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THE STUDY OF AERODYNAMICS REGULAR PACKING IN THE FORM OF STREAMLINED PROFILE OF THE POLYMER NETWORK

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Abstract. Presents the results of experiments on the aerodynamics of dry and irrigated regular packing. Elements of the nozzle in the form of streamlined profiles. The material of the nozzle used polymer network made of Mylar filaments. The material and structure of the grid with two-way within the liquid film on its surface. Proven design elements of the regular packing can be used as an effective load of biofilters for air pollution control devices. Experimental data on the hydraulic resistance of dry and irrigated nozzle shown in the form of plots of $\Delta P = f(W_o)$. the increasing load on the air Wo from 0.056 m/s to 0.870 m/s pressure drop $\Delta P/H$ dry nozzles CR-1K increase with the value of 6.0 Pa/m to 34.0 Pa/m.

Keywords: biofilter, regular packing, polymer, charge, pollution.

1. Introduction

Air treatment unit with granular layer, including biofilters, are becoming more common in the industry. Designs air pollution control devices are studied in several papers. In (Zagorskis 2009) studied the aerodynamics of modern biofilter made as a cassette system, in which as the load used pieces of bark (Pushnov *et al.* 2010).

The results shows of hydraulic tests of the biofilter with a loading in the form of pieces of bark, design Vilnius Gediminas technical university (Zagorskis 2009). The average size of fragments in these experiments ranged from 25 to 70 mm (Pushnov *et al.* 2010).

Various methods are used to clean the air from volatile organic compounds, including adsorption, absorption, condensation and oxidation. However, the application of these treatment techniques is expensive as charge regeneration and a sophisticated structure of devices are needed (Hashisho *et al.* 2007; Baltrėnas and Zagorskis 2010).

In some cases, biofilters used irregular nozzle loads into the unit in bulk. For example, in (Dik *et al.* 2005) the results of the study of mass transfer from the water film to the layer of filling in the form of Raschig rings having a high surface area.

The main element of biological air treatment devices is a charge, i.e. a filtering medium that may be composed of organic and inorganic substances. The charge is activated when it is being humidified with the water saturated with biogenic elements. During the process of air treatment molecules of the supplied pollutant are slowly moving through the charge. After being transferred from the gaseous to the liquid phase they are degraded by microorganisms during fermentation processes occurring on the biofilm that has formed on the charge (Ardjmand *et al.* 2005; Engesser and Plaggemeier 2000).

A filtering medium, necessary as a substrate of microorganisms and at the same time supplying them with required nutrients is used in biofilters of different structures for biological air treatment. In practice the following charges of a natural origin are used as filtering media: compost, peat, wood chips, barks, activated sludge (Shareefdeen *et al*. 2003; Baltrėnas and Zagorskis 2009).

Charges of the artificial origin, composed of polyurethane, propylene, polyethylene, glass, ceramic balls and other materials, are also often used. However, all these materials are destructed by microorganisms in the course of time (Yun and Ohta 1998; Torkian *et al.* 2003).

The efficiency of biological air treatment largely depends on the humidification and heating systems installed in biofilters. The charge's optimum humidity is 40–60 %. Where humidity is insufficient, the charge starts cracking and becomes dried, which exacerbates air flowing and reduces the activity of microorganisms. This may result in the loss of charge's filtering properties. In order to avoid parching, the charge is humidified – water saturated with biogenic elements is sprayed over it. In case of a high humidity of the charge anaerobic areas increasing its aerodynamic resistance emerge inside the filtering layer (Baltrėnas and Vaiškūnaitė 2003).

In general, the well-known designs air pollution control devices with granular layer has the following disadvantages: high hydraulic resistance, as well as the presence of the harmful effect of wall-pass, which is due to increased friability styling elements of the nozzle near the walls of the apparatus (Pushnov *et al.* 2010). An alternative is to use a regular nozzle. Proposed in (Pushnov and Kharitonov 2010; Farakhov 2009; Dmitrieva *et al.* 2006; Pushnov *et al.* 2010; Ryabushenko 2009) regular nozzle operates as elements of corner profiles, rolled tips, nozzles in the form of vertical corrugated sheets, or in the form of regularly arranged circular orifices or helicoid elements. A common shortcoming of these designs is their regular nozzle low aerodynamic quality. In this regard, MSUEE developed efficient designs of regular orifices made in the form of regular well streamlined profiles. When developing new designs for the regular packing analysis was adopted by a well-known design ramjet separator Karbeyta (Yushin *et al.* 2005).

