International Standard

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Fine bubble technology — Evaluation method for determining the shear viscosity of ultrafine bubble dispersions

Technologie des fines bulles — Méthode d'évaluation pour déterminer la viscosité en cisaillement dans les dispersions de bulles ultrafines

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Contents

Page

Foreword

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This document was prepared by Technical Committee ISO/TC *281*, *Fine bubble technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Ultrafine bubble dispersions are used in a wide range of applications such as wastewater/groundwater treatment, froth flotation, drag reduction, agriculture, and healthcare. Determining the fluid properties and dynamic behaviours of ultrafine bubble dispersions can help to achieve precise control of them. In practice, however, the interaction between the ultrafine bubbles and the liquid can change the flow field, thus affecting the drag forces. This leads to significant variations in the macroscopic mechanical properties, especially the shear viscosity, of the ultrafine bubble dispersions. Research has demonstrated that the presence of ultrafine bubbles can significantly reduce the viscosity of a matrix[1-3]. In some highly viscous matrices, this reduction can be as high as 90 %[3]. Furthermore, the extent of viscosity reduction depends on many factors such as shear rate, bubble content, and storage time, as detailed in Annex A and References, [2], [4] and [5].

Conventional shear viscosity measurement standards are not well suited for ultrafine bubble dispersions due to the special properties of ultrafine bubbles, such as strong hydrogen bonding, negatively charged, electrical double layers, hydrophobicity, adsorption, etc. Meanwhile, due to the sensitivity of gas solubility to pressure, the sample extraction and transfer specifications are different from those for pure materials or other multiphase fluids in general. Commonly used methods such as injection and stirring and mixing should be avoided as much as possible. Without considering the above issues, the measurement of the shear viscosity of ultrafine bubble dispersions can be questionable, and the results from different experiments can be incomparable and inconsistent. An inaccurate viscosity measurement will seriously affect the assessment of the flow process and flow state, which can involve all aspects of production, transport and application. Therefore, a standardized method for evaluating the shear viscosity of ultrafine bubble dispersions is of critical importance.

This document is intended to specify the evaluation method of shear viscosity of ultrafine bubble dispersions: parallel-plate rotational shear, cone-plate rotational shear, and coaxial-cylinder rotational shear, which have been selected from the methods most widely used in industry. In general, these rotational shear methods allow for a wide range of adjustable shear strengths, and they also provide a higher degree of measurement accuracy. Standardized measurement methods allow the measurement of the shear viscosity of a dispersion of ultrafine bubbles in different liquids, as well as a variety of shear behaviours such as steady state and oscillatory.

Fine bubble technology — Evaluation method for determining the shear viscosity of ultrafine bubble dispersions

1 Scope

This document specifies a method for evaluating the shear viscosity of ultrafine bubble (UFB) dispersions.

The method is based on any of the three measurement devices, namely parallel-plate rotational shear, cone-plate rotational shear and coaxial-cylinder rotational shear. The average effective shear viscosity of the ultrafine bubble dispersion is calculated from the measured stress (or strain rate) and the strain rate (or stress) applied to the sample. There are commercially available instruments based on these measurement methods in the market. This document applies to UFB produced using different methods of production.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3219-1, *Rheology — Part 1: Vocabulary and symbols for rotational and oscillatory rheometry*

ISO 3219-2, *Rheology — Part 2: General principles of rotational and oscillatory rheometry*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3219-1 and ISO 3219-2 and the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
matrix
liquid media containing ultrafine bubbles

3.2
generation time
running time of the bubble generator, which is positively correlated with the bubble content in the dispersion

3.3
storage time
time interval between the moment when the preparation of ultrafine bubble dispersion is completed and the moment when the test starts