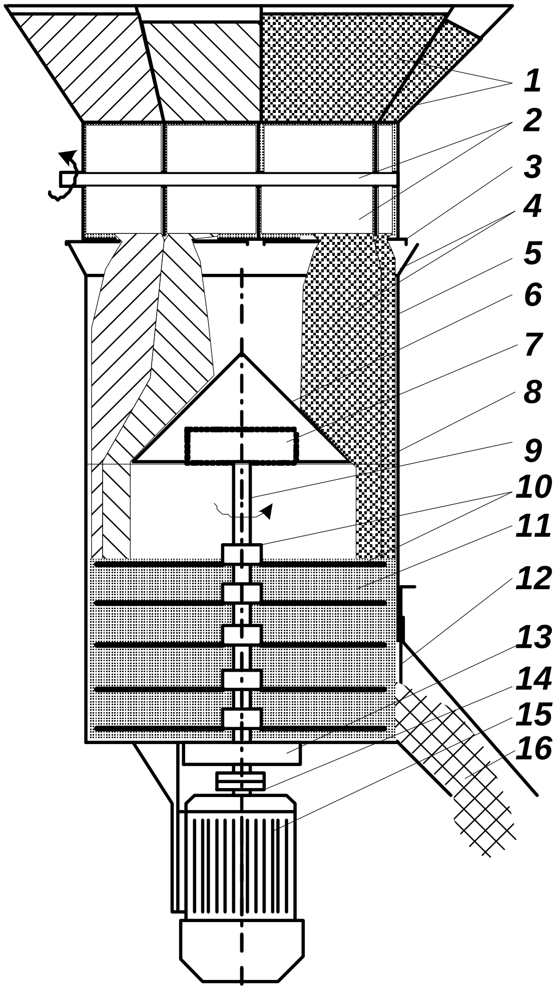

Fig. 1: Technological scheme of the mixer: 1– batcher with components of the mixture; 2– metering devices of a multicomponent dispenser; 3– metering shutters; 4– guide cone; 5– walls of the mixing tank; 6– guide cone; 7– upper bearing support; 8– cone supports; 9– shaft; 10 - paddle mixer; 11– components during mixing; 12– slide valve; 13– lower bearing support; 14– joint; 15– electric motor; 16– discharge tray with the finished mixture

16.6; 25.0 s^{-1}) were changed. In the second series, the mixer performance (from 1.5 to 3.0 kg/s) and the proportion of the control component (from 2 to 16%) at a speed of 16.6 s^{-1} and 5 paddles were changed. The coefficient of variation in the mass of barley grains in barley-wheat dert of 20 samples was calculated. The density of the mixture was 710 kg/m^3.

When preparing the mixture (Fig. 1), its components from the batchers 1 are dosed with a multicomponent blade dispenser 2. The component delivery rate is dosed with the shutters 3. The falling component flows are directed by the cone 6 to the ends of the mixer blades 10. The rotating paddles 10 mix the mixture components with their blades. At the bottom of the mixing tank 5, the prepared mixture is unloaded by the lower mixer through the hole on the discharge chute 16. Depending on the density of the mixture, the height of the layer of the components to be mixed is regulated with the slide valve 12. The minimal layer of the mixture components 11 is provided above the upper paddle.

3. Results

By analogy with the diffusion of materials, an exponential form of the mixture quality regression equation was used to process the results [Chupshev *et al*. (2016), Kushnir *et al*. (2019)]

$$\nu = 1 - e - K \cdot T \qquad (1)$$

where, ν – the coefficient of variation of the mass of barley grains in the samples, 0.01%; k – the empirical coefficient of mixing intensity for the investigated working unit; T – the duration of the active mixing of the components of the mixture, sec.

