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Methods of Jet Control in Ventilation

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Abstract. Inlet jet parameters are one of the influencing factors on microclimate parameters in rooms. There are many solutions of air distributing technique. Some of them are widespread; others are special purposes solutions and applied on sporadic objects. Nevertheless, there is not enough detailed classification of jet control methods, used in the air distributing solutions. In this work, such classification is proposed, based on thousands of inventors certificates and patents. For easier classification, the methods are systematized by four main groups: with flow turbulization, without significant turbulization, with flow stabilization and combined. Possibilities of jet range change is also shown. This classification is upgradable during the development of air distribution technique.

Keywords: air distribution, jet, ventilation, air exchange.

Introduction. One of the important influencing factors of efficiency of air exchange organization is jet parameters. The modern air distribution technique can provide wide range of geometry and decay intensity of jets. However, the jet classification in textbooks is meagre to satisfy the modern ventilation development. We propose extended jet control classification.

Relevance of research. Jet control classification may help developers to position new idea in the air distribution technique and make the best resolve. It may help in ventilation education for effective learning of air distribution principles. Therefore, the jet control classification is a relevant task.

Recent studies and publications. The modern textbooks such as [1-3] give only the jet classification. Nevertheless, the same jet geometry can provide wide range of jet decay intensity using different air distributing devices. Authors analyse tens thousands of author certificates and thousands of patents. Most of them are special-purpose air distributors. Only some kinds of them are produced and available on the market. The most popular are air gratings with fixed or adjustable jalousie, multiple dilative pipes (diffusers) one-inside-other, screened air outlet, axial twister, possibly beside grating or diffusers. The twisters may consist of vanes, slots with inclined screens etc. However, the good classification of air distributing devices was not found. Very often all air-distributing devices are called diffusers. Nevertheless, this term coincides with dilative pipes that is one of the popular air distribution solutions. Therefore, we will avoid using the term "Diffuser" in meaning other than dilative pipe.

Purposes of the article. The goal of the work is to propose classification of jet control methods

in air distribution technique.

Main principles. The proposed classification of the jet control (fig. 1) is open for expansion during the technique development. Jet control methods can be divided by four main groups: with flow turbulization, without significant turbulization, with flow stabilization and combined.

Jet control with flow turbulization. To increase the jet decay intensity it is possible to intensify initial turbulence using turbulizers i.e. chords (for Karman vortex street generation) near to the outlet or plate(s) for generation of separation flow. Also dead-ends [4] can be embedded for vortex generation (fig. 2,a). The effect is not very strong if an air distributor generates small-scale turbulence only. To add large-scale turbulence movable (pliable materials, swinging plates or motor driven vanes) turbulizers can be used. Interaction of opposite flows before inlet hole cause low-frequency pulsations (waves). This principle is used in modern air diffusers VGK (Russian Federation, not the same as SU air diffusers series 4.904-68).

Twisted jets with initial swirling have not only very high initial turbulence but also different structure, so the twisting is a different jet control method (fig. 2,b,c). Concave wall jets have additional vorticity due to Goertler effect. During the laying their decay intensity decreases but after separation the decay intensifies because of initial turbulence.

Jets interaction is the way for jet decay intensification. Interaction of opposite jets in some sources is called impingement. The most common and traditional interaction diffuser is a grid. It forms many jets that interact on the interaction part. This principle is improved in air distributors (fig. 3,a) with impingement of non-coaxial jets [7].

