

FILTER MEDIAS FROM GRANULATED FOAM-GLASS, PROPERTIES INVESTIGATED FOR WATER TREATMENT POSSIBILITIES

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Abstract. Inorganic material – granulated foam-glass produced from glass breakage in small porous granule shape. Foam-glass is gotten by connecting thoroughly grounded glass with foamers, later this composition is heated in the furnace in especially high temperature and is turned into various diameter greyish granules. Granulated foam-glass is a unique ecological material of which inner structure pores are arranged in such a way that air is trapped inside. Foam-glass production technology is one of the most advanced since the product is made from secondary raw materials, not leaving any third row waste. From granule surface images it can be seen that granule surface has pores and voids, some of these pores are closed, others are connected with granule's inner pores, all pore walls are smooth, and the wall material is vitrified. Pores and voids are arranged chaotically in smaller granules, bigger granules inner space structure is tidy, bigger part is occupied by correctly arranged bigger pores and space between them is filled with smaller pores. Granules are composed of amorphous phase, in mineralogical composition can emit one material cristobalite. In the work were researched two fraction granules: 0/2 and 2/4 as well as determined 0/4 fraction granular-metric composition. Researched and determined main physical granule properties and properties related to water effect to the material, shown in micro-structural granule surface and inner structure images. According to explored properties it can be noted that granules can be adapted in water cleaning technologies.

Keywords: absorption, effective granule porosity, foam-glass granules, granule surface structure, porous space reserve.

Introduction

In the year 2009 production of foam-glass granules started in Lithuania from collected glass waste in the country. Granulated foam-glass – it is an inorganic thermo-insulated material, produced from glass breakage, in small pore granule form. It is unique in that to produce it regular household glass is used. Foam-glass is gotten when connecting grounded to small pieces glass with foamers, later this compound is heated in a furnace in especially high temperature as well as made into various diameter greyish granules. Granulated foam-glass is a unique ecological product produced from waste. Granulated foam-glass is a unique and ecological material which has inner structure pores arranged in such a way that it seems air is held inside. Foam-glass production technology is unique and one of the most advanced since the product is made from secondary raw-recycled materials, not leaving third row waste, in production technology little amount of energy is used due to the equipment adjusted to minimal energy amount usage, and made products fit thermo-insulated and sound isolating needs for buildings, as well as can be used for decorative mortars and other uses. Wide granule size

spectrum allows using them in various areas. Granulated foam-glass can be used in such areas like farming, supply systems, oil extraction, bio filtration and other.

Granulated foam-glass is produced into two different types: produced into white and grey foam-glass granules. The grey foam-glass granules are of such fractions: 0/2, 2/4, 0/4, 4/8, 8/16 mm, white granules in the factory are divided into more fractions: 0.1/0.3, 0.25/0.5, 0.5/1, 1/2, 2/4, 4/8, 8/16 mm. However when bleaching foam-glass granules are put into chemical compounds that are unfit in water preparation technologies. Different reused filter media materials are in use nowadays (Albalawneh *et al.* 2017; Sabiri *et al.* 2017).

Porous granulated foam-glass granule research was carried out in the work. The research used granulated foam-glass granules produced by UAB “Stikloporas” (Druskininkai, Lithuania) production line. The main characteristics of foam-glass granule during the research were explored. It was determined whether grey foam-glass granules fit according to their characteristics related to water effect to material using contaminated water cleaning technologies.

Methodology

Separate fraction surface image fixation of porous granulated foam-glass was carried when using different magnification. 2/4, 0/2 mm fraction granule general view and granule surface image when magnification is 14 and 28 times. 0/2 and 2/4 fraction granule image analyzation was carried out. Granule surface and cut images were gotten with raster electronical microscope. Micro-structure was researched with outside emission scanning electronical microscope SEM JSM-7600F (JEOL). Researched sample cleaving surface when there was lower (4 kV) accelerating voltage. This way an opportunity was formed to research uncovered with electrically conductive layer cleaving surface and also to carry out research on changes that appear in chosen surface place due to heating.