The duration of active mixing was

$$T = \frac{V_0 \cdot \rho}{Q} = \frac{\left(\pi D^2 \cdot h \cdot Z_r\right) \cdot \rho}{4 \cdot Q} \qquad (2)$$

Where, V_0 – the volume of the mixture material, while actively mixed, m^3; ρ - mixture heap density, kg/m^3; Q - continuous mixer performance, kg/sec; D - mixing tank diameter, m; h - distance between axes of paddle blades, m; Z_r - number of paddles, pcs.

Preliminary correlation analysis (Fig. 2) showed the absence of interdependence between the number of paddles and their rotation frequency, as well as between the mixer performance and the share of the

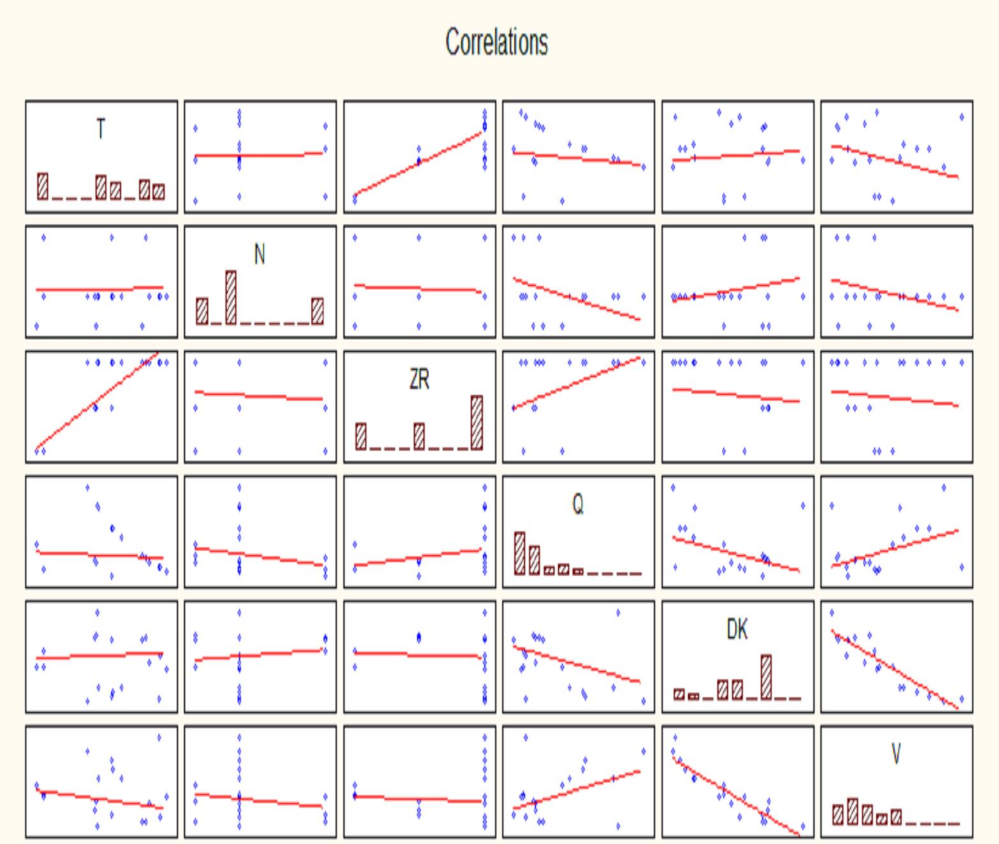

Fig. 2: Correlation of factors Zr (number of tiers of paddles), N (their rotation frequency - n), T (mixing time), Q - mixer performance and Dk (fraction of the control component) by n (coefficient of variation of the control component)

