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# DEVELOPMENT OF NOZZLE-FREE CAPILLARY POROUS DUST-AND-GAS COLLECTORS WITH FOAM GENERATING AND DEFOAMING STRUCTURES

**Abstract.** The nozzle-free foam generators of air mechanical foam were designed along with its case, inlet and outlet nozzles, a set of grids and sprayer. They help to conduct foam generation processes with high effectiveness under low hydro-and-gas dynamic resistance. For further enhancement of the combined processes of gas mechanical foam and collecting micro-and-ultramicroscopic dust, a dust collector along with its case, inlet and outlet nozzles, a set of grids and sprayer was proposed, which is equipped with defoaming grid porous structure, whereas foam generating and defoaming structures are installed into in case consequently as per the dusty gas movement and sludge collector. Besides, each subsequent grid of foam generating porous structure is made with the increased size of cells following the cleanable gas; e.g. made of metal cells for clearance 0,08*0,14*1, and defoaming made of grids with decreasing size of cells following the cleanable gas, e.g made of metal cells for clearance 0,4*0,14*0,08.

**Keywords:** dust-and-gas collector, capillary porous structures, porous foam generator, foam generation, heat-mass exchange, vapor bubble.

Research of heat-mass exchange processes by boiling of pure liquids in capillary porous structures revealed a behavior of the internal (thermal hydraulic) characteristics, generation of vapor phase, the density of generation centers, discharge of drops from the structure, bubble departure diameter and frequency of bubble departure, the speed of bubble growth [1-5]. The different porous systems were developed applicable to heat and power units [6] and the relevant calculations were performed to verify trial data with accuracy ±20% in a form of criterion equation for bubbling, injection, suction, pseudo fluidization, foam generating [7] and focused on highly effective nozzle-free capillary porous dust-and-gas collectors with foam generating and defoaming structures [8-13].

Let’s review a new class of nozzle-free dust-and-gas collectors. Invention called “Dust Collector” [article No.1456608, MKI E21F 5/04, 1989] refer to the different industries of national economy for highly effective gas (air) cleanup from micro-and ultramicroscopic dust (size of fractions less than $5*10^{-6}$ m and $0,25*10^{-6}$ m accordingly), for example, in fuel combustion, processing and transportation of dusty materials, removal of vent emissions.

There is a known device for collecting gases and aerosols [article No.309717, kl.V. OId 47/04, 1971], which contains inlet and gas removal nozzles, case, fiber attachment located in case, gasket and baffle, mist separator.

The disadvantage of this device is its low effectiveness for collecting micro-and ultramicroscopic dust, defined by the size of nozzle pores, that leads to a high material consumption, high hydraulic resistance as per the liquid movements and gas dynamic resistance whilst flushing gas (air).

A short duration of operations between generations due to pore plugging of fiber attachment causes a significant problem. Foam is generated outside of porous body and attacks its surface. That reduces the effectiveness of dust collection and enhancement of the mass transfer process, which increases material consumption, dimensions and weight of the device.

Gas flow penetrating a fiber attachment overcomes a high gas dynamic resistance. It is due to the excess energy and its boosting. Duration of operations between generations of such device will be low because pores in fibers tend to be blocked by dust particles. This leads to the complicated operations of the device, and minimizes its reliability.

In the suggested capillary porous structures of nozzle-free dust-and-gas collector [8-13] a high effectiveness for collecting micro-and ultramicroscopic dust could be explained by diffusion mechanism of dust settling in the foam flow and at the structure surface, when dust particles are under continuous influence of gas molecules, which are in the Brownian movement, whereas mobility of particles will be increased with the help of thermophoresis due to difference of temperature between skeleton of porous structure, foam flow and dust particles on the one hand, and due to diffusiophoresis caused by the gradient of concentrated components of foam flow, enforced with vapor process of foam forming solution within a porous structure and partial steam condensate of foam flow on the other hand.

High resistance and stability of liquid film in cells of grid structures is ensured with an equal injection of the sprayer liquid and allows to reduce a consumption of foam forming solution 1.5 to 2 times retaining the foam stability, dispersion and multiplicity of foam formed in foam generating structure [8-13.]

