Yield Stress of Emulsions and Suspensions as Measured in Steady Shearing and in Oscillations

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Abstract:
The yield stresses of five samples (two highly concentrated emulsions, two Kaolin dispersions and mayonnaise) were determined in two ways. In one case, steady shear experiments were performed over a range of incrementally decreasing shear rates. The resulting flow curves, plotted as shear stress against shear rate, clearly showed the existence of a yield stress for each sample, the Herschel-Bulkley model being fitted to obtain values. In the second case, oscillatory amplitude sweeps were performed at three frequencies, and the "dynamic yield stress" was defined as the stress at which deviation from linearity occurred; this procedure has often been used to determine the yield stress of emulsions. It was found that the dynamic yield stress is frequency dependent, and cannot therefore be thought of as physically meaningful material property. At no frequency did the dynamic yield stress correlate with the yield stress obtained from the flow curves.

Zusammenfassung:
Die Fließgrenzen von fünf Proben (zwei hochkonzentrierte Emulsionen, zwei Kaolin-Dispersionen und Mayonnaise) wurden auf zweierlei Arten ermittelt. In einem Falle wurden stetige Scherversuche über eine Reihe von stetig abnehmenden Scherraten durchgeführt. Die sich ergebenden Fließkurven, dargestellt als Fließgrenze gegenüber der Scherrate, zeigten klar das Bestehen einer Fließgrenze für jede Probe, wobei das Herschel-Bulkley-Modell zur Errechnung der Werte angepasst wurde. Im zweiten Falle wurden oszillierende Amplitudensweeps bei drei Frequenzen durchgeführt, wobei die „dynamische Fließgrenze" definiert wurde als die Spannung, bei der eine Abweichung von der Linearität auftrat. Dieses Verfahren wurde oft für die Ermittlung der Fließgrenze von Emulsionen verwendet. Es wurde festgestellt, dass die dynamische Fließgrenze frequenzabhängig ist und daher nicht als sinnvolle Materialeigenschaft angesehen werden kann. Bei keiner Frequenz korrelierte die dynamische Fließgrenze mit der aus den Fließkurven hervorgehenden Fließgrenze.

Résumé:
La contrainte d'écoulement de cinq échantillons (deux émulsions à forte concentration, deux dispersions au Kaolin et une mayonnaise) a été déterminée de deux façons. Dans un cas, les expériences de cisaillement continu ont été effectuées sur une gamme de taux de cisaillement décroissants. Les courbes d'écoulement résultantes, tracées comme contrainte de cisaillement par rapport au taux de cisaillement, montrent clairement l'existence d'une contrainte d'écoulement dans chaque échantillon, le modèle Herschel-Burkley ayant été utilisé pour obtenir les valeurs. Dans le second cas on a effectué un balayage d'amplitude oscillatoire sur trois fréquences, et la « contrainte dynamique d'écoulement » a été définie comme la contrainte à laquelle avait lieu la déviation de la linéarité ; cette procédure a souvent été utilisée pour déterminer la contrainte d'écoulement des émulsions. On a trouvé que la contrainte dynamique d'écoulement dépend de la fréquence, et par conséquent ne peut pas être considérée comme une propriété physiquement signifiante du matériel. Sous aucune fréquence la contrainte dynamique d'écoulement a été en corrélation avec la contrainte d'écoulement obtenue des courbes d'écoulement.

Key words: yield stress, emulsions, kaolin, mayonnaise, flow curves, amplitude sweep

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4 CONCLUSION

Different visco-plastic materials – suspensions and emulsions – were studied in steady flow mode over a wide range of shear rates and in oscillatory mode with different amplitudes of stress (and strain) and at different frequencies. Flow curve measurements, which were carried out in the downward sweep mode of shearing, showed the existence of a yield stress which was obtained by the fitting of Herschel-Bulkley model.

It was demonstrated that the critical shear stress point estimated from oscillating regimes of deformation as the interception of two lines (corresponding to linear and non-linear domains) in stress against strain dependence, and sometimes considered as the "dynamic yield stress", depends on frequency and therefore cannot be treated as a point with some physical meaning. There is no correlation between the flow curve yield stress (which really reflects the physics of the visco-plastic nature of materials under study) and the dynamic yield stress, no matter at what frequency the latter has been measured.

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