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DEVELOPMENT OF AN EXPERIMENTAL PLANT OF A NON-NOZZLE POROUS FOAM GENERATOR FOR PRODUCING OF AIR (STEAM) AND MECHANICAL FOAM

Abstract. On the basis of studies of heat-mass exchange processes by boiling of pure liquids and with the addition of surface-active agents, a new class of non-nozzle porous foam generator for producing of air (steam) and mechanical foam was developed. The results of the experiment are generalized by the criteria equations of heat-mass exchange with an accuracy of ±20% with respect to the processes of bubbling, foam generation, pseudo-fluidization and boiling. The combined action of capillary and mass forces for capillary-porous structures of the 3x0,4 type made it possible to boost the operating mode of the foam generator by 1,5-2 times and reduce the consumption of the foam generating agent and reduce the hydraulic resistance tenfold.

Key words: porous foam generator, foam generation, heat-mass exchange, capillary-porous structures.

Studyoftheheatandmassexchangeof boilingpureliquidsincapillary porous structures, development of control methods for these processes [1]allowed to summarize trials with pure foam and dust-foam flows and study a single equation for calculation of the heat and mass exchange with an accuracy up to ±20 % [2], whereby boiling processes, bubbling, pseudofluizidation and foam generation were summarized as well.

Anewclassofnozzle-freefoamgeneratorsandfoam-dust catchers along with bubbling capillary porous grids were invented [3], as well as foam generating and defoaming structures located vertically. Duetothe controllinginternal characteristics of two-phase flows [4]different types of foam-dust catchers were designed[5-13]. Itispossibletoincreaseeffectivenessofdust-gascatchingbecauseofcontrollinggeometry of micro channels of porous material [6], separation of flow into wave energy and gas (steam) energy [7,11], forming generator with the help of power (without incoming flotation) [8], design of turbulizers as foam generating and defoaming structures using a joint action of gravitation and capillary forces, pressure and vibration forces.

InaccordancewiththearticleNo.358012, 1972 a method of electrostatic gas cleanup was described where electrization of settling elements was produced using a tribo effect. This effect was used earlier, though during electrization of filter elements they had a conductive layer on their surface, which reduced the electrostatic filtration component. Thereviewedmethoddescribesthataneffectiveness of electrostatic filters will be increased because it is recommended to implement electrization with the help of circulation of weight fine grained electrified agent in hollow settling elements.

MethodofelectrostaticgascleanupasperthearticleNo.358012, 1972intermsofdust settling effectiveness exceeds the known methods. However, incomparisonwiththeknownmethods it has a low dust settling productivity.

Therefore, it is possible to increase effectiveness of dust electrization in air flow by using a tribo effect. Though it requires to solve a problem of dust cleanup productivity.

Inadditiontomethodsofgascleanupfromdustthereisamethod/articleNo. 247241, 1969/, where it issuggestedtocatchthinaerosolsprayswiththehelpofchargingaerosolsprayparticleswhentheelectrostaticsprayedeasilyevaporatingliquids are settled onthem, hence a liquid vapor in a form of condensate will be re-used. Such method has an advantage over method of dust catching by charging electrostatic sprayed water, because a mutual attraction of dust particles and drops of sprayed water leads to their adhesion, and growth of particles along with charge neutralization.

A common disadvantage of electric methods is a minor size and porous structure of formed aggregation of dust particles. Underimpactiontheycanbeeasilydestroyed. Low effectiveness of dust suppression process could be expected from settling of fine dust. Thus, itisrequiredto develop adust suppressionmethod, whichwouldallowsignificantlyincreaseresistance to destruction of formed dust aggregation whilst processing an air dust flow by electric field with retention of high productivity of dust cleanup.

Itisinterestingtoseethe air dedustingmethod using porous blankets /article No. №368413, 1973/. In order to increase an effectiveness of dust catching a dust flow goes through the parallel blankets that moist liquid. Amovingairflowhelps to vibrate blankets due to the irregular speeds. Dustparticleslocatedinairturbulentflowarebeingmoisturized andcoagulated. Fiberismoisturizedbywatersupplytopipe frame where the blankets are fixed.

Toachievearequiredeffectivenessofdustcatchingitisnecessarytoconductmultipletestresearchesinvarious modeparameters, aswellasperform newdesignstudiesforforminganaerodynamicstructureofairdustflow.