As shown in trials [8,13] hydraulic resistance of the grid porous structures in comparison with the fiber attachment is reduced a few times, as well as a gas dynamic resistance. Since the suggested porous structures have large cell sizes in comparison with pores of the fiber attachment that tend to increase a duration of grid regeneration, and thus it simplifies operations and enhances the reliability of dust collector and its service life.

It is impossible to organize a stable process in multiphase layer with the help of fiber and filter materials similar to them (metal ceramic, sintered powders) as foam bubbles block nozzle pores and stop access of fresh portions of foam generating liquid to bubble generating pores at loads 2 to 2.5 times less than for the grid structures.

Dust collector operates in the following way as below.

Flow contaminated by dust is injected through the nozzle of dusty gas 1 into dust collector case 2 (fig.1). Gas cleanup from microscopic dust is performed in foam generating porous structure 3 of type 0.08*0.14*1. Gas mechanical foam 10 is blown by gas flow from the structure cells, supplied by foam forming solution 9, for example, 110-12, supplied by sprayer 4.

Porous structure in comparison with isotropic structure helps significantly enhance mass exchange processes flown in their volume and on the surface because of simplified growth of bubbles 8 from top of the cone to its base, that increases coagulative feature of foam. Therefore, enhancement of processes leads to higher effectiveness of catching microscopic dust due to raising rate of catching dust by foam in volume of structure and on its surface.

Gas mechanical foam 10 will be destroyed from the surface and in the volume of defoaming porous structure 5 of type 0.4*0.14*0.08. Foam bubbles 11 start intensively burst in structure due to the growth of resistance from the cone base to its top. Microscopic dust contained in destructive gas mechanical foam under influence of gravity and pressure leaking from sprayer along the porous surface moves towards sludge collector 7.

Gas will be additionally cleaned up from microscopic dust in a defoaming structure where the destructive process of gas mechanical foam is significantly enhanced because grids are collected with minimized cell sizes.

This result in increasing effectiveness of collecting microscopic dust on its surface and in volume due to raising rate of catching dust and increases coagulative feature of the destructive foam flow.

Gas cleaned up from the microscopic dust is removed from the device through the outlet nozzle of clean gas 6.

Test demonstrated [8,11] that in comparison with the filtering materials such as metal ceramic and sintered powders, consumption of form forming solution is reduced 1.5 to 2 times retaining the foam stability, dispersion and multiplicity of foam, hydraulic resistance for transportation of foam forming liquid is reduced 10 to 20 times, gas dynamic resistance 1.8 times that minimizes pump and fan (smoke exhauster) capacity, material consumption and dimensions 2 to 2.5 times, weight of device 3 to 4 times.

