# Drop impact close to a pore: experimental and numerical investigations

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**Abstract**
This work is motivated by the phenomena of drop impact onto a porous media. It is modeled experimentally as single drop impact onto a plates with an array of holes. The corresponding flow shows complex three-dimensional behaviour. This behaviour is explained using CFD simulations.

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## Introduction

Drop impact onto a dry or wetted interface is one of the elements of various industrial applications and one of the lovely topics of many research groups [1]. The phenomena of drop impact onto a smooth dry substrate is already well understood. The evolution of drop diameter is determined by the Reynolds number, Weber number and by the wettability [2]. The evolution of the dimensionless height of the lamella at the very initial stage is universal. It almost doesn't depend on the impact parameters [3]. At the later stages the lamella height is influenced by the flow in the near-wall viscous boundary layer [4].

Much less is known about the mechanisms of drop impact onto a porous plate, which is relevant to ink-jet printing, needle-less injection, rain-soil interaction, *etc*.

The main subject of the present experimental and numerical study is the investigation of a single drop impact onto a porous substrate. In order to get a better understanding of the physics behind the drop impact on porous media it is necessary to decompose the process into simple models. One of simplifying approaches is to model a porous media as a group of unconnected cylindrical vertical pores. Experiments on this setup have shown various interesting phenomena *e.g.* the development of a liquid-jet behind the pores. By further simplifying the model to a drop impact close to just one pore it is possible to investigate these phenomena in detail.

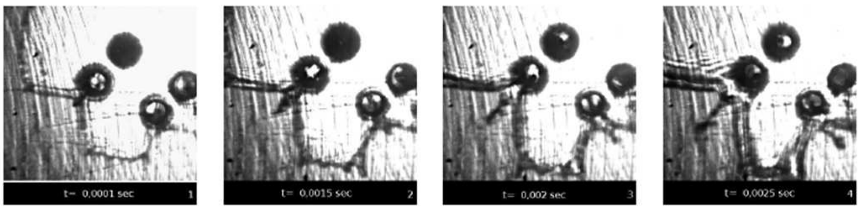


**Figure 1.** Example of a drop impact close to a group of pores

## Materials and Methods

The experimental setup for investigation of single drop impact and its spreading on a porous plates is shown in Fig.2. For the target, a plexiglas pad with a 1 mm pore was used. The Pictures were taken by a High-Speed Camera filming from below the plexiglas pad. The drops were created using a drop generator installed at various heights above the target to vary the impact velocity. In the experiments the distance between the impact axis and the holes, the size and the number of the holes are varied.

Additionally, drop impacts have been numerically simulated using the interFoam solver of OpenFOAM v1.6. InterFoam models a free surface flow with a volume of fluid (VoF) method based on a finite volume discretisation. The mesh used for the simulation (See figures 2b and 2c) consists of 2.8 million hexahedral cells and includes two major features to improve the efficiency of the computation. The computational domain is split to one fourth by introducing two symmetry planes. The mesh is built of stacked layers to ensure fine resolution of the flow in a liquid drop. The time discretisation is changed dynamically during the simulation to ensure a maximum Courant-number of 0.5.

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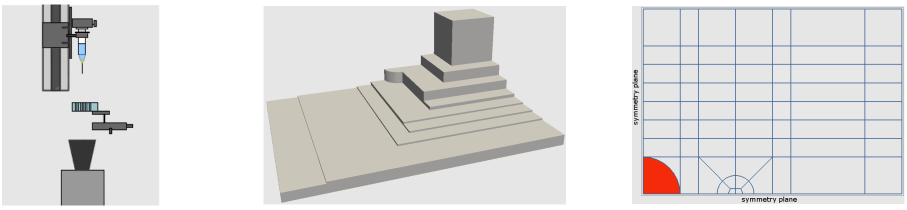


**Figure 2.** Left: Experimental setup; Middle: 2D-View of the mesh structure; Right: Surface view of the mesh used for the simulations. The drop impacts on the lower left corner

## Results and Discussion

Several interesting phenomena were observed, which do not occur during single drop impact onto a smooth substrate. One of these phenomena is the creation of a high-speed finger-like jet ahead of the spreading front behind the pore. This jet is shown in Fig.3. In Fig.3 the experiments are compared with the numerical simulations. The agreement is rather good.

However, the flow leading to the emergence of these jets cannot be easily observed in the experiments since the pore is covered by the liquid lamella. The mechanism of jet formation is explained solely from the numerical simulations. This mechanism is shown in detail in Figs.3. The flow in the lamella partially enters the hole and impacts the frontal part of the hole surface. This impact generates two main high-speed jets: one free uprising jet and the jet penetrating the porous media. The deviation of the spreading lamella and its acceleration towards the hole is probably caused by the very high shear stresses at the contact line released when the contact line passes over the hole.

## Conclusions

These experiments and numerical simulations show that the phenomena of drop impact onto a porous substrate is not so trivial as one could predict. It is reach of various phenomena. Some of them are investigated in this study.

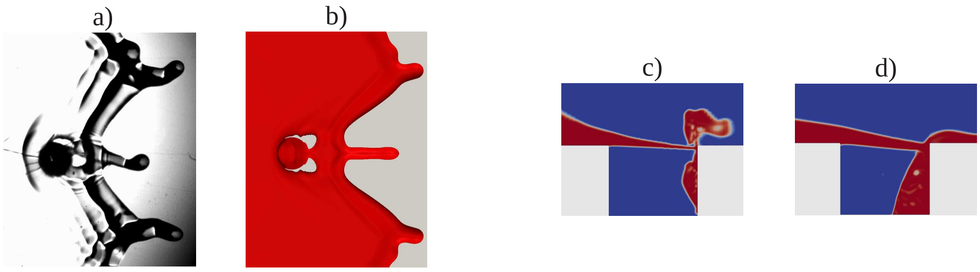


**Figure 3.** Topview of the drop impact: a) experimental result, b) numerical result. Side view: c) $t = 0.4$ ms, d) $t = 0.725$ ms

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