Národní konference s mezinárodní úcastí

INŽENÝRSKÁ MECHANIKA 2002

13. – 16. 5. 2002, Svratka, Ceská republika

ON NON-MONOTONOUS BEHAVIOUR OF SHEAR-VISCOSITY FUNCTION

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Abstract: *The aim of this contribution is to propose a new phenomenological model enabling description of non-monotonicity of shear-viscosity function for rheologically complex fluids. The applicability of this model is discussed with the emphasis on the number of model parameters and experimentally examined.*

Key words: phenomenological models, apparent viscosity, shear thinning, shear thickening, telechelic polymers, associated polymers

Materials exhibiting both shear-thinning and shear-thickening behaviour have been recently intensively studied. However literature on modelling such behaviour is very scarce.

Phenomenological models describing flow curves of shear-thinning materials were discussed and further developed in Roberts et al.[4,5]. One of principal problems consists in a number of parameters appearing in the proposed model. Its number originally ranged - in the standard models (a list of several of them is given in the Scheme 1) – from two to four. Nevertheless with appearance of more sophisticated materials there is a necessity – for proper characterisation of their flow curves – of usage of multi-parametrical models. One example of these models is introduced in Roberts et al.[4] where 8-parametrical modified Ellis model is applied to experimental data covering various shear-thinning materials.

In the case of materials for which shear thickening appears, the above mentioned models cannot be used as these models represent in the diagram viscosity vs. shear rate decreasing functions with no possibility to model a local maximum. For this case the following 6-parametrical model is proposed

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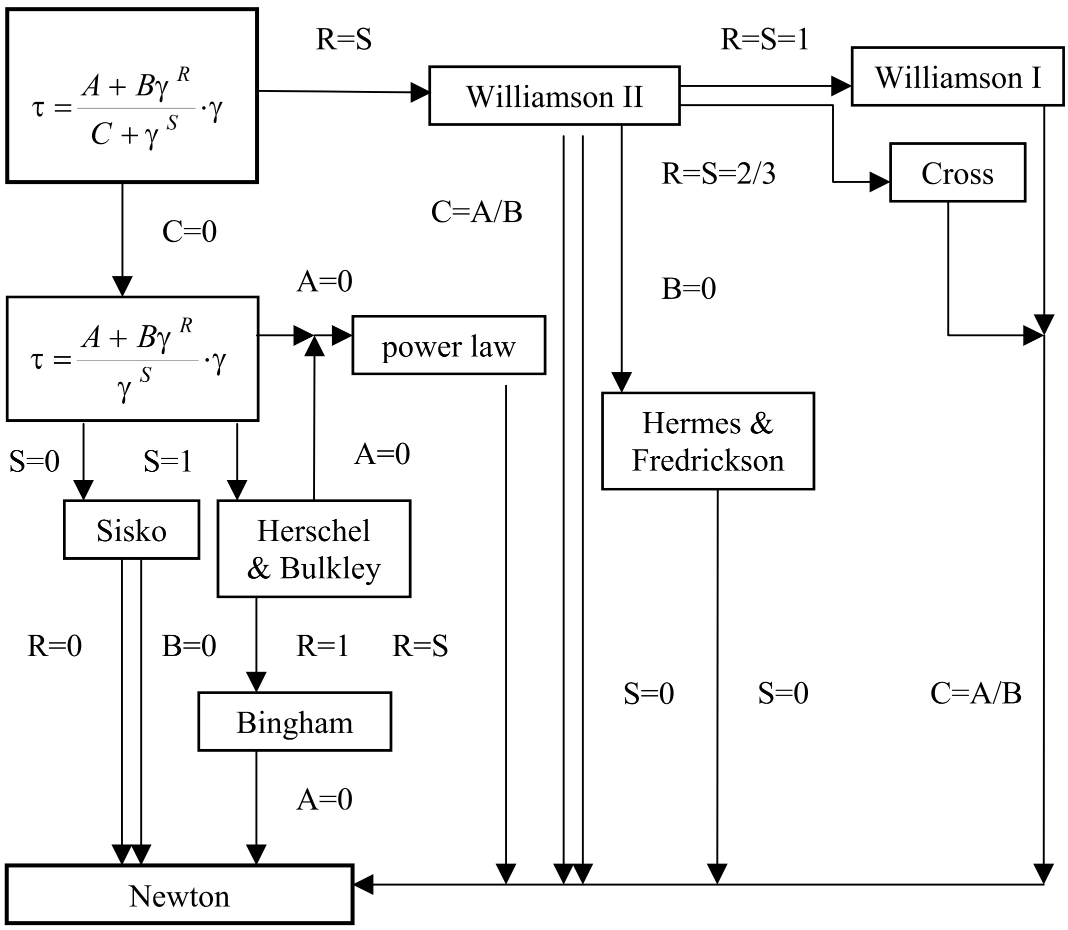
$$\eta = \frac{\eta_\infty \exp(f(\gamma;c,p,q)) + \eta_0 \exp(-f(\gamma;c,p,q))}{b + \exp(f(\gamma;c,p,q)) + \exp(-f(\gamma;c,p,q))} \quad , \qquad (1)$$

$$f(\gamma;c,p,q) = sign(c\gamma - 1)\cdot \left|\log(c\gamma)^p\right|^q \qquad (2)$$

where the non-negative parameters η_0 and η_∞ determine the first and second Newtonian plateau, respectively. The parameters c, p, q are supposed to be positive, proper choice of non-negative b results in the description of behaviour of shear-thinning materials, choice of b ($-2<b<0$) enables to describe non-monotonous course of shear viscosity (involving local maximum).