2. Methods

Experimental tests were performed using the regular packing CR-1K.

Figure 1 shows the general appearance of the regular packing type CR-1K in the form of droplets profile.

These elements nozzles were made of linen stiff polymer network of filaments Mylar. The structure of the grid shown in Figure 2.

When you choose the grid into account previously established in (Pushnov *et al.* 2009) the property of two-way flow of liquid film on both sides of its surface.

Schematic diagram of experimental stand is shown in Figure 3. Experienced column stand was made of detachable glass drawer side diameter of 200 mm, height 1000 mm.

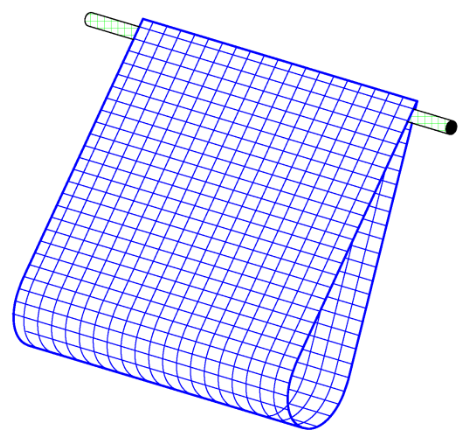

Fig 1. The overall appearance of the regular packing CR-1K

As regular packing CR-1K has a regular structure and pores of identical size and is distinguished by a large internal specific surface area as well as thermal stability, it is widely used in air treatment as an adsorbent. When regular packing are using, the charge's service life is extended and the sorption properties of the filtering medium are improved (Baltrėnas and Zagorskis 2009).

The cultures of spontaneous microorganisms will be able to develop in regular packing CR-1K. Microorganisms that have accumulated in the biofilm formed on the packing surface will degrade organic compounds accumulated in pores.

In this case the charge will be distinguished by better properties of humidity sorption, a big area of the treated surface, low density and cost-effectiveness.

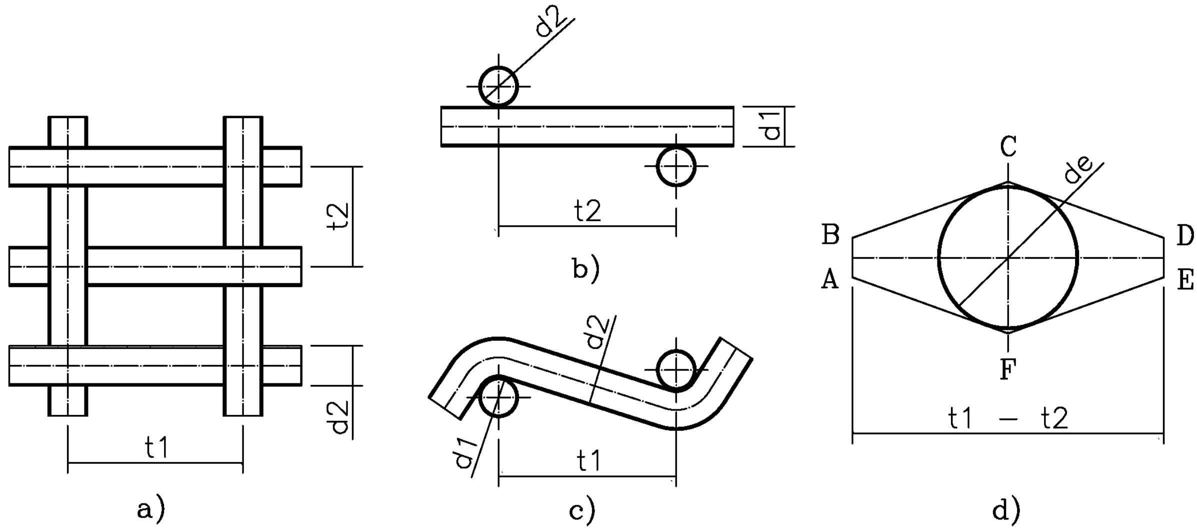

Fig 2. The structure of the mesh plain weave, and scan the surface of the grid holes. a - the structure of the grid in the world; b - a cut of the threads „base“ grid; c - cut strands of „duck“ grid; d - scan the surface of the grid holes; Figure notes: d_2 - the diameter of the thread „duck“; d_1 - filament diameter „Fundamentals“; d_e - equivalent diameter hole mesh fabrics; t_2 and t_1 - step filaments „duck“ and „foundation“ respectively

