REGULAR PACKING FOR HEAT AND MASS EXCHANGE PROCESSES BY THE DIRECT CONTACT OF PHASES

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The new effective regular packing PN-3D for heat and mast exchange processes performance with quasi-isotropic properties of structure was offered. The test results of new packing are shown in comparison with other well-known regular and irregular industrial packing.

Key words : *cooling packing, heat and mass transfers, aerothermodynamic test*

1. Introduction

Known industrial packing, regular and irregular, have certain demerits. As a rule, regular structured packing are made as a pack of vertical corrugated plates [1], forming in space of device practically isolated parallel ports, excluding the possibility of transversal intermixing of contacting streams. Also regular packing provide minimal pressure loss, simultaneously with high developed specific surface. Irregular packing, filled up freely and chaotic into the device, are providing better transverse immixture. But, because of the inevitable wall contact, concerned with high fractional void volume of the packing layer, near the walls of device, the unnecessary bypassing of gases can take place [2].

New suggested construction, devoid of these imperfections, is regular packing with three-dimensional structure, combining certain advantages of regular and irregular packing. At it's development were used ideas, evolving in works of A. P. Karnauhov, including the model of 'non-crossing bars' [3].

The construction of a regular packing film-drop type, made of helical polymeric elements, was designed. The 3D construction of the packing type PN-3D gives it the isotropic properties. This new quality of the packing provides better transverse immixture of the contacting streams, compared to well-known plate-structured packing, e.g. made by the firm Sulzer [1].

The main view of the block with new packing PN-3D is shown on the Fig. 1. Single elements of the packing are helical and produced by the extrusion method. The helicoids are shown conditionally in the form of cylinders. The ability to distribute liquid phase inside the device, independent from the initial irrigation, are the extra advantages of the packing PN-3D.

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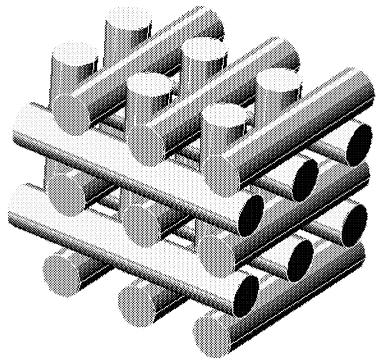


Fig.1: The scheme of Helicoid-Structural quasi isotropic packing in the form of cylinders, type PN-3D of the height 0.41 m

2. Experimental setup and method description

Aerothermodynamic test of a fragment of the packing (size in plan $0.5\times1\,m^2$) was carried out on the experimental setup, using water-air system (Fig. 2). Density of the irrigation q_l and the average air velocity w_0 were varied in the following ranges: $q_l = 7.0\ldots11.0\,m^3/(m^2\,h)$, $w_0 = 1.0\ldots2.0\,m/s$.

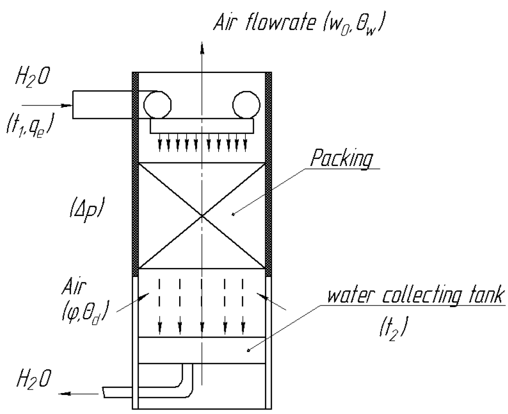


Fig.2: Laboratory experimental setup, the measured parameters are shown in the brackets (see legend)

During the tests, when liquid (water) and gas (air) were in direct contact, the heat exchange was investigated. The density of irrigation q_l, the air velocity w_0, temperature of hot water t_1 and cool water t_2, relative humidity φ, dry-bulb temperature θ_d and wet-bulb temperature θ_w, were controlled in the course of the aerothermodynamic tests. The air density is denoted by ϱ_{air}. Moreover, the average air velocity (in the relation to full section of an empty device) and pressure losses Δp were under control as well. In these series of tests, the stream velocity was changed from 1.4 till 4.0 m/s. The highs H of the packing layer were 410 and 900 mm, respectively. The hydraulic resistance coefficient of packing fragment ξ (doubled Euler criteria) was being calculated with the help of measured pressure losses value byWeisbach' s formula [4]

$$\xi = \frac{2\,\Delta p}{\varrho_{\rm air}\, w_0^2}\ . \tag{1}$$

The error of the pressure losses measurement Δp was less than 1 Pa.

