FLOW COEFFICIENT FOR GATE MIXER WITH MODIFIED SCREW

V. M. Barabash[1], A. N. Lobanov[2]

[1] Al. Nevskogo str. 9, Saint-Petersburg, Russia, barabash@mixing.ru
[2] Al. Nevskogo str. 9, Saint-Petersburg, Russia, lobanov@mixing.ru

Abstract: This document describes a new structure of the gate mixer featuring the modified screw. We have conducted certain experiments to evaluate the flow coefficient for the proposed mixer. The experimental data proves that the flow coefficients for helical-screw mixer and for the gate mixer featuring the modified screw have practically similar values.

Keywords: apparatus, mixer, helical-screw mixer, gate mixer, mixing.

According to the experimental results [1], the relation between the circulation flow rate q (volume expense) and mixer's characteristics can be described, using the following equation:

$$q = K_q \cdot n \cdot d_a^3 \,, \tag{1.1}$$

where n – mixer rotation frequency, rps; d_a – mixer diameter, m.

The flow coefficient K_q varies within wide ranges and depends on the mixer type, its dimension ratio and, according to certain authors, on the apparatus dimensions and medium properties. According to the results of experimental studies conducted by various methods in apparatuses with baffle plates [1], for open-type turbine mixers (Rushton turbine) K_q = 0.5÷1; for propeller-type mixers K_q = 0.2÷0.6. For apparatuses with gate mixers, K_q = 0.033 [2].

To determine the flow coefficient K_q that applies to the helical-screw mixer and to the gate mixer with the modified screw [3], we have assembled the unit, the diagram of which is shown in Fig. 1.

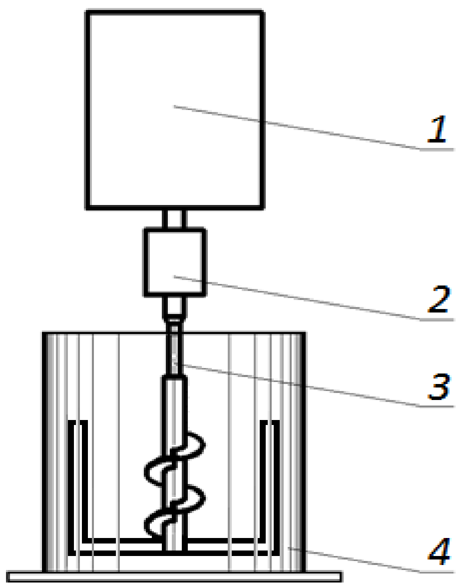

Figure 1: 1 – electric motor; 2 – torque meter; 3 – mixer: 4 – vessel.

Figure 2: Gate mixer with modified screw

The glass vessel with a flat bottom, inner diameter of 224 mm (4) is filled with high-viscosity liquid. The mixer (3) is rotated by the variable-speed electric motor (NORDAC controller) fastened to the special support.

For mixing, we have used the modified helical-screw mixer, diameter of 80 mm, and the gate mixer, diameter of 220 mm, with the modified screw, diameter of 80 mm (Fig. 2).

The concentrated glycerin solution has been used as a mixed medium. The solution density ρ is equal to 1180 kg/m^3, viscosity μ – 30 mPa·s. To determine the medium viscosity, we have utilized the viscometer "Rheo-Viskometer nach Hoppler".

The marker, the density of which is equal to the medium density (ρ = 1180 kg/m^3) has been put into the vessel filled with the medium. The marker has been in the state of rest in relation to the mixed medium. Mixing creates the flows in the vessel. These flows move the marker within the entire working volume of the apparatus. Knowing the working vessel volume and the time required for the marker to go down from the surface to the bottom and then to come to the surface, we can determine the circulation flow rate q, using the following formula:

$$q = \frac{V}{t} = \frac{\pi \cdot D^2 \cdot \mathrm{H}}{4 \cdot t}, \tag{1.2}$$

where V – working vessel volume, m^3;

D – vessel diameter, m;

H – filling height, m;

t – marker circulation period in the vessel circulation circuit, s.

The formulae (1.1) and (1.2) show that $K_q = \frac{\pi \cdot D^2 \cdot \mathrm{H} / 4 \cdot t}{n \cdot d_a^3}$.

The experimental results are shown in the flow coefficient K_q – Reynolds number diagram (Fig. 3).

