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Characterization of Aluminosilicates and Verification of Their Impact on Quality of Ceramic Proppants Intended for Shale Gas Output

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Abstract : Nowadays, the rapid growth of global energy consumption and uncontrolled depletion of natural resources become a serious problem. Shale rocks are the largest and potential global basins containing hydrocarbons, trapped in closed pores of the shale matrix. Regardless of the shales origin, mining conditions are extremely unfavourable due to high reservoir pressure, great depths, increased clay minerals content and limited permeability (nanoDarcy) of the rocks. Taking into consideration such geomechanical barriers, effective extraction of natural gas from shales with plastic zones demands effective operations. Actually, hydraulic fracturing is the most developed technique based on the injection of pressurized fluid into a wellbore, to initiate fractures propagation. However, a rapid drop of pressure after fluid suction to the ground induces a fracture closure and conductivity reduction. In order to minimize this risk, proppants should be applied. They are solid granules transported with hydraulic fluids to locate inside the rock. Proppants act as a prop for the closing fracture, thus gas migration to a borehole is effective. Quartz sands are commonly applied proppants only at shallow deposits (USA). Whereas, ceramic proppants are designed to meet rigorous downhole conditions to intensify output. Ceramic granules predominate with higher mechanical strength, stability in strong acidic environment, spherical shape and homogeneity as well. Quality of ceramic proppants is conditioned by raw materials selection. Aim of this study was to obtain the proppants from aluminosilicates (the kaolinite subgroup) and mix of minerals with a high alumina content. These loamy minerals contain a tubular and platy morphology that improves mechanical properties and reduces their specific weight. Moreover, they are distinguished by well-developed surface area, high porosity, fine particle size, superb dispersion and nontoxic properties - very crucial for particles consolidation into spherical and crush-resistant granules in mechanical granulation process. The aluminosilicates were mixed with water and natural organic binder to improve liquid-bridges and pores formation between particles. Afterward, the green proppants were subjected to sintering at high temperatures. Evaluation of the minerals utility was based on their particle size distribution (laser diffraction study) and thermal stability (thermogravimetry). Scanning Electron Microscopy was useful for morphology and shape identification combined with specific surface area measurement (BET). Chemical composition was verified by Energy Dispersive Spectroscopy and X-ray Fluorescence. Moreover, bulk density and specific weight were measured. Such comprehensive characterization of loamy materials confirmed their favourable impact on the proppants granulation. The sintered granules were analyzed by SEM to verify the surface topography and phase transitions after sintering. Pores distribution was identified by X-Ray Tomography. This method enabled also the simulation of proppants settlement in a fracture, while measurement of bulk density was essential to predict their amount to fill a well. Roundness coefficient was also evaluated, whereas impact on mining environment was identified by turbidity and solubility in acid - to indicate risk of the material decay in a well. The obtained outcomes confirmed a positive influence of the loamy minerals on ceramic proppants properties with respect to the strict norms. This research is perspective for higher quality proppants production with costs reduction.

Keywords : aluminosilicates, ceramic proppants, mechanical granulation, shale gas
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