Thereisadustsuppressionmethodbased on enriched water steam. Withasteamcondensatethe area of low pressure is formed where all particles move and could be caught. The disadvantage of such method is its low effectiveness that is caused by unreasonable use of generated steam for the purposes of dust suppression. Besides, toachieveareequirednormofdust content large steam resources are required, and that result in unreasonable costs for steam generation.

Similarmethodtotheabove-mentionedmethodisamethod(articleNo.130461), whereairdustflowismixedwithsteamspraywithfurthersettlingofsteam-dustflow by the sprayed water.

Under such process it is expected to obtain a low degree of dust catching. Condensateeffectwillbeshowninunstableway, takesprobabilistic nature depending on random contact of water sprayed drops with water steam molecules and will be determined by turbulence degree of airdust flow. Dust coagulation effectivenessis expected as minor in conditions of enriching air dust flow by steam. Thatiswhywater steam and sprayed water are used unreasonably, and there is increased consumption of steam and water.

Whenstudyingamovementofaerosolparticles in the steam diffusion field it was evident that the aerosol particles are intensively remote from a cold surface. Aerosolswithspeed 1 m/swere put though the condenser of 0,5 m long and 5x10-3m wide. Metalwalliswashedbywaterwithtemperatureatcondenserinlet20°Cand outlet about minus 70°C. Particle concentration was 1012 particles/m^3. Catchingdegreevariedinlargelimits75-95%. Mechanismofthedustsuppressionprocessisbasedontwoprinciples: I) condensateenlargementofaerosolparticleslikecondensation nucleus; 2) directed movement of steam particles mainly towards a cold surface.

Mechanismofthedustsuppressionprocessisverycomplicated, thoughthemainactingfactorscould be indicated suchasStefanflowof condensed steam as a driving force of aerosol particles. Alsoitisenforcedbytheavailablediffusion, thermophoreticforcesandconvective flows, large particles are removed from flow due to the gravitation and centrifugal forces; some particles in air steam flow are minimized because of coagulation process.

Studyofthemechanismofdustsuppressioninthesteamdiffusionfieldrequiresfurther development, in particular it is related to enhancement of the steam condensation process, steadiness of liquid film distribution, development of new devices for feeding air dust flow by the enriched steam.

Someenhancement of the dust suppression processes could be achieved by additional power sources /article No.1032197, 1983/. Itissuggestedtochargewatersteamanddispersedwateroppositely, whereas water should be previously magnetized. Steam is injected to a tank with hot mass, which goes through the electric field formed at the steam nozzle outlet. Steam-air-dust flow leaving a tank is condensed at sprayed drops of electrically charged and magnetized water.

Undertheweightsteamconsumptionequalto7x10-3 kg/f and over, a relative air dust content reaches up to 3-6% and becomes self-simulated in relation to steam consumption. Theincreaseofprocesseffectivenessinthedescribedcondensate system of dust suppression occurs 1,5-2 times (probably in relation to condensate system without electric charge of steam, water and magnetization of water). Alsoitisunclearhowit impactsupon theprocessof water magnetization, and what contribution of electric charge separately for steam and water is.

Thereachedeffectisexplainedbythefactthatwhenoppositely electrically charged sprays of water and steam are injected to thedust source due to electric gravity forces between steam molecules and water drops it leads to more enhanced and ordered steam condensation at water drops. Atcondensatesurfacealargerhydrodynamic flotation occurs rather than at non-charged aerosols, which directs to drops that collects dust particles and tends to their catch by drops. Duetothatamassivedustparticlesaresettled. Capture rate of dust particles by water drops also is increased due to minimizing forces of surface tension of electrically charged drops.

Thedescribedmethodofdustsuppressionhasanadditionaleffectonsettlingdustparticles. However, itisachievedbyhugeeffortsasitrequirestheelectricchargeofsteam, water, watermagnetizationthatsignificantlycomplicatesa condensate system of dust suppression, and extra costs for establishing electric fields and ensuring electrical safety of manpower.

Therefore, furthertheoreticalandexperimentalstudiesofthedustsuppressionprocessesshouldbeaimed at new design solutions that are based on the reviewed methods using evaporator-condensing multiphase systems of dust collection and surface-active agents.

Basically, intermsoftheexistingtypesoffoamgeneratingagentswecouldhopeforthe newaerodynamicdiagramsandstructures, which will determine a behavior of dust suppression process, significantly increasing a cleanup degree of dust flow, and become reliable and easy to fabricate and operate and meet safety requirements whilst operating the equipment [8-13].

