Productivity of Self-Suction Mixers on Expense Coefficient

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***Abstract* – Self-suction mixers are the most effective mixing devices which are used in technological schemes applying aggressive of a gas ous reagents. The known methods and calculations of mixer productivity for a gas phase are mainly associated with increased rotational speed and a mixer diameter. Changing these parameters automatically increases power to mixing. The article presents the results of research to increase the productivity of the gas by increasing the discharge coefficient..**

Key words – self-suction mixer, expense coefficient, agitator, gas reagent, hudrodinamic.

I. Introduction

In order to carry out mass exchange processes in the gas-liquid system in chemical industry large volume apparatuses with self-suction mixers are used in recent times. The supply of a gas reagent in such devices is performed due to the vacuum resulting from rotation and flow of the mixed liquid of the mixer blades.

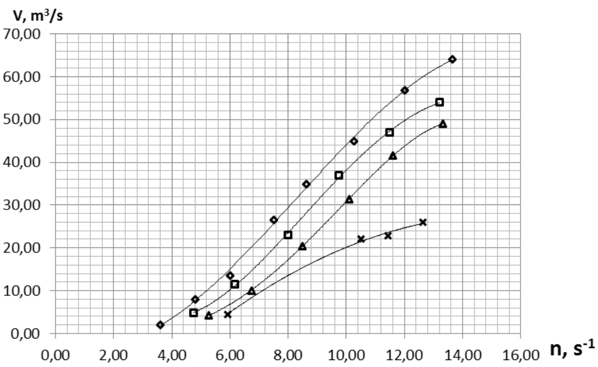
II. Main part

Structurally self-suction mixers are rotors in the form of an inverted cup, the surfaces of which are full of holes connecting the rotor cavity with its blades. The investigations carried out with the laboratory model of this apparatus with the sulf-suction mixer are presented in the form of a graphical relationship (Fig. 1).

From the dater mentioned above it implies that productivity increase at the gaseous phase depends on immersion depth, diameter and rolation frequency of the mixer. The hydrodynamics of liquid or gas outflow through holes or nozzles has been thoroughly studied and presented in the literature. While the investigation of the same problem for sulf-suction mixers is scanty.

We have carried out some research which aimed at increasing self-suction mixers productivity by means of changing discharge coefficient. For this purpose the devices being samples of a self-suction mixer rotor with a slot hole and interchangeable nozzles similar to Rollow blades, have been made. These devices enabled to carry out research on determining the coefficients of resistance and liquid discharge at its outflow from the cylindrical part of the mixer rotor through the slot hole. The parameters of rotors samples correspond to rotor parameters of the self-suction mixer under review. On the forming part of the laboratory rotor models some rectangulas holes of side ratio 1:5 have been cut.

The upper part of cylindrical tube of the device is capped, and on the cap there is a connection pipe for connecting a piezometer. Two types of these devices have been made. One type of the device models is a transparent tube with a slot rectangular hole with straight edges; the other type has combined edges, one side of the slot having a straight edge, the other – a rounded or bevel angle a to the blade axis. The hydrodynamics has been studied, water being used as transition material. The liquid supply was performed from the bottom through the outlet located at the blade axis. The outlet cross section for liquid supply was chosen as an equil one to the slot hole or the nozzle cavity. To uniform the flow rate along the flow rate along the tube cross-section and to eliminate the liquid pulsation effect on the outflow conditions a flow conditioning plate made of thin wire was installed at the bottom of the device.The measurements of discharge and piezometric pressure according to the recommendations [1],[2] were being carried out in the experiment process.



◊ – h=0,04 m; □ – h=0,07 m; Δ – h=0,1 m; x- h=0,16 m;

Fig. 1. Dependence of self-suction mixers productivity on their speed at different immersion depths

The device studied was installed on the test bench strictly in the upright (vertical) position. The liquid flow rate was controlled (monitored) with the help of a rotameter PC-5, the pressure being determined according to the piezometer readings. The cases of liquid out flow through the rectangular slot with straight edges and through the slot where one vertical edge was rounded and had a slont angle 60° and 45° have been studied.

The liquid ɸdischarge, piezometrical pressure in the cylindrical part of the model were summarized in the table. The data received were applied for the further calculations of the discharge coefficient μ which was determined according to the formula:

$$\mu = \frac{Q}{S\sqrt{2gH}}\,, \qquad (1)$$

where Q – liquid discharge for this experimental installation, m^3/s; H – flow rate liquid height in the piezometric tube, m; p – liquid density kg/m^3; S – cross section of the slot, m^2.

In the process of investigation it was found out that the discharge coefficient μ through the slot hole and the nozzle depends on the Reynolds number Re. Moreover the greater the number Re, the lower the dependency, the unit $\mu = const$ when the numbers Re being ≥ 50000.