The calculation of evaporation, mass feedback volumetric coefficients for packing are carried out with the help of the thermal investigation experimental data by the identification method [5]. The correlation between heat $\alpha_{\rm v}$ [J/m^3 °C] and mass feedback volumetric coefficients $\beta_{\rm pv}$ [kg/m^3 °C], respectively, was taken equal to the theoretical relation

$$\frac{\alpha_{\rm v}}{\beta_{\rm pv}} = 6.9036\,{\rm J/kg^3\ °C}\ , \tag{2}$$

in accordance with well-known Berman's work [6].

The evaporation coefficient (usually called Merkel Number Me) was calculated with the help of known mass feedback volumetric coefficient

$$K_{\rm pv} = \frac{\beta_{\rm pv}\, H}{a_1}\ . \tag{3}$$

Parameters A and n, taken from empirical formula for the evaporation number

$$K_{\rm pv} = A\,\lambda^n\ , \tag{4}$$

were defined by the least squares method. The ratio of air density flux to the water density flux $\lambda = a_{\rm air}/a_1$ is so-called air number. The small dependence of parameter A on packing height H is obvious in Table 1.

3. Test results

Comparative efficiency of packing fragments was defined by the value of the multiplier A for the fixed value $n = 0.6$. The results of the experimental investigation of the influence of the height H of the cooling tower packing on the evaporation number (4) are indicated in the Table 1.

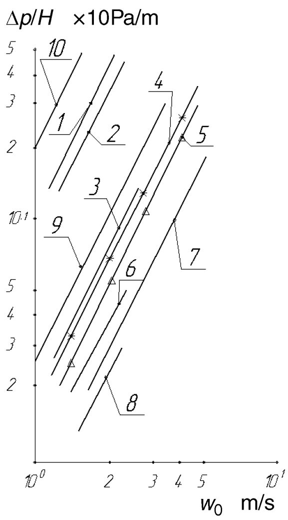
Packing height H [m]	0.41	0.9
A	0.55	0.68
n	0.6	0.6

Tab.1: The dependence of the evaporation number coefficients (4) for two different heights H

w_0 [m/s]	1.4	2.0	2.8	4.0
ξ/H [m^{-1}]	2.806	2.83	2.84	2.854

Tab.2: Pressure loss of dry packing

The dependence of the pressure losses $\Delta p/H$, for the dry packing of the type PN-3D, on the gas stream velocity w_0 is plotted in the Fig. 3. Moreover, it is shown the comparison with the data from the work [8]; for the standard polymeric packing of cooling towers (Baltimore Aircoil, France), and also with the following irregular packing: ceramic Pall'a rings and 50×50 Intalocks saddles [7], regular corrugated plastic packing with different flutes orientation in nearby plates. We can see on Fig. 2 that specific pressure looses of new packing are essentially smaller than Pall's rings and Intalox saddles and are near with regular packing [8]. The results of both investigated packing heights are summarized in the Table 2, where the hydraulic resistance coefficient of new dry packing construction calculated for 1 meter for a given air stream velocity range is shown



1 – Intalox saddles, ceramics, 50×50 (Alikperova) [7]
2 – Pall's rings, ceramics, 50×50 (Alikperova) [7]
3 – Regular plate PVC packing (Arefiev) [8]
4 – PN-3D packing
5 – Baltimore Aircoil (authors tests)
6 – Regular plate PVC packing (Arefiev) [8]
7 – Packing 'Sulzer'
8 – Regular plate PVC packing (Arefiev) [8]
9 – Regularly set ring packing PSL type [9]
10 – Regularly set ring packing PSImax type [9]

Fig.3: $\Delta p/H = f(w_0)$ dependence for PN-3D packing at $q_l = 0$, w_0 is average air velocity, calculated for full section of empty device

4. Conclusion

The offered packing provides effective transverse immixture of contacting streams, and it's even distribution in device section, because of packing quasi-isotropic property. The last circumstance defines the promising using of PN-3D packing in heat and mass exchange devices, including cooling towers, were packing property is very important to prevent the icing in the lowest cooling tower packing parts. This packing is introduced into the system of water circulation system of hotel group, attached to reconstruction cool towers Baltimore Aircoil, which were installed instead of old structural packing, The quasi-isotropic packing, type PN-3D, see Fig. 1, provides demanded technological cooling temperature parameters with closed hydraulic resistance coefficients.

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