DILATANT BEHAVIOR OF SYSTEMS WITH THE THIXOTROPIC AGENT AEROSIL 380 IN THE EPOXY RESIN ARALDITE GY260

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ABSTRACT
Model suspension with Aerosil 380 in epoxy resin Araldite GY260 and Aerosil 380 in silicone oil M20000 are compared. The systems with 7.5%, 10% and 12.5% Aerosil 380 in Araldite GY260 show shear thickening flow behavior. A shear induced hydrodynamic force effects at the onset of shear thickening a disorder of the well ordered movement of the Aerosil particles in layers. The Aerosil particles build-up a pseudo-mixture that lead to a sudden development of a three dimensional structure, i.e. to viscosity increase. One can assume that the shear thickening can be explained with an order-to-disorder transition. The viscosity increase of the shear thickening region is limited – It can reach topmost the plastic viscosity curve that has to be expected from the beginning. The dilatant system begins in the third straight line section to coincide the viscosity curve of the expected plastic system for the subsequent thixotropic agent concentration.

ZUSAMMENFASSUNG

RéSUMÉ
Des suspensions modèles de Aerosil 380 dans une résine epoxy Araldit GY260 et de Aerosil 380 dans une huile de silicone M20000 sont comparées. Les systèmes avec 7.5%, 10% et 12.5% d’Aerosil 380 dans l’Araldit Gy260 présentent un comportement rhéo-épaississant. Une force hydrodynamique induite par le cisaillement a pour effet, au commencement du comportement rhéo-épaississant, de désordonner le mouvement en couche bien ordonné des particules d’Aerosil. Celles-ci s’arrangent en un pseudo-mélange qui conduit au développement soudain d’une structure tri-dimensionnelle, et par suite à une augmentation de la viscosité. On peut expliquer ce “rhéo-épaississement” avec une transition order-désordre. Cette augmentation, dans la région de comportement rhéo-épaississant, est limitée. Au mieux, la viscosité peut rejoindre la courbe de viscosité plastique à laquelle on s’attend depuis le début. Le système dilatant commence dans la troisième section à coincider avec la courbe de viscosité du système plastique correspondant pour une telle concentration en agent thixotrope.

KEY-WORDS:
Dilatancy, order to disorder transition, limited viscosity increase

1 INTRODUCTION
Reynolds describes for the first time the so-called volumetric dilatancy. According to him, the liquid phase in a concentrated suspension fills out uniformly the space between the solid particles [1]. At low shear rates, friction within the system is slight because the liquid phase behaves as lubricant. At high shear rates, the uniform distribution of the solid particles is destroyed. The distance between the particles increases and the liquid phase can no longer fill out the space in-between. Consequently, the volume of the suspension increases - volumetric dilatancy.

According to Reiner dilatancy is much more complex than the explanation as deformation of volume expansion [2]. Bauer and Collins maintain that the appearance of dilatancy does not have to be necessarily preceded by an increase in volume [3]. On the other hand, according to...
development of a three dimensional structure. At a very special shear stress (12, 13 and 15 Pa for the suspension with 7.5%, 10% and 12.5% Aerosil 380 in Araldite GY 260) a shear induced hydrodynamical force effects a disorder of the well ordered movement of the particles in the layers. The Aerosil particles come to a kind of pseudo mixture, that leads to a suddenly development of the expected three dimensional structure, i.e. to viscosity increase. We can also assume that the shear thickening of the measured systems can be explained with an order to disorder transition.

This shear induced viscosity increase will happen stronger with rising Aerosil 380 concentration (see Fig.1). The viscosity increase of the shear thickening region (see viscosity curve of 10% Aerosil 380 in Araldite GY 260) is limited — it can reach topmost the plastic viscosity curve that has to be expected from the beginning (compare for example with the viscosity curve of 7.5% Aerosil 380 in M20000). Once reached the potential possibly three dimensional structure, the dilatant system begins in the third region to coincide the viscosity curve of the expected plastic system for the subsequent thixotropic agent concentration.

The dilatant viscosity increase of the suspension with 7.5% (4.31 Vol%) Aerosil 380 in Araldite GY 260 can not reach the viscosity curve of the directly comparable plastic system with 7.5% (3.57 Vol%) Aerosil 380 in M20000 (see Fig.9). The comparision of both suspensions is limited because they have different liquid phases.

The third straight line section of the suspension with 12.5% Aerosil 380 in Araldite GY 260 has higher values compared to the plastic system with 7.5% Aerosil 380 in M20000. The suspension with 12.5% Aerosil 380 in Araldite GY 260 is due to the high thixotropic agent concentration able to develop a shear induced structure, that corresponds to a plastic system with more than 7.5% Aerosil 380 in M20000.

4 SUMMARY

The dilatant systems with Aerosil 380 in Araldite GY 260 have in the first straight line region an unexpected low viscosity. Aerosil 380 acts in this region as a filler. The Aerosil particles are obviously in well ordered layers in the flow direction that makes difficult the development of a three dimensional structure. At a very special shear stress (between 12 and 15 Pa for the suspension with 7.5%, 10% and 12.5% Aerosil 380 in Araldite GY 260) a shear induced hydrodynamical force effects a disorder of the well ordered movement of the Aerosil particles in the layers. The Aerosil particles come to a kind of pseudo-mixture, that leads to a suddenly development of the expected three dimensional structure, i.e. to viscosity increase. We can also assume, that the shear thickening of the measured suspensions can be explained with an order to disorder transition.

The viscosity increase of the shear thickening region is limited: it can reach topmost the plastic viscosity curve that has to be expected from the beginning. Once reached the potential possibly three dimensional structure, the dilatant system begins in the third straight line section to coincide the viscosity curve of the expected plastic system for the subsequent thixotropic agent concentration.
REFERENCES