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A case study on the dynamic process of water drop impacting on heated wood surface ☆☆

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ABSTRACT

A preliminary case study of the impact of a water drop of 2.4 mm diameter upon a heated wood surface is presented. The coupled problem of liquid and air flow, and heat transfer via wood surface was predicted by using a VOF-based method. The dynamic process of the water drop impacting the heated wood surface was visualized with a Photron Fastcam high speed video camera. The impact velocities of the drops were varied from 1.71 m/s to 2.81 m/s. The effects of several case parameters, such as wood surface temperature and basic density, liquid surface tension, and drop–wood contact angle were considered and discussed. The results show that an obvious deformation occurs on the hot wood surface, and the maximum non-dimensional rebound height increases as the collision velocity increases. The numerical simulated results agree well with the experiments.

1. Introduction

The fluid dynamic phenomena of a liquid drop during its impingement upon hot surfaces occur in many fields, such as in internal combustion engines, electronic circuits, refrigeration cycles, fire suppression, liquid coating and spray/mist cooling, etc. [1]. Numerous literatures refer to the impingement dynamics of a drop impacting on hot surfaces [2–8]. The results show that collapse, bouncing, splashing, vapor explosion and Leidenfrost phenomena may occur during the liquid drop impact. Fundamental studies also show that the phenomena of liquid drop deformation are affected by the drop impacting velocity, drop diameter, surface temperature, contact angle, surface roughness, surface density, etc. [9–12], where the well-known non-dimensional numbers, such as Weber number (*We*), Reynolds number (*Re*), and Ohnesorge number (*Oh*) were considered to describe the collision dynamics.

However, most of the above studies just focused on hot metallic surfaces or liquid surfaces. There are few studies that consider the drop impact on heated wood surfaces, although wood is one of the widely used materials for architecture and furniture, and wood fire is the typical type of class A fires. The effects of the wood surface characteristics on drop deformation had been studied by Chen et al. [13], but only the cases of wood surfaces at room temperature were considered.

Water mist has been regarded as a potential fire suppression technology that can replace the conventional means of fire suppression due to many merits [14–16]. But the dynamical processes of a water drop impacting on heated wood surfaces are still not clear. Therefore, in order to deepen the knowledge on the mechanism of wood fire suppression with water

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Table 1
Properties of the test materials.

Materials	Surface tension (N/m)	Viscosity (Pa s)	Density (kg/m^3)	Contact angle (at 80 °C) (deg)	Contact angle (at 100 °C) (deg)	Contact angle (at 120 °C) (deg)
Water	0.072	0.001	998	78	81	82
Wood	–	–	520	78	81	82

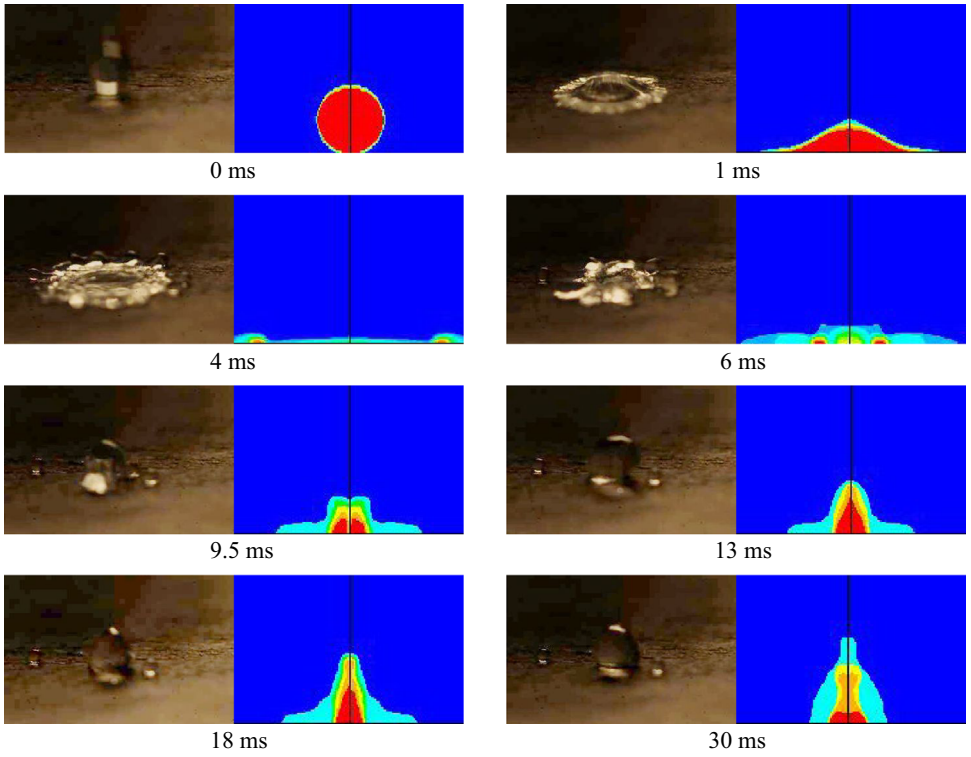

Fig. 1. Comparison of the simulated drop impact on wood surface with the experimental results. (V_0=1.71 m/s, We=97, D_0=2.4 mm).

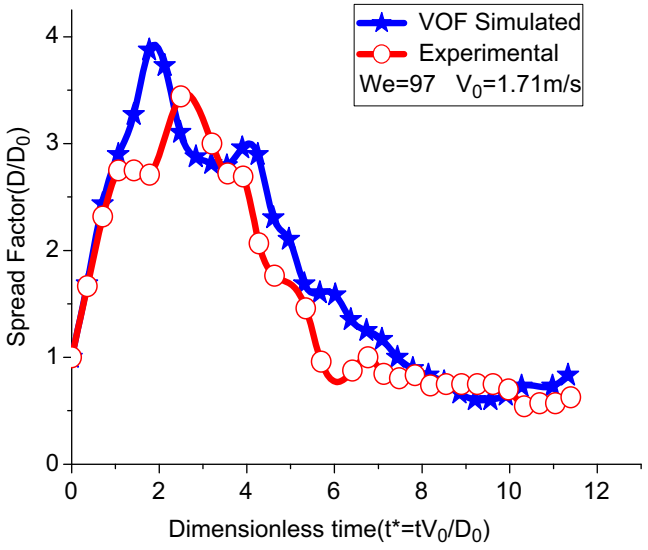

Fig. 2. Comparison of the simulated drop spreading factor with the experimental results.