The use of expanded clay dust in paint manufacturing

S V Sverguzova, Zh A Sapronova, Yu L Starostina and E A Belovodskiy
Belgorod Shukhov State Tecnological University, Kostyukova str., 46 Belgorod, 308012, Russia
e-mail: starostinairinav@yandex.ru

Abstract. Production increase of useful products is accompanied by the formation and the accumulation of vast amounts of industrial wastes, the bulk of which is not involved in the recycling processes. An example of such wastes is dust bag filters of ceramsite production. At the large enterprises, the volume of its formation can reach 7-8 tons of dust per day, which is 10-15% of feedstock mass. The studies on the use of ceramsite production dust as filler pigment in the composition of organic mixed primer of red-brown color are carried out in this work. For comparison, red iron oxide pigment (Pg FGM) was used. The results showed that, primer with the use of expanded clay dust is characterized by the short drying time and meets all regulatory requirements.

1. Introduction
Currently in Russia and in the whole world, production volume of useful products increase is accompanied by the formation and the accumulation of vast amounts of industrial wastes. This indicates about irrational use of natural resources, as only a small part becomes the final product but the greatest part of the feedstock withdrawn passes into the heap. In the Russian Federation alone annually, tens of billions tons of industrial waste are produced, the bulk of which is not involved in the recycling processes but takes huge areas of fertile soils and contaminants contained in such wastes in the form of dust particles and dissolved precipitation substances enter the environment [1-3].

The production of building materials is one of the most important factors that have a negative impact on the environment [4-11]. The various production waste of construction materials are: breakage, scrap, non-standard situation, pulps, sludge, dusts [12]. One of these wastes is the bag filters dust of ceramsite production, which is now not in demand, and stored at industrial sites.

According to experts, today in Russia, there are about 160 factories for the ceramsite production. Total annual production is about 3.5 million m^3 [13]. Dust is formed during the preparation of raw materials, ceramsite granules dry, burning, cooling and inoculating of material into fractions with the addition of large pieces [14]. The dust is trapped in factories by dust precipitating chambers, cyclones, bag filters. Utilization of expanded clay dust is a serious problem. In the large ceramsite plants every day 7-8t of dust may be formed that is 10-15% of feedstock mass [14].

Ceramsite production dust, as we can know is widely used in the manufacture of ceramsite gravel (again), fine filler of light weighted concrete (instead of silica sand), ceramic bricks and insulating backfill [15-18].

However, despite many of the described methods, the use of expanded clay dust is mostly stored in the dump. Therefore, the development of new alternative methods of utilization of expanded clay dust is an urgent task. According to a preliminary study of the composition and properties of ceramsite production dust, we propose to use it as a filler pigment.
2. Material and methods

Grain sized composition of raw material was measured by a laser granulometry analyzer at the laser analyzer Microtrac S3500 (US).

The main physico-chemical and mechanical parameters of the considered materials were determined according to the standard fillers pigments procedures [19-21].

X-ray diffraction patterns analyze (XDA) was carried out on a diffractometer DRON-4 using Cu-anode radiation according the method of powder diffraction patterns. The diffraction patterns identification was carried out by catalogue ICDD (International Centre for Diffraction Data (USA)).

Thermal Analysis (DTA) was carried out with the help of derivatograph of model 431Q -1500 and device of synchronous thermal analysis STA 449 F1.

The study of changes in the main indicators of quality of filler pigments were carried out in accordance with GOST[20]. The microstructure of the material was studied by the scanning electron microscope TESCANMIRA 3 LMU (Poland).

Material humidity (%) was determined according to the difference between the initial sample mass (its mass is 1 g) and dried one at 100° C to constant weight. pH of water extract was determined after three minutes of 5g fine-grained dust boiling into 50sm³ of distilled water with the first figure of pH equal to 7.0.

The true density was found by pycnometric way. To determine the bulk density the method ASTM D2854-70 "Standard method of controlling the apparent density of active carbons was used.

The chemical composition of the expanded clay dust sample was determined by X-ray fluorescence analysis (X-ray workstation "ARL 9900 series x-ray work station" with radiation of Co-anode and Kav I is 60 kV and energy dispersive analysis (analyzer meals, combined with ion-electron microscope Quanta 200 3D).

3. Results and discussion

The following materials were used in the work such as

- bag filters dust of ceramsite production of Belgorod plant JBK-1
- red iron oxide pigment (GHG FGM).

