

HIGH-PRESSURE RHEOLOGICAL MEASUREMENT METHODS: A REVIEW

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ABSTRACT:

A review of rheological in situ measurement techniques applied to liquids and soft solids at high pressures of more than 100 MPa is presented. The instruments reported in the literature fall into four groups: concentric cylinder rheometers, falling body and rolling ball viscometers, capillary viscometers and oscillatory systems. The measurement techniques are classified with respect to the possibility of carrying out an absolute measurement. Some typical experimental problems and error sources connected with high-pressure conditions are outlined and briefly discussed. The majority of the measurement techniques described in the literature are designed for the determination of the dynamic shear viscosity or viscosity function and only a few contributions report on the development of devices for the determination of other rheological parameters, e.g. normal stress differences or viscoelastic moduli.

ZUSAMMENFASSUNG:

Dieser Beitrag gibt einen Überblick über in-situ rheologische Messverfahren, die eine Anwendung für Untersuchungen von Flüssigkeiten und weichen Festkörpern bei Drucken höher als 100 MPa finden. Die in der Fachliteratur beschriebenen Instrumente lassen sich in vier Gruppen unterteilen: konzentrische Zylinderrheometer, Fallkörper- und Kugelrollviskosimeter, Kapillarviskosimeter und oszillatorische Messsysteme. Die Messverfahren werden hinsichtlich ihrer Eignung zur Durchführung einer absoluten Messung klassifiziert. Einige typische experimentelle Schwierigkeiten und Fehlerquellen, verbunden mit Hochdruckbedingungen, werden dargestellt und kurz diskutiert. Die meisten Beiträge berichten von Messverfahren, die sich für die Bestimmung der dynamischen Scherviskosität oder Viskositätsfunktion eignen. Die Literatur beschreibt nur wenige Methoden zur Bestimmung der anderen rheologischen Parametern, wie z. B. normale Spannungsdifferenzen oder viskoelastische Module.

RÉSUMÉ:

Une revue des techniques de mesures rhéologiques in-situ appliquées aux liquides et solides mous soumis à de hautes pressions supérieures à 100 MPa est présentée. Les instruments reportés dans la littérature sont répartis en 4 groupes: les rhéomètres à cylindres concentriques, les viscosimètres à corps tombant ou à boule roulante, les viscosimètres capillaires et les systèmes oscillatoires. Les techniques de mesure sont classifiées suivant leur possibilité d'opérer une mesure absolue. Des problèmes expérimentaux typiques, et les sources d'erreurs associées avec les conditions de haute pression sont soulignés et brièvement discutés. La majorité des techniques de mesure discutées dans la littérature est conçue pour la détermination de la viscosité dynamique de cisaillement ou d'un paramètre visqueux, et seulement quelques contributions relatent le développement d'instruments permettant la détermination d'autres paramètres rhéologiques comme par exemple les différences de contrainte normale ou les modules viscoélastiques.

KEY WORDS: high pressure, rheometer, viscometer, rheological measurement techniques

1 INTRODUCTION

As a principal thermodynamic variable, pressure influences in a basic manner the state of material systems. However, in comparison with the many publications dealing with the effect of temperature, the literature on high-pressure effects is very sparse. This is a consequence of the serious difficulties that must be overcome when managing high-pressure systems in the labora-

tory or, even more crucially, in industrial production. Nevertheless, in the last decade pressure has been recognized as a tool which offers unique possibilities in influencing molecular and cellular systems [10, 26, 38, 49]. One of the most prominent features of high pressure consists in modifying the rheological behaviour of matter. In turn, rheological properties belong to the important process parameters that influence

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