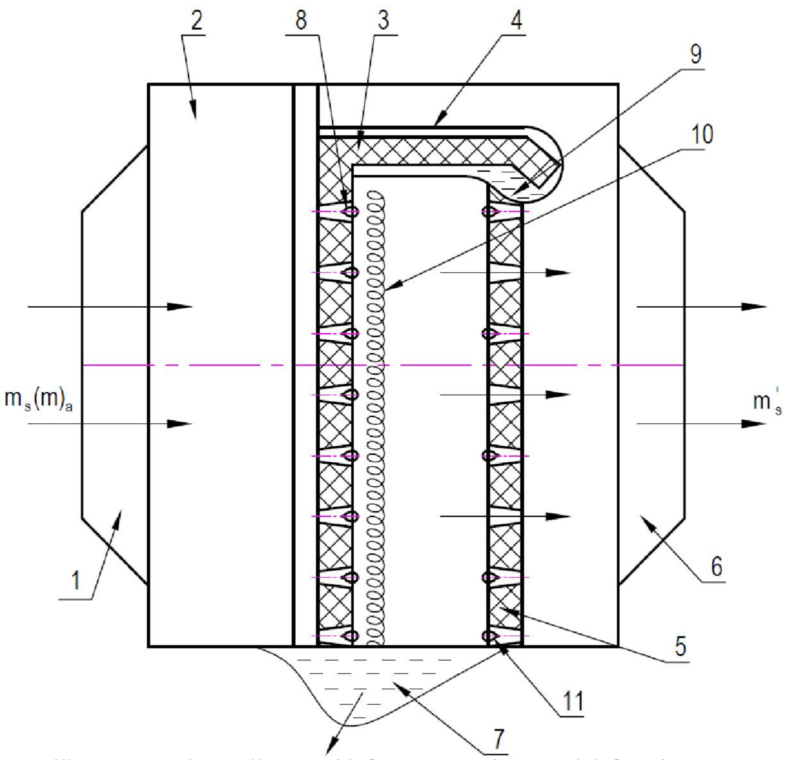


Figure 1 - Nozzle-free capillary porous dust collector with foam generating 3 and defoaming 5 structures: 1 – inlet nozzle; 2 – dust collector case; 3 – foam generating porous structure; 4 – sprayer; 5 – defoaming porous structure; 6 – outlet nozzle; 7 – sludge collector; 8 – bubble; 9 – defoaming porous structure; 10 – gas mechanical foam; 11 – foam bubbles; mf, ma, $m^I_s$, – consumption of foam, air (steam)

Time between regeneration is significantly increases, as well as effectiveness of catching microscopic dust, which could reach values up to 99.6-99.8%, thus it simplifies operations and enhances the reliability of dust collector and its service life, which is proved by relevant acts of Trust Alma-AtaInzhstroi and Almaty Heat & Power Plant-2.

Cost from implementing the suggested dust collector will be saved because of reduced consumption of foam forming solution 1.5 to 2 times, minimized hydraulic resistance for transportation of foam forming liquid up to 10 to 20 times, gas dynamic resistance for pumping of dusty flow up to 1.8 times, material consumption and dimensions up to 2 to 2.5 times, weight of device 3 to 4 times. Also, the device operations are getting simplified, the duration between regenerations increases, and thus it enhances reliability and service life of the device, which saves capital and operational costs.

## REFERENCES

[1] V.M. Polyaev, A.N. Genbach, A.A. Genbach. Methods of Monitoring Energy Processes // Experimental thermal and fluid seience, International of Thermodynamics, Experimental Heat Transfer, and Fluid Mechanics. Avenue of the Americas. New York, volum 10, april, **1995**. p.273-286.

[2] Poljaev V.M., Genbach A.A. Plotnost' centrov paroobrazovanija i vybros kapel' iz poristoj struktury // Izvestija vuzov. Mashinostroenie. **1990**.№9. S.50-55.

[3] Poljaev V.M., Genbach A.A. Otryvnoj diametr i chastota otryva parovyh puzurej v poristyh strukturah // Vestnik MGTU, serija Mashinostroenie. **1990**.№1. S.69-72.

[4] Poljaev V.M., Genbach A.A., Minashkin D.V. Vizualizacija processov v poristom jellipticheskom teploobmennike // Izvestija vuzov. Mashinostroenie. **1991**. 10-12. S.75-80.

[5] Poljaev V.M., Genbach A.A. Skorost' rosta parovyh puzyrej v poristyh strukturah // Izvestija vuzov. Mashinostroenie.- **1190**.№10. S.56-61.

[6] Poljaev V.M., Genbach A.A. Oblasti primenenija poristoj sistemy // Izvestija vuzov. Jenergetika. **1991**. №12. S. 97-101.

[7] Polyaev, V.M., Genbach A.A., Heat Transfer in a Porous System in the Presence of Both Capillary and Gravity Forces, Thermal Engineering, 40 (**1993**), 7, pp. 551-554.

[8] Genbach A.A., Shokolakov K. Poristyj pennyj pyleulovitel'. MON RK, Mezhdunarodnyj nauchnyj zhurnal - prilozhenie Respubliki Kazahstan. Poisk №2 /**2011** S. 266-271.

[9] Genbach A.A., Kul'bakina N.V. Pylepodavlenie i pyleulavlivanie s pronicaemoj peregorodkoj // Jenergetika i toplivnye resursy Kazahstana. №5. **2011**. S. 85-87.

[10] Genbach A.A., Genbach N.A. Puti poluchenija trebuemoj informacii pri razrabotke kapilljarno-poristyh sistem jenergoustanovok // Vestnik AUJeS. Almaty. №2 (21). **2013**. S.12-18.

[11] Genbach A.A., Genbach N.A. Issledovanie penogeneratora s obogrevaemoj poverhnost'ju // Vestnik AIJeS.-Almaty.-**2009**. №4. S.24-27.

