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Characterization of shear induced granular motion on regular substrates under laminar conditions

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We study experimentally the critical conditions for incipient motion of spherical particles deposited on a regular substrate under laminar flow conditions. The substrates are triangular and quadratic arrangements of identical glass spheres of same size. For the latter, the distance between the substrate spheres is varied, resulting in different partial shielding of the deposited particle to the shear flow. We found that for particle Reynolds numbers of order one and smaller, the critical Shields number is independent from the particle density and from the particle Reynolds numbers but it depends significantly on the geometry of the substrate. In addition, we studied how neighboring beads affect the onset of motion. We observed that, in stream-wise direction, only spheres that are closer than about 3 particle diameters influence incipient motion by shielding to the shear flow. Unlike for a single bead, we found the same critical Shields number for pair of identical beads deposited on different substrate geometries. However, we found different mechanism of motion, i.e. rolling or sliding, taking place in each of the configurations. We also observed that, if particle contact is avoided by a sudden jump in the Shields number, the critical Shields number for onset of continuous particle motion can be reduced considerably. Besides incipient motion we also study the particle motion along the substrate at supercritical Shields numbers and show how the substrate geometry also affects the mean velocity of the particle. The velocity appears to be a linear function of the supercritical Shields number for all the substrates. However, the slope of the curve strongly depends again on the substrate geometry. Taking data for different viscosities, particle densities and substrate geometries and based on ideas of Bagnold and Charru et al., we obtained a master curve between the particle velocity normalized by the Stokes settling velocity and the super critical Shields number.