Simulation of Droplet Impingement on Solid Surface by the Level Set Method and Phase Field Method

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Abstract

The simulation of multi-phase flow with moving interfaces is important in a wide range of applications, such as ink-jet printing, metal depositions, spray cooling, and biomedical engineering applications. Level Set and Phase Field methods are two well-known techniques for tracking the moving interfaces. Each model has its own strength and weakness. This paper compares the two surface tracking models in the simulation of droplet impingement process. The simulations are carried out by employing the Level Set and Phase Field models in COMSOL. The dynamic impingement processes is presented for a glycerin droplet impacting a non-wetting wax surface. The simulated spreading factor and apex height are compared with experimental results for the two surface tracking models.

Introduction

Figure .1 Droplet of Inkjet impact on paper

The droplet spreading height and radius are important for controlling accuracy for inkjet printing

Droplet Impingement

A glycerin droplet of a diameter of 2.45 mm impacts at 1.41 m/s

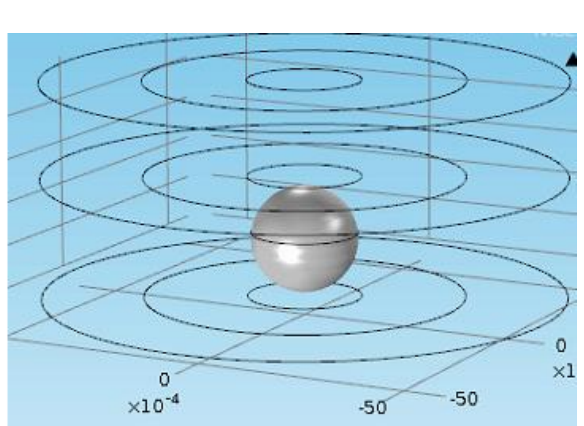
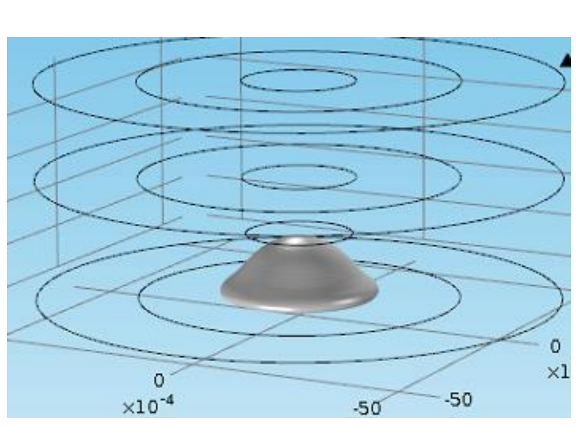


Figure.2 Droplet before impingement



The viscosity of droplet is 0.116 Pa·s, the density is 1220 kg/ m³, and surface tension is 0.063 N/m.

Figure.3 The spreading of Droplet

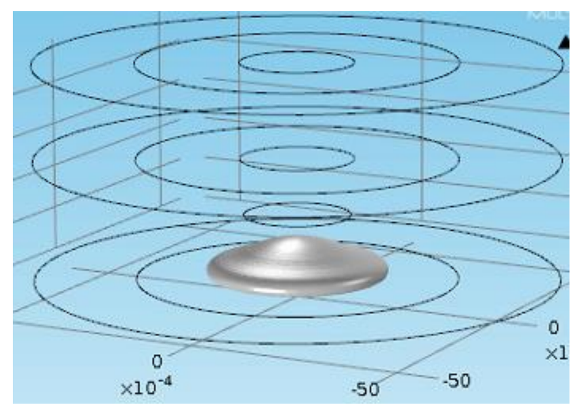


Figure.4 The process of spreading

This case shows a glycerin droplet impinges onto a wax surface with advancing and reverse contact angels as 97º and 90º.

The Reynolds number (Re), Weber number (We), and Ohnesorge number (Oh) for this case are: Re = 36, We = 94 and Oh = 0.27.

