Rheological behavior of non-Newtonian fluids under quasi-static and shock wave loading

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The work is devoted to the study of behavior of viscoelastic surfactant solutions, which are used as a proppant-retaining fluid for hydraulic fracturing. Quasi-static experiments to determine the values of dynamic viscosity of fluids based on guar and viscoelastic surfactant (Surfogel D grade produced by JSC "Polyex") were carried out using a falling ball viscometer (Stokes method). Viscoelastic properties of liquids were studied using rheometers with measuring systems of "cone-plane" and "cylinder-cylinder", which implement shear deformations in liquid. It was found that a liquid based on a viscoelastic surfactant has stable rheological properties at wide range of strain rates. Shock-wave loading experiments of fluids based on guar and viscoelastic surfactant were carried out under the conditions of wire electroexplosion. From the experimental dependences of the free surface velocity, the values of compression pulse amplitudes and strain rate at the compression and rarefaction wave fronts at different distances from the explosion initiation site were calculated. The values of shear viscosity and shear strength of the studied fluids were determined from the velocity profiles. It was found that the studied fluids exhibit pseudoplastic (non-Newtonian) properties. The values of strength can be taken into account in the formation of cavitation bubbles in possible rarefaction zones in fracturing processes. Additionally, high-speed imaging made it possible to detect fluid oscillations around proppant particles during shock-wave propagation, caused by viscoelastic properties of the fluids.
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