Analysis of granule material mineralogical was carried out by x-ray research method using diffractometer DRON-7. Anode – Cu, filter – Ni were used, anode voltage – 30 kV, anode current 12 mA, goniometer gaps (0.5; 1.0; 1.5) mm. ICDD database for x-ray decryption was used. Different fraction granules were explored.

From the factory there were also gotten a granule mix which particle size was 0–4 mm, granule granular-metric composition was determined by sieving through 0.063, 0.125, 0.25, 0.5, 1, 2, 4 mm sieves.

When determining physical properties of granule foam-glass granules were dried and easily poured different fraction granule bulk volume was determined according to the LST EN 1097–3 “Filler mechanical and physical property determining methods. Part 3. Bulk volume and void determination”. Granules were submerged in water until they reached constant mass. By submerging soaked granules into water occupied granule volume and granule density were determined. According to these indicators (LST EN 1097–3:2002) separate fraction granule void was calculated. Selected granules were grinded in laboratory

mortar and pestle to such small size that sieved material could pass through sieve 008 and composing materials density was determined by drying shrinkage method.

Separate granule fractions were poured into porous meshes from polyamide, weighted and submerged in $(20\pm 2)^{\circ}\text{C}$ temperature water, after 1, 3, 5, 10 min and 24, 48, 72, 96 h meshes were taken out from water and, after waiting for excess water to run off, were weighted. Granule separate fraction absorption was calculated by percent according to mass. Granule absorption according to mass was recalculated to granule absorption according to volume.

When determining foam-glass granule absorption by vacuuming, separate granule fractions were poured into porous meshes from polyamide, weighed and put into vacuum utensil (desiccator). System was vacuumed from 0.98 atm. After 60 min vacuuming desiccator was filled with water of $25\text{--}30^{\circ}\text{C}$ temperature until the samples were completely submerged. After 60 min air was released into the system. Submerged water granules were left for 24 h. After 24 h granules were taken out of water and, after letting excess water to run off, were weighted.

Results

Foam-glass granules, which are of 0/2, 2/4 mm fractions, surface and inner structure images are shown in Figures 1–3. By analysing granule outer and inner images such conclusion can be made: granule exterior is covered in small particles which are of plate shape, hexagon form. These particles have width from 0.5 to 3 μm , while thickness is up to 0.1 μm . Granule interior is a big amount of bigger and smaller pores. These pores are usually of perfect shape; pore walls are smooth, vitrified. Bigger granule 2/4 mm fraction inner pore structure is tidier, less chaotic and has less smaller granules – 0/2 mm. Bigger granule frame is composed of big round pores while voids between them is filled with smaller pores (Zurauskiene 2013).



Fig. 1. General granule image: 0/2 fraction (left), 2/4 fraction (right)
1 pav. Granulių vaizdas: 0/2 frakcijos (kairėje), 2/4 frakcijos (dešinėje)

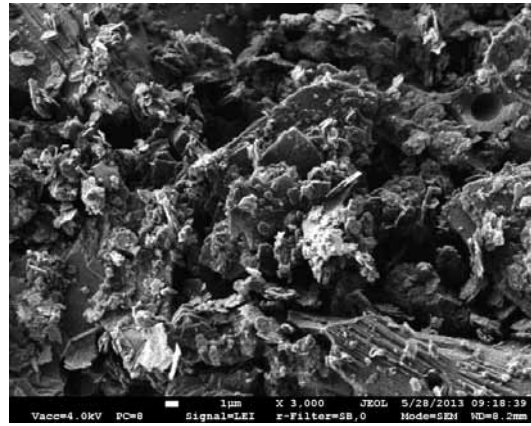
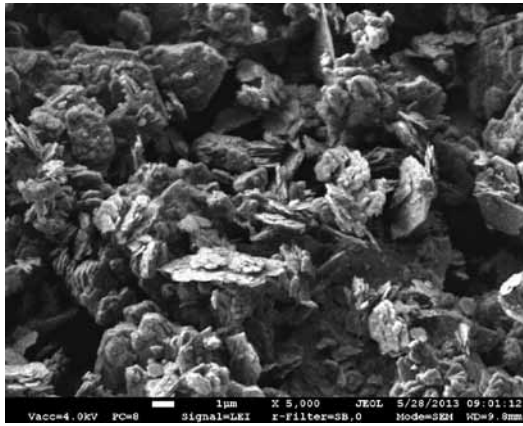


