VISCOSITY MEASUREMENTS ON POWDERS WITH A NEW VISCOMETER

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Abstract
At a closer look powder is found throughout all kind of industries. Dough and sugar in the food industry, pigments in the paint industry and drugs in the pharmaceutical industry, just to mention a few. Even though powder is obviously a common substance of a product or raw materials and therefore ingredients have to be handled as a powder, none or only little work has been done to characterize their flow properties. Probably the lack on suitable measuring devices gives reason for that. Therefore a new powder viscometer has been developed. Prior to the presentation of the achieved results from that new machine, an introduction to powder properties, examples for bulk materials in the industry and a comparison of adhesive forces in bulk materials will be given.

Kurzfassung
Pulver bzw. Schüttgüter sind bei näherer Betrachtung in zahlreichen Industriezweigen zu finden. Mehl und Zucker innerhalb der Lebensmittelindustrie, Pigmente in der Farbindustrie und Wirk- und Hilfsstoffe in der pharmazeutischen Industrie sind nur einige, hier erwähnte Beispiele. Obwohl Schüttgüter wesentliche Ausgangsstoffe von Produkten oder Rohstoffen sind und folglich wesentliche Inhaltsstoffe als Pulver gehandhabt werden, wurde kaum oder ein nur geringer Arbeitsaufwand auf die Charakterisierung der Fließeigenschaften investiert. Vielleicht liegt der Grund hierfür am Mangel an geeigneten Messgeräten. Infolgedessen wurde ein neues Pulverviskosimeter entwickelt. Bevor die erzielten Ergebnisse mittels neuen Gerätes präsentiert werden, wird einleitend auf Pulvereigenschaften, Beispiele von Schüttgütern in der Industrie und Kräfte in Schüttgütern eingegangen.

Résumé
A premiere vue, on trouve de la poudre dans toutes sortes d'industries. Les farines et le sucre dans l'industrie alimentaire, les pigments dans l'industrie des peintures et les médicaments dans l'industrie pharmaceutique, pour ne citer que quelques exemples. Même si la poudre apparaît comme une matière courante pour un produit ou en tant que matériaux bruts (qui doivent être manipulés comme des poudres), peu de travaux ont été entrepris afin de caractériser leurs propriétés d'écoulement. Sans doute le manque d'appareils de mesure adaptés en est la raison. C'est pourquoi un nouveau viscosimètre pour la caractérisation des poudres a été développé. Avant de présenter les résultats obtenus avec ce nouvel appareil, les propriétés des poudres seront introduites, des exemples de matériaux industriels seront présentés et une comparaison des forces d'adhésion dans les materiaux en volume sera donnée.

Key Words: new powder viscometer, flow rate, torque, particle size, inter-particular forces

1 INTRODUCTION

The quality of a product needs to be guaranteed from the very beginning of production. It cannot be generated or improved by inspections of the finished product. Qualified process parameters and raw materials are basic conditions for high-quality products. Critical process steps need to be optimized and validated already in the early stages. Raw materials for formulas are often bulk materials or powders which are moved in many different ways or have to flow. Here the flow behavior, the movement of the powder particles under the influence of gravitational force or the pressure drop are of special importance. The basis or background regarding the flow behavior of bulk materials are to be investigated with special emphasis on the following questions:

- How can powders be differentiated from fluids or solids?
- What properties of the powder influence their flow behavior?

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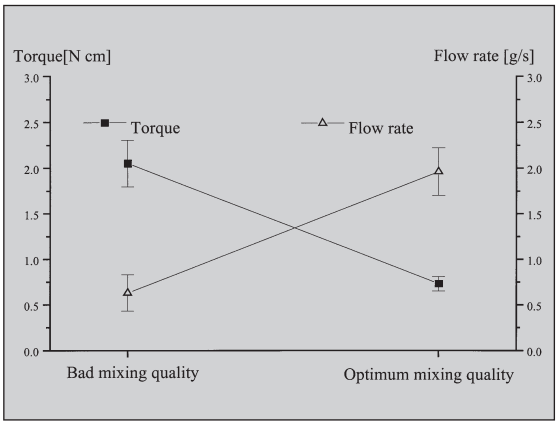

Figure 14 (left): Torque and outflow speed as a function of the mixing quality.