[12] Genbach A.A., Piontskovskij M.S. Poristyj pylegazoulovitel' s upravljaemoj geometriej mikrokanalov // Jenergetika i toplivnye resursy Kazahstana. **2010**. №4. S. 59-61.

[13] Poljaev V.M., Genbach A.A., Minashkin D.V. Processy v poristom jellipticheskom teploobmennike // Izvestija vuzov. Mashinostroenie. **1991**. №4-6. S.73-77.

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## КӨБІК ӨНДІРЕТІН ЖӘНЕ КӨБІК СӨНДІРЕТІН ҚҰРЫЛЫМДАРМЕН БҮРКІГІШСІЗ КАПИЛЛЯРЛЫ-КЕУЕКТІ ТОЗАҢ-ГАЗ ТҰТҚЫШТАРДЫ ӘЗІРЛЕУ

**Аннотация.** Корпус, кіру және шығу келте құбырлары, торшалар топтамасы, тозаңдатқыштан тұратын ауа-механикалық көбікке арналған бүркігішсіз көбік генераторлары әзірленді. Олар аз гидро және газдинамикалық қарсылықтарда жоғары тиімділікпен көбік өндіру процестерін жүргізуге мүмкіндік береді. Газ-механикалық көбікті өндіру мен микро және ультрамикроскопиялық тозаңды тұту бірлескен процестерін әрі қарай сәйкестендіру үшін көбік сөндіретін торкөзді кеуекті құрылыммен және қақ жинағышпен жабдықталған корпус, кіру және шығу келте құбырлары, торшалар топтамасы, тозаңдатқыштан тұратын тозаң тұтқыш ұсынылды, бұл ретте көбік өндіретін және көбік сөндіретін құрылымдар корпусқа тозаңдатылған газ қозғалысының бағытын бойлай орнатылды. Бұдан өзге, көбік өндіретін торкөзді кеуекті құрылымның кейінгі торшасы тазартылатын газдың қозғалыс бағыты бойымен ұяшықтардың ұлғаятын өлшемімен, мысалы, саңылауға ұяшықтарының өлшемі: 0,08*0,14*1 болатын метал торлардан, ал көбік сөндіретін торша - тазартылатын газдың қозғалыс бағыты бойымен ұяшықтардың кішірейетін өлшемімен, мысалы, саңылауға ұяшықтарының өлшемі: 0,4*0,14*0,08 болатын метал торлардан орындалды.

**Түйін сөздер:** тозаң-газ тұтқыш, капиллярлы-кеуекті құрылымдар, кеуекті көбік генераторы, көбік өндіру, жылу-масса алмасу, бу көпіршігі.

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## РАЗРАБОТКА БЕЗФОРСУНОЧНЫХ КАПИЛЛЯРНО-ПОРИСТЫХ ПЫЛЕГАЗОУЛОВИТЕЛЕЙ С ПЕНОГЕНЕРИРУЮЩИМИ И ПЕНОГАСЯЩИМИ СТРУКТУРАМИ

**Аннотация.** Разработаны безфорсуночные пеногенераторы воздушно-механической пены, содержащий корпус, входной и выходной патрубки, пакет сеток, распылитель. Они позволяют проводить процессы генерации пены с высокой эффективностью при малых гидро- и газодинамических сопротивлениях. Для дальнейшей интенсификации совместных процессов генерации газомеханической пены и улавливания микро- и ультрамикроскопической пыли предложен пылеуловитель, содержащий корпус, входной и выходной патрубки, пакет сеток, распылитель, который снабжен пеногасящей сетчатой пористой структурой, причем пеногенерирующая и пеногасящая структуры установлены в корпусе последовательно по ходу движения запыленного газа, и шламосборником. Кроме того, каждая последующая сетка пеногенерирующей сетчатой пористой структуры выполнена с увеличивающимся размером ячеек по ходу движения очищаемого газа, например, из металлических с размером ячеек на просвет: 0,08*0,14*1, а пеногасящая – из сеток с уменьшающимся размером ячеек по ходу движения очищаемого газа, например, из металлических с размером ячеек на просвет: 0,4*0,14*0,08.

**Ключевые слова:** пылегазоуловитель, капиллярно-пористые структуры, пористый пеногенератор, пеногенерация, тепломассообмен, паровой пузырь.