Fig. 2. Foam-glass granules separate fraction surface image: 0/2 fraction, magnification 5000 times (left); 2/4 fraction, magnification 3000 times (right)

2 pav. Atskirų putstiklio granuliu frakcijų paviršiaus vaizdas: 0/2 frakcijos, esant 5000 kartų didinimui (kairėje), 2/4 frakcijos, esant 3000 kartų didinimui (dešinėje)

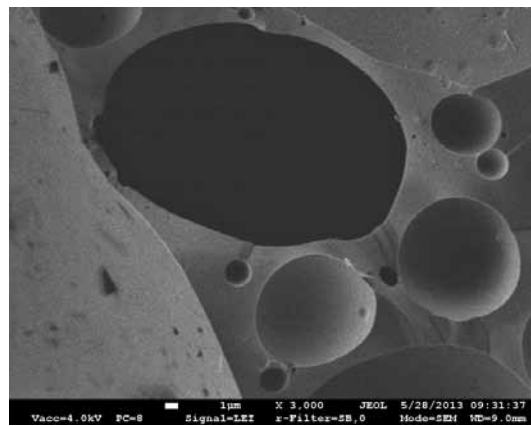
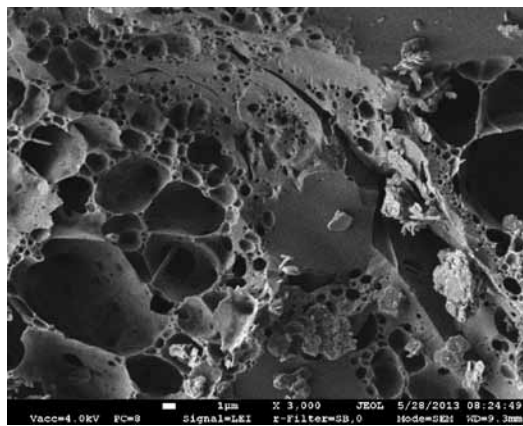


Fig. 3. Foam-glass granules inner structure image, magnification 3000 times: 0/2 fraction (left); 2/4 fraction (right)

3 pav. Atskirų putstiklio granuliu frakcijų lūžio vaizdas, esant 3000 kartų didinimui: 0/2 frakcijos (kairėje), 2/4 frakcijos (dešinėje)

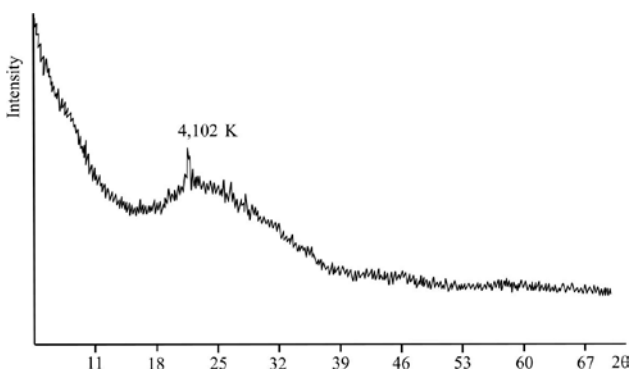


Fig. 4. Granulated foam-glass granule (2/4 mm) material mineralogical composition