Figure 1 demonstrates a new class of nozzle-free foam generator with foam generating capillary porous structure.

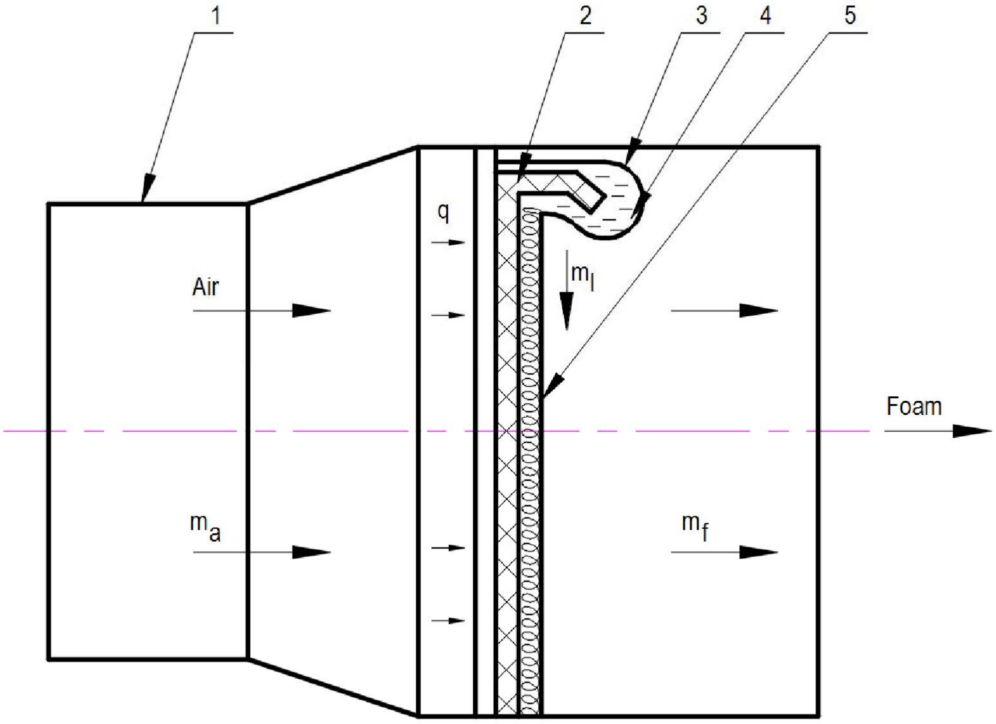

Figure 1 – Nozzle-free capillary porous foam generator of air (steam) mechanical foam:
1 – cylindrical case; 2 – capillary porous structure; 3 – spray device (feeding artery); 4 – foam generatingsolution;
5 – air (steam) – mechanical foam; ma, ml, ms – consumption of air (steam), liquid (foam generating solution), foam;
q – incoming (foam generating) flow energy density.

