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AIR DISTRIBUTION BY VENTILATION AND AIR CONDITIONING SYSTEMS IN CIVIL BUILDINGS BY CEILING FAN JETS

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Annotation. This article examines the specifics of air distribution in ventilation and air conditioning systems in residential buildings using ceiling-mounted air diffusers that generate fan-shaped airflows. The authors note that proper ventilation system design is key to ensuring standardized meteorological conditions in buildings.Using the fitness center's top-floor gyms as an example, an analysis of heat and moisture exchange during warm and cold periods of the year was conducted. Based on heat and moisture balance calculations, the mass and volume flow rates of supply air were determined, and the number and type of air diffusers were selected.

It was demonstrated that the use of ceiling diffusers with fan jets allows for uniform distribution of supply air throughout the room, eliminating the sensation of a draft and providing comfortable conditions for exercisers. The authors conclude that such devices are highly effective when their diameter, air flow rate, and location within the room are properly selected.

Keywords: ventilation, air distribution, ceiling diffusers, microclimate, air conditioning.

Introduction. In order to ensure the normalized meteorological conditions in the premises of the administrative buildings according to the required allowable or optimal parameters of the indoor environment in the served area of the premises, a good organization of air exchange with correct air distribution can be sufficient [1].In this process, one of the most important aspects of ventilation and air conditioning systems is the accurate design calculation of airflow rates, the correct assignment of airflow patterns in the room volume and the correct selection of air distributors. The air flow rate per room can be determined based on the multiplicity of air exchange rates for the room for its purpose and area, or by compiling a balance of priority harm and air balance. Selection of air distribution devices and their location in the room depends on the purpose and size of the room, combination of types of harmful emissions, requirements for the air environment, placement of equipment and workplaces in the room and other conditions [2].

To date, theory and practice recommend many [3-4] types of air diffusers and some of them ceiling air diffusers (plafonds) producing fan jets (Figure 1).

When organizing ventilation systems, the structural design of the building must be taken into account. The correct solution of ventilation determines the convenience of installation and operation of ventilation systems, the availability of the system for repairs, good appearance of the room and, most importantly, high efficiency of air exchange. The issue of air supply and disposal depends on the specific conditions.

Research materials and methods. As an example, the system of air conditioning of fitness center gyms with ceiling air diffusers is considered. These are definitely three gyms located on the top floor of the fitness centre with exercise equipment and stained glass windows (Figure 2). Given that this is a room where there can be a large number of people and they are engaged in physical exercise, releasing into the environment of the room heat, moisture and the product of breath - carbon dioxide, there is an imbalance of these hazards.

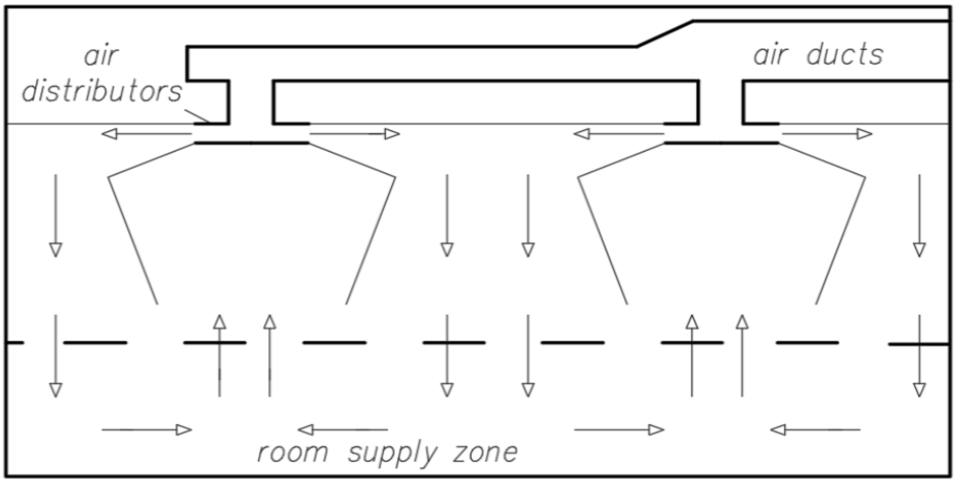

Figure 1 – Air distribution scheme with ceiling diffusers

Factors that affect the moisture and heat balance in this case. In the cold season it is - heat supply, moisture supply by people, heat supply of equipment, heat loss to the outside environment, through outdoor structures, and heat supply from heating devices of the heating system.In the warm season - heat, moisture from people, heat from electrical equipment, solar radiation entering the room through the windows and roof.In order to normalise and create a good microclimate in such rooms, the moisture and heat balance is determined (Table 1).

