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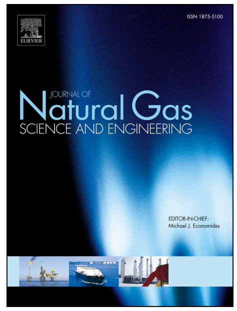

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Experimental and simulation study of foam stability and the effects on hydraulic fracture proppant placement

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Abstract

Foam has previously been used as fracturing fluid; however, there have not been enough study on foam stability and its effectiveness on proppant placement during hydraulic fracturing. In this paper, an experimental study was performed using free drainage method at 90°C. Then, the rheological characterisation of foam was produced based on dynamic foam quality change during foam drainage experiments and also based on viscosity breakdown by disproportionation. Subsequently, a 3-D hydraulically fracturing simulation was developed to evaluate the foam performance as a fracturing fluid using different vertical well scenarios. The results show that foam stability is dependent not only on the overall treatment time but also to fracture closure on proppant. For example, longer closure time accelerate proppant settling and accumulation at the bottom of the fracture, lowering propped area, and reducing productivity. The simulation results indicate that this lower productivity can be attributed to the final propped area, proppant distribution confirming the relationship between foam stability, foam rheology, proppant transport and fracture effectiveness.

Keywords: *Foam stability, Hydraulic Fracturing, Proppant Placement, Drainage*

Introduction

Foams were introduced as fracturing fluid in the early-1980s, and they have been extensively used in various liquid sensitive and depleted reservoirs where water-based fluids were less effective (Craft et al., 1992; Goelitz and Evertz, 1982; Wamock et al., 1985). It has been commonly reported that foams can achieve faster clean-up, low leak-off and less formation damage than conventional water-based fracturing fluids (Burke et al., 2011; Garbis and Taylor, 1986; Goelitz and Evertz, 1982; Harris, 1985; Toney and Mack, 1991). Other reported benefits include lower water consumption and reduced swabbing (Blauer and Kohlhaas, 1974; Gaydos and Harris, 1980). Increasing transportation costs in remote locations, storage costs and high surface pumping requirement have been identified as limitation of field application (Wanniarachchi et al., 2015). However, the main issue of using foam in hydraulic fracture treatments is foam stability, particularly in high temperature conditions that foam becomes more unstable (Fei et al., 2017). Because the ability of a foam to induce fracture and carry proppant, it is essential to maintain foam stability at high shear rates while pumping and low shear rates while fracture is closing. The failure of maintaining foam stability results in proppant screen-out either in the fracture or at the wellbore or inadequate proppant distribution in the targeted interval at fracture closure, based on inadequate foam stability and proppant redistribution during closure (Johnson, 1995).

In this paper, the workflow of different tasks is discussed in the next section. Then, different mechanisms of foam stability are reviewed followed by the details of the experimental procedure and results. Furthermore, foam characterization and rheological modelling are discussed followed by the results of 3-D simulation. Finally some conclusive remarks are presented.

Methodology

This study involved 3 major tasks; 1- Foam stability experiments; 2- Foam rheological characterization and 3- 3D hydraulically fracture simulation. The details of the workflow are shown