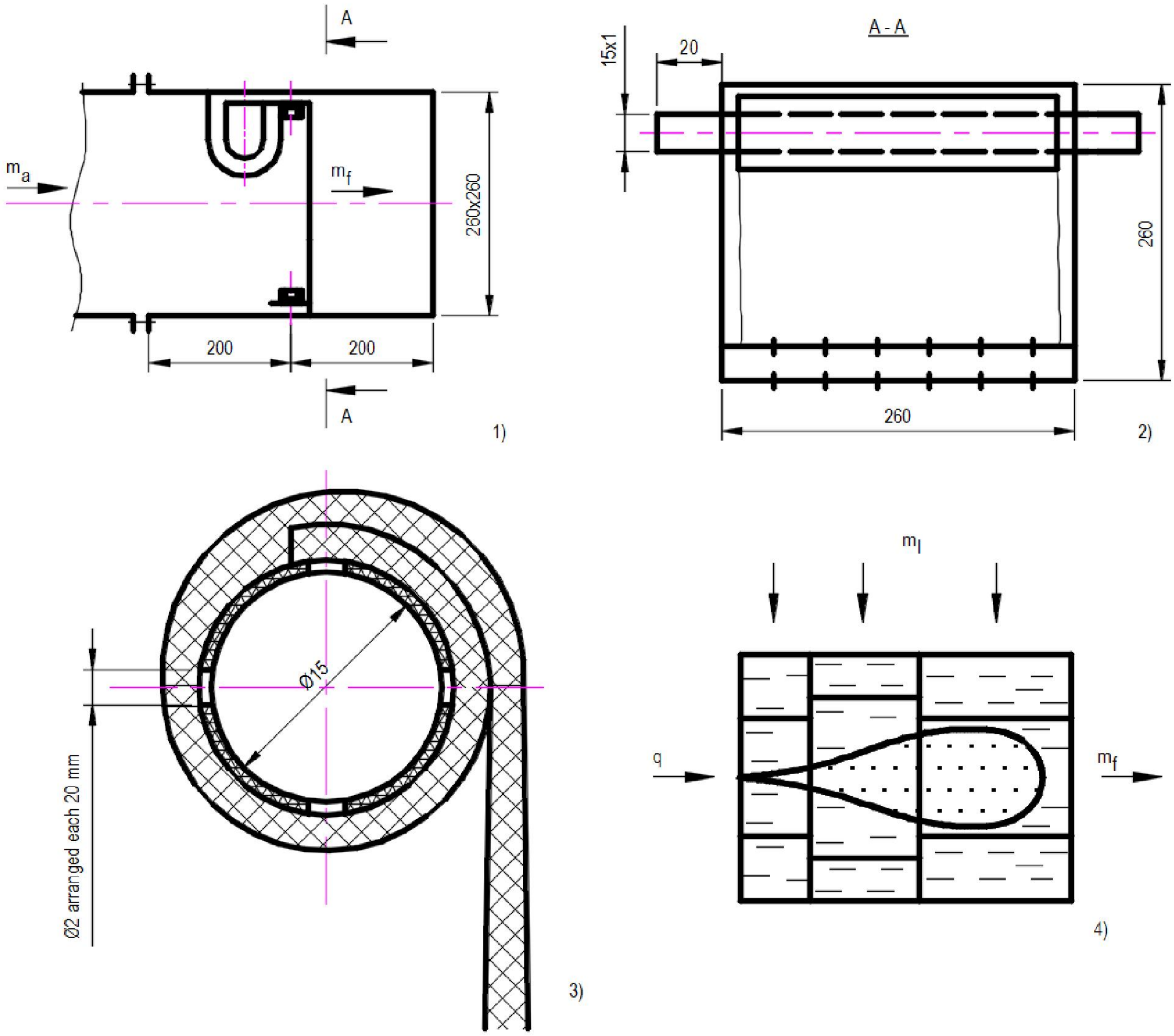

Figure 2 – Test facility for research of foam generation process:
1 – Foam generator; 2 – spray device; 3 – connection of capillary porous structure; 4 – bubble dynamics in structure

Figure 2 demonstratesatestfacilityforresearchofair (steam) generation processes - mechanical foam. Combineduseofmassandcapillaryforcesensuresformationofuniformandstablefilmfordistributionofthefoamgenerationsolutionthroughoutallcapillary porous structure 3x0,4 (three layers of grid where cell width in light is $0{,}4 \cdot 10^{-3}$ m). Thisallowstoincreaseoperational mode of foam generator up to 1,5-2 times, reduce consumption of foam forming agent whilst retaining foam stability, dispersion and high expansion rate.

Valueofhydraulicresistancewillbea few times less because of nozzle unavailability rather than in foam generators GVPV-400 or PGG-4.

REFERENCES

[1] Polyaev V.M., Genbach A.A. Upravlenieteploobmenomvporistihstrukturah // Izvestiya Rossiiskoi akademii nauk. «Energetikai transport». 1992. Vol. 38, N 6/ P. 105-110.

[2] Polyaev V.M., Genbach A.A. Teploobmen v poristoisisteme, rabotaushiiprisovmestnomdeistviikapillyarnihigravitacionnihsil // Teploenergetika. 1193. N 7. P. 55-58.

[3] Genbach A.A., Kulbakina N.V. Pilepodavlenieipileulavlivanie s pomoshucirkuluacionnogopenogeneratora s poristoistrukturoi // Energetikaitoplivnieresursi Kazakhstana. 2010. N 4. P. 62-65.

[4] Polyaev V.M., Genbach A.A. Upravlenievnutrennimiharakteristikamikipeniya v poristoisisteme // Kriogennayatehnikaikondicionirovanie: sborniktrudov MGTY. 1991. P. 224-237.

