The ball measuring system - a new rheometric tool to determine the flow curve of large particle material

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In an increasing field of application (natural hazards, construction material, drilling material for oil&gaz exploration, food) the determination of the flow curve of fluids containing large particles is required. By contrast, rheometric systems which enable to do so are few in number and often require large sample volumes but are limited in range of application and measuring accuracy.

The ball measuring system, installed in a conventional rheometer, is a new rheometric tool which enables the determination of the flow curve of large particle material up to 5 to 10mm grain size with 0.5 l sample volume only in a wide range of shear rates and shear stresses. It consists of an excentrically rotating sphere which is dragged across the sample material with defined rotational speeds by measuring the according torques. The relation between the drag flow around the measuring sphere and the defined shear flow, say the conversion of measured data (speed, torque) into rheological data (shear rate, shear stress) is the core of the present study: Applying Metzner-Otto theory the conversion was found for specific material groups (Newtonian material, Power Law material, Yield Stress material) in function of the sphere Reynolds number by investigating the specific materials in a conventional measuring system (reference system) as well as in the new system.

The relationship derived for the fine particulated yield stress material was then used for the investigation of different large particulated yield stress material (different coarsed and concentrated debris flow material). The results obtained with the ball measuring system were then compared with the results obtained by the use of existing rheometric systems for the flow curve and yield stress determination.

The comparison showed a relatively good agreement of the results obtained with the different systems. We therefore conclude that the ball measuring system is a useful robust tool to determine the flow curve of large particle material.

[1] Schatzmann, M.; Fischer, P.; Bezzola, G. R. Journal of Hydraulic Engineering 2003, 129, 796.
[2] Schatzmann, M.; Bezzola, G. R.; Minor, H. E.; Fischer, P. "The ball measuring system - a new method to determine debis-flow rheology?" 3rd International conference on debris-flow hazards mitigation: mechanics, prediction and assessment, 2003, Davos, Switzerland.