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How MRI can assist Rheology?

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Introduction

Rheology is the study of the flow of matter in response to an applied force. The studied fluids are often complex and the standard macroscopic rheology analysis is not sufficient to understand certain phenomena associated with flow or material heterogeneities. A local rheology analysis is then crucial. In addition, the MRI technique is a convenient solution especially when the fluid is opaque. Here are three examples of application.

Thixotropic suspension

The study of non-Brownian fiber suspension rheometry in a Taylor-Couette device is done thanks to the velocity profiles obtained by MRI measurements (flow encoding spin-echo protocol). The local rheological data are acquired for different shear rates and volumetric factions.

Temperature and velocity measurements

The study of thermal transfer by conduction and convection represents a wide field of industrial and environmental applications. We investigate the possibility to measure velocity and temperature profiles with MRI in a fluid layer submitted to heat transfer.

Wall slip mechanism

We carried out a series of experiments with the aim of completing our knowledge of wall slip characteristics. The study is based on internal measurements of the velocity profile of inverse emulsion into a capillary tube. They are acquired using a flow encoding spin-echo protocol with in addition bipolar gradient pulses in order to encode the phase shift arising from the flow.

Temperature resolution : 1°C
Spacial resolution : 400µm

Glycerol (Newtonien fluid)
Conduction (T<sub>d</sub>)
Vertical stratification

Convection (T>d)
Rolls

Temperature
Velocity

Velocity profile
Inverse emulsion 75%

Average velocity profile at different flows

Slip velocity vs shear stress from IRM (8) and rheometer (4)

Linear variation of the velocity with the stress
At the approach of the yield stress value the velocity increases steeper = quadratic law
A change of both regime and physical process for wall slip when the yield stress fluid is in its liquid regime along the wall

Classical capillaries of different diameters (0.6 to 2 mm).

Micro-imaging probe (MicROE® Bruker)
Flow rate-controlled syringe