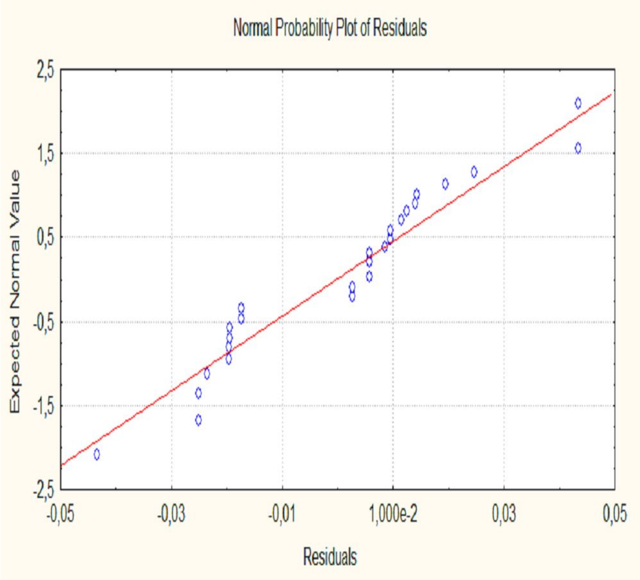

Fig. 3: Distribution chart of residues unaccounted by the regression model

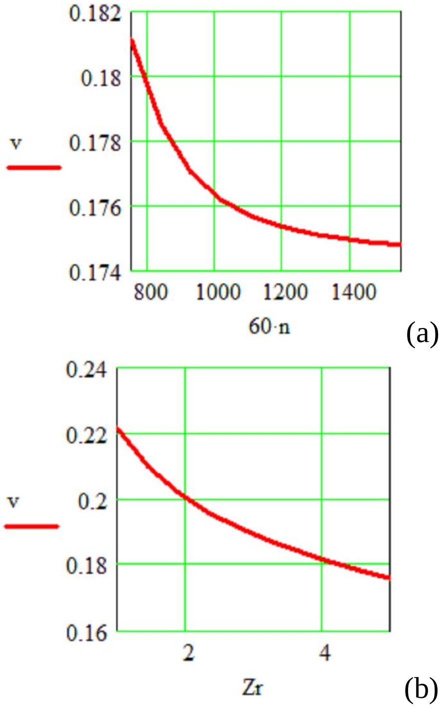

Fig. 5: Nature of variation coefficient of variation n of the content of the control component in the samples when changing the values of the factors: (a) – n (frequency of rotation of the mixer shaft); (b) – Zr (number of paddles on the mixer shaft)

control component. At the same time, there is a relationship between the number of paddles and mixer performance with the duration of active mixing of the components, which corresponds to f.2. The growth of the studied factors improves the quality of the mixture.

Processing the experimental results of the mixture quality allowed to obtain a regression model of the mixture quality ν (0.01%) on the studied parameters:

$$\nu = 1 - e^{[-0.127\cdot(1.11\cdot Zr^{(-1.165)} + 657.6\cdot n^{(-4.53)})\cdot(-0.753+0.39\cdot Q^{1.52} + 6.25\cdot D_k^{(-0.84)})\cdot T]} \quad (3)$$

Pearson's correlation coefficient is R = 0.969368, and F-test = 0.900695, which indicates the adequacy

