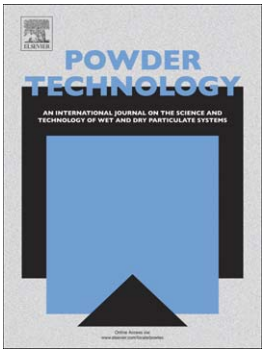

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PII: S0032-5910(16)30124-3
DOI: doi: 10.1016/j.powtec.2016.03.031
Reference: PTEC 11563

To appear in: *Powder Technology*

Received date: 1 December 2015
Revised date: 17 March 2016
Accepted date: 19 March 2016

Please cite this article as: R. Li, H. Yang, G. Zheng, B.F. Zhang, M.L. Fei, Q.C. Sun, Double speckle-visibility spectroscopy for the dynamics of a passive layer in a rotating drum, *Powder Technology* (2016), doi: 10.1016/j.powtec.2016.03.031

Double Speckle-Visibility Spectroscopy for the Dynamics of a Passive Layer in a Rotating Drum

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Abstract:

We design synchronized double speckle-visibility spectroscopy (SVS) equipment to measure the particle rearrangements within the passive layer of granular flows in a rotating drum. We determine that the particle rearrangements within the passive layer are triggered by granular avalanches occurring in the active layer. Particle rearrangements exhibit alternating small and large pairs, and a statistical analysis demonstrates that they satisfy a power-Gaussian distribution. Furthermore, it is determined that the spatial distribution of the granular temperatures within the passive layer is not symmetrical about the center of the drum, which is different from that in the active layer. These results indicate that particle rearrangements develop independently following a granular avalanche trigger. Both the granular temperature and rearrangement frequency increase with the increasing drum rotation speed, but the periodicity of the particle rearrangements becomes weak as the rotation speed increases.

Keywords: speckle-visibility spectroscopy; granular flows; granular temperature

1. Introduction

Granular flows in rotating drums are of wide interest, as they serve as model systems in the study of the physics of granular media. In the particular case where a drum is rotating at a relatively low speed [1], the granular flows can resemble an avalanche, or slumping, and provide a typical approach for investigating the mechanisms of debris flow and snow avalanches [2,3,4], resulting in the presentation of numerous models to date [5,6,7,8]. These models usually divide the granular bed in rotating drums into two parts: an active (or avalanche) layer and a passive layer directly below it [5, 7]. There have been a large number of theoretical and experimental studies of the active layer, while the passive layer has received very little attention, mainly as a consequence of the lack of an effective method to measure the tiny displacements of grains (typically less than 1/10 of the particle radius [9]) in a rotating drum.

Numerical simulations based on the discrete element method (DEM) have provided insight into the dynamics of the passive layer, which have not yet been observed in experimental measurements. Simulations by Yin *et al.* suggest that a granular temperature is produced in the active region and is transported to the passive region [10]. A numerical study on two-dimensional disk packing also suggested that the grains in the passive layer are deformable and can be rearranged if prescribed disturbances are applied [9]. In the simulation of the slumping cycle of wet grains in a rotating cylinder, Liu *et al.* [11] described the dynamics of the passive layer in