There are a number of specific requirements to the pigment fillers in the paint industry such as: high dispersion, low oil absorption, low density, low cost and availability of raw materials, minimum content of water-soluble impurities (electrolytes). As an example, in table 1 shows some of the properties used in the paint industry of fillers.

| Filler  | Density, kg·m⁻³ | Oil absorption, g·(100g)⁻¹ | pH of water extract |
|---------|-----------------|---------------------------|-------------------|
| Barite  | 4500            | 6-10                      | 8-9               |
| Dolomite| 2850            | 15-19                     | 10                |
| Chalk   | 2710            | 10-17                     | 9-10              |

The results of physical and chemical properties study of expanded clay dust selected after the bag filters are shown in table 2.

| Poured Density, kg·m⁻³ | Original Density, kg·m⁻³ | Oil absorption, g·(100g)⁻¹ | pH of water extract | Humidity, % |
|------------------------|--------------------------|-----------------------------|---------------------|-------------|
| 1250                   | 2490                     | 14-17                       | 10.2                | 1.68        |

As it can be seen from table 2, such indicators of expanded clay dust as original density, oil absorption, pH of water extract were compared with those ones for traditionally used fillers from...
table1 Oxide dust composition determined by X-ray fluorescence method is specified in table 3, the elementary composition is given in table 4.

**Table 3.** Oxide composition of expanded clay dust samples, mass. %

| № test | SiO₂ | Al₂O₃ | Fe₂O₃ | CaO | MgO | K₂O | TiO₂ | Na₂O | MnO | SO₃ | ZrO₂ | V₂O₅ | ZnO | Cr₂O₃ |
|--------|------|-------|-------|-----|-----|-----|------|------|-----|-----|------|------|-----|------|
| 1      | 62.4 | 20.31 | 6.91  | 2.76| 2.91| 2.52| 0.93 | 0.90 | 0.1 | 0.04| 0.03 | 0.01 | 0.018|
| 2      | 61.9 | 19.17 | 7.05  | 4.14| 2.79| 2.63| 0.95 | 0.97 | 0.11| 0.02| 0.05 | 0.02 | 0.017|
| Medium | 62.15| 19.74 | 6.98  | 3.45| 2.85| 2.58| 0.94 | 0.93 | 0.10| 0.02| 0.05 | 0.03 | 0.018|

**Table 4.** The elementary composition of expanded clay dust samples, [mass. %]

| № test | Si  | Al  | Fe  | Ca  | Mg  | K   | Ti  | Na  | Mn  | S   | Zr  | V   | Zn  | Cr  | O  |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|
| 1      | 29.21| 10.75| 4.83| 1.97| 1.76| 2.09| 0.56| 0.67| 0.078| -   | 0.027| 0.018| 0.01 | 0.012| 48.02|
| 2      | 28.98| 10.14| 4.93| 2.96| 1.68| 2.18| 0.57| 0.72| 0.084| 0.009| 0.04 | 0.018| 0.013| 0.012| 47.66|
| Medium | 29.095| 10.445| 4.88| 2.47| 1.72| 2.14| 0.565| 0.695| 0.081| 0.009| 0.034| 0.018| 0.012| 0.012| 47.84|

The analyze results of dispersed dust composition are shown in figure 1.

![Figure 1](image_url)

**Figure 1.** Differential and integral distribution of dust particles, selected after the bag filters (a - is the beginning of work, b - is the end of work).

Expanded clay dust roentgenograms selected after the bag filter are shown in figure 2 and 3.
Figure 2. X-ray of expanded clay dust selected after the bag filter at the beginning of work where:
A - is quartz SiO$_2$; B - is calcite CaCO$_3$; C - is albite NaAlSi$_3$O$_8$; D - is orthoclase KAlSi$_3$O$_6$;
E - is muscovite KAl$_2$Si$_3$AlO$_10$(OH)$_2$; F - is palygorskite Mg$_5$Si$_8$O$_20$(OH)$_2$·18H$_2$O; H - is kaolinite Al$_2$Si$_2$O$_5$(OH)$_4$.

Figure 3. X-ray of expanded clay dust, selected after the bag filter at the end of the work where:
A - is quartz SiO$_2$; D - is orthoclase KAlSi$_3$O$_6$; E - is muscovite KAl$_2$Si$_3$AlO$_10$(OH)$_2$;
F - is palygorskite Mg$_5$Si$_8$O$_20$(OH)$_2$·18H$_2$O; H - is kaolinite Al$_2$Si$_2$O$_5$(OH)$_4$.

For more complete data on the physical and chemical properties of ceramsite production dust, the study investigated the structure of the particle surface with the help of electronic center MIRA3 microscope TESCAN scientific & research center of the higher technologies FGBOU VO "Belgorod State technological University named after V G Shukhov" was considered. Figure 4 shows the photomicrographs of particles dust surface made at different magnifications. In micrographs one can observe a highly developed surface of dust particles with clearly defined interface.

To make the dust much higher, it is dispersed and was further milled with the help of bead mill. For further study, the fraction with a particle size of less than 50 [microns] was selected with the help of a
sieve №005. The dust sample prepared in this way was tested for its suitability in paint production in the conditions of the production laboratory of “Paint factory Quil”.

Figure 4. Parts of expanded clay dust production surface at different magnification.