Scheme 1. Outline of standard phenomenological models.

The following rheograms depicting behaviour of various materials (experimental points of which were scanned from the figures in referred literature) are modelled by means of the above stated model. The individual flow curves are characterised by means of 6-parametrical relations (1,2), values of parameters are specified in the figure captions.

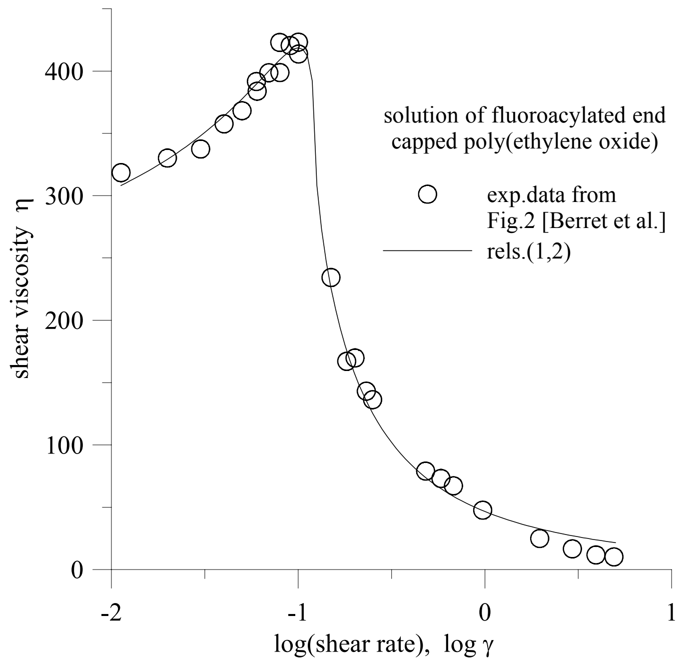


Fig.1 Application of rels.(1,2) to experimental data in Berret et al.[1]; parameters in rels.(1,2): η_0=180, η_∞=0, b=-1.51, c=8.3, p=1, q=0.5

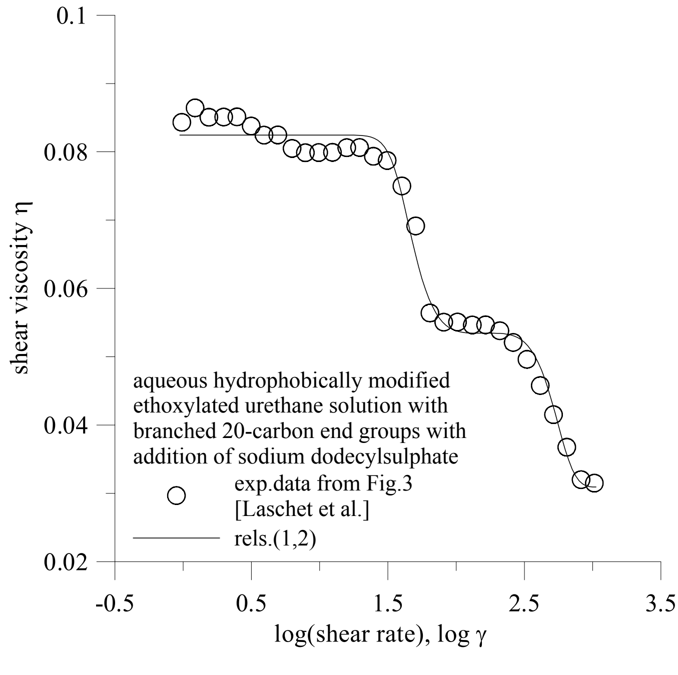


Fig.2 Application of rels.(1,2) to experimental data in Laschet et al.[2]; parameters in rels.(1,2): η_0=0.0825, η_∞=0.031, b=0.123, c=0.0062, p=1.66, q=4

