Contribution ID: **574** Type: **Oral 20 Minutes**

Droplet impact and penetration on porous stones

Monday, 14 May 2018 10:05 (15 minutes)

Droplet impact on porous surfaces is a phenomenon of interest in several applications and is studied here in the context of wind-driven rain impacting building facades. The aim of the this work is understanding and controlling the droplet dynamics and penetration into the porous surface. Despite of the wide applications of this phenomenon, the studies in this field are mostly limited to the impact on impermeable surfaces so far.
During a heavy rain event, more and more droplets hit a porous surface, spread and get adsorbed. At some point, the porous material is saturated at its surface and the subsequent water droplets will lead to a water film to form on the surface [1]. This phenomenon is studied in this work in detail for different porous stones. The rain event is simulated using a train of droplets impacting at the same place, with definite time intervals. The water distribution inside the porous samples is obtained using neutron imaging at the Neutra beamline of the SINQ at Paul Scherer Institute (PSI), Villigen, Switzerland and the droplet impact dynamics is captured using shadowgraphy imaging with high speed camera. These two informations are combined together to understand the relation between the droplet spreading behavior, the moisture content at the surface and the water distribution within the porous stones during the train of impacting droplets.
It is found that the droplet spreading ratio increases with increasing surface moisture content, however this increment is different for each stone, depending on porosity, and pore size distribution, surface tension effects and energy dissipation on the wetted surface. An energy balance model for droplet impact on porous surfaces is proposed and the effect of moisture distribution inside the material on droplet spreading is determined. The model is compared with the experimental results showing good agreement. Moreover, the movement of wetting front inside the material is studied using the neutron images. It is seen that the water penetration into the stones depends mainly on impact velocity, but also a role of stone characteristics is identified. The water distribution inside the material cannot be considered neither as resulting from a uniform source, nor a point source.

References

[1] Lee, J. B., Radu, A. I., Vontobel, P., Derome, D., & Carmeliet, J. (2016). Absorption of impinging water droplet in porous stones. Journal of colloid and interface science, 471, 59-70.

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Session Classification: Parallel 1-F

Track Classification: MS 1.19: Interface driven processes in porous media