J. Non-Newtonian Fluid Mech. 157 (2009) 145–146

Contents lists available at ScienceDirect

Journal of Non-Newtonian Fluid Mechanics

journal homepage: www.elsevier.com/locate/jnnfm

# Engineering the future of rheology within the UK

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ARTICLE INFO

*Keywords:*
British Society of Rheology
UK Rheology Review

ABSTRACT

This short communication reviews the past, current and future state of rheology within the UK. It is a personal view that predicts in the future there will be significant changes in UK rheology, mainly because of the way universities, industry and most of all funding agencies have changed their priorities in the area of science and engineering.



## 1. UK rheology in the 20th century

In the last 50 years rheology within the UK has enjoyed a high academic and technological status. The meaning of the word rheology is not easily understood by those outside the subject and consequently the subject has had an air of mystery to many. Rheology has however thrived and the British Society of Rheology (http://innfm.swan.ac.uk/bsr/frontend/home.asp) has formed a strong backbone to the subject's growth. This was matched, and to some extent surpassed, by the strength of the Society of Rheology (http://www.rheology.org/sor) in the USA. Both societies ensured that high academic standards were maintained and the emergence of polymers as a major commodity material also meant that rheology and its link with processing behaviour became a high priority for leading Petrochemical Companies.

With the discovery in the 1930s of commodity polymers such as Nylon and Polyethylene rheology has had an important part to play in the development of the plastics industry. The flow behaviour of high viscosity sticky fluids was no longer the sole domain of applied mathematicians. The subject became commercially important as well as mathematically fascinating. Viscoelasticity became a serious subject not only to the pure scientist but also the technologist too.

The 1950s to the late 1980s saw a golden age of free thinking rheology, which was happily funded by Universities and Research Councils as at the time rheology was one of the few areas in applied mathematics and physics where a direct pragmatic and useful connection with applied relevance could be made.

From the 1970s onwards the steady development of computers and mathematical numerical techniques has had a profound effect on applied mathematics and engineering in general. It became possible to mathematically solve complex engineering problems, where before only semi-analytic solutions existed, if at all. Rheology was a beneficiary of this movement to numerical solutions and the pioneering work of Marcel Crochet in commercialising the numerical code Polyflow (http://www.fluent.com/software/polyflow/) was a significant landmark. Using numerical codes it became possible to model complex fluid behaviour within complex flow situations.

In the 1970s companies such as Rheometrics (now TA instruments http://www.tainstruments.com) and others pioneered high resolution rheometers and an explosion of reliable rheological data appeared. Rheologically minded academics were also busy during this period evolving ever more complex constitutive equations to describe mainly polymer melt flow behaviour and the culmination of high level rheological data, new models and new numerical techniques resulted in the current ability to predict complex fluids in complex flows with at least engineering if not full scientific precision.

In the late 1980s the commercial position of the UK great Chemical Companies changed and with it their commercial interest in rheology. ICI transformed itself and both Shell and BP actively disengaged from substantial polymer activity. At the time only Unilever, with its strong interest in complex fluid foodstuffs, personal and home care, remained loyal in substantial support of rheology research in UK Universities. The tide was turning away from thermoplastic polymers, although the initiative of Prof. Tom McLeish at Leeds University to maintain interest in the link between molecular rheology and macroscopic properties of polymers should be acknowledged with the highest praise.

## 2. The current position

Government and its funding agencies have steadily moved in the direction of bio and with the ever increasing demands of new emerging subjects, rheology has become a not particularly glamorous area of science and engineering. There are of course many rheologically important aspects in relation to biological systems. Most of these involve low viscosities and so rheologists are

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doi:10.1016/j.jnnfm.2008.11.003

having to adapt to looking at rheological events for fluids with base viscosities closer to that of water than high viscosity polymer melts.

It has become increasing difficult to secure funding for fundamental rheological studies and whilst some UK Small Manufacturing Companies (SMEs) are at the vanguard of any remaining UK engineering innovation, they rarely have funds to support background research as they are fighting front line rheological and other problems that need to be solved the quick (and non-scientific way).

The current overall picture is of a fast changing environment. British-based Multinational industry disengaging from rheological activity. Universities under stringent economic pressure causing academic-based non-fashionable subjects to be squeezed out of the agenda. Grant giving organisations continue to relentlessly chase the nano, bio and medical words. All this combines to making rheology look rather quirky and unexciting.

## 3. The future of rheology

How can rheology move forward and remain resilient? Certainly the strengthening and emergence of the European Society of Rheology (ESR http://www.rheology-esr.org) is a major success story. There might not be critical rheological mass in any one European country alone, but there can be within Europe as a whole and this has to be a way forward for the future. Another crucial thing seems to be finding a way that rheology can maintain its specialist excellence, but still link with other subjects and topics. Certain biologists need rheology and we need to make the link. Certain medical applications need rheologists and we need to make the link. Certain Nano Scientists needs rheology and we need to make the link. If we cannot beat them, we should join them.

From a global point of view we should be optimistic that rheology will continue to have a sound future. From a European point of view there is still grounds for optimism, however the position in the UK is less clear. There needs to be a change of attitude at a high level recognising that in a knowledge-based society where technical innovation is required, rheology does still play an important and valuable part. Both experimentally and from a mathematical point of view rheology is a fascinating and intellectually challenging subject. We can only hope that in the future the UK Government, Industry and Universities will cease "chasing the dragon" in the way they are doing at present and return to a more measured and academic approach to subjects such as rheology.

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