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Abstract

THE EFFECT OF TEMPERATURE ON FLOW PROPERTIES OF POWDERS

Supervisors
Prof. Massimo Poletto
Dr. Diego Barletta

Ph.D. student
Igino Tomasetta

Scientific Referee
Prof. Roberto Pantani

Ph.D. Course Coordinator
Prof. Paolo Ciambelli

Changes of cohesive flow properties of powders at high temperature are observed in many industrial process units, such as fluidized bed reactors, granulators and dryers. Many authors investigated the behaviour of powders at high temperature through fluidization experiments (Formisani *et al.*, 1998 and 2002; Lettieri *et al.*, 2000 a d 2001), measurements of the interparticle forces (Pagliai *et al.*, 2004 and 2007) and direct measurements at the bulk level (Kamiya *et al.*, 2002). However, the understanding of the effect of temperature on interparticle interactions and flow properties of bulk solid is not clear yet.

A common approach in engineering science consists of the direct characterization of the rheology of powders like bulk solids by means of shear cells. In this work a High Temperature Annular Shear Cell, originally designed at University of Salerno, was set-up and used to measure yield loci up to 500°C and to directly evaluate the effect of temperature on the macroscopic flow properties of sample of fluid cracking catalyst powder, fly ashes, corundum, synthetic porous α-alumina and glass beads.

Different behaviour was observed for each material. The flowability of the FCC powder, fly ashes and corundum did not show change as the temperature increased differently from glass beads and, at lower extent, porous alumina for which an increment of the cohesive behaviour was observed.

In order to give an interpretation of the effect of temperature on the interparticle interactions, a theoretical framework was developed according to the particle-particle approach of Rumpf (1974) and Molerus (1985 and 1993). Furthermore, the availability of a microscopic model able to estimate quantitatively the

interparticle interactions might extend the experimental findings to different compaction conditions, in particular lower than within the powder tester.

For this purpose, the tensile strength of the powder experimentally evaluated was related to contact forces acting between particles by coupling the Rumpf equation with the equation of the contact force. Only van der Waals' forces were assumed as present inside the bulk solid, according to DSC analysis performed in this work that revealed no melting points and formation of liquid bridges for all materials in the range of operating temperature.

With this regard two alternative assumptions of elastic or plastic deformation at the contact point of particles were considered. Both the assumptions provide correct order of magnitude results in terms of tensile strength, provided that a plausible value of the local curvature at contact points of particles is taken into account by correctly considering the effect of surface roughness and asperities, according to SEM magnification performed for all the materials.

A sensitivity analysis on the main parameters of the theoretical framework was performed. Both the increasing cohesive consolidation and the slight increase of the cohesive behaviour with the temperature suggest the occurrence of the plastic deformation of the contact points and, therefore, that the plastic deformation assumption should be adopted to explain the effect of the temperature on the interparticle interactions. However, at room temperature, the effect of consolidation seems to be correctly represented considering also the decrease of the voidage.

Finally, a significant increase of the macroscopic cohesive behaviour of powder with the temperature was measured in presence of a liquid phase which promoted the aggregation of the particles, as verified with shear tests and SEM magnifications performed on sample of glass beads mixed with the low-melting temperature high-density polyethylene (HDPE) powder.

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