Lawrence Berkeley National Laboratory

Recent Work

Title

Rheometer Strain and Strain-Rate Errors

Permalink

<https://escholarship.org/uc/item/7nn0m61v>

Authors

Giles, D.W.
Denn, M.M.

Publication Date

1990-05-01

Center for Advanced Materials

CAM

To be presented at the Golden Jubilee Meeting
of the British Society of Rheology and Third
European Rheology Conference, Edinburgh,
Scotland, September 3-7, 1990, and
to be published in the Proceedings

Rheometer Strain and Strain-Rate Errors

D.W. Giles and M.M. Denn

May 1990

For Reference

Not to be taken from this room

Materials and Chemical Sciences Division
Lawrence Berkeley Laboratory • University of California
ONE CYCLOTRON ROAD, BERKELEY, CA 94720 • (415) 486-4755

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

Rheometer Strain and Strain-Rate Errors

D.W. Giles and M.M. Denn

Department of Chemical Engineering
University of California

and

Center for Advanced Materials
Materials and Chemical Sciences Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

This work was supported by the Director, Office of Energy Research,
Office of Basic Energy Sciences, Materials Science Division of the
U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

For presentation at the Golden Jubilee Meeting of the British Society of Rheology and 3rd European Rheology Conference, Edinburgh, September 3 - 7, 1990. To appear in a volume of Extended Abstracts published by Elsevier.

RHEOMETER STRAIN AND STRAIN-RATE ERRORS

DAVID W. GILES and MORTON M. DENN

Center for Advanced Materials, Lawrence Berkeley Laboratory
and

Department of Chemical Engineering, University of California at Berkeley
Berkeley, CA 94720 USA

ABSTRACT

We have found systematic errors which can affect measured rheological properties in the instrumentation of two commercial rheometers. Users of commercial instrumentation should establish the extent to which these and similar errors may exist in their systems.

INTRODUCTION

We have found systematic errors in the operation of two commercial rheometers, the Rheometrics Mechanical Spectrometer Model 705M (*RMS*) and the Rheometrics Stress Rheometer Model 8600 (*RSR*). The errors appear to be inherent in the designs, though we do not know the extent to which such errors exist in other examples of these models or in similar rheometers produced by the same or other manufacturers. Users of commercial instrumentation should establish the extent to which these and similar errors may exist in their systems.

MECHANICAL SPECTROMETER

The error in the *RMS* is in the steady strain-rate drive system, which has an oscillatory component superimposed on the steady component. The oscillations are illustrated in Figs. 1a and 1b at strain rates of 0.001 and 0.01 s⁻¹, respectively, for a polydimethylsiloxane test fluid (code 040890) at 23°C. The measurements were carried out in the cone-and-plate geometry with 25mm platens and a 0.1 rad cone angle, using the 100 gm-cm transducer. The oscillation amplitude is about twelve percent of the mean

Figure 1. RMS measurement of stress vs time for PDMS at (a) 0.001 s^{-1} and (b) 0.01 s^{-1} . Note the changes in the time and stress axes.

stress in each case, and the stress is proportional to strain rate. The time axes are scaled by strain rate; the full scale is 1,000 s in Fig. 1a and 100 s in Fig. 1b, so the total strain is the same. The two experimental traces nearly superimpose on these axes, demonstrating that the error is in the rotational displacement, with a frequency proportional to the strain rate. It should be noted that the period of the oscillation is very small relative to the period of rotation of the platen.

An error of this magnitude will probably have little effect on the measured steady-state rheological properties of flexible-chain polymers, where the linear region can be quite large and oscillations of this type will average to zero. The effect on the measured properties of highly nonlinear materials, such as thermotropic liquid crystalline polymers, cannot be established without independent shear measurements that are truly steady. We do note that we have obtained overlap of RMS and RSR steady shear data for a fully-nematic liquid crystalline copolymer of 80% p-hydroxybenzoic acid and 20% poly(ethylene terephthalate) to within the apparent precisions of the two instruments as discussed here [1].

STRESS RHEOMETER

We have discussed the error in the strain measurement of the RSR in detail elsewhere [2]. A single, linear conversion is used at low rates to interpret the output of two independent strain sensors, each of which operates over a different angular range. This causes a position-dependent strain error which can be of order five percent. A position-dependent calibration can be developed.

ACKNOWLEDGMENT

This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Science Division of the U. S. Department of Energy under contract number DE-AC03-76SF00098.

REFERENCES

1. Kalika, D. S., Giles, D. W., and Denn, M. M. Shear and time-dependent rheology of a fully-nematic thermotropic liquid crystalline polymer, *J. Rheology*, 1990, 34, 139-154.
2. Giles, D. W. and Denn, M. M., Strain-measurement error in a constant-stress rheometer, *J. Rheology*, 1990, 34, in press.

LAWRENCE BERKELEY LABORATORY
CENTER FOR ADVANCED MATERIALS
1 CYCLOTRON ROAD
BERKELEY, CALIFORNIA 94720