Visualization of atomization by dimple using High-Speed Camera

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Urea SCR System is attracting attention as a method of removing NOx emitted from a diesel engine. However, it is required to promote vaporization by atomization, because the purification efficiency of NOx is lowered by the urea aqueous solution that is not completely vaporized at the low temperature such as the time of starting engine. In this paper, surface texturing is proposed as a new atomization method, and dimples are processed on the impingement walls of spray droplets. These impingement behaviors were visualized using a high-speed camera, and the atomization effect was evaluated by the Weber number.

Keywords: Atomization, Surface Texture, Visualization, Urea-SCR system, Leidenfrost phenomenon

1. Introduction

Selective catalytic