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Book review

Magnetoviscous Effects in Ferrofluids
S. Odenbach (Springer-Verlag, Berlin, Heidelberg, 2002)

During the last half century, research on magnetic liquids has been very productive in any fields. Strong efforts have been undertaken to synthetize stable suspensions of magnetic particles with different performances in magnetism, fluid mechanics or physical chemistry. Experimental and theoretical physicists and engineers gave significant contributions to ferrohydrodynamics and its applications. Ferrohydrodynamics concerns usually non-conducting liquids with magnetic properties and constitutes an entire field of physics close to magnetohydrodynamics but still different.

The present book is concerned with the influence of the magnetic field on the rheological behaviour of the liquid. After a short introduction and a presentation of ferrofluids, Chapter 3 introduces the magnetoviscous effects in highly diluted liquids. The experimental work of R.E. Rosensweig in 1969 and Shliomis' theory introducing the rotational viscosity are the starting points of this part. The author gives physical reasons for the change of viscosity under static electromagnetic fields and introduces the equations of the flow and the internal momentum relaxation. The fluid is assumed to be Newtonian and the Navier–Stokes equations are modified by new force densities due to the contributions of the magnetic field gradient and the internal couple distribution. The presentation of the ferrohydrodynamics Navier–Stokes equations may be insufficient for readers that are unfamiliar with generalized continuum media. This part ends with the negative viscosity phenomenon introduced by Shliomis and Morozov in 1994, which appears under alternating fields. In this chapter particle–particle interactions are neglected, so that the single particle model holds only for highly diluted suspensions. If the magnetic volume fraction is increased the interactions become significant for the rheological behaviour of the magnetic liquids. This situation is envisaged in Chapter 4. A full description of a system with magnetic interactions between the particles and in the presence of particle chains is too complex to achieve a rheological study. Therefore, assumptions have to be made to obtain a reduced model. This section focuses on the rheology of suspensions giving non-Newtonian behaviours. Shear stress/shear rate graphs, yield stress or viscosity change are obtained for different strengths of the applied magnetic field. A clear dependence between the field and viscoelastic properties is shown. This chapter leads to the last part (Chapter 5) dedicated to magnetorheological fluids. This term stands for liquids containing magnetic particles with a size of order of several microns. The volume concentration is usually high. These liquids show the Bingham behaviour. The yield stress depends of the applied magnetic field and it can be several orders larger than for ferrofluids.

It is clear that this work, as the title says, does not touch the whole domain of ferrohydrodynamics for which there is a satisfactory literature. Stefan Odenbach's book treats the rheological aspect of magnetic liquids submitted to a magnetic field and it is intended for students, engineers and scientists alike. Experimental results occupy a good place as well as the classical means used in rheometry and a detailed description of a specialized rheometer for the investigation of magnetoviscous effects in magnetic liquids. This book would be of interest not only for the people working in ferrohydrodynamics but also for the rheologists. The magnetic field allows a control of the microstructures and this property can be exploited in fundamental rheology. In spite of the critical remark about the ferrohydrodynamics Navier–Stokes equations, both the basic theory and the experimental approach are clearly presented, this should make the book very useful for students.

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