TUAT Fluid Dynamics Seminar

Turbulent air-jet impact on granular surfaces

Lecturer:

Post-doctoral researcher of Osaka University

Dr. Prasad Sonar

Date: Tuesday, 23rd May, 2023 / Time: 14:45 - 15:30

Place: Building 6 - Room201

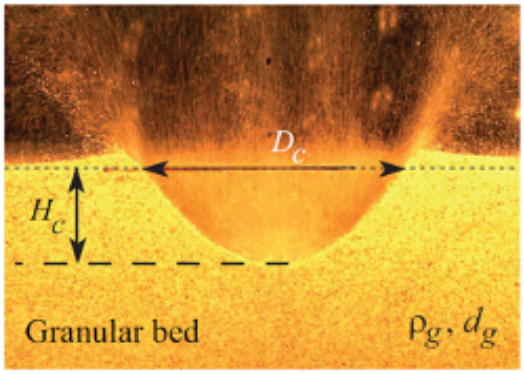
Biography

Prasad Sonar has been a post-doctoral researcher at the Earth and Space Science Department of Osaka University since December 2020. He received his M.Eng (Mechanical design) degree from BITS-Pilani, India, in 2012, and his Ph.D.(Mechanical) from IIT Kanpur, India, in 2019. During his Ph.D., he worked on simulating granular flows over vibrated bases, which have applications in construction, food processing, and pharmaceutical industries. At Osaka University, Prasad has experimentally studied the fluidized behavior of cohesive powders. Currently, he is investigating air-jet impacts on granular surfaces via experiments. Apart from this, Prasad is interested in wildlife, hiking, and playing football.

Abstract

Crater formation due to an impact is an extremely complex phenomenon. Jet-impact crater formation further involves the interaction between continuously impinging pressurized fluid and granular surface, which results in erosion of the surface, outward transportation of grains, and formation of bowl-shaped depression. The cratering process is dynamic, and the crater shape varies with the properties of eroding material and the impinging fluid. Landing rockets on planetary surfaces and erosion near hydraulic structures are some important examples relating to impact-induced cratering. Here, we consider the former application to focus on the cratering phenomenon that may cause problems during the landing and re-launching of rockets, like tilting of rockets, hardware damage to rocket bodies, etc.

We investigate crater morphology and thrust forces in a rocket landing scenario, where a turbulent air-jet impinges on the granular surfaces. To reveal the fundamental aspect of this phenomenon, systematic experiments are performed with various air velocities, nozzle positions, grain sizes, shapes, and densities. We characterize the crater morphology using an aspect ratio, $R_c = D_c/H_c$, where D_c and H_c are crater diameter and depth, respectively. As a result, we find R_c is governed by the product of $Mn = v_n/C$ and $G_n = d_n/h_n$, where v_n, C, d_n, h_n are air velocity at the nozzle, speed of sound in the air, nozzle diameter, and nozzle distance from the surface, respectively. We find that the non-dimensional thrust force is solely governed by M_n. These results suggest that the turbulent nature of air-jet mainly controls both the crater shape and thrust force. Moreover, we report a novel drop-shaped sub-surface cratering phenomenon.



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