

FEM simulation of the rheometry of a non-linear viscoelastic fluid

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Silicone oils (PDMS) have many applications from fundamental research to industry, thus the measurement and modeling of their rheological parameters are essential in numerous fields.

The viscosity of silicone oils depends on shear rate and temperature, furthermore these materials have also elastic properties. These result in viscoelastic behaviour whose detailed understanding is necessary in more complex applications. For this purpose, the constitutive equation of the fluid is needed to be known. This contains material parameters which can be most accurately measured by rotational rheometers.

As the PDMS is a non-linear viscoelastic fluid, a mechanical stress perpendicular to the plane of the shear develops in the fluid's volume. As a result of this, the liquid creeps onto the measuring rod of the rheometer. This phenomenon is known as *Weissenberg-effect*. It was an important question for us, how much the creep affects the accuracy of the measurement, furthermore how accurately the 3-dimensional constitutive equations (*upper-convected Maxwell-model*) can describe the behaviour of the liquid at large deformations. The FEM simulation was implemented is *COMSOL Multiphysics 4.3b*.

The results of the simulation show that the free surface of the silicone oil agrees well with the surface that can be observed during the measuring process. This result supports the validity of the 3D model. We have also shown, that the viscoelastic stress changes the flow field such a way, that the changes of the torque on the different boundary surfaces of a concentric cylinder (CC) geometry almost cancel each other, thus their resultant sum only negligibly influences the accuracy of a rheological measurement.