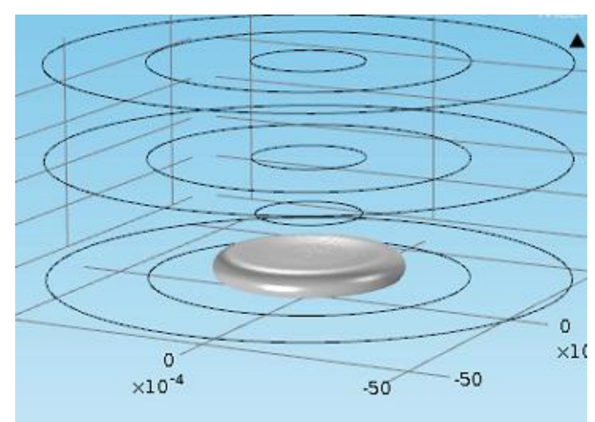


Figure.5 The process of spreading

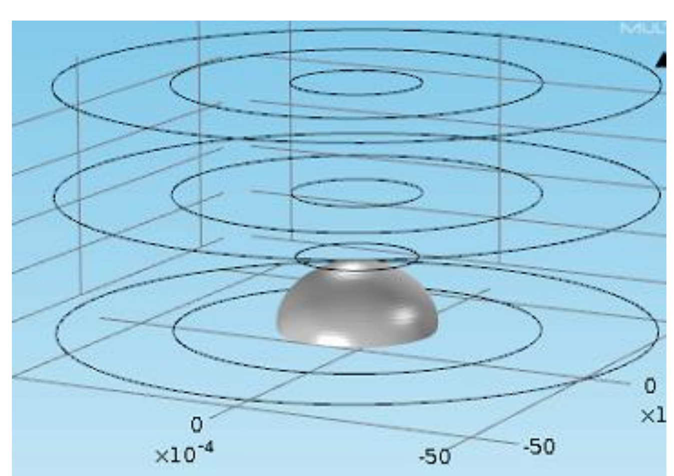


Figure.6 The process of rebounding

Velocity fields

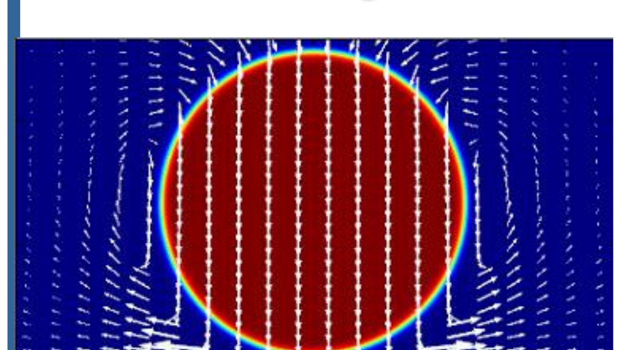


Figure. 7 The velocity field in the droplet and surrounding air at 0.1 ms

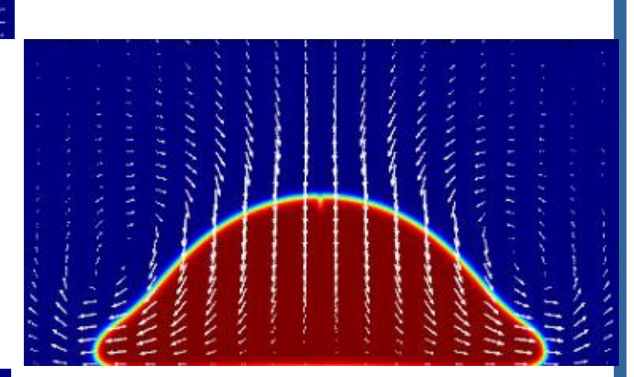


Figure. 8 The velocity field in the droplet and surrounding air at 1 ms