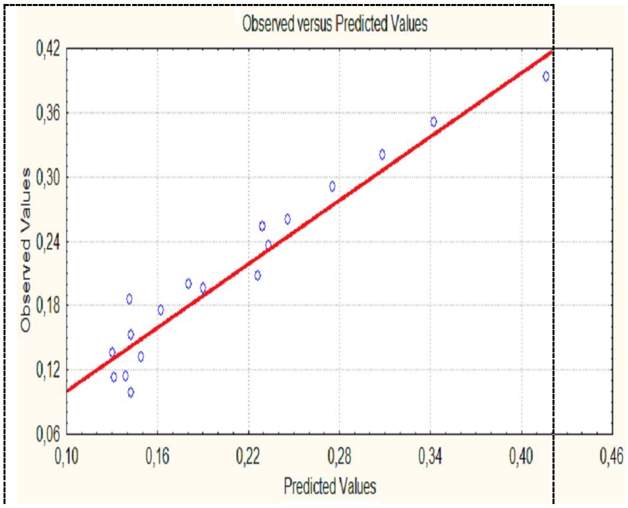

Fig. 4: Schedule of compliance of calculated values with the experimental data

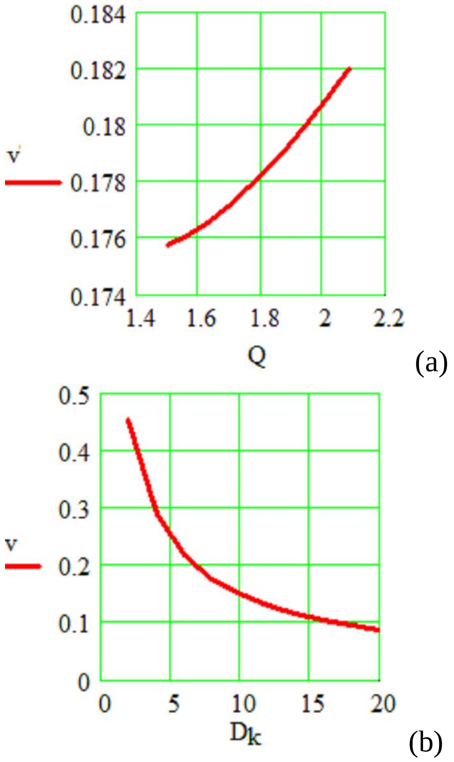

Fig. 6: The nature of the change is the coefficient of variation n of the content of the control component in the samples when the values of the factors change: (a) - D_k (proportion of the control component); (b) - Q (mixer performance)

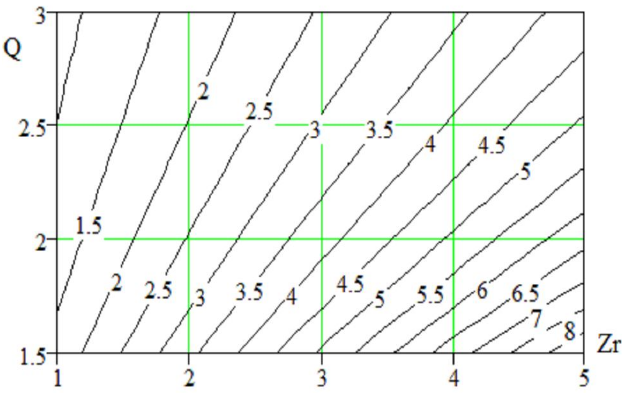

Fig. 7: Two-dimensional cross section of the response surface according to the influence of factors Zr (number of paddles) and Q (mixer capacity) on the duration of active mixing of the components T, sec

of the model. The residues unaccounted for by the model are random (Fig. 3) and the calculated values are close to the experimental results (Fig. 4).

A graphical analysis of the nature of the change in the quality of the mixture ν depending on the change in each factor of expression 3 is shown in Figs. 5, 6, 7. The numerical values of the resulting indicator of factors (the frequency of rotation of the mixer shaft, the number of paddles on the shaft of the mixer, the proportion of the control component) have a hyperbolic nature of the change in the numerical values for the exponential function.

With a shaft rotation frequency of more than 1000 rpm, the quality of the mixture does not actually improve. With an increase in the number of paddles over 5 pcs. a significant improvement in the quality of the mixture cannot be achieved. With an increase in the proportion of the control component, the achieved mixture quality improves. A coefficient of variation of less than 0.1 is possible with a proportion of the control component of more than 15%. The impact of performance is exponential with a numerical value of more than one. The number of paddles and mixer performance (Fig. 7) determine the duration of active mixing of the mixture (f.2). The longest mixing time is observed with the greatest number of paddles and the smallest mixer productivity and is about 8 sec.