4 pav. Putstiklio granuliu (2/4 mm) mineraloginė sudėtis

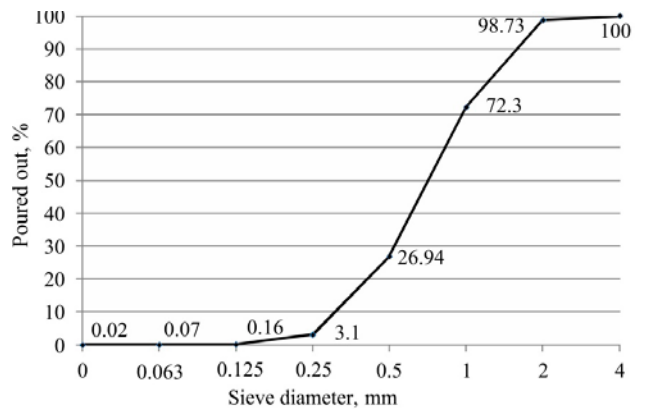


Fig. 5. Foam-glass granule mixture 0–4 mm granular-metric composition curve

5 pav. Putstiklio granuliu 0–4 mm mišinio granulimetrinė sudėtis

X-ray research results are shown in Figure 4. By analysing research results it can be noted that granules consist of amorphous material in which a small cristobalite peak can be emitted. In small granules cristobalite peak has a slightly higher intensity than determined when researching bigger granules.

0/4 mm fraction mixture produced in the factory was researched determining this mixture granular-metric composition (Figure 5). From 0/4 mm fraction granule granular-metric composition curve (Fig. 4) we can see that main part of granules 45.4% is composed of granules from 0.5 to 1 mm size, smaller granules like 0.25 mm compose only 2.9%, and granules bigger than 2 mm only compose 1.3%.

Foam-glass granule bulk density, granule density, voids and material density is shown in Table 1.

Foam-glass granule absorption results, when there are different submerging durations, are shown in Table 2, as well as Table 3 shows and recalculated granule absorption results according to volume.

According to absorption research results it can be noted that granule absorption depends on foam-glass granule fractions. According to granule volume less water gets absorbed by bigger granules, while biggest absorption is of granules that are composed of smallest fraction grains and have in their composition lots of small particles, that's 0/2 mm fraction particles. According to absorption (absorption according to volume) research results it can be concluded that the bigger particle specific surface area, the more water the particle absorbs – particle surface becomes covered in water and water gets into surface pores and stays in particle surface disparities.

Granule absorption by vacuuming them is shown in Table 4. Porous space reserve show that granule inner open space part, which when submerged in water under normal conditions at the start does not fill with water, however, granules when affected by long-term submerging process gradually filled with water (Zurauskiene *et al.* 2017).

Water infiltrates into foam-glass granules during vacuuming through surface open pores and gets into deeper

Table 1. Foam-glass granule physical properties
1 lentelė. Putstiklio granulių fizikinės savybės

Foam-glass granule fraction	Physical properties				
	Bulk density, g/cm ³	Particle density, g/cm ³	Fraction's void, %	Fraction's porosity, %	Material density, g/cm ³
0/2	0.493	0.857	42.5	73.4	1.85
2/4	0.195	0.364	46.3	89.5	

Table 2. Foam-glass granule absorption according to mass determining results
2 lentelė. Putstiklio granulių absorbcijos pagal masę rezultatai

Foam-glass granule fraction	Submerging duration							
	1 min	3 min	5 min	10 min	24 h	48 h	72 h	96 h
0/2	25.17	26.36	27.26	27.80	31.06	35.07	35.97	37.86
2/4	33.39	33.77	33.95	35.11	38.73	46.80	53.11	59.24

Table 3. Foam-glass granule absorption according to volume determination results
3 lentelė. Putstiklio granulių absorbcijos pagal tūrį rezultatai

Foam-glass granule fraction	Submerging duration							
	1 min	3 min	5 min	10 min	24 h	48 h	72 h	96 h
0/2	12.41	12.99	13.44	13.70	15.31	17.29	17.73	18.67
2/4	6.51	6.58	6.62	6.85	7.55	9.13	10.36	11.55