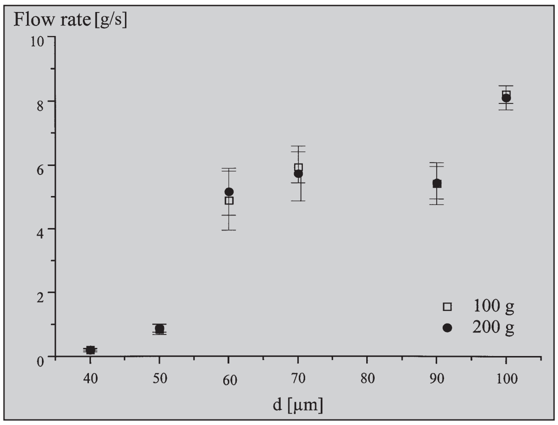

Figure 15: Flow rate of different sample volumes in dependence of the particle size.

4.2.4 FLOW RATE OF DIFFERENT PARTICLE SIZES IN DEPENDENCE OF THE SPEED

The flow rate depends on the properties of the bulk material like particle size and particle shape. The outflow rate of a particle size again depends of the speed of the stirrer (Fig. 13). At small average particle sizes and therefore high interparticular forces the bridge is not only stable but also quickly reforms. In the growing part of those curves bridges can form faster than they can be destroyed by the stirrer. Only at higher stirrer speeds can the optimum outflow speed for a certain particle size fraction can adjust. Consequently, information about the dynamics of the bridge formation in the hopper can be obtained by the relation between outflow speed and torque. The optimum stirring speed can be determined from the stirrer and the hopper which show analogue geometry in production.

4.2.5 CONTROL OF THE MIXING QUALITY WHEN ADDING FLOW PROMOTER

Another important parameter for the quality is the control of the mixing quality of bulk materials when flow promoter are added. The mixing quality can be tested with a powder viscometer because small differences in the flow of different bulk materials can be determined. Mixing time and quantity of flow promoter can thus be optimized. Comparing the torque and flow rate which are dependent upon a bad and an optimum mixing quality a trend can be recognized (Fig. 14). The sample with the optimum mixing quality flows faster out of the hopper. The torque and thus the interparticular interactions of this sample are lower than those of the sample with the bad mixing quality.

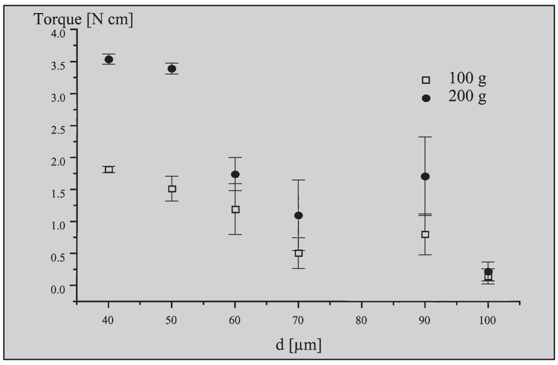

Figure 16: Torque of different sample volumes.

4.2.6 FLOW RATE AND TORQUE OF DIFFERENT SAMPLE VOLUMES

Fig. 15 shows the flow rate of different sample volumes as a function of the particle size. The different sample volumes have no significant influence on the flow rate.

The torque dependent upon the sample volume but only by specific particle sizes (Fig. 16). For cohesive bulk materials (*e.g.* 30 and 40 µm) a considerably higher torque has to be exerted for larger sample volumes than for freely flowing bulk material sizes. The assumption is confirmed that the quality and quantity of bridges in the bulk material increase with increasing interparticular forces respectively smaller particle sizes.

5 CONCLUSION

With the powder viscometer a simple, well reproducible and exact procedure for the description of the flow properties of bulk materials has been developed. The flow properties and also the interparticular forces are determined. The data registration allows also a determination of even small differences in the flow behavior. The flow differences are caused by the properties of the bulk material. Here the particle size, the shape factors of the individual particles as well as the changing portions of mixing parameters or the addition of flow promoter are here of importance. The specific investigations of influential parameters and interparticular forces in the bulk material allow exact actions for the improvement or the control of the flow behavior. With this knowledge optimum formulas can be developed e.g. by the specific selection of quantity and kind of flow promoter or by fixing the optimum mixing time.

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The powder viscometer is suitable to avoid production problems and can be used in research and development in order to obtain first experiences with a bulk material or in the quality control. The powder viscometer can also be used for further tasks. Tests can be performed in temperature or vacuum chambers in order to determine the influence of temperature, humidity, and vacuum on the flow behavior. First tests showed that the flow behavior of bulk materials worsens after heating.

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