[5] Polyaev V.M., Genbach A.A. Primenenieporistoisistemi v energeticheskihustanovkah // Promishlennaya energetika. 1192. N 1. P. 40-43.

[6] Genbach A.A., Piontskovskii M.S. Poristiipilegazoulovitel s upravlyaemoigeometrieimikrokanalov // Energetikaitoplivnieresursi Kazahstana. 2010. N 4. P. 59-61.

[7] Polyaev V.M., Genbach A.A., Minashkin D.V. Processi v poristomellipticheskomteploobmennike // Izvestiyavuzov. Mashinostroenie. 1991. N 4-6. P. 73-77.

[8] Genbach A.A., Genbach N.A. Issledovaniepenogeneratora s obogrevaemoipoverhnostu // Vestnik AIES. Almaty, 2009. N 4. P. 24-27.

[9] Genbach A.A., Genbach N.A. Issledovaniekapillyarno-poristihsistem v teplovihenergeticheskihustanovkahelektrostancii // Vestnik AIES. Almaty, 2011. N 2(13). P. 57-62.

[10] Genbach A.A., Genbach N.A. Primeneniekapillyarno-poristihsistem v teplovihenergeticheskihustanovkahelektrostancii // Vestnik AIES. Almaty, 2011. N 3(14). P. 4-11.

[11] Polyaev V.M., Genbach A.N., Genbach A.A. 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, 1995. Vol. 10. P. 273-286.

[12] Genbach A.A., Shokolakov K. Poristiipenniipileulovitel. MON RK, Mezhdynarodniinauchniizhurnal – prilozhenieRespubliki Kazakhstan – Poisk. 2011. N 2. P. 266-271.

[13] Polyaev V.M., Genbach A.A. Plotnostcentrovparoobrazovaniyaivibroskapelizporistoistrukturi // Izvestiya vuzov. Mashinostroenie. 1990. N 9. P. 50-55.

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АУА (БУ) – МЕХАНИКАЛЫҚ КӨПІРІКТІҢ БҮРІККІШСІЗ БОРҚЫЛДАҚ КӨПІРІК ГЕНЕРАТОРЫН ЭКСПЕРИМЕНТАЛДЫ ОРНАТУДЫ ӘЗІРЛЕУ

Аннотация. Таза сұйықтықтарды қайнатумен және қабатты-белсенді заттарды қосумен жылу-салмақ алмастырғыш үдерісті зерттеу негізінде ауа (бу) – механикалық көпірікті бүріккішсіз капиллярлы-борқылдақ көпірік генераторларының жаңа класы әзірленді. Эксперимент нәтижелерін жылыну мен масса тасымалының критикалық теңдеулеріне көбік, поролон жасау, псевдоожолдау және қайнау процестеріне қатысты ±20% дәлдікпен қорытылады. Капиллярлы-бұрқылдақ құрылымдар үшін 3х0,4 түріндегі капиллярлы және салмақты бірыңғай әрекеттер көпірік генераторының жұмыс режимін 1,5-2 есе тездетуге, көпірік қалыптастырушының шығындарын қысқартуға және гидравликалық қақтығысты он есе азайтуға мүмкіндік берді.

Түйін сөздер: борқылдақ көпірік генераторы, көпірік генерациясы, жылу салмақ алмастырғыш, капиллярля-борқылдақ құрылымдар.

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РАЗРАБОТКА ЭКСПЕРИМЕНТАЛЬНОЙ УСТАНОВКИ БЕЗФОРСУНОЧНОГО ПОРИСТОГО ПЕНОГЕНЕРАТОРА ВОЗДУШНО (ПАРО) – МЕХАНИЧЕСКОЙ ПЕНЫ

Аннотация. На основе исследований процессов тепло-массообмена кипением чистых, жидкостей и с добавкой поверхностно-активных веществ разработан новый класс безфорсуночных капиллярно-пористых пеногенераторов воздушно (паро) – механической пены. Результаты эксперимента обобщаются критеристыми уравнениями тепло- и массообмена с точностью ±20% применительно к процессам барботажа, пеногенерации, пвсевдоожижения и кипения. Совместное действие капиллярных и массовых сил для капиллярно-пористых структур вида 3х0,4 позволило форсировать в 1,5-2 раза режим работы пеногенератора, сократить расход пенообразователя и в десятки раз уменьшить гидравлическое сопротивление.

Ключевые слова: пористый пеногенератор, пеногенерация, тепломассообмен, капиллярно-пористые структуры.