The Impact of Liquid Droplets on Granular Media

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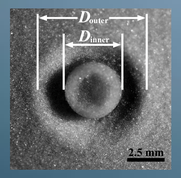
Introduction

The phenomenon of liquid droplets on granular media is a common scene in the environment. It has great importance in environmental sciences: water erosion of soil, formation of mud-rock flow, and acoustic behavior of soil are all a result of this phenomenon. In addition, industrial coating and printing apply the same mechanics. However, studies of this phenomenon are very rare. In the previous studies, the drop maximal extension Douter, was investigated by Delon to be scaled as We^0.25。. The studies of Nefzaoui mainly focus outer diameter of the crater and water droplets. But the relationship between the inner diameter and outer diameter, the effects of the physical properties of liquid is poorly explored. Thus, the goal of our project has established which is to explore this relationship.

Methods

The dynamics of impacts depend on the impact velocity of water droplets, the size of water droplets and the size of granular grains. We systematically varied these parameters and explore how these parameters modify the impact. Four different drop sizes: diameter equals 1.4 mm,2.6mm, 3.1mm, and 4.6 mm on 100 micrometer grains used in our experiments. Besides water, three other liquids at 20 degrees are listed in the following table. These liquids have a wide range of surface tension and viscosity, which can be used to test the dependence of the Douter scaling on different material properties.

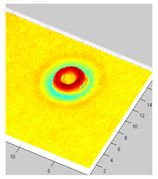
Drops were released from 0.65 cm to 201 cm by syringe pump. The outer diameter and inner diameter was measured by laser profilometr and analyzed by Matlab.



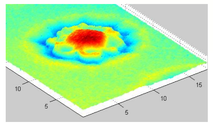
	Density (g/cm³)	Surface tension (mN·m⁻¹)	Viscosity (mPa·s)
Methanol	0.79	22.50	0.593
Water	1	72.86	1.002
Ethylene glycol	1.11	47.7	21.3
Water/Glycerol mixture (1:1 volume ratio)	1.15	68.08	8.40

Observation

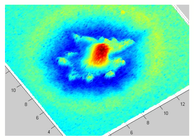
Static pictures and 3-D structure for carters caused by 3.1 mm water drop shown below. The morphology of inner part of sand ball gradually changes as releasing height increase.



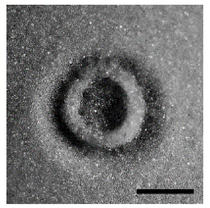
1.3 cm



55.9 cm



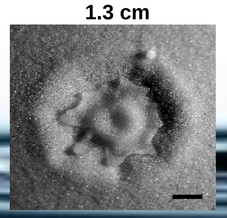
142.24 cm



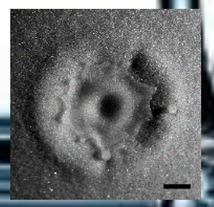
1.3 cm

12.7 cm

35.6 cm

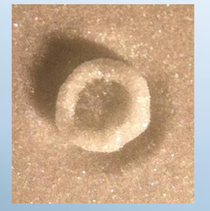


142.24 cm

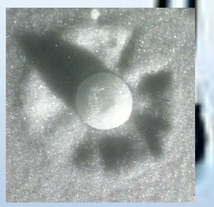


182.8 cm

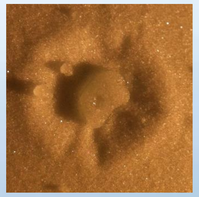
The static pictures shown below is the Crater morphology for three chemicals at different height.



Methanol , 1.3 cm



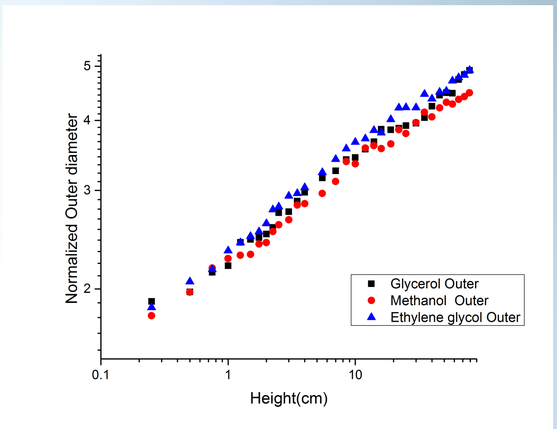
Water Glycerol mixture, 12.7 cm



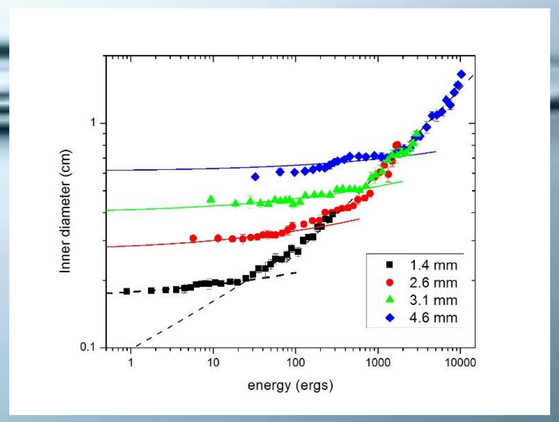
Methanol , 35.6 cm

Results

The outer diameter of three chemicals: methanol, glycerol water mixture, and ethylene glycol were plotted verses releasing height. The outer diameter followed the same trends and all have slope around 0.17. Although those chemicals have huge difference on viscosity. The results implies that the impact of drop on granular material is independent of viscosity of the liquids.



The inner diameter for four different water drop sizes plot versus the impact energy. The inner diameter increase slightly before the splash regime, and increase steeply after splashing. Before splashing, the inner diameter can be postulated by its outer diameter. The dash lines are postulation line. After splashing, the inner diameter follow the same line, grew as same polynomial function.



Selected Reference

1. A. L. Yarin, *Drop Impact Dynamics: Splashing, Spreading, Receding, Bouncing …*, Annu. Rev. Fluid Mech. 38, 159 (2006).
2. E. Nefzaoui and O. Skurtys, *Impact of a liquid drop on a granular medium:Inertia, viscosity and surface tension effects on the drop deformation*, Exp. Therm. Fluid Sci 41, 43 (2012).
3. H. Katsuragi, *Morphology Scaling of Drop Impact onto a Granular Layer*, Phys. Rev. Lett. 104, 218001 (2010).

Acknowledgement

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