Flow Velocity and Effective Viscosity of a Fluid Containing Rigid Cylindrical Inclusions

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The determination of the flow properties of a fluid containing a cylindrical inclusion with its long axis oriented parallel to the vorticity direction is a 2-dimensional problem which is treated as a special case in a calculation of the corresponding D-dimensional problem. The velocity and pressure are obtained from the solution of the equations of hydrodynamics where D-dimensional multipole potential tensors are used. The effective viscosity of a dilute suspension is evaluted via the entropy production, as suggested by Einstein, and via an effective stress tensor. The relative change of the viscosity is proportional to the volume fraction. For $D = 2$ the proportionality factor Z is found to be 2 and 3 when the inclusion rotates with an angular velocity equal to the vorticity and when the inclusion does not rotate, repectively. The corresponding results for $D = 3$ are the well known number $Z = 2.5$ and $Z = 4$.

Key words: Effective Viscosity; Dispersion Rheology; Rigid Inclusion.