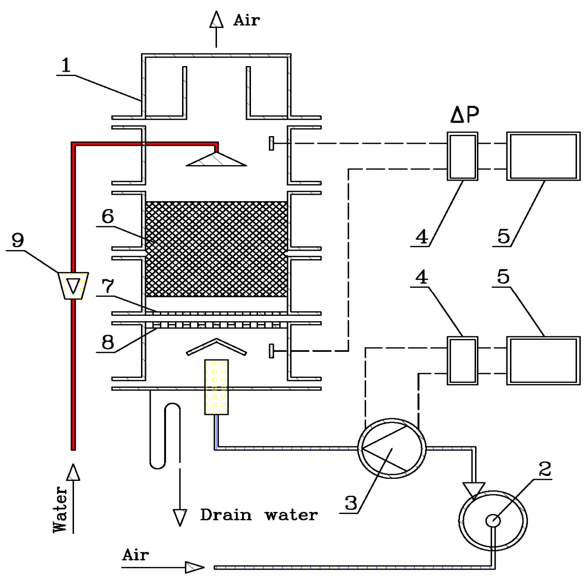

Fig 3. Schematic diagram of apparatus: 1 – column; 2 – fan; 3 – flow meter of air (diaphragm type); 4 – differential pressure gauge; 5 – dual-channel meter; 6 – nozzle; 7 – sieve plates; 8 – a failing dish; 9 – rotameter

General view of the column with the test nozzle is shown in Figure 4. The experiments were conducted in a countercurrent mode: air - water.

Fig 4. General view of the pilot plant

Air blower 2 through the flow meter air flow 3 was applied to the column 1. The pressure drop in the column were measured by differential pressure gauge 4. In the dual gauges 5 signal from pressure gauge 4 was converted and issued in digital form. Experiments were carried out with the air flow G in the range of 7.7 m^3/h to 97.30 m^3/h and flow L in the range of 10.0 m^3/ (m^2 h) to 16.0 m^3/(m^2 h).

Air velocity in calculating the total cross section of empty vehicle Wo ranged from 0.063 m/s to 0.860 m/s.

During the experiments, controlled flow of liquid and gas, as well as the pressure loss ΔP, Pa.

3. Results and discussion

Experimental data on the hydraulic resistance of dry and irrigated nozzle shown in Figures 5 and 6, respectively, in the form of plots of $\Delta P = f(W_o)$.

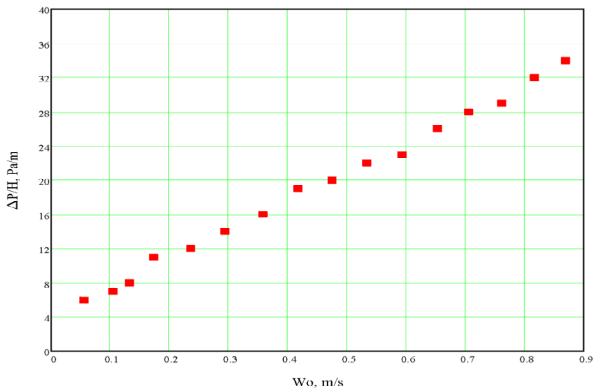

Fig 5. Dependence of hydraulic resistance ΔP/H non-irrigated regular packing type CR-1K

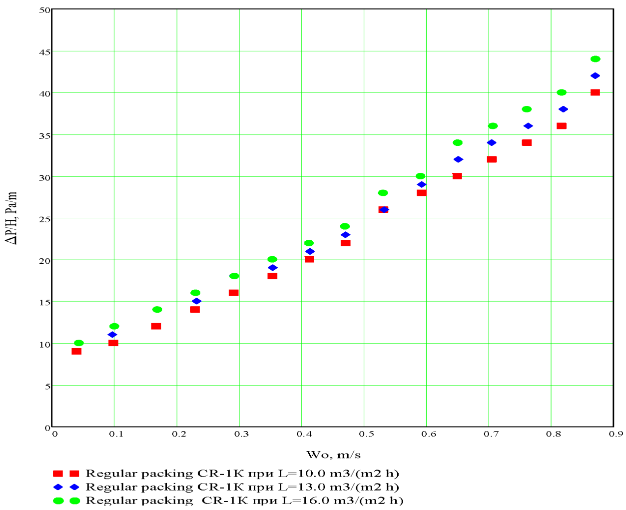

Fig 6. Dependence of hydraulic resistance ΔP/H irrigated regular packing type CR-1K

