Experimental study of the influence of particle concentration in gas-particle mixtures

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Gas-particle mixtures (PDC´s, plumes) are known to result from explosive volcanic eruptions, which can generally be differentiated into two end-members: dilute and dense gas particle mixtures [1]. In dilute flows the particles are carried by the turbulent gas and usually show concentrations around 1 %, whereas dense flows carry particle concentrations between 30 – 50 % [2]. Recent work by Cantero [3] suggests that the turbulence that is received in dilute flows is suppressed if the particle concentration is above a given threshold, because too much kinetic energy would be needed to maintain the particles in suspension. This issue was addressed through laboratory experiments on gas-particle mixtures. Therefore experiments were performed in a vertical tube (75 cm) with an underlying air flow system. Air runs in through a porous plate at the bottom and escapes through a grid at the top, whereas the particles are kept inside the tube (fig. 1). To simulate a gas-particle mixture glass beads of 75-80 µm were used as particles with varying concentrations from 0,5 vol.% to 20 vol.%. The particles were either injected incrementally during a run or stepwise between the runs. A high speed video camera was used to observe the experiments. To ensure that the flow conditions are turbulent, dimensionless numbers as the Reynolds number and the Stokes number were taken into account. The Reynolds number (*Re*) represents the ratio of inertial to viscous forces, the flow is turbulent when the inertial forces overcome the viscous forces, which is valid for $Re > 4000$. A turbulent flow typically produces circular currents which are known as eddies or vortices. The Stokes number (S_T) determines the coupling of the particles to the eddies formed by the gasphase and should yield values $S_T < 1$ to preserve turbulence [1]. The ratio U/Ut (terminal fall velocity) ~1 represents that the particles are maintained in suspension and indicates a stable gas-particle mixture for a certain flow velocity. In visual observations the addition of particles suggests that turbulence of the ascending air flow is significantly affected at particle concentrations larger than 5-10 %. This could implicate that volcanic gas-particle mixtures are not stable at intermediate conditions and that an entire range of particle concentration is not possible. A goal for further experiments is the investigation of larger particle concentrations as well as the finding of a precise particle concentration threshold for turbulent suppression. In later experiments this affection will also be investigated in lock-exchange experiments.

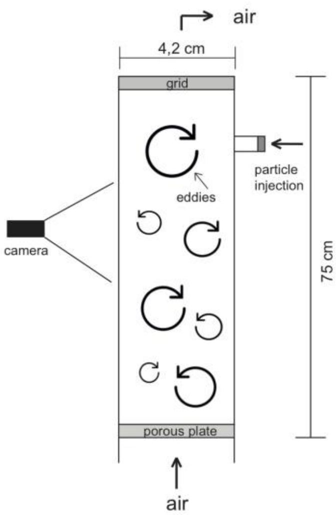

Figure 1 schematic sketch of experimental device

References

[1] A. Burgisser, W. Bergantz (2002), Reconciling pyroclastic flow and surge : the multiphase physics of pyroclastic density currents, *EPSL* (202) 405-418
[2] O. Roche (2015), Nature and velocity of pyroclastic density currents inferred from models of entrainment of substrate lithic clasts, *EPSL* (418) 115-125
[3] M.I. Cantero, M. Shringarpure, S. Balachandar (2012), Towards a universal criteria for turbulence suppression in dilute turbidity currents with non-cohesive sediments, *Geophys. Res. Lett.* (39) L14603