NUMERICAL MODELING TO PRESSURE DROP OF TANGENTIAL SWIRLS

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The results of the study of numerical simulation of the hydraulic resistance of a vortex contact stage by the finite element method using k-ε turbulence models are presented. The dependence for calculating the coefficient of hydraulic resistance is obtained.

Keywords: swirl, hydraulic resistance, numerical simulation.

The rotation of gas-liquid flows is used frequently in the intensification processes of heat and mass transfer, separation of dispersed particles by the chemical and petrochemical industry. For such devices, the largest use of tangential (radial) type devices providing intensive flux rotation with a simplified design of the devices [1, 2].

Hydraulic resistance it’s one of the main calculated characteristics of the swirl, which determines the structural parameters of the equipment.

The dependences used to calculate the value of the resistance coefficient of the swirls of the tangential type are presented in Table 1.

Table 1

Dependencies of the resistance coefficient of tangential swirls

№	Formula	Reference
1	$\xi = \exp(4{,}23 - 2{,}345 \cdot A)$	[3]
2	$\xi = 3{,}1 \cdot \alpha^{0{,}7} \cdot (B/b)^{1{,}54} \cdot (h/D_{ст})^{-1{,}48}$	[4]
3	$\xi = 0{,}5 \cdot (1 - A)$	[5]
4	$\xi = \xi_{вх} + \xi_{вых} + \xi_{г} + \xi_{тур}$ $\xi_{тур} = 1{,}36 \cdot 10^{-2} \alpha^{0{,}75} b^{1{,}3} n^{1{,}3} R^{-2{,}5}$ $\xi_{вх} = 0{,}5 \cdot \left(1 - \frac{f}{F}\right)^{\frac{3}{4}}; \xi_{вых} = \left(1 - \frac{f}{F}\right)^2;$ $\xi_{г}$ = 0,2- for swirl by plate $\xi_{г}$ = 0,6 – for swirl this parallel channels	[6]
5	$\xi = 21\,Re^{-0{,}28} \cdot \left(\frac{h}{b}\right)^{-0{,}25}$	[1]
addition: A = f/F – Spinning factor; f = n ·h ·b – square of channels; b – channel width; h – height of channel; n – number of channels; F = π·$D_з$·h – square of swirl; α – channel angle; Dз- Diameter of swirl; B – blade width; $D_{ст}$ – diameter of tray; $\xi_{тур}$ – turbulent component of the resistance coefficient; $\xi_{вх}$ – input resistance coefficient; $\xi_{г}$ – turbulent gas movement coefficient; Re – Reynolds number.		

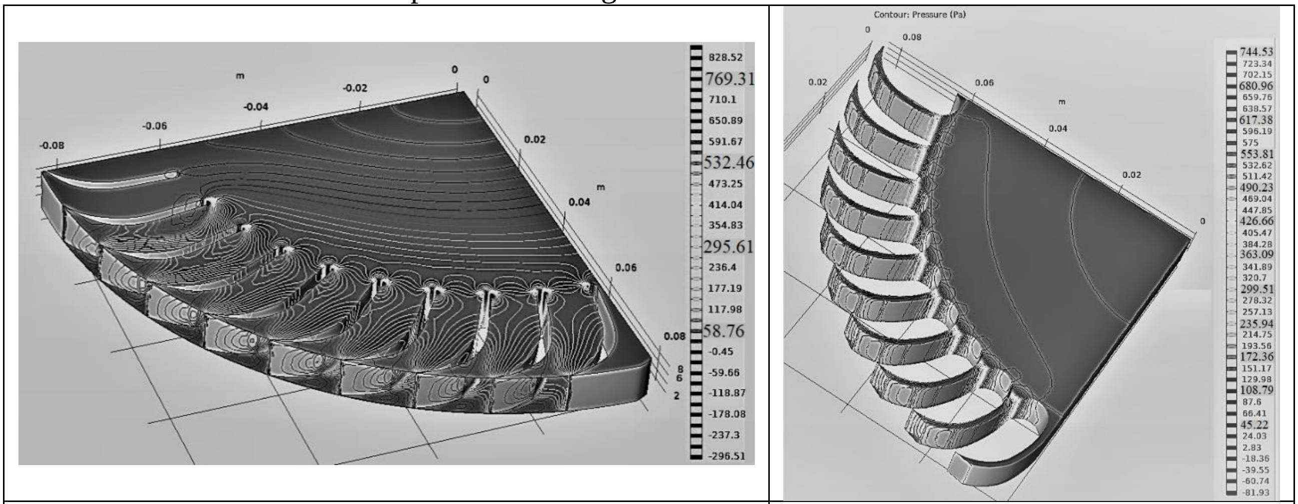
To determine all the parameters that can affect the hydrodynamics of the swirl, the ComsolMultiphysic program is used. since physical experimental models do not allow to identify the degree of influence of each parameter.