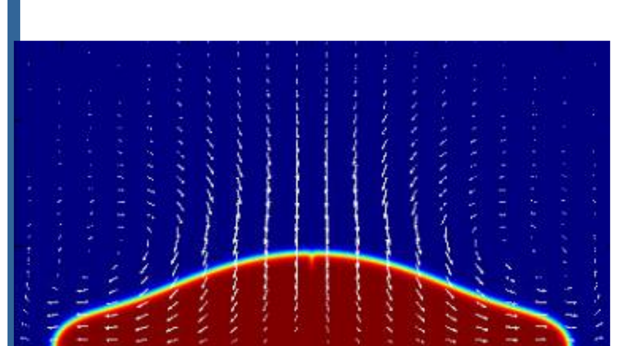


Figure. 9 The velocity field in the droplet and surrounding air at 1.5 ms

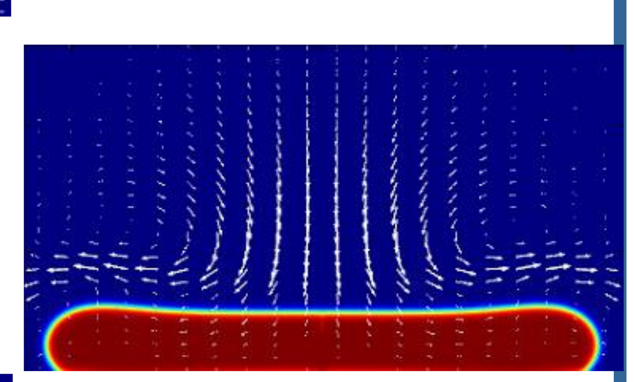


Figure.10 The velocity field in the droplet and surrounding air at 3 ms

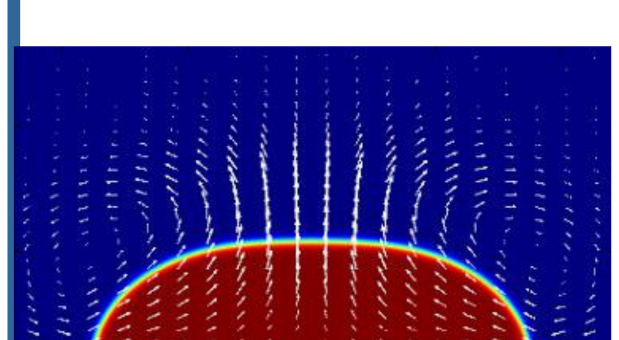


Figure.11 The velocity field in the droplet and surrounding air at 8ms

