Journal of Achievements in Materials and Manufacturing Engineering

International Scientific Journal published monthly by the World Academy of Materials and Manufacturing Engineering

Influence of deflocculant addition on rheological properties of the slurries based on bauxite

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ABSTRACT

Purpose: The objective of the paper is to present the properties of ceramic slurries based on bauxite with different deflocculants.

Design/methodology/approach: The slurries were performed in air conditioned laboratory by a mechanical mixer. The rotation speed of the mixer was 300 RPM and the mixing time was 3 hours. To characterize the bauxite structure, SEM Hitachi SU-70 was used. Furthermore, chemical composition by XRF method was executed. Grain size of bauxite was measured by Horiba laser diffractometer. The rheological properties were studied at Rheometer MCR 102 (Anton Paar) by coaxialcylinders method.

Findings: Investigated ceramic slurries based on bauxite show stable rheological properties in time. It could be concluded that ceramic slurries with obtained properties might be used in ceramic proppant manufacturing in the future.

Research limitations/implications: The main restriction in rheological properties of ceramic slurries modification is to use aqueous binders and deflocculant solutions. In Polish manufacturing water as a main binder (max. 5 wt. %) and of deflocculant (0.25 wt. % with respect to the powder) additives are required. This kind of limitation has an influence on the part of the solid phase concentration of ceramic slurries. For that reason ceramic slurries with 45 wt. % solid content are investigated.

Practical implications: Presented ceramic slurries could be used in ceramic proppant fabrication by spray drying process in the future.

Originality/value: This is one of the first application of bauxite to produce ceramic proppants using spray dryer in Poland. Ceramic proppants could be used as additives to fracturing liquid in shale gas extraction process.

Keywords: Ceramic slurries; Deflocculant addition; Proppants fabrication; Raw materials;

Reference to this paper should be given in the following way:

M. Koralnik, M. Małek, P. Wiśniewski, J. Szymańska, D. Zarzycka, J. Mizera, K.J. Kurzydłowski, Influence of deflocculant addition on rheological properties of the slurries based on bauxite, Journal of Achievements in Materials and Manufacturing Engineering 73/2 (2015) 106-109.

PROPERTIES

1. Introduction

Today industry, but not only, is mostly based on conventional gas recources. Households wildly used natural gas for heating and other processes. Natural gas is a mixture of hydrocarbons and nitrogen. It is popular because is not difficult for transport and extraction. Moreover, production of energy from natural gas is more environmental friendly than coal. Deposits of natural gas are easily available. For many years hydrocarbons with other gases migrates through the rocks form deepest to shallower decks. Due to widespread exploration shallow decks are getting less common. It causes increasing exploration costs.

The alternative to natural gas is shale gas [1, 2]. The kind of gas possess the same chemical composition as natural one but the extraction process is different and more difficult. It occurs in shales, brittle rocks deposited hundred years ago on the bottom of the prehistoric sea. The kind of rock is impervious so the gases they contain could not come out.

To extract shale gas a special technology is needed. In the past when natural gas was acceptable cheap it was not necessary to explore the shale gas. Technology of extraction shale gas was expensive and poorly developed. The United States of America has the most expanded shale gas extraction technology in the world. There are many beds of shale gas in US and it is wildly extracted and used in industry [3, 4].

Shale gas beds are located very deeply. It is often a few kilometers under the ground. Lately technology development has allowed for their exploration. One of the most common methods to explore the bed and extract gas is hydraulic fracturing process. In that method mixture of fluid and sand is used to output gas from the shale. The fluid under high pressure is pumped and crumbles the shales. Gas contained in the rock can go out through the cracks. Sand prevents to collapse the deposit and enables the extraction of the gas. Presently researches to replace sand by ceramic proppants have been carried out [5].

2. Experimental methodology

Ceramic slurries based on bauxite were investigated. The slurries consisted of water as a binder and CS, Duramax 3005, Dispex-N40 and Polikol deflocculant as an addition. Solid state content was 45 wt.%. Addition of deflocculant was 0.25 wt.% as an aqueous solution with respective to powder amount. The sample without additives as a reference was used. X-ray fluorescence (XRF) analysis were carried out to measure chemical composition. Bruker S4 Explorer X-ray fluorescent spectrometer was used. The spectrometer was equipped with a Rh tube with a copper anode, Cu, Pb and Al filters, 0.23°, 0.46°, 1°, and 2° collimators, and LiF200, Ge, PET, and XS-55 crystals. In order to determine the morphology of the powder SEM observation was done. The YAG BSE detector with 15 kV accelerating voltage were used. Grain size of the starting material by laser diffraction was made.