The point of the work is to identify the parameters affecting the resistance of tangential vortices through numerical simulation.

The simulation results revealed that the number of channels in the swirl affects the resistance of the output in the case of its dense placement, in this case the gas jets of adjacent channels intersect at the outlet of the swirl, is the turbulence stream.The height of the channel channels affects the input resistance coefficient, the value of the resistance coefficient is subject to the dependences $\xi \approx (h/b)^{-0,22}$, this is consistent with the known data [1].

Experimental data have shown that an increase in channel width this a permanent number of Reynolds The value of the coefficient increases and confirmed this during modeling.

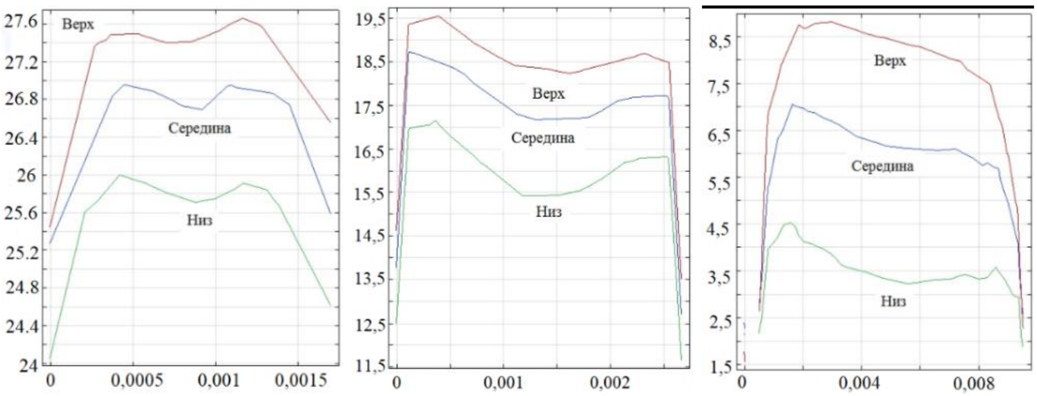
The characteristic calculated values of the pressure distribution in the swirls with a channel width of 1.5 mm and 9 mm are presented in Fig. 1.



a) б)

Fig.1. Calculated pressure of a channel width of 1.5 mm (a) and 9 mm (b) for H = 8 mm

The inlet speed profile has the greatest effect on the hydraulic resistance of the swirl. In Fig. 2. The gas speed is distributed on the width of the channel at the inlet into the swirl channel if the Reynolds number is constantly.



а) б) в)

Fig.2. Profiles of full speed at the entrance. Re = 2200: a) B = 1.5 mm; b) b = 3 mm and c) b = 9 mm

A higher resistance coefficient with an increase in the channel width is devoted to the speed profile at the inlet in the channel comparable to the Laminar Flow.

Engineering calculation of the value of the resistance coefficient is possible on the dependence approximated from Fig. 1b

$$\xi = A\,[Re^{-n} \cdot (h/b)^{-0,22} \cdot Re^{*-1}]^{0,44},$$

Re^{*}- Dynamic number Reynolds; A=64 – for profiled and straight channels and A=23 – For annular channels.

The data obtained will be in demand when prototyping and designing heat and mass transfer contact stages of distillation and absorption columns.

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