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To cite this version:
Maude Ferrari, M. Jenny, S. Kiesgen de Richter, Sebastien Leclerc, Christel Metivier, et al.. How MRI can assist Rheology?. ICMRM, Aug 2019, Paris, France. hal-02268195

HAL Id: hal-02268195
https://hal.univ-lorraine.fr/hal-02268195
Submitted on 20 Aug 2019

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How MRI can assist Rheology?

M. Ferrari¹, M. Jenny¹, S. Kiesgen De Richter¹, S. Leclerc³, C. Métivier¹, X. Zhang², P. Coussot²

¹LEMTA, Univ. de Lorraine, Nancy, France, ²Navier, Univ. Paris Est, Champs sur Marne, France.

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 fractions.

Temperature et 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.

- Velocity measurements: spin-echo imaging sequence + gradient dipolar
- Temperature measurements: T2 calibration

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.

Spatial resolution: 5µm

Average velocity profile at different flows

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

Flow direction

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

Micro-imaging probe (MicWB40) Bruker

Flow rate-controlled syringe

http://lemta.univ-lorraine.fr/  @ : Maude.Ferrari@univ-lorraine.fr