Elasto-capillary imbibition

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ABSTRACT

When two parallel plates separated by a small gap are dipped in a wetting liquid, the latter rises between the walls owing to capillary forces. The very common phenomenon of capillary imbibition occurs in various situations such as oil recovery, paper and food industries, construction materials, the feeding of animals and rise of sap in tall trees. The two classical results about capillary rise in a porous medium deal with the equilibrium height and rising dynamics of the liquid front. In the 18th century, the equilibrium height of a liquid front was shown to be inversely proportional to the size of the pores, a result known as Jurin's law. In the early 1900s, the wetting front was determined to progress as $t^{\frac{1}{2}}$ (at short times). While these laws are pretty robust, they fail in describing experimental results in a number of situations, in particular when the wicking medium is deformable.

In this communication, we report experimental work on capillary rise of wetting liquid between flexible plates. We show that the collapse of the imbibition cell under the negative hydrostatic pressure caused by the ascent enables liquid to rise without limit between the plates. The height of the rising front is found to increase with time as $t^{\frac{1}{3}}$, a characteristic of capillary imbibition in a wedge. The mechanical and geometrical characteristics of the imbibition cell set the shape of the wetting front and enable to predict wether a cell behaves as rigid or flexible.