The slurries were prepared in air conditioned laboratory. The samples were made by mechanical stirrer. The rotation speed of the mixer was 300 RPM with 3 hours mixing time. To determine dynamic viscosity of the samples Rheometer MCR 102 (Anton Paar) was used. The measurement was carried out using the rotating spindle with 10-200 RPM. For good liquefaction the sample was mixed by the spindle for 10 s in 200 RPM.

3. Results

Bauxite is a kind of clay sedimentary rock. It consists of a large share of alumina [6]. To check the chemical composition of raw powder XRF spectroscopy was made. The results of the measurement are shown in Table 1.

Table 1.
Chemical composition of raw bauxite

Formula	Concentration
Al_2O_3	82.40
SiO_2	11.00
TiO_2	2.86
Fe_2O_3	1.75
CaO	0.76
SO_3	0.55
P_2O_5	0.47
ZrO_2	0.24

Large concentration, about 82%, of alumina was detected. Secondly, the most common composition in the sample was silicon dioxide. Moreover, titanium dioxide and other commonly occurring oxides were detected.

To show the morphology of the raw bauxite SEM observation were taken. Figure 1 shows the image of the investigated powder. The image presents small particles of the powder. There are few biggest particles observed in the image. The shape of the big particles is different than

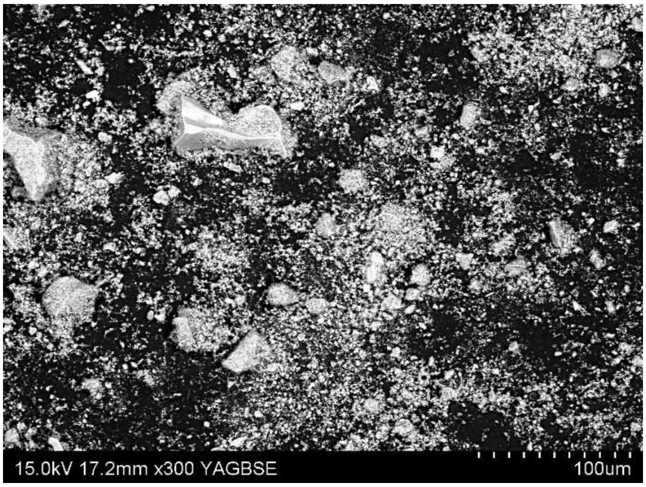

Fig. 1. The image of the investigated bauxite powder

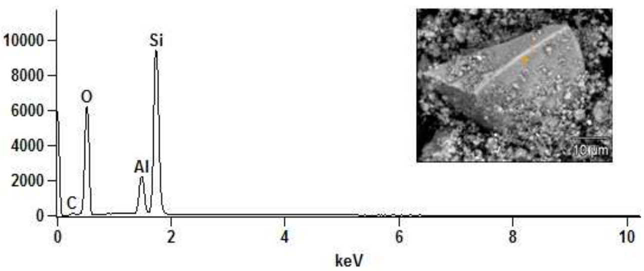

Fig. 2. EDS spectrum of unknown particle

smaller ones. The investigated particle and EDS spectrum are shown in Figure 2.

EDS diffraction shows that bigger than the rest, sharp ended, angular particles are silicon dioxides. Silicon dioxide particles were detected by XRF. EDS investigation and confirmed that besides alumina dioxide, silicon dioxide is the most common oxide in powder.

The study of the powder by laser diffraction allowed to obtain size distribution of the particles. The results are shown in Figure 3. Figure 3 presents the grain size distribution of the investigated powder. The diagram has bimodal character. Particles of characterized bauxite powder are in the range of 1-30µm and 30-230µm. Mean grain size is 35.48µm.