Table 4. Foam-glass granule absorption after vacuuming
4 lentelė. Putstiklio granulių absorbcijos rezultatai po vakuumavimo

Foam-glass granule fraction	Properties			
	Granule absorption after vacuuming them, mass %	Effective granule porosity, %	General granule porosity, %	Porous space reserve, %
0/2	38.06	30.83	32.62	5.49
2/4	65.70	19.33	23.92	19.17

connected pores. Porous space reserve shows that how much empty space that is connected through connected pores and capillaries in researched material. This space when affecting granules with water or water solutions slowly fills with water.

Conclusions

1. From granule surface images we can see that granule surface has pores and voids, some of these pores are closed, others are connected with granule's inner pores, all pore walls are smooth, wall material is vitrified. In smaller granules pores and voids are arranged chaotically, bigger granule inner space structure is tidy, bigger part is occupied by properly arranged bigger pores and space between them is filled with smaller pores.
2. Granules are composed of amorphous phase, can emit one mineral cristobalite of which small amount can be found both in smaller and bigger granules.
3. Researched granule main properties: 0/2 mm fraction: density – 493 kg/m³, absorption after 96 hour absorption – 37.86 %, porous space reserve – 5.49; 2/4 mm fraction: density – 195 kg/m³, absorption after 96 hour absorption – 59.24 %, porous space reserve – 19.17; mixture 0/4 mm fraction: density – 269 kg/m³.

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PUTSTIKLIO GRANULIŲ FILTRAVIMO GALIMYBIŲ TYRIMAS PANAUDOJANT JAS VANDENS VALYMO TECHNOLOGIJOSE

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Santrauka

Neorganinė medžiaga – granuliuotas putstiklis – gaminama iš stiklo duženų, nedidelių porėtų granuliuotų pavidalu. Putstiklis gaunamas sujungiant smulkiai sumaltą stiklą su putokšliais, vėliau šis junginys kaitinamas krosnyse ypač aukštoje temperatūroje bei paverčiamas įvairaus skersmens pilkšvomis granulėmis. Granuliuotas putstiklis yra unikali ekologiška medžiaga, kurios vidinėje struktūroje poros išdėstytos taip, kad oras yra lyg sulaukomas viduje. Putstiklio gamybos technologija yra viena iš pažangiausių, nes produktas gaminamas iš antrinių žaliavų, nepalikant trečios eilės atliekų. Iš granuliuotų paviršiaus vaizdų galime matyti, kad granuliuotų paviršius turi porų ir tuštumų, kai kurios iš šių porų yra uždarnos, kitos yra susisiekiančios su granulės viduje esančiomis poromis, visų porų sienelės yra glotnios, sienelių medžiaga sustiklėjusi. Mažesnėse granulėse poros ir tuštumos yra išsidėsčiusios chaotiškai, didesnėse granulėse vidinės erdvės struktūra tvarkinga, didžiąją dalį užima taisyklingai išsidėsčiusios didelės poros, o erdvė tarp jų yra pripildyta mažesnių porų. Granulės sudaro amorfinę fazę, pagal mineraloginę sudėtį galima išskirti vieną mineralą kristobalitą. Darbe buvo tiriamos dviejų frakcijų granulės: 0/2 ir 2/4, taip pat nustatyta 0/4 frakcijos granuliuotinė sudėtis. Iširtos ir nustatytos pagrindinės fizikinės granuliuotų savybės ir savybės, susijusios su vandens poveikiu medžiagai, pateikti mikrostruktūriniai granuliuotų paviršiaus ir vidinės struktūros vaizdai. Pagal iširtas savybes matyti, kad granulės gali būti pritaikomos vandens valymo technologijose.

Reikšminiai žodžiai: absorbcija, efektyvusis granuliuotų poringumas, putstiklio granulės, granuliuotų paviršiaus struktūra, poringosios erdvės rezervas.