As seen from Figure 5 with the increasing load on the air Wo from 0.056 m/s to 0.870 m/s pressure drop ΔP/H dry nozzles CR-1K increase with the value of 6.0 Pa/m to 34.0 Pa/m.

Similarly, from Figure 6 shows that increasing the load L by the liquid from 10.0 m^3/(m^2 h) to 16.0 m^3/ (m^2 h), naturally leads to an increase in pressure loss ΔP/H irrigated packing CR-1K from 9.0 Pa/m to 44.0 Pa/m .

Figure 7 shows the results of comparing our data to a new regular packing CR-1K with other well-known industry of regular and irregular orifices (Pushnov *et al.* 2009). As is evident, the proposed new regular packing made in the form of a package of streamlined airfoils is at 55 % less resistance compared with Pall rings (irregular nozzle) and 40 % less resistance than a regular nozzle Mellapak 250Y.

The proposed design regular packing type CR-1K, in the form of streamlined profile of the polymer network can be used as an alternative download biofilters for air pollution control devices that work in the film flow regime. In this case, compared with the loading of pieces of bark, is a sufficiently large pore space, which contains necessary for the occurrence of aerobic biochemical reactions of the air, which is required for the reproduction of an organization associated (forward flow) or counter-air flow (backflow).

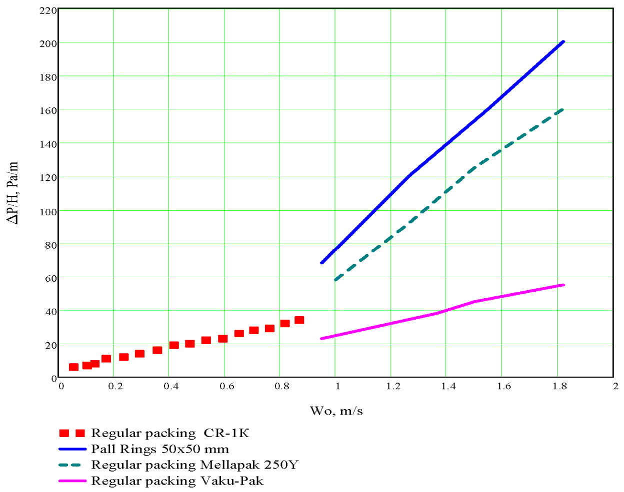

Fig 7. Comparison of pressure losses of various irregular and regular nozzle to be tested regularly nozzle type CR-1K for L = 0

The results of aerodynamic testing of regular packing, made as a streamlined profile made from a polymer mesh. Tests were conducted in the range of loads on gas G from, and the liquid L from before. The proposed design can be used as an alternative pieces of bark biofilters for air pollution control devices, load, working in the film flow.

As investigations carried out by researchers show, the aerodynamic resistance of synthetic-origin charges depends on time. The resistance of a charge composed of ceramic rings reached 1 500 Pa (Liu *et al.* 2006). Bio-filter's aerodynamic resistance of 1 700 Pa/m was achieved upon using other materials, such as a mixture of peat and bark. The lowest aerodynamic resistance, 200 Pa/m, was obtained upon using wood chips for biological treatment (Kennes and Thalasso 1998).

4. Conclusions

1. The increasing load on the air Wo from 0.056 m/s to 0.870 m/s pressure drop ΔP/H dry nozzles CR-1K increase with the value of 6.0 Pa/m to 34.0 Pa/m.
2. The proposed new regular packing made in the form of a package of streamlined airfoils is at 55 % less resistance compared with Pall rings (irregular nozzle) and 40 % less resistance than a regular nozzle Mellapak 250Y.
3. The proposed design regular packing type CR-1K, in the form of streamlined profile of the polymer network can be used as an alternative download biofilters for air pollution control devices.
4. Naturally leads to an increase in pressure loss ΔP/H irrigated packing CR-1K from 9.0 Pa/m to 44.0 Pa/m.

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