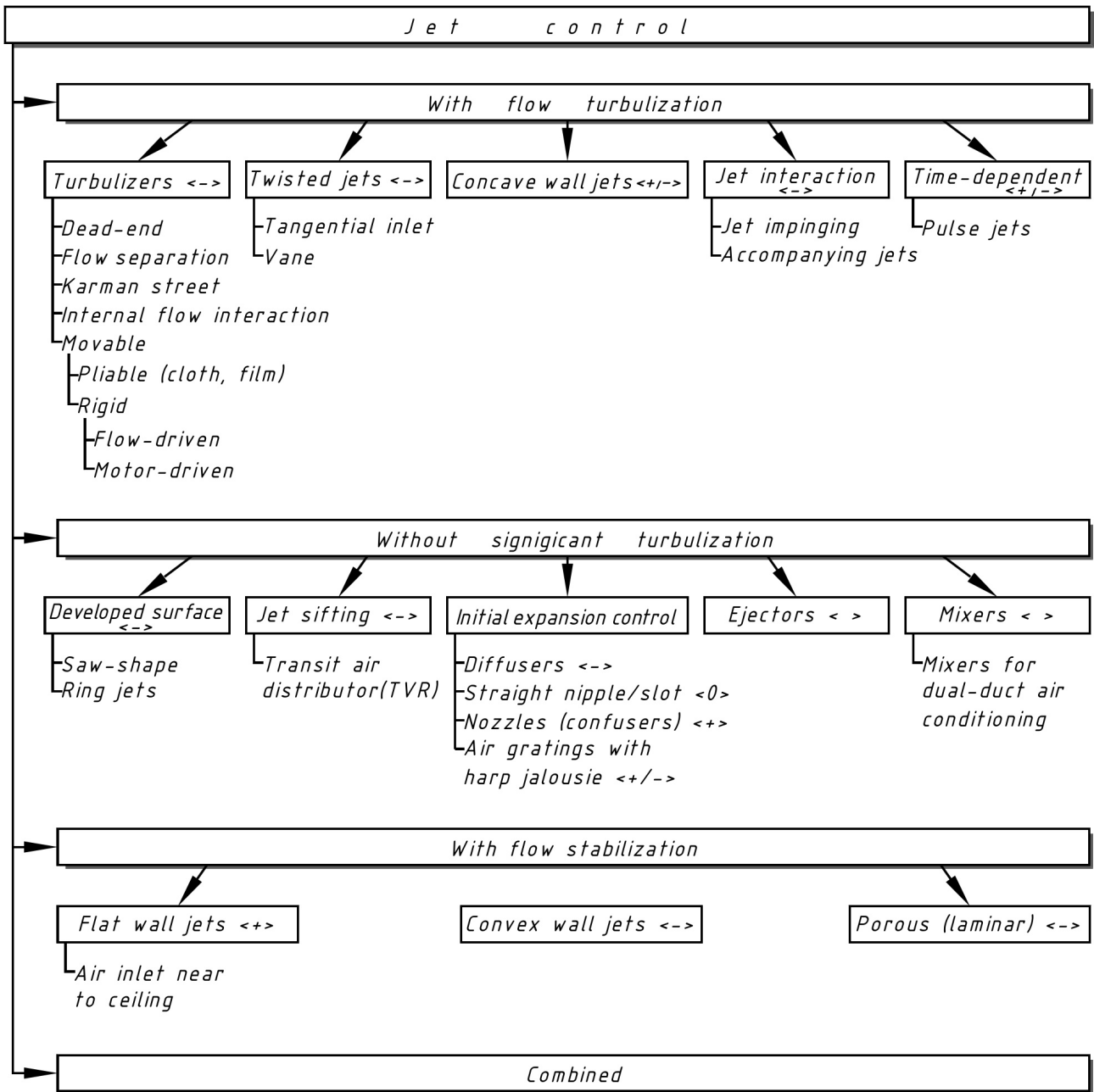


Fig. 1. Jet control classification:

<+> – increasing the jet range; <-> – intensifying the jet decay; <+/-> – can change the jet range anyway;
 <0> – the basic jet range; <> – no direct influence on the jet range)

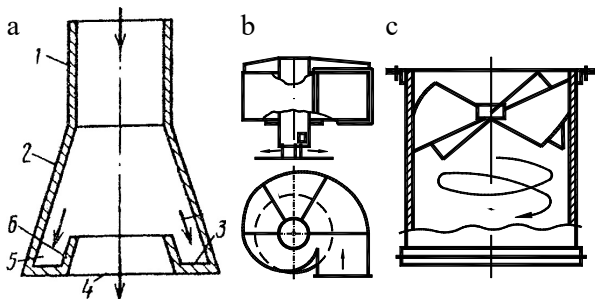


Fig. 2. Air distributors: a – with dead-end turbulizer [4];
 b – tangential inlet air distributor for twisted jet [5]; c – vane air distributor for twisted jet [6]:
 1 – body; 2 – diffuser nipple; 3 – dead-end; 4 – outlet hole;
 5 – dead-end turbulizer; 6 – flowing diffuser

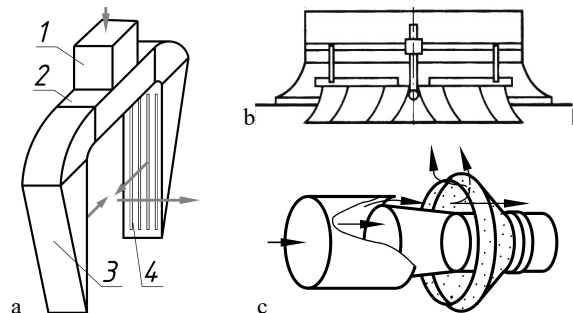


Fig. 3. Air distributors: a – non-coaxial jet impingement [7];
 b – air distributor with multiple diffusers [9]; c – transit air distributor (with sieve) TVR [10]:
 1 – air inlet; 2 – duct; 3 – uniform air distributor; 4 – outlet slot

Jet control without significant turbulization.

This type of jet control is the simplest. Jet turbulence is not a goal of the control. The turbulence change is side effect and it is not as significant as in the previous group. As flow turbulization cause normative requirement [8] of air velocity decrease, this group is very important. The simplest way is to control the initial jet expansion. Confusers (nozzles) are used to provide long-range jets, comparably with straight pipe, and diffusers - for quicker jet decay. Usually multiple diffusers are used to avoid the flow detach [9]. It is not possible to obtain very intensive jet decay. The jet core have initial expansion impulse but the jet boundary layer is formed the same way as in a free jet from a straight pipe.

A jet can be sifted through sieve, located on the jet way (fig. 3,c). This principle is used in transit air distributors (TVR) developed by Kyiv National University of Construction and Architecture.

The next possibility of jet decay control is development of jet boundary surface. It is possible by releasing the jet from a hole of complex geometry. The simplest way is using the ring conical pipe forming ring jet. A saw-shaped slot can form near to flat jet with higher decay intensity [11]. There are two effects: greater air consuming area and additional vacuum near to the surface folds or inside the ring jet.

The next two methods are used for control of initial air parameters of a jet, not for the jet type control. Including ejector cause recirculation of the room air and mixing with the inlet air. If the ejector is very close to the jet outlet, it cause turbulization. In multi-duct air conditioning, mixing valves can be embedded in air distributors for temperature control.

Jet control with flow stabilization. This group stay very important because flow stabilization cause greater air velocity in working zone. Wall jets is a paradoxical case of jets. Flat wall jet has higher range and lower turbulence level. However, convex wall jet has lowest turbulence and high decay intensity. It is very perspective for air distribution to the working zone because lower turbulence intensity allows higher velocity keeping the same heat dissipation of human body.

In clean rooms special-purpose air distributors are used, which have porous media (filter) at air outlet [12]. It cause laminar flow output. The same principle can be used for displacement ventilation with very low turbulence, which allow greater velocities

Combined jet control. Combined jet control uses two or more principles in one air distributor. Interaction [9] of twisted jets (air distributors VEPSH and VPEP), interaction [13] of twisted and concave wall jets (fig. 4,b, developed by National University "Lviv Polytechnic"), interaction of convex wall jets (fig. 4,c, air distributors PET [14] developed by Kyiv National University of Construction and Architecture) are the examples. Most of the principles above can be combined. Therefore, it is not possible to show known combined jet control options in single figure (fig. 1).

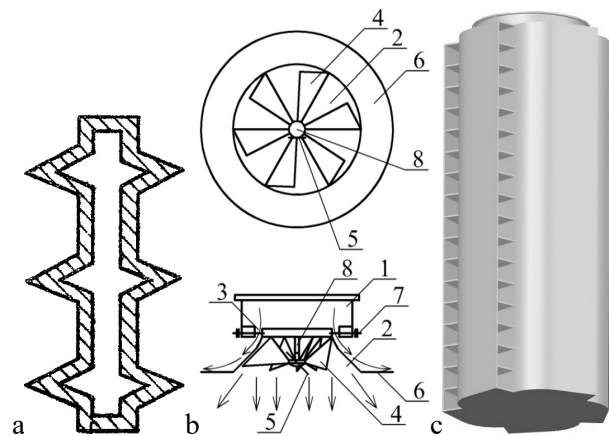


Fig. 4. Air distributors: a – saw-shape [11]; b – interaction of twisted and concave wall jets [13]; c – air distributor PET with interaction of convex wall jets [14]: 1 – nipple; 2 – diffuser; 3 – ring controlled slot; 4 – vanes; 5 – control handle; 6 – visor; 7 – screw for the slot 3 control; 8 – rod

This is not complete list of all possibilities of jet control. New principles will be developed for widening the jet properties, especially in highly demanding VAV systems.

Conclusions. Proposed classification of control of jet decay intensity broaden the known classification of jets. It can be expanded during development of air distributing technique.

Perspectives for further research. In this work, there is only one aspect of air distributors classification – jet control principle(s). Other aspects will be classified in the future works.

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Способи керування струминами у вентиляції

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Анотація. Параметри припливних струмин є одним з впливових факторів, що визначають параметри мікроклімату в приміщенні. Існує багато різних рішень у техніці повітророзподілення. Окремі з них широко впроваджені, інші є спеціалізованими рішеннями та впроваджені на окремих об'єктах. Проте, недостатньо розробленою залишається класифікація методів керування струминами, які використовуються в повітророзподільних пристроях. У даній роботі запропонована така класифікація на базі тисяч авторських свідоцтв і патентів. Для більшої зручності, способи систематизовані за чотирма головними групами: з турбулізацією потоку, без суттєвої турбулізації, зі суттєвою стабілізацією, а також, комбіновані. Також показано можливості зміни далькості струмини. Ця класифікація може бути розширена з розвитком повітророзподільної техніки.

Ключові слова: повітророзподілення, струмина, вентиляція, повітрообмін.

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Способы управления струями в вентиляции

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Аннотация. Параметры приточных струй являются одним из влияющих факторов, которые определяют параметры микроклимата в помещении. Существует много различных решений в технике воздухораспределения. Отдельные из них широко внедрены, другие являются специализированными решениями и внедрены на отдельных объектах. Однако, недостаточно разработанной остаётся классификация методов управления струями, которые используются в воздухораспределительных устройствах. В данной работе предложена такая классификация на базе тысяч авторских свидетельств и патентов. Для большего удобства, способы систематизированы по четырём главным группам: с турбулизацией потока, без существенной турбулизации, с существенной стабилизацией, а также, комбинированные. Кроме того, показаны возможности изменения дальности струи. Предложенная классификация может быть расширена с развитием воздухораспределительной техники.

Ключевые слова: воздухораспределение, струя, вентиляция, воздухообмен.

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