Of the operating modes of the mixer (Fig. 8), the number of installed paddles have a greater effect than the frequency of rotation of their shaft. With a small number of paddles, the rotational speed does not practically affect the quality of the mixture. With 5 paddles, the quality of the mixture improves, but a

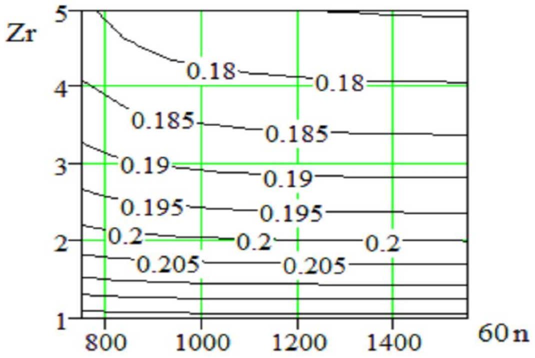

Fig. 8: The two-dimensional cross section of the response surface according to the influence of factors Zr (number of paddles) and n (rotation frequency) on the coefficient of variation n, 0.01%

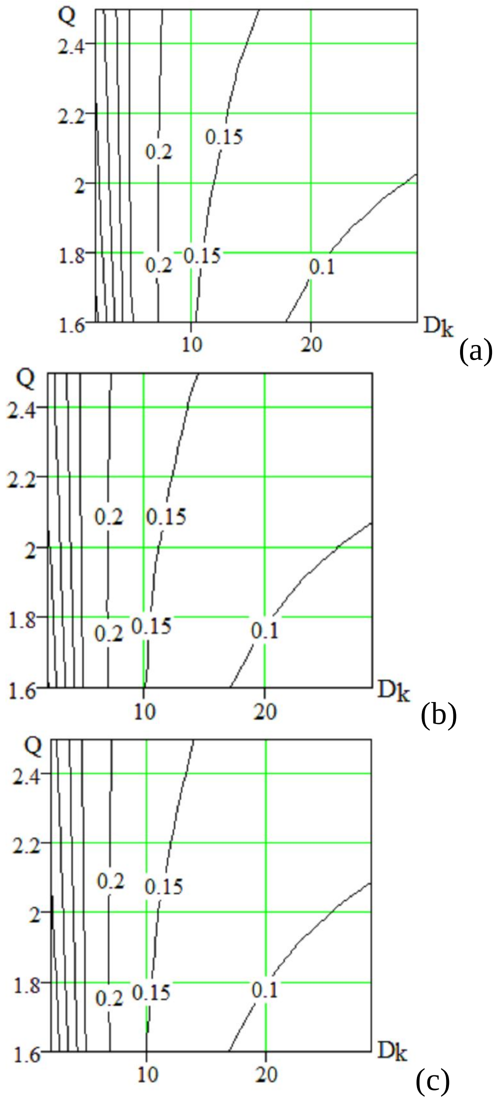

Fig. 9: Two-dimensional cross section of the response surface according to the influence of the share of the control component Dk and mixer productivity Q on the coefficient of variation n, 0.01%: for Zr = 5, at a speed of rotation, rpm: (a) – 750; (b) – 1000; (c) – 1500

rotation speed of less than 1000 rpm increases the coefficient of variation (Figs. 8, 9.a).

The technical characteristics of the mixer with 5 paddles in terms of the quality of the mixture for the share of the control component and the performance of the mixer, confirmed the previously established nature of the influence of the rotational speed (Fig. 9.a, b, c). An increase in the rotational speed of the mixer over 1000 rpm is impractical due to the stabilization of the mixture quality (Fig. 9.b, c) and the expected increase in the power consumed by the engine. An increase in the proportion of the control component in combination with a decrease in mixer performance (contributing to an increase in the duration of active mixing) significantly affects the quality of the prepared mixture. The best quality of the mixture corresponds to the longest processing time.

