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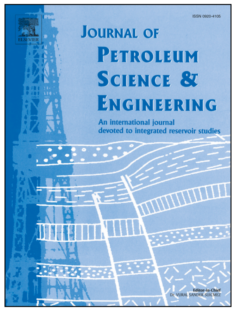

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A New Method for Mechanical Damage Characterization in Proppant Packs using Nuclear Magnetic Resonance Measurements

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Abstract

Proppant performance can significantly affect the success of hydraulic fracturing treatments and production in unconventional plays. Performance of proppants can decrease rapidly by mechanical damage. Quantifying the impact of mechanical damage on proppant performance can be challenging either in the laboratory or in-situ condition. This paper introduces a new method based on Nuclear Magnetic Resonance (NMR) Transverse relaxation (T_2) measurements to characterize pore-size distribution in proppant packs. Quantifying the pore-size distribution in proppant packs enables enhanced evaluation of porosity and conductivity of proppant packs and possible mechanical damage to the packs. The objectives of this paper are (a) to evaluate the performance of this new NMR-based method for characterizing pore structure of the proppant packs, and (b) to isolate and quantify the mechanical damage in proppant packs due to generating of fines in the laboratory using this new NMR-based method.

First, we prepared proppant pack test samples in three categories including (a) different types of proppants with different surface relaxivity, (b) mixture of proppants with different sizes, and (c) proppants undergone different levels of mechanical damage. We measured NMR response in proppant packs and quantified the impacts of proppant type, size, and mechanical damage on NMR T_2 distribution. Next, we used the fractional packing model to quantify the efficiency of packing of proppant mixture and to quantify the changes in porosity of in proppant packs caused by variation in size and fraction of fines. Finally, we used Kozeny-Carman (KC) equation and modified Schlumberger Doll Research (SDR) equation to correlate the variation in T_2 distribution to the decrease in proppant pack permeability.

Results showed that NMR T_2 distribution is sensitive to pore-size distribution in the proppant packs. The variable pore-size distribution was either a consequence of having a mixture of proppants with different sizes or different levels of mechanical damage. The impacts of fines on the pore-size distribution of the proppant packs was measureable, which is promising for the successful application of the introduced method for time-lapse quantification of generated fines. We also observed a measurable sensitivity of T_2 distribution to mechanical damage in the proppant packs, which enables quantifying the level of damage in proppants through quantifying pore structure in the proppant packs. The NMR T_2 measurements were, however, sensitive to the presence of paramagnetic materials such as iron in proppants. This sensitivity was more significant in cases

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