The Influence of Thickener Addition on Filter Cake Formation During Dewatering of Mineral Suspensions

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Abstract:
A novel method to continuously measure the rate of build-up of an immobilised layer (apparent filter cake) was demonstrated for three mineral suspensions containing carboxymethyl cellulose and polymer latex. These suspensions were designed to be similar to those normally used as coating colours within the paper industry. The instrumentation was based on a rheometer equipped with units for controlling (and measuring) the normal forces acting on the rotating upper plate and precise measurements of the gap height in parallel–plate geometry. The bottom plate in the measurement cell was perforated and connected to vacuum, giving the driving pressure for flow through the filter. The technique should so far be taken as a qualitative, but is an attractive method for measuring filtration in thin films under controlled shear rate. The technique enables the apparent filter cake height to be calculated at any time during dewatering of the coating colours.

Zusammenfassung:
Eine neue Methode zur kontinuierlichen Messung des Aufbaus einer immobilisierten Schicht (scheinbarer Filterkuchen) wurde für drei Minearlsuspensionen, welche Carboxymethylcellulose und Kunststofflatex enthalten, aufgezeigt. Diese Suspensionen wurden so ausgelegt, dass sie ähnlich jenen sind, welche üblicherweise in der Papierindustrie als Beschichtungsfarben benutzt werden. Die Messapparatur bestand aus einem Rheometer, das mit Vorrichtungen ausgerüstet ist, welche zur Kontrolle (und Messung) der Normalkraefte dienen, die auf die rotierende obere Platte wirken und eine genaue Messung der Spaltweite in der Platte-Platte Geometrie ermöglichen. Die Bodenplatte in der Messzelle war perforiert und mit einer Vakuumkammer verbunden, welche den Antriebsdruck für die Strömung durch den Filter lieferte. Die Methode sollte zum jetzigen Zeitpunkt als eine qualitative angesehen werden, aber sie stellt ein vielversprechendes Verfahren zur Messung der Filtration in dünnen Filmen unter kontrollierter Scherrate dar. Die Technik erlaubt die Berechnung der scheinbaren Filterkuchendicke zu beliebigen Zeiten während der Trocknung auf den Beschichtungsfarben.

Résumé:
Une nouvelle méthode de mesurer le taux d'accroissement d'un lit immobilisé a été montrée pour trois suspensions minérales de différentes concentrations de carboxyméthylcellulose (CMC) et de latex styrène-butadiène. Les suspensions ont été étudiées au moyen d'un rhéomètre avec la possibilité de contrôler (et mesurer) les forces normales s'appliquant sur le plan supérieur dont l'élévation était précisément connue. Le plan bas de la cellule de mesure à disques parallèles était troué et relié à une pompe à vide, ainsi constituant une force motrice du flux à travers le filtre. La technique montrée dans cet article ne devrait pas encore être considérée comme plus qu'une méthode qualitative. Elle est quand même une méthode attractive pour obtenir d'information sur la vitesse de filtration à travers des gâteaux minces sous un taux de cisaillement contrôlé. Cette technique rend possible le calcul de l'épaisseur d'un gâteau apparent au cours de l'essai.

Key words: filter cake formation, immobilisation, carboxymethyl cellulose, paper coating colour, dewatering

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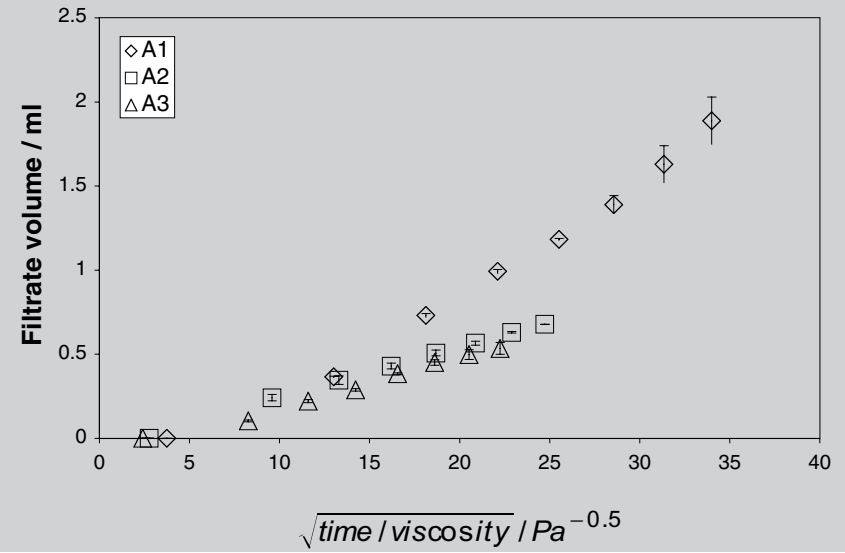

