3rd International Conference on Tomography of Materials and Structures
Lund, Sweden, 26-30 June 2017, ICTMS2017-55

CORRESPONDENCE OF IMAGE-BASED GRANULOMETRY TO SIEVE ANALYSIS

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Keywords: x-ray microtomography, image processing, proppant

Summary: Comparison between results of X-ray microtomography (microCT) studies, 2D photo analysis and sieving of proppant sand was carried out. Said techniques were applied for determination of particles size distribution and shape factors. Correlations of particles dimensions obtained by different methods were derived.

1. INTRODUCTION

Granular materials (sands or ceramic) injected into the artificially created fractures during hydraulic fracturing to keep them open are called proppant agents or proppants in the oil and gas industry [1]. The shape and size distribution of the proppant grains are among the key proppant properties that affect proppant pack permeability, which is one of the most important factors for hydrocarbons extraction using hydraulic fracturing. Thus, the quality control of the proppant shape and size characteristics is important for the success of well stimulation operation.

Oil and gas industry professionals had developed several standards for proppant grains characterization and quality control including optical microscopy and sieve analysis [2,3]. However, application of microCT technology for experimental studies of different processes happening in proppant pack (like single- and multiphase fluids flow, proppant grains crushing under stress, fines migration, etc.) requires development of procedures allowing translation of excessive information provided by microCT 3D images of particles into the nomenclature used in industry accepted standards.

In this work, we describe procedures allowing measurements of key proppant particles size and shape parameters using analysis of 2D grains images along with data obtained through the microCT studies at a level sufficient for comparison with sieve analysis.

2. EXPERIMENTAL METHOD

In the work being reported, several types of proppant sands were analyzed using three different techniques: 1) 3D microCT image processing 2) Sieve analysis 3) 2D photo image processing. MicroCT imaging experiments were performed using laboratory X-ray microCT system SkyScan 1172 (Bruker microCT).

The sieve analysis was performed using AS400 automatic sieve shaker manufactured by Retch. It measures the ability of grain to fit into the sieve opening of a known size. Discrete set of mesh sizes lets us obtain the distribution of proppant grain sizes corresponding the specific mesh size. The sieving procedure was carried out according to API RP 19D standard [2].

For the 2D image processing the proppant photos from a CCD camera with resolution of 12 MP were used. The 2D images were processed to study 2D contours and areas of grains to compare/correlate the obtained 2D attributes with the attributes obtained from the 3D microCT images. During the study, various types of sands having different grain size ranges (120-350, 200-600 and 400-1000 μm) were analyzed. The statistical analysis of the grains attributes obtained from the different techniques was carried out with the purpose to estimate correlations of the corresponding attributes obtained from the different methods, as well as the estimation of a consistency of the grain

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geometry model used to reconstruct a 3D grain from a 2D projection.

3. RESULTS

The results show good agreement between proppant characteristics obtained from the 3D microCT images, 2D photo images and sieve analysis (Fig.1). They show the consistency of the grain geometry model used to reconstruct a 3D grain from a 2D grain projection. The obtained results make it possible to consider the approach of proppant characterisation based of the 2D photo images as an express method of the proppants quality control.

References

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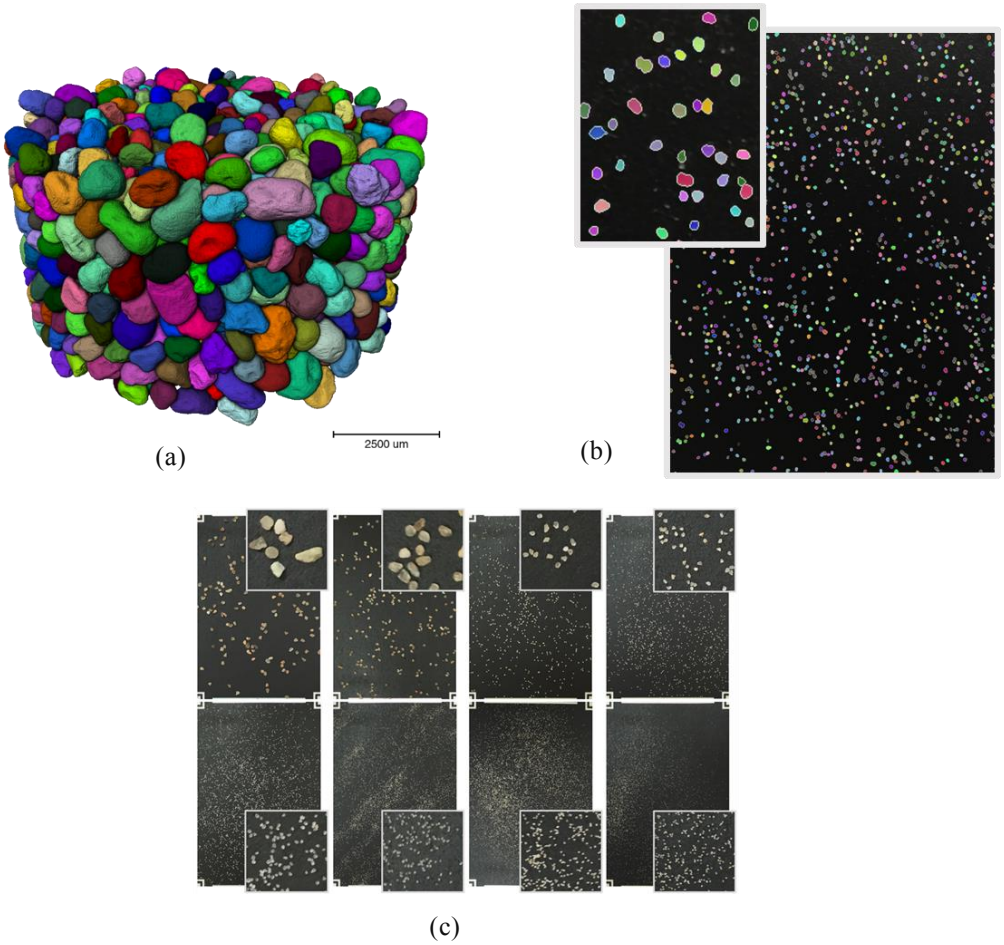

Figure 1: (a) 3D microCT image of a sand proppant grains; (b) 2D image of same proppant sand grains after segmentation algorithms application; (c) the variety of 2D images of studied proppant sands after sieving.