Figure 4 shows the diagram as a function of shear stress versus shear rate for tested ceramic slurries consists addition of different deflocculants. For low value of shear rate the attraction forces between slurry particles are higher than the hydrostatic pressure of the liquid sample. During measuring time and increase shear rate increasing of the share stress is observed.

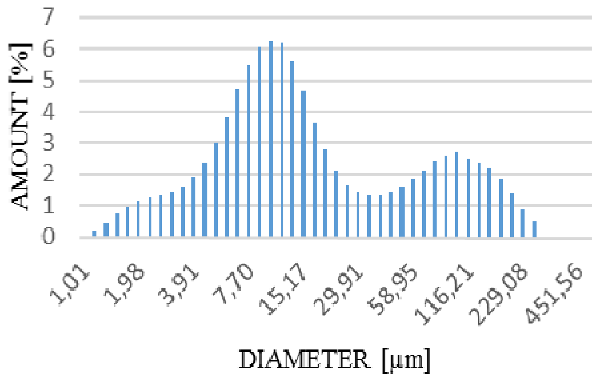

Fig. 3. Grain size of the raw bauxite powder

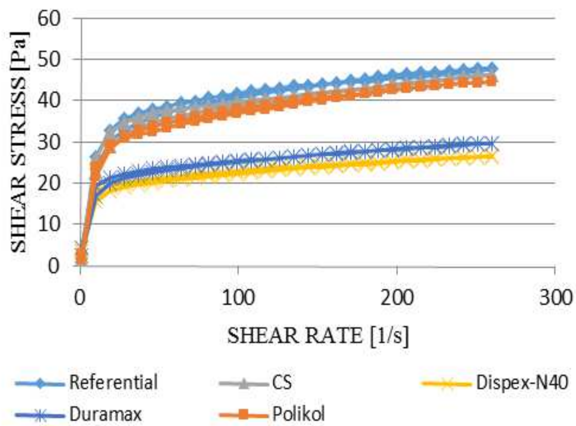

Fig. 4. Flow curves of shear stress vs. shear rate for tested bauxite ceramic slurries

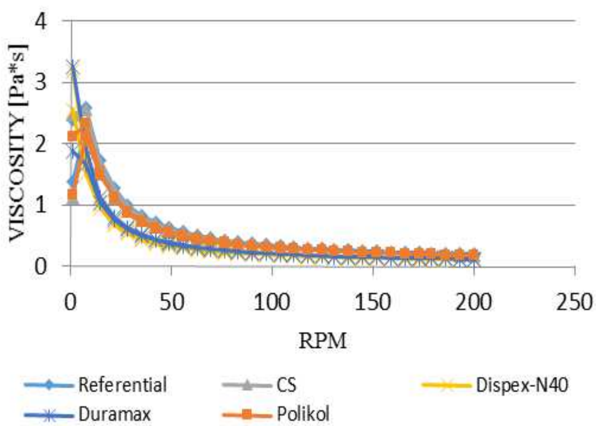

Fig. 5. Viscosity vs. RPM distribution of bauxite based ceramic slurries

It is observed that an addition of the Dispex-N40 deflocculant cases receive ceramic slurry with the lowest value of shear stress. Similar to Polikoland CS addition. Duramax also significantly decreases the value of the shear rate. Rheological properties were slightly lower than the referential.

Figure 5. presents the distribution of viscosity of the investigated ceramic slurries. For all measured samples decreasing of the viscosity in relation to increasing RPM is observed. After reached viscosity plateau it can be stated that the addition of Dispex-N40 gives the lowest value of viscosity. The viscosity of CS and referential are very similar.

4. Conclusions

Outcarried test proved that rheological parameter can be modified by deflocculant addition. This test allows to make ceramic slurries with higher solid phase content. Presented results show that obtained ceramic slurries based on bauxite are stable in time. The lowest rheological properties received by addition of 0.25 wt.% aqueous solution of Duramax 3005 and Dispex-N40. Those kinds of ceramic slurries could be used as additives in ceramic proppants production by a spray drying method.

Acknowledgements

Financial support of BLUE GAS financed from The National Centre for Research and Development-Project “Optimizing the lightweight high strength and low specific gravity ceramic proppants production technology maximally using naturally occurring Polish raw materials and fly ash”, No. BG1/BALTICPROPP/13 is gratefully acknowledged.

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