The results of experimental data processing for the cases of liquid outlet through a rectangular slot hole with straight edges and one hole with one vertical rounder edge have been presented (Figs. 2 and 3) as graphical dependence.

As one see from the diagram (Fig. 2) rounding of one vertical edge of the slot hole significantly increases discharge coefficient as compared with the device having the slot hole with straight edges. It has resulted from the data mentioned above that discharge coefficient value through the rectangular nozzle dependson the pitch angle of one vertical edge of the slot hole and the adge change from 90° to 60° and 45° increases the discharge coefficient, the largest value corresponding to the pitch angle of 45° (Fig. 3). These data allowed to determine the empirical dependence of expense coefficient the pitch angle of one vertical edge of the slot hole.

$$\mu = 0,54 + 0,00012(90^0 - \theta)^2 \quad (2)$$

where θ – pitch angle

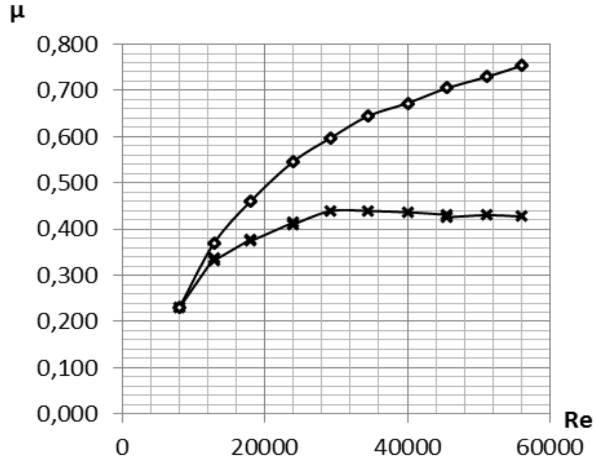


Fig. 2. Dependence of discharge coefficient change of the slot hole on Reynolds criterion.
The edges of the slot: x – straight; ◊ – rounded

The investigations have shown that, the change of one vertical edge configuration of the slot result in increasing liquid discharge coefficient and therefore in increasing transition flow discharge. This, in its turn, enables to change the configuration of the seif-suction mixer channels and to increase its productivity in the self-suction mode without increasing its diameter and rotation frequency.

In the process of mixer rotation, due to the mixed liquid flow along the blades, in the hollow rotor and blade cavity, the pressure over fall (from extreme to negative) occurs and it is determined for the solid compact mixed medium according to the formula:

or for the gasous and liquid media:

$$\Delta p = 0,5\pi^2 n^2 d^2 \rho (1 - \varphi_0)\xi \quad (3)$$

where n – mixer rotation rate; d - mixer diameter; ρ - liquid density; φ_0 - gas content in the mixer blade zone (area); ξ - mixer resistance coefficient.

The negative pressure in the blade cavity and the mixer rotor provides suction and dispersion of the air into the mixed amount in the case if it exceeds the sum of the hudrostatic pressure of the liquid column above the mixer $\Delta p = \rho g H$ and the resistance rohich is overcome by the suction flow inside mixer $\Delta p_1 = \zeta \frac{v^2}{2g}$.

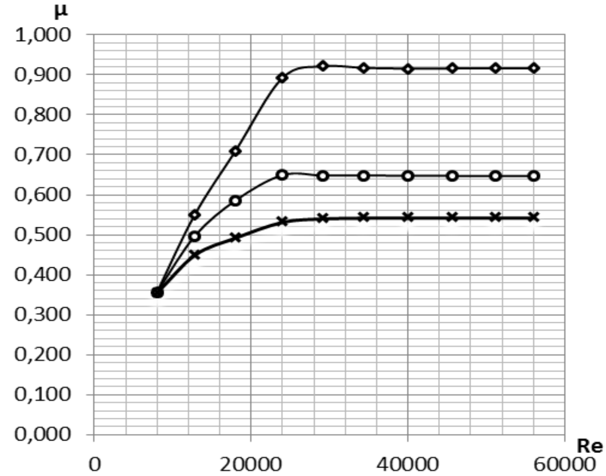


Fig. 3. Dependence of discharge coefficient change for the rectangular nozzle on Reynolds criterion The bevel angle of the input edge: x – 90^0; ○ – 60^0; ◊ -45^0

In the previous formula ζ - is a resistance coefficient of the hole, through which the gas out flow from the cavity to the hollow blades of the self-suction mixer is performed.

The amount of the gaseous reagent, sucked in by the self-suction mixer, is determined according to the formula:

$$Q = \mu S \sqrt{\frac{2\Delta p}{\rho}}, \quad (4)$$

where: μ – discharge coefficient for such type of mixer, S – cross-section area of hollow channels of the mixer blades, ρ – density of the mixed medium.

Conclusion

Laboratory data comparison showed that the discharge coefficient of the second model with the rounded or pitch edge increased by 15-20%. In accordance with these data some variants of self-suction mixers were developed, these being patented in Ukraine.

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