Dust tests as a filler pigment were carried out in the following main parameters: dispersibility, the degree of grinding, relative viscosity, hardness, drying time, adhesion, and elasticity. Test specimen of pigment filler was put into the formulation of organic mixed primer of red-brown color for carrying out according to the given data. The red ferrous oxide pigment used in paint industry was applied as a material for compressing. The primer was made on the pigment materials under equal conditions. Samples were put by the method of pneumatic spraying on previously clear and degreased plates (in accordance with GOST 8832-76, Section 3) of grade steel 08 with a size 150 70mm, thickness of 0.8-0.9mm of GOST 16523-70 for determination of stroke indicators, adhesion and appearance of the coating. Film elasticity at bending was determined on plates with the size 90h 120mm, thickness 5mm.

Comparison of the results of the technical characteristics of the primer, prepared using expanded clay dust-based pigments, showed compliance with all regulatory requirements.

4. Conclusion
The test of primer with the use of pigment materials showed similar results. Primer with the use of expanded clay dust corresponds to all regulatory requirements. However, it is necessary to pay attention to the short drying time (drying time indicators at 20°C).

The determination of stroke indicators, adhesion and elasticity were made within 24 hours after material application. The hardness determination was done after 48h after material application.

Acknowledgments
The work has been carried out within the framework of the Flagship University Development Program on the base of BSTU named after VG Shukhov.

References
[1] Petin A N 2004 Geocological consequences of the iron ore deposits KMA development and the problems of optimal subsoil in the region. Proc. of the Federal Research Center of Hygiene them. FF Erismann: Regional hygienic problems and strategies to protect public health (Belgorod) 10 149 – 158
[2] Kornilov A G, Prisny Yu A, Kolchanov A F and Prisny A V 2008 Izvestiya Proc. of the Russian Academy of Sciences Geographical Series 2 85 – 92
[3] Petin A N 2005 Mineral resources of the Kursk magnetic anomaly and environmental problems of industrial development Bulletin of Peoples' Friendship University A series of engineering studies 12 124 – 25
4. 2014 On the state and Environmental Protection of the Russian Federation, the environment in 2013 year State report (Moscow: The Ministry of Natural Resources of Russia) p 463
5. 2015 On the state and Environmental Protection of the Russian Federation, the environment in 2014 year State report (Moscow: The Ministry of Natural Resources of Russia) p 473
6. 2016 On the state and Environmental Protection of the Russian Federation, the environment in 2015 year State report (Moscow: The Ministry of Natural Resources of Russia) p 640
7. Lobachyova G K, Zheltobryukhov V F, Prokopov I I and Fomenko A P 2005 The issue of wastes and modern methods of their processing (Volgograd: Volgograd State University Press) p 176
8. ZhenikhoV Y N and Ivanova V N 2013 The waste production and consumption (Tver: TvGTU) p 164
9. Chistyakov B Z and Lyamina A I 1984 The use of mineral industry wastes (Leningrad: Stroyizdat) p 132
10. Arbuzova T B, Shabanov V A, Korenkova S F and Chumachenko N G 1993 Construction of industrial wastes (Samara: Book Publishing) p 96
11. 2002 The state of the environment and natural resources of the Belgorod region in 2001 Annual report 2002 (Belgorod: Main Department of Natural Resources and Environment Ministry of Russia for the Belgorod region) p 95
12. 2003 Environment and natural resources of the Belgorod region in 2002 Annual Report Ed V S Pashkova (Belgorod: Main Department of Natural Resources and Environment Ministry of Russia for the Belgorod region) p 89
13. Production of expanded clay as a business http://abcbiznes.ru/biznes-idei/369-proizvodstvo-keramzita-kak-biznes.html
14. Ivleva I A, Shimanskaya M S and Nemets I I 2011 The technology of gettingceramsite from slightly swelling up clay raw materials Glass and ceramics 11 17 – 8
15. Alfimova N I and Cherkasov V S 2010 Prospects of using wastes of ceramsite production in building materials. Bulletin of BSTU named after V G Shukhov 3 21 – 4.
16. Kulikov V A, Abdrahimov V Z, Kovkov I V 2011 Study of the porous structure of ceramsite on the basis of flotation coal enrichment Izvestiya vuzov Stroitelstvo 8 31 – 7
17. Alfimova N I, Vishnevskaya Ya Yu, Cherkasov V S and Kalatozi V V 2010 Improving the efficiency of composite astringents using ceramsitewastes production and optimization of the mode hardness. The Research, nanosystems and energy saving technologies in the industry of buildings materials: a collection of papers of the international scientific-technical conf. (XIX Scientific Conference) (Belgorod) 1 36 – 8
18. Rakhimov R Z, Hamullin M I and Gaifullin A R 2012 Composite gypsum astringents with the use of ceramsite dust and blast furnace slag Building materials 7 13 – 15
19. Hodakov G S 1968 Basic methods of analysis of the dispersion powders (Moscow: Stroyizdat) p 126
20. 1999 GOST 10503-71 Oil paints ready for use. Specifications Russian national standards (GOST) (Moscow: Publishing House of Standards) p 10
21. 1999 GOST 21119.8-75 The Common test methods for pigments and fillers / definition of oil absorption Russian national standards (GOST) (Moscow: Izdatelstvo standarstov) p 5