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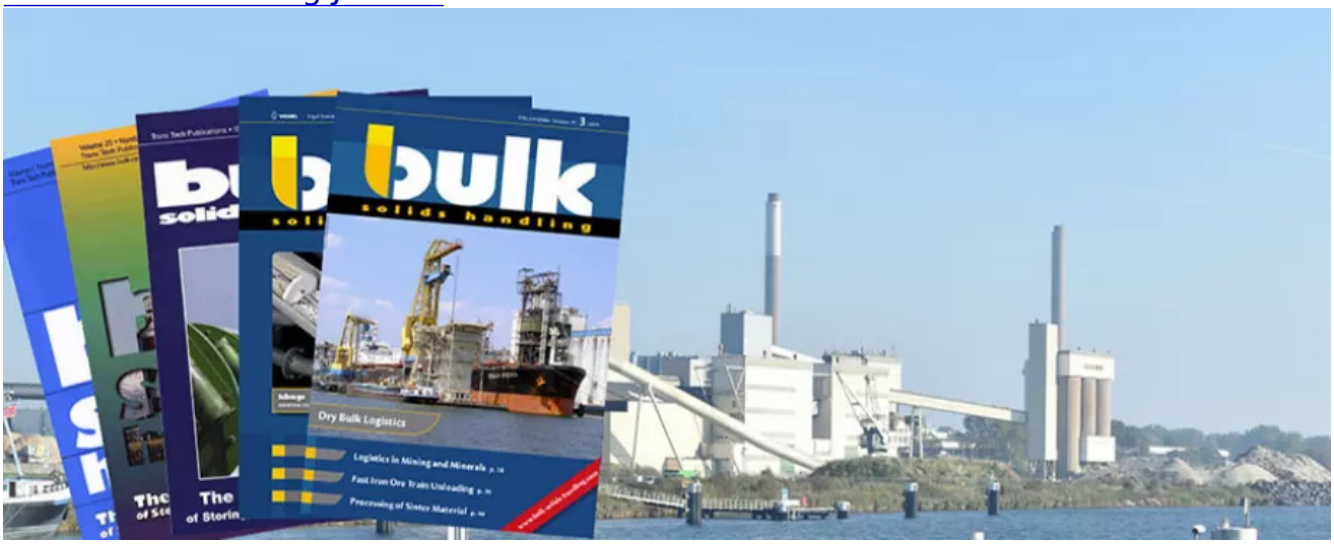

Forschungsbeitrag

Rapid Poiseuilie Flow of Granular Materials

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We solve the problem of rapid Poiseuille flow of a granular material in a pipe. The material is viewed as an incompressible continuum with a stress given by a Reiner-Rivlin type constitutive equation. Two material parameters appear in the constitutive equation. The magnitude of one of these parameters is related to the flow rate of the granular material in the pipe and the magnitude of an applied pressure gradient.

Recently Shahinpoor and Lin (1982) and Shahinpoor (1981) have analyzed the rapid couette flow of granular materials The granular material is viewed as an incompressible continuum with a stress given by a Reiner-Rivhn.

type constitutive equation McTigue (1978) had proposed that such a model may be appropriate for analyzing general flows of granular materials For a general Reiner-Rivhn material (granular material) two material functions appear in the constitutive equation for the stress (see Reiner (1945) and Rivhn (1948)) These functions depend on the principle invariants of the rate of deformation tensor Shahinpoor and Lin make explicit this dependence so that the stress is compatible with the experimental results of Bagnold (1954) They are able to solve the equations of motion for couette flow between concentric cylinders and by means of a simple experiment they determine one of two material parameters We investigate here the rapid Poiseuille flow of a granular material in a pipe and

illustrate how the magnitude of the remaining undetermined material parameter may be determined.

Poiseuille flows belong to a class of flows which Pipkin and Tanner (1974) call partially controllable viscometric flows Viscometric flows are ones in which each material element is undergoing a steady simple shearing motion plus possibly a rigid translation and rotation. These viscometric flows can be visualized as the sliding motion of a sheaf of inextensible material surfaces (see Lodge (1964), Pipkin (1967) and Yin and Pipkin (1970)) Partially controllable viscometric flows are viscometric flows in which the shape of the slip surfaces is known in advance, but their speeds depend on the form of a viscosity function (see Pipkin and Tanner (1972)) The important feature of these flows is that the normal stress distribution does not influence the velocity distribution Within this context the couette flow studied by Shahinpoor and Lin (1982) is a partially controllable viscometric flow The use of a viscometric flow to assess the validity of a given stress response is restrictive since two materials with different stress responses could behave kinematically the same in such a flow Nevertheless, if we assume that a given stress response is valid then we are at liberty to choose any flow whatsoever as a means of determining any unknown material parameters that can be determined The validity of our assumptions with regard to stress responses is to be ascertained by comparing theory with experiment for yet more general flows.