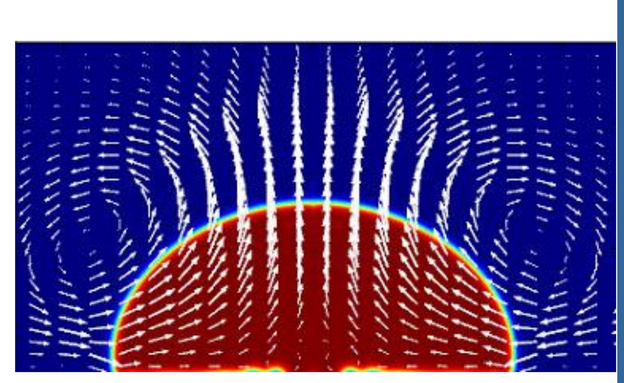


Figure.11 The velocity field in the droplet and surrounding air at 10 ms

Comparison

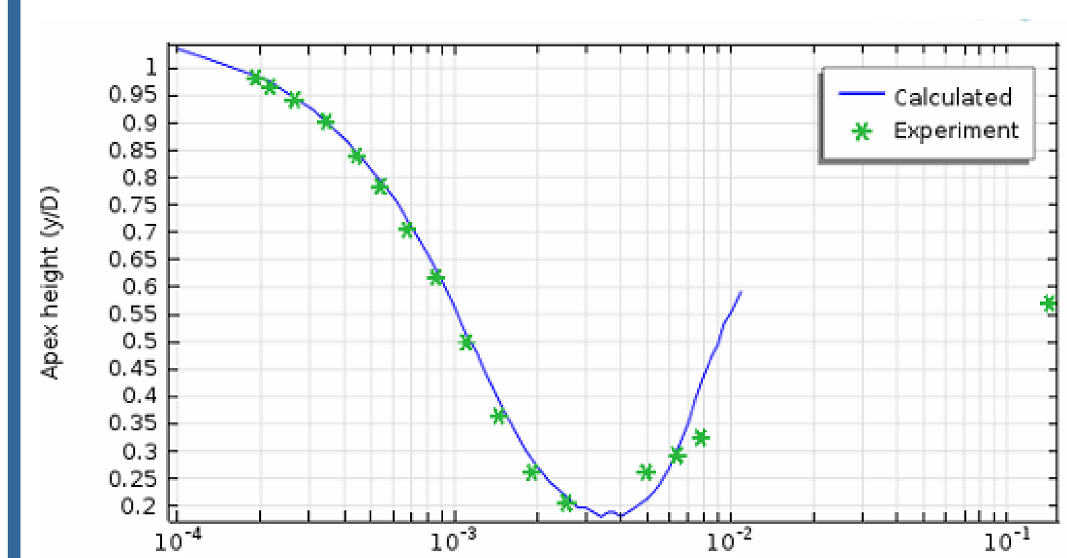


Figure.12 The comparison of calculated apex height byLevel Set method with experiment result

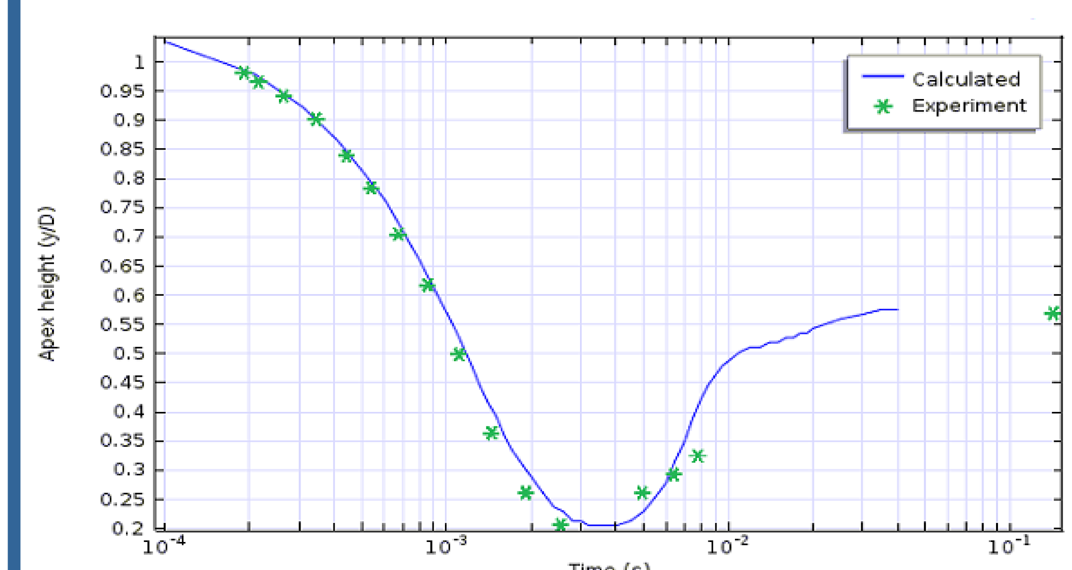


Figure.13 The comparison of calculated Apex height by Phase Field method with experiment result