Figure 5: Filtrate volume versus $(t/\eta)^{1/2}$ for coating colours A1, A2 and A3.

obtained for A1, which may be explained in terms of the faster dewatering achieved with lower amount of co-binder (i.e. CMC). Furthermore, the difference in apparent cake thickness between coating colour A1 on the one hand and coating colours A2 and A3 on the other diminishes with time. The apparent cake thickness of coating colour A1 seems to reach a plateau value at about 0.54 mm, whereas the values for coating colours A2 and A3 are steadily increasing during the whole measurement.

3.3 FILTER CAKE STRUCTURE

The build-up of a thinner apparent filter cake at a certain time for the higher CMC-level may be understood with the lower initial dewatering rates observed for these coating colours. This effect is counteracted by less dense packing of material at high levels of CMC, giving higher apparent cake thickness with time. This will be discussed in terms of the filtration equation [11]:

$$V = \sqrt{\frac{2A^2}{Rv}\frac{(-\Delta P)t}{\eta}} \qquad (5)$$

In Eq. 5, V is the volume of filtrate that has passed in time t, A the total cross-sectional area of the filter cake, v the volume of cake deposited by unit volume of filtrate, η the viscosity of the filtrate and R a constant for the material. A plot of V versus $(t/\eta)^{1/2}$ in the same time interval as in Figs. 2 to 4 is shown in Figure 5.

For all three coating colours, the volume of filtrate varied approximately linearly with $(t/\eta)^{1/2}$, as predicted by filtration theory. If the structure of the filter cake had been identical for each level of CMC, all three curves would have fallen on the same line. However, coating colour A1 deviates significantly from the others, indicating that the volume of cake deposited per volume of filtrate and/or the specific resistance of the cake may be higher at high CMC levels. A higher resistance to break-up of the uppermost layer of immobilised material due to shear, that is delayed filter cake build-up [11], is also a plausible explanation to the steadily increasing apparent filter cake thickness values of coating colours A2 and A3 seen in Fig. 4. In the case of the less shear resistant coating colour A1, the plateau in Fig. 4 reached after approximately 300 s is explained as the net effect of filter cake build-up balanced by shear forces breaking down the immobilised layer.

Considering the initial dewatering rates given in Table 1 on the one hand and the results from the measurements of apparent cake thickness on the other there are fundamental differences in the dewatering behaviour between the three addition levels. There is no significant difference in initial dewatering rate between coating colours A1 and A2. However, Fig. 4 shows that the apparent filter cake build-up for coating colour A2 continues for a considerably longer period of time. A possible explanation for this might be the higher resistance to shear in the filter cake from coating colour A2. This is also indicated in Fig. 5, where the structure of coating colour A1 differs considerably from those of coating colours A2 and A3.

The reliability of the newly proposed method for *in situ* measurements of apparent filter cake height was supported by the good correlation between the initial dewatering rates observed by the new method, the immobilisation time by the ceramic plate method [9] and the dewatering rate by the pressurised static dewatering cell [5] as shown in Table 1. It should however be stressed that the strength of the proposed method is to give qualitative values of the thickness of thin immobilised layers. Such values are not easily attainable with other methods.

4 CONCLUSIONS

In measuring the rheological properties of calcium carbonate-based coating colours containing CMC by means of the immobilization cell, it was clear from visual observation that a filter cake consisting of immobilised solid material was formed on the Teflon filter base sheet. From the definition of shear stress in a parallel–plate geometry, a qualitative value for the thickness of

an apparent filter cake formed may be obtained. This novel technique is complementary of other measurement methods, such as NMR and ultrasound attenuation in the studying of dewatering and filter cake build-up. This method takes shear forces into consideration at thin applied layers. The thickness of the layers was typical for industrial coating processes. An increased addition level of water-soluble polymer seems to result in an immobilised layer of higher specific resistance.

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