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CONFERENCE REPORTS

Magnetic fluids

3rd international conference on magnetic fluids
28–30 June 1983 at the University College of North Wales, Bangor, Wales

Magnetic fluids consist of colloidal suspensions of solid single domain magnetic particles in some carrier liquid such as a hydrocarbon, diester, water, mercury, etc. In order to prevent aggregation of the particles, the particles are kept small so that attractive magnetic forces between them are reduced to less than the thermal energy. The particles are also coated with polymer or long chain molecules to prevent aggregation due to van der Waals' forces. These fluids possess the usual properties of liquids and in addition have a number of unique properties because of their magnetisation. The presence of an external magnetic field causes the particles to move in the direction of highest field, imparting motion to the liquid as a whole, as would be expected of an intrinsic ferromagnetic liquid, which has yet to be discovered.

Because of the increasing importance of the fluids' technological applications in the last 18 years, widely dispersed research groups investigating the chemistry, physics, mechanics and applications of these fluids have been formed. However, it was realised a number of years ago that there was a lack of an active exchange of ideas and scientific information between these groups, as well as a need for discussions on future likely technological applications.

It was in 1977 that Dr B Berkovsky, now of the Institute of High Temperature, Moscow, USSR, organised, under the auspices of Unesco and the International Centre for Mechanical Sciences (CISM), Udine, Italy, an international advanced course on the thermomechanics of magnetic fluids at the International Centre in Udine. It was at this meeting that I had the pleasure and opportunity of presenting a paper on the work being carried out at Bangor on the physics and chemistry of magnetic fluids. This first meeting was so successful and fruitful that it was realised by the participants that future meetings must be arranged on some more permanent basis; this meeting became in essence the first international conference on magnetic fluids and as a result the second was arranged in the USA under the direction of Professor M Zahn, now of MIT, Boston, and Dr R E Rosensweig of Exxon, Linden, New Jersey. Evidence for the worldwide interest in the properties and technological applications of magnetic fluids was clearly reflected in the number of papers (40) and wide ranging topics presented by participants from all over the world.

The third international conference, held at Bangor, covered the following topics: magnetic fluid theory, measurements, physicochemistry, hydrodynamics, thermomechanics and applications. Forty eight papers were accepted for publication covering these topics and 60 participants from 16 countries attended the conference.

The opening invited paper was given by Professor E P Wohlfarth of Imperial College, London, on the subject of the magnetic properties of single-domain ferromagnetic particles and was followed by a number of short talks on the magnetic properties of the fluids, neutron scattering measurements and ultrasound experiments. Dr P C Schölten of Philips Research Laboratories, Eindhoven gave the invited paper at the commencement of the afternoon session. He discussed the factors which determine the upper limit of the magnetisation of magnetic fluids and made a prediction for this upper limit. This was followed by a couple of talks on the preparation of new magnetic liquids and a poster session which covered topics such as particle size analysis, magneto-optic experiments, Mössbauer spectroscopy, ultrasonic measurements and magnetic measurements.

The morning session on the second day was mainly devoted to magnetic fluid hydrodynamics – Dr R E Rosensweig gave an invited talk on 'Labyrinthine instability in magnetic and dielectric fluids' – and that of the final day covered applications and magnetic fluid theory. Magnetic fluids are currently used in vacuum and high-pressure rotary seals and feedthroughs, in loud-speakers and in damping systems. Other applications being studied include scrap separation, printers, display systems, bearings, switches and medical techniques. Mr R L Bailey of Ferrox Ltd talked about some of these lesser known applications and two very interesting papers on the use of magnetic fluids in high-speed quality printing were also presented. The afternoon session was devoted entirely to poster presentations about applications and magnetic fluid hydrodynamics.

Because of the comparatively small number of participants it was not necessary to run parallel sessions. This undoubtedly contributed to the success of the conference, enabling participants to attend all talks and poster sessions and still have time for fruitful discussions about new developments and possible collaboration in the future. The proceedings will be published in an issue of *Journal of Magnetism and Magnetic Materials* devoted entirely to the conference. A bibliography which includes references to 595 papers and books and 231 patents published largely since 1980 will be incorporated.

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Tribology of textile fibres

Friction of textile fibres
Institute of Physics (Tribology Group)
5 July 1983 at Imperial College, London

The frictional forces which are generated between textile fibres and between these fibres and other counterfaces are sensed directly by us all. The tactile properties of fabrics are largely governed by these forces; they provide the local restraints within the very complex assembly of fibres of the fabric which induce mechanical deformation of the fibres themselves. The gross deformation of the fabric is controlled by the interaction of these frictional forces and the mechanical properties of the fibres.

The term 'fibre' is a loose description which we may envisage as any unit whose length greatly exceeds its width. The basic unit is the single coherent monofilament and these units are drawn and twisted together with other monofilaments to produce a composite which is sometimes called a fibre. Several fibres are similarly combined to produce a yarn which is ultimately woven into a fabric. During these fabrication processes the magnitude of the friction between the fibres and the machine is an important factor in formulating the quality of the product. The control and prediction of the friction forces in these systems is therefore an important feature of the efficient production of textiles.

The science of friction in general is not well founded and our *a priori* predictive capacity is poor; much of what is useful has arisen from empiricism, and this is particularly the case for fibre systems where rather unusual problems arise. The short meeting held at Imperial College was an occasion to review some of these problems and add to our store of empirical results. While the subject is of general importance it is one of great speciality and hence the audience was rather small – about forty participants. There were four formal presentations.

The subject was introduced from a fundamental view and set in an historical context by Professor D Tabor (University of Cambridge), with emphasis upon unlubricated monofilament friction. Professor Tabor introduced the adhesion model of friction and used early data of his own to exemplify its use. The friction is thought of as arising from the shear of adhesive functions and these junctions are regarded as having an interface shear yield stress which is comparable with the bulk yield stress. The contact area is calculated using contact mechanics, which requires a knowledge of the deformation properties of the fibres under normal load as well as the contact geometry. The basic assumptions are that fibres are smooth and that the contact area is determined solely by the applied load. The interface shear stress is taken to have a constant value. This analysis leads to a relatively simple relationship which is able to describe the observed friction of fibres of various diameters over a wide range of loads. Professor Tabor emphasised the weakness of the classical approach and cited more recent work which accounts for surface roughness, the variation of the interface shear stress in the contact and the fact that in systems of this sort the adhesive forces may be comparable with the applied load. Simply, there is a finite contact area even for zero applied load. The more recent models which include these features improve our predictive capacity but the major trends may often be accounted for without recourse to these modifications. The recent work does however shed light on the complex nature of the friction process. Professor Tabor concluded with remarks on the influence of surface roughness and the role of lubricants in modifying friction which indicated the complex nature of all lubrication processes and served to highlight the scope for further study.

Mr A Winkler (Imperial College) presented a joint paper with M J Adams and B J Briscoe on the statistics of the friction of monofilament contacts. When a sliding velocity is imposed on a monofilament contact in an assembly the relative motion of the contact is discontinuous: stick–slip motion occurs. In an assembly of contacts the mean