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NORMAL STRESSES AT THE YIELDING POINT

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ABSTRACT

Normal stresses are found in most complex fluids, and yield strength materials are ubiquitous in nature and industries. These facts are the motivation of the present research, which aims to study normal stresses developed in shear flow for different yield strength materials, namely a Carbopol dispersion, a commercial hair gel, and a highly concentrated emulsion. The goal is to analyze the stress state required to cause yielding in yield strength materials when a shear load is imposed. A simple but efficient experimental protocol is introduced, using a commercial strain-controlled rheometer to measure the normal stresses while the fluid undergoes steady and transient shear rheological tests. Furthermore, the validity of the Von Mises criterion is checked for the materials tested in this study. The results of this study allow, for shear flow, the determination of the yield strength tensor, that is the stress tensor at the yielding point. It was observed that the initial state plays an important role in the normal stresses. Residual stresses were found to be responsible for the difficulty in reaching repetitive measurements. At low shear rates, values of normal stresses substantially higher than the shear yield strength are observed, for all yield strength materials investigated. In addition, for one of these materials, the measured normal stresses go from positive to negative values as the shear stress is varied from above to below the yield strength. The normal stress values for the Carpobol dispersion tested remained constant at low shear rates. Among other findings, it is observed that the time needed to reach a steady state is much longer for normal stresses than for the shear stress, as already stablished in the literature for polymeric liquids.