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Experimental study of particle saltation motion in high Stokes number regimes for different basal roughness

Gaspard Minster (1,6), France Floc'h (2), Alexandre Valance (4), Nicolas Le Dantec (2,3), Amandine Nicolle (1,5), Benoit Zerr (1,6)

(1) ENSTA Bretagne, Brest, France (gaspard.minster@ensta-bretagne.org, amandine.nicolle@ensta-bretagne.fr, benoit.zerr@ensta-bretagne.fr), (2) Domaines Océaniques UMR 6538, UBO/IUEM (france.floch@univ-brest.fr), (3) CEREMA, DTecEMF, F-29280 Plouzané,France (nicolas.ledantec@univ-brest.fr), (4) Institut de Physique de Rennes,Rennes,France (alexandre.valance@univ-rennes1.fr) , (5) Station Biologique de Roscoff, Laboratoire Adaptation et Diversité en Milieu Marin (AD2M), UMR 7144, (6) Lab-STICC,UMR CNRS 6285, Brest France

We study experimentally the saltation motion of large particles in rapid shear turbulent flows. This study is motivated by the need to better characterize sediment transport in extreme flow conditions with regard to the installation of Hydrokinetic turbines on the sea bed at the site of "Raz-Blanchard" (France). This environment is submitted to one of the strongest tidal currents in the world (up to 12 knots during spring tide). Evidences of pebbles (diameter $\sim$ some cm) jumps at tens of centimeters above the bed have been obtained during previous field campaigns. The saltation motion of coarse particles flux may represent a constraint for the scaling of hydrokinetic turbines because they can damage the immerged turbines and associated devices. However, until now, the coarse particles charge over the turbines was not taken into account.

Experiments are carried in an open flume (40 cm wide, 60 cm height and 500 cm long). The hydraulic pump allows reaching high mean flow velocity up to 1.07m/s. We focus on the rolling and saltation motion in high Stokes number regimes (St=1000) on rough rigid bases. We used spherical glass particles from 1 to 5cm in diameter. Particle trajectories were recorded via a high speed video camera and mean quantities such as saltation height and saltation length were calculated over a minimum of 600 jumps. We considered 3 different basal roughnesses made of glued spherical particles with diameters d_b=1.2, 1.6, 3.6 cm respectively.

We determine a critical Shield number associated with the transition from rolling to saltation motion. Results show that the critical Shield number varies between 0.1 and 0.3 depending on the relative roughness, defined as the size of saltated particle relative to the size of bed particles. The jumps height and length increase with increasing fluid velocity and decrease with increasing relative roughness. The jump height can be inferred simply from the rebound velocity, meaning that the viscous forces play a negligible role in comparison with particle inertia for such high Stokes number. The restitution coefficient characterizing the rebound is shown to depend weakly on the impact angle and to decrease significantly with increasing relative roughness.

These experimental results will help to calibrate saltation models available in the literature and to derive robust and quantitative laws for the particle mass saltation flux under extreme conditions.