4. Conclusion

An adequate exponential regression model of the coefficient of variation depending on the rotation frequency of the working body, the number of mixers, mixer performance and the proportion of the control (smaller) component was established. The mixing time of the mixture is determined by the performance of the mixer and the number of paddles. The proportion of the control component hyperbolically affects the quality of the mixture. Good quality of the mixture is possible with a share of a smaller component of more than 15-18%. With increasing mixer performance, the quality of the mixture decreases slightly. An increase in the number of paddles significantly improves the quality of the mixture and should be at least 5. The rotation frequency (750-1500 min^{-1}) does not significantly affect the quality of the mixture. At the paddles rotation speed of 1000-1500 min^{-1}, the quality of the mixture remains practically unchanged.

References

Al-Hasanie, L.N.H. and A.D. Al-Maadhedi (2017). Influence of irrigation periods and organic fertilizer on two rice varieties grown under the system of rice intensification (SRI). *Iraqi J. Agric. Sci*., **48(3)**, 823-840.

Al-Hilfy, I.H.H. and M.I. Flayyah (2017). Response of two bread wheat varieties yield to mineral, bio-and organic fertilizers. *Iraqi J. Agric. Sci*., **48(6)**, 1661-1671.

Al-Maidi, A.A.H., D.V. Nikitin, Y.V. Rodionov, D.A. Chernetsov, A.V. Shchegolkov and N.V. Mikheev (2018). Mathematical modeling of thermo-regulation of fuel in diesel engines yamz-238. *The Iraqi Journal of Agricultural Science*, **49(4)**, 670- 676.

Celik, O. and C. Bonten (2019). A novel experimental setup for characterization of polymer blends in single-screw extruders. *AIP Conference Proceedings*, Series 2055 020008. https://doi.org/10.1063/1.5084809.

Chupshev, A., V. Konovalov and M. Fomina (2018). Optimization in work modeling of a mixer. *IOP Conf. Series: Journal of Physics*, Series 1084 012010. Doi: 10.1088/1742-6596/1084/1/012010.

Chupshev, A., V. Teryushkov, V. Konovalov, A. Mishanin, V. Novikov and M. Fomina (2019). Functional model of energy consumption for mixing with a vertical paddle mixer. *IOP Conf. Series: Earth and Environmental Science*, Series 403 012102. Doi: 10.1088/1755-1315/403/1/012102.

Dhary, S.I. and M.H.K. Al-Baldawi (2017). Response of different varieties of faba bean to plant source organic fertilizers. *Iraqi J. Agric. Sci*., **48(4)**, 1148-1157.

Ebrahimi, M., A. Yaraghi, F. Ein-Mozaffari and A. Lohi (2018). The effect of impeller configurations on particle mixing in an agitated paddle mixer. *Powder Technology*, 332, 158-170. https://doi.org/10.1016/j.powtec.2018.03.061.

Emeljanova, I., A. Anishchenko and O. Dobrokhodova (2018). Means to enhance operating efficiency of the means to enhance operating efficiency of the concrete mixer trucks with the purpose of highly-homogeneous concrete mix. *Preparation Int. J. Eng. and Technol.,* **7(3),** 102-106.

Habchi, C., A. Ghanem, T. Lemenand, D. Della Valle and H. Peerhossaini (2019). Mixing performance in Split-And-Recombine Milli-Static Mixers-A numerical analysis. *Chemical Engineering Research and Design*, **142**, 298-306. https://doi.org/10.1016/j.cherd.2018.12.010.

Kushnir, V., N. Gavrilov and S. Kim (2016). Justification of the Design of the Two-shaft Mixer of Forages. *Procedia Engineering*, **150**, 1168-1175. https://DOI: 10.1016/jpropro.2016.07.231.

Li, L., D. Wang, C. Li, D. Jiang and Z. Ping (2017)/ Design and Experimental Optimization of Combined-type Ration Mixer of Drum and Blade. *Nongye Jixie Xuebao Transactions of the Chinese Society for Agricultural Machinery*, **48(10)**, 67. https://DOI: 10.6041/j.issn.1000-1298.2017.10.008.