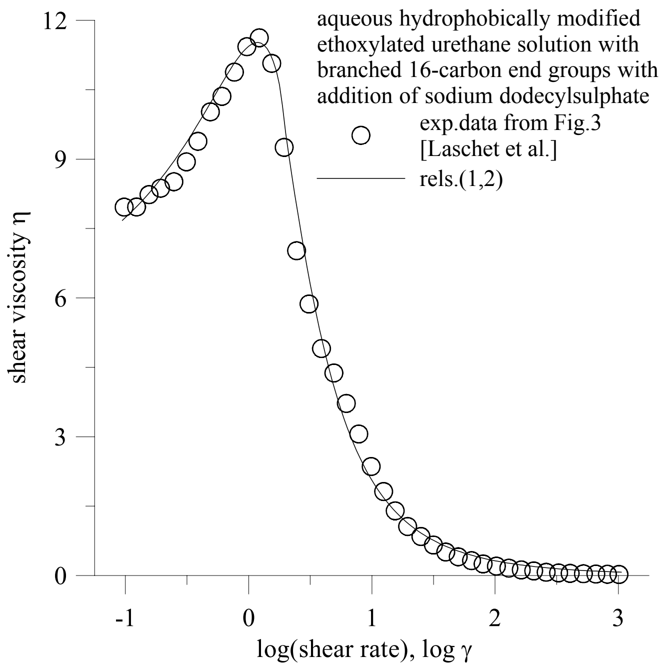


Fig.3 Application of rels.(1,2) to experimental data in Laschet et al.[2]; parameters in rels.(1,2): η_0=4.95, η_∞=0.007, b=-1.51, c=0.53, p=1, q=0.8

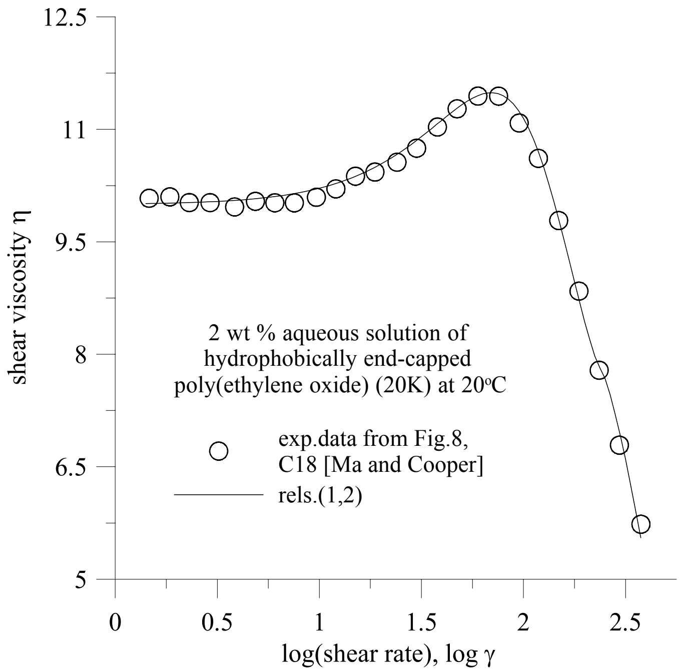


Fig.4 Application of rels.(1,2) to experimental data in Ma and Cooper [3]; parameters in rels.(1,2): η_0=10, η_∞=0, b=-0.72, c=0.0042, p=1.9, q=1.3

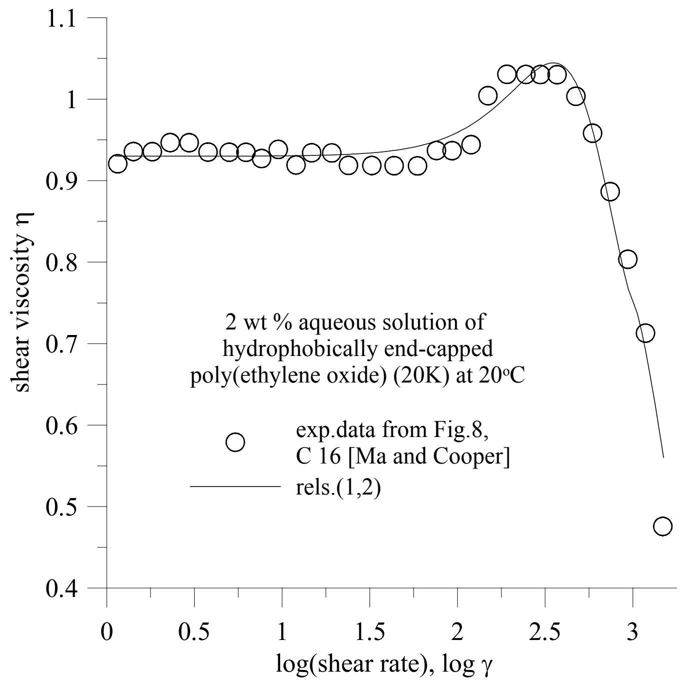


Fig.5 Application of rels.(1,2) to experimental data in Ma and Cooper [3]; parameters in rels.(1,2): η_0=0.93, η_∞=0.1, b=-0.63, c=0.001, p=2.3, q=1.3

Acknowledgement

The authors wish to acknowledge GA AS CR for the financial support of Grant No. A2060202.

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