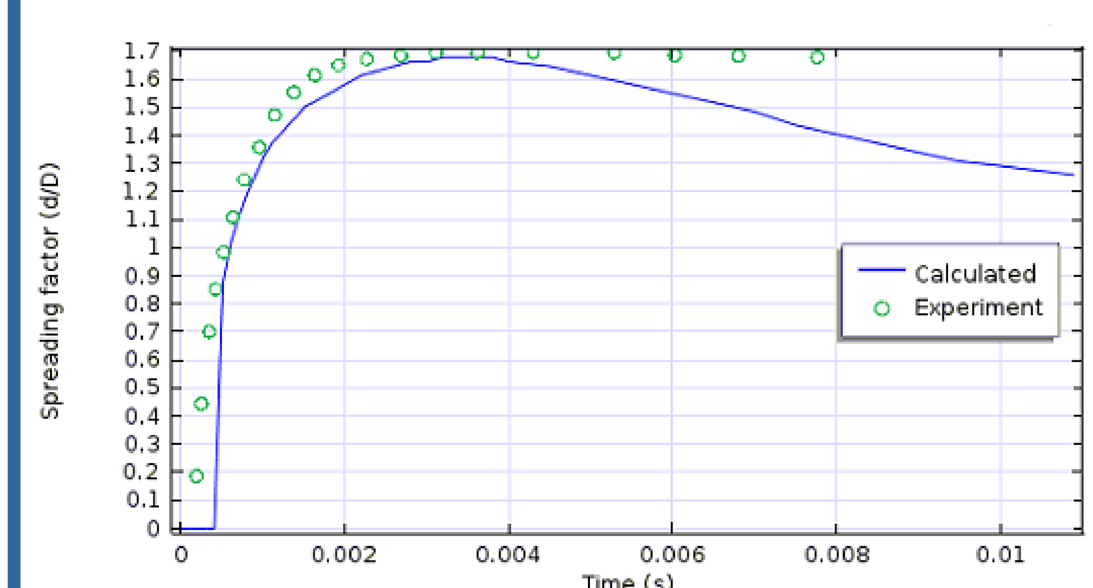


Figure.14 The comparison of calculated spreading factor by Level Set method with experiment result

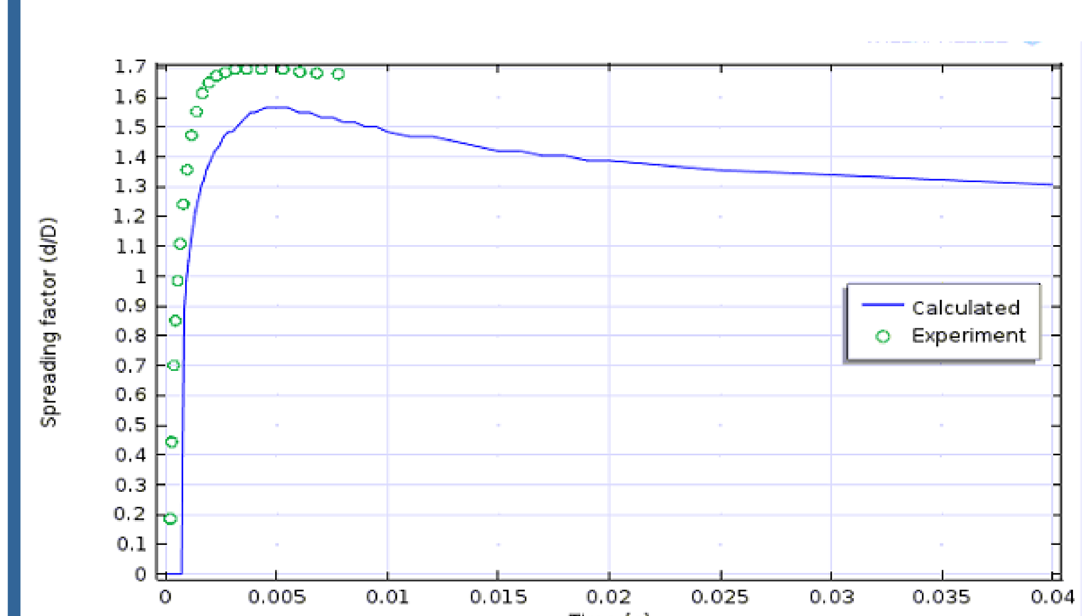


Figure.15 The comparison of calculated spreading factor by Phase Field method with experiment result

Conclusion

In this study, the dynamic process of a glycerin droplet impinging onto a wax surface is simulated in COMSOL with the two phase Level Set and Phase Field models. The apex height and spreading factor are compared with experimental results. It is found that Level Set obtain a very good result during the spreading process. However, Phase Field model can predict a better rebounding process.