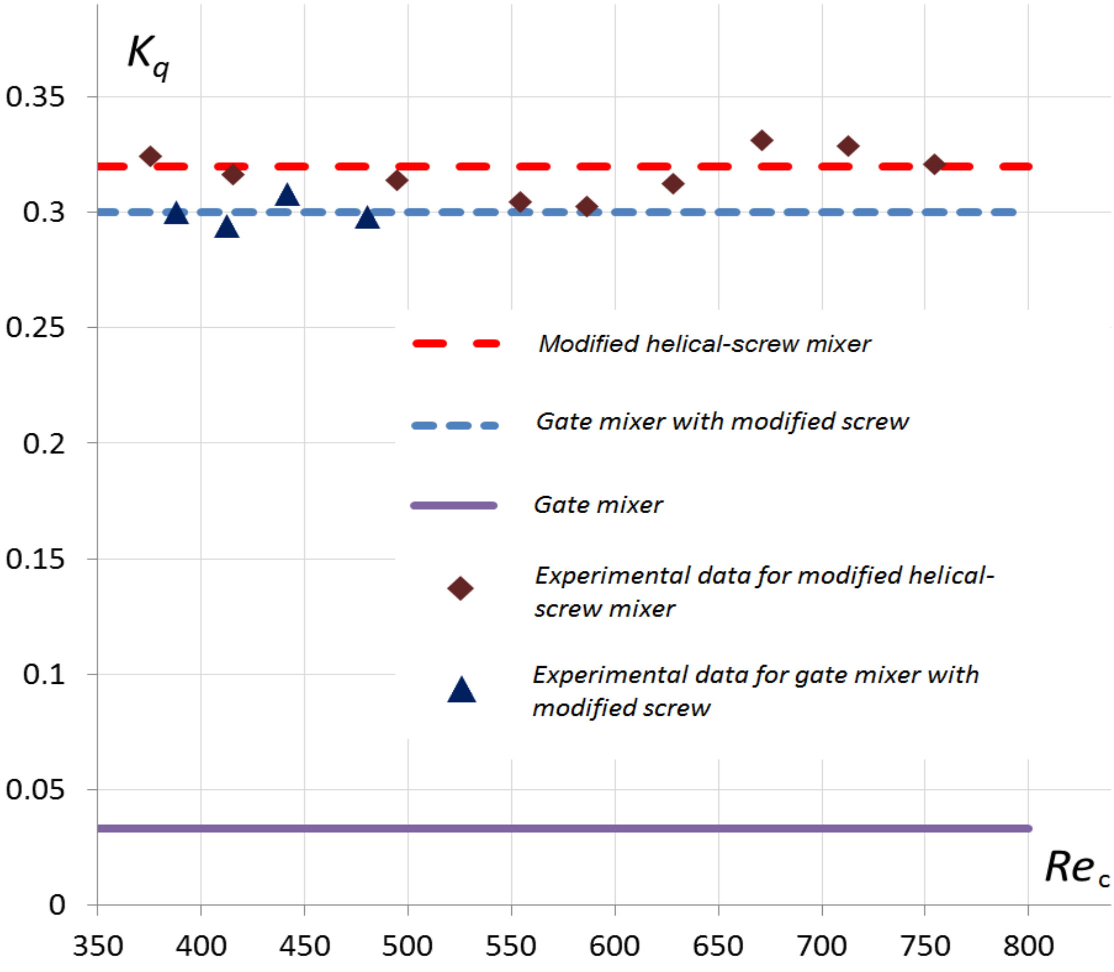

Figure 3: Flow coefficient-Reynolds number diagram

The diagram shown in Fig. 3 proves that the flow coefficient K_q for the gate mixer with the modified screw (K_q = 0.3) and for the modified helical-screw mixer (K_q = 0.33) has near similar values. This means the position of the frame in relation to the screw may not increase the circulation flow rate. In its turn, the position of the screw in relation to the frame may increase the circulation flow rate almost by 10 times, because the flow coefficient K_q for the gate mixer is equal to 0.033 (Fig. 3).

The practical use of the gate mixer with the modified screw has proved its high efficiency, in particular, when mixing high-viscosity media during the processes that require the heat exchange intensification. Thus, for example, when this mixer was used for lithium grease production, the heating/cooldown time was reduced by more than 2.5 times in comparison to the application of the common gate-type mixer.

Designations

q – circulation flow rate, m^3/s;
K_q – flow coefficient;
Re_c – Reynolds number, centrifugal;
ρ – fluid density, kg/m^3;
n – mixer rotation frequency, 1/s;
D – inner vessel diameter, m;
d_a – mixer diameter, m;
μ – fluid dynamic viscosity, Pa s;

References

[1] Strenk F. Mixing and apparatuses with mixers. Poland, 1971, Translation from Polish Edited by Shchuplyak I. A., L., “Chemistry”, 1975.
[2] Braginsky L.N., Begachev V.I., Barabash V.M. Mixing in fluid media. – L.: Chemistry, 1984. – 336 p.
[3] Barabash V. M., Begachev V. I., Lobanov A. N., 2015. On the power characteristics of a modified helical-screw mixer. *Proc. 15th European Conference on Mixing, Saint-Petersburg, Russia, July 2015,* 52-56.