Table 1 – Moisture and Heat Balance, kJ/h and kg/h

Seasonofyear	Thermal power of solar radiation		Thermal power of the illuminator-equipment-blowing	Thermal flux emitted by people	Thermal power of the heating system	Thermal flow lost from the room	Excessheat	Excessmoisture
	Acrossthewindows	acrosstheroof						
1	2	3	4	5	6	7	8	9
Summer	42452,5	8658,6	23020,8	43712,3	-	-	117844,1	10,56
Winter	-	-	23020,8	42958,6	-	-	65979,4	8,94

Based on the data obtained (Table 1), the engineering method of calculation determines the mass flow rate of the inflow air G and the volume flow into the room L (Table 2).

When the air flow rate for each training hall is known, you can determine the number of air diffusers.When selecting air diffusers, it is important to consider the supply air movement.To ensure a good microclimate for people in the training halls, respectively, it is necessary to eliminate the feeling of blowing air, because with a smooth distribution of air-ha, the person does not feel the fresh air supplied, which contributes to good health.Such an opportunity is given to us by the ceiling water distributor, which has a flat plate twice the size of the supply pipe.The jet attacking it will change direction and spread in all directions along the radius, such jets are called fan jets.

The jet width increases rapidly as it moves away from the supply opening, resulting in a sharp drop in speed and an intensive change in temperature and hazard concentrations. This supply air principle is used to eliminate the feeling of blowing at high air velocities [5-9].

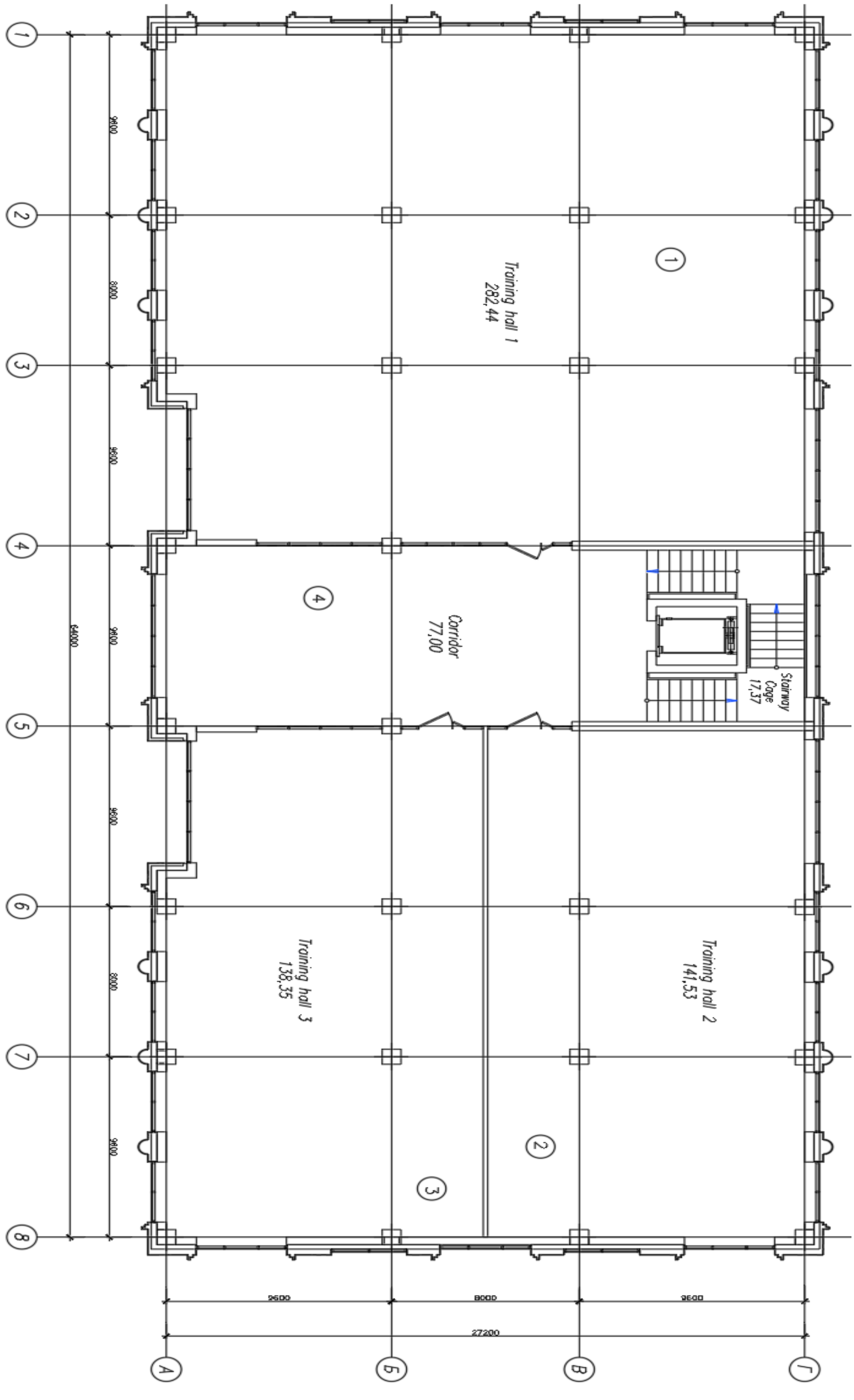

Figure 2 – Training hall plan

Therefore, in the case under discussion, the preferred method of air distribution is by ceiling mounted air diffusers.

Table 2 – Supply air expenses

Name ofroom	Area, м^2	G, kg/h	L, м^3/h
Training hall 1	282,44	8289,37	6907,81
Training hall 2	141,53	4153,78	3461,49
Training hall 3	138,35	4060,45	3383,71
Corridor	77	2259,88	1883,24

Results and discussion. When calculating the ceiling air diffuser, special instructions regarding the use of the maximum permitted air velocity and the diameter of the supply spigot must be followed [10-12]. Place air diffusers not closer than 10-20 diameters of necks between them at the intersection of diagonals of squares or rectangles in a ratio of 3:2. Following the instructions for air flow rates, the number of air diffusers is determined using the following formula:

$$P = \frac{L}{2820 * \vartheta * d^2} \quad (1)$$

When, L –room air requirement, m^3/h; ϑ – air speed, м/с, $\vartheta = 3 \div 5$m/s; d –diameter of the neck, m.

The diameters of the air diffuser necks are taken according to the data. According to air consumption, diameters were taken in each gym:hall1 – 350mm, hall 2, 3 and corridor – 250mm.

When designing ventilation and air conditioning systems for civil buildings, it is essential to ensure that the air exchange process maintains the required microclimatic conditions according to the purpose and occupancy of the room. A properly designed ventilation system provides not only thermal comfort but also effective removal of excess heat, moisture, and harmful emissions. The efficiency of such a system largely depends on the correct determination of airflow rates and the rational selection of air distribution devices.

The structural characteristics of the building must also be considered, since the placement of air ducts, diffusers, and exhaust outlets affects both the installation process and the overall performance of the ventilation system. The correct arrangement of air supply and exhaust points ensures ease of maintenance, good aesthetic appearance of the space, and most importantly, uniform air distribution throughout the occupied zone.

As an applied example, this study examines the air conditioning system of three training halls located on the top floor of a fitness center. Each hall is equipped with exercise machines and large stained-glass windows, which contribute to significant internal and external heat gains. During operation, the high occupancy level and physical activity of people lead to the emission of heat, moisture, and carbon dioxide, which creates an imbalance of thermal and moisture loads in the indoor environment.

To maintain comfort, it is necessary to calculate the overall heat and moisture balance for both warm and cold seasons. Table 1 presents the results of these calculations, expressed in kJ/h and kg/h. It can be seen that the total excess heat in summer reaches 117,844.1 kJ/h, while in winter it decreases to 65,979.4 kJ/h. Correspondingly, the moisture excess is 10.56 kg/h in summer and 8.94 kg/h in winter [13-16].

Once the required air supply for each room was determined, the number and type of air diffusers were selected. Ceiling-mounted diffusers with fan-shaped jets were chosen due to their ability to distribute air evenly across the ceiling surface. This method prevents the sensation of drafts and ensures uniform temperature distribution within the occupied zone.

The number of diffusers (P) can be estimated according to the formula:

$$P = L / (v \times \pi \times (d^2 / 4)) \quad (2)$$

Where, L is the room air requirement (m^3/h), v is the average air velocity at the diffuser outlet (m/s), and d is the diffuser neck diameter (m).

According to the design recommendations and air consumption data, diffuser diameters were selected as 350 mm for Hall 1, and 250 mm for Halls 2, 3, and the corridor. To ensure proper air mixing, diffusers should be installed at intervals of 10–20 neck diameters, preferably along the diagonals of square or rectangular zones in a 3:2 ratio.

The study results confirm that ceiling-mounted fan jet diffusers are particularly effective in large-volume spaces with high physical activity. When high-speed air collides with the diffuser plate, the jet spreads radially, rapidly reducing its velocity and temperature. This creates a smooth, gentle airflow that promotes thermal comfort and improves air quality without causing discomfort to occupants.

Thus, the use of ceiling fan jet diffusers in ventilation systems ensures high air exchange efficiency, uniform temperature distribution, and a favorable indoor microclimate. Compliance with design standards and proper diffuser placement significantly enhance the overall performance and energy efficiency of ventilation and air conditioning systems in public buildings.

The results of the heat and moisture balance calculations for summer and winter show significant variations in thermal loads, mainly caused by solar radiation, occupancy levels, and operation of lighting and equipment. Based on these data, the required supply air volumes were determined for each training hall, which then served as the basis for selecting appropriate ceiling air diffusers.

Ceiling diffusers with fan-shaped jets were chosen because they allow the supply air to spread evenly along the ceiling surface before descending slowly into the occupied zone. This distribution method provides smooth air movement without creating drafts or discomfort, even when the air enters the room at a relatively high velocity. Such systems are especially effective in large rooms with active occupants, as they ensure uniform temperature distribution and consistent air quality throughout the space.

In order to achieve optimal air mixing and avoid dead zones, air diffusers were positioned at calculated intervals along the diagonals of rectangular areas. This approach helps maintain balanced airflow and prevents overlapping of individual air jets. Proper diffuser arrangement also minimizes noise and ensures that the entire room receives adequate ventilation, regardless of the number of people or changes in activity level.

The research demonstrated that ceiling-mounted fan jet diffusers are highly effective for use in spaces with high ceilings and large occupancy. Their design enables smooth air dispersion, reduces temperature stratification, and enhances the sense of freshness within the room. Moreover, this method contributes to energy savings, as the even distribution of air helps maintain comfort conditions without requiring excessive cooling or heating power.

Therefore, the application of ceiling fan jet air distribution can be considered one of the most efficient and practical approaches for ensuring a comfortable indoor climate in public and sports facilities. It combines technical simplicity with excellent functional results, providing both comfort and stability in demanding environments.

Conclusion. In volumetric rooms with physically active people, ceiling air diffusers are effective, which spread clean supply air by means of a fan stream. The air that is supplied at high speed when colliding with the shield gradually reduces the speed and temperature, forming a smooth movement of air, which has a favorable effect on human well-being and, of course, better blowing effect. When choosing ceiling-mounted air diffusers, clear instructions for their use should be followed, otherwise the air exchange in the room will be unsatisfactory.

References:

[1] ҚР ЕЖ 4.02-101-2012*. Ауаны жылыту, желдету және кондиционерлеу / СП РК 4.02-101-2012* Отопление, вентиляция и кондиционирование воздуха. – Астана, 2018. – 90 б. (93 с.).

[2] **Гримитлин, М.И.** Распределение воздуха в помещении. – Санкт-Петербург: АВОК, Северо-Запад, 2004.

[3] Системы вентиляции и кондиционирования. Теория и практика / Ананьев В.А., Балуева Л.Н., Гальперин А.Д., Городов А.К., Ерёмин М.Ю., Звягинцева С.М., Мурашко В.П., Седых И.В. – М.: Евроклимат, 2003. – 415 с.

[4] ASHRAE Handbook – Fundamentals // Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021. – 1040 p.

[5] **Орешкин, В.И.** Микроклимат и вентиляция производственных помещений. – М.: Изд-во МГСУ, 2016. – 295 с.

[6] **Котляр, А.Н.** Системы кондиционирования воздуха зданий различного назначения. – М.: Академия, 2017. – 352 с.

[7] **Кочетков, А.В.,** Смирнов А.С. Воздушное распределение в помещениях с использованием потолочных диффузоров // Вестник строительных наук, 2019. – №4. – С. 45-52.

[8] ГОСТ 30494–2011. Здания жилые и общественные. Параметры микроклимата в помещениях. – М.: Стандартинформ, 2012.

[9] **Fanger, P.O.** Thermal Comfort: Analysis and Applications in Environmental Engineering. – New York: McGraw-Hill, 1970. – 244 p.

[10] **Соколов, Е.Я.** Вентиляция и кондиционирование воздуха. – М.: Стройиздат, 2015. – 432 с.

[11] **Акимов, В.И.** Проектирование систем вентиляции и отопления общественных зданий. – СПб.: БХВ-Петербург, 2018. – 286 с.

[12] **Куликов, Н.П.** Аэродинамика и организация воздухообмена в помещениях. – М.: АСВ, 2014. – 368 с.

[13] СНиП 41-01-2003. Отопление, вентиляция и кондиционирование. – М.: Госстрой России, 2003.

[14] **Лапин, А.В.** Анализ эффективности систем вентиляции спортивных сооружений. // Инженерные системы, 2020. – №2. – С. 15-21.

[15] EN 13779:2007. Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems. – Brussels: CEN, 2007.

[16] **Иванов, П.Г.,** Сапожников Д.В. Расчет воздухообмена при проектировании фитнес-центров. // Вестник МГСУ, 2021. – №3. – С. 101-108.

References:

[1] QR EZh 4.02-101-2012*. Auany zhylytu, zheldetu zhane kondicionerleu / SP RK 4.02-101-2012* Otoplenie, ventiljacija i kondicionirovanie vozduha. – Astana, 2018. – 90 b. (93 s.). [in Kazakh]

[2] **Grimitlin, M.I.** Raspredelenie vozduha v pomeshhenii. – Sankt-Peterburg: AVOK, Severo-Zapad, 2004. [in Russian]

[3] Sistemy ventiljacii i kondicionirovanija. Teorija i praktika / Anan'ev V.A., Balueva L.N., Gal'perin A.D., Gorodov A.K., Erjomin M.Ju., Zvjaginceva S.M., Murashko V.P., Sedyh I.V. –M.: Evroklimat, 2003. – 415 s. [in Russian]

[4] ASHRAE Handbook – Fundamentals // Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2021. – 1040 p.

[5] **Oreshkin, V.I.** Mikroklimat i ventiljacija proizvodstvennyh pomeshhenij. – M.: Izd-vo MGSU, 2016. – 295 s. [in Russian]

[6] **Kotljar, A.N.** Sistemy kondicionirovanija vozduha zdanij razlichnogo naznachenija. – M.: Akademija, 2017. – 352 s. [in Russian]

[7] **Kochetkov, A.V.,** Smirnov A.S. Vozdushnoe raspredelenie v pomeshhenijah s ispol'zovaniem potolochnyh diffuzorov // Vestnik stroitel'nyh nauk, 2019. – №4. – S. 45-52. [in Russian]

[8] GOST 30494–2011. Zdanija zhilye i obshhestvennye. Parametry mikroklimata v pomeshhenijah. – M.: Standartinform, 2012. [in Russian]

[9] **Fanger, P.O.** Thermal Comfort: Analysis and Applications in Environmental Engineering. – New York: McGraw-Hill, 1970. – 244 p.

[10] **Sokolov, E.Ja.** Ventiljacija i kondicionirovanie vozduha. – M.: Strojizdat, 2015. – 432 s. [in Russian]

[11] **Akimov, V.I.** Proektirovanie sistem ventiljacii i otoplenija obshhestvennyh zdanij. – SPb.: BHV-Peterburg, 2018. – 286 s. [in Russian]

[12] **Kulikov, N.P.** Ajerodinamika i organizacija vozduhoobmena v pomeshhenijah. – M.: ASV, 2014. – 368 s. [in Russian]

[13] SNiP 41-01-2003. Otoplenie, ventiljacija i kondicionirovanie. – M.: Gosstroj Rossii, 2003. [in Russian]

[14] **Lapin, A.V.** Analiz jeffektivnosti sistem ventiljacii sportivnyh sooruzhenij. // Inzhenernye sistemy, 2020. – №2. – S. 15-21. [in Russian]

[15] EN 13779:2007. Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems. – Brussels: CEN, 2007.

[16] **Ivanov, P.G.,** Sapozhnikov D.V. Raschet vozduhoobmena pri proektirovanii fitnes-centrov. // Vestnik MGSU, 2021. – №3. – S. 101-108. [in Russian]

РАСПРЕДЕЛЕНИЕ ВОЗДУХА В СИСТЕМАХ ВЕНТИЛЯЦИИ И КОНДИЦИОНИРОВАНИЯ В ГРАЖДАНСКИХ ЗДАНИЯХ С ПОМОЩЬЮ ПОТОЛОЧНЫХ ВЕНТИЛЯТОРОВ

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Аннотация. В данной статье рассматриваются особенности распределения воздуха в системах вентиляции и кондиционирования в жилых зданиях с использованием установленных на потолке диффузоров, которые создают веерообразные воздушные потоки. Авторы отмечают, что правильное проектирование системы вентиляции является ключом к обеспечению стандартных метеорологических условий в зданиях. На примере тренажерных залов на верхнем этаже фитнес-центра был проведен анализ тепло- и влагообмена в теплые и холодные периоды года. На основе расчетов теплового и влажностного баланса были определены массовый и объемный расход подаваемого воздуха, а также выбраны количество и тип воздухораспределителей.

Было продемонстрировано, что использование потолочных диффузоров с вентиляторными форсунками позволяет равномерно распределять приточный воздух по всему помещению, устраняя ощущение сквозняка и обеспечивая комфортные условия для занимающихся спортом. Авторы приходят к выводу, что такие устройства обладают высокой эффективностью при правильном выборе их диаметра, скорости воздушного потока и расположения в помещении.

Ключевые слова: Вентиляция, воздушное распределение, потолочные диффузоры, микроклимат, кондиционирование воздуха.

ТӨБЕЛІК ЖЕЛДЕТКІШТЕРДІҢ КӨМЕГІМЕН АЗАМАТТЫҚ ҒИМАРАТТАРДАҒЫ ЖЕЛДЕТУ ЖӘНЕ АУАНЫ БАПТАУ ЖҮЙЕЛЕРІНДЕГІ АУАНЫҢ ТАРАЛУЫ

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Аңдатпа. Бұл мақалада желдеткіш тәрізді ауа ағындарын жасайтын төбеге орнатылған диффузорларды қолдана отырып, тұрғын үйлердегі желдету және ауаны баптау жүйелеріндегі ауаның таралу ерекшеліктері қарастырылады. Авторлар желдету жүйесін дұрыс жобалау ғимараттардағы стандартты метеорологиялық жағдайларды қамтамасыз етудің кілті екенін атап өтті. Фитнес-орталықтың жоғарғы қабатындағы жаттығу залдарының мысалында жылдың жылы және суық кезеңдерінде жылу және ылғал алмасуына талдау жасалды. Жылу және ылғалдылық балансының есептеулеріне сүйене отырып, берілген ауаның массалық және көлемдік шығыны анықталды, сонымен қатар ауа таратқыштардың саны мен түрі таңдалды.

Желдеткіш саптамалары бар төбелік диффузорларды пайдалану кіретін ауаны бүкіл бөлмеге біркелкі таратуға мүмкіндік береді, бұл жоба сезімін жояды және спортпен шұғылданушылар үшін қолайлы жағдай жасайды. Авторлар мұндай құрылғылар олардың диаметрін, ауа ағынының жылдамдығын және бөлмедегі орналасуын дұрыс таңдағанда жоғары тиімділікке ие деген қорытындыға келеді.

Тірек сөздер: Желдету, ауа тарату, төбе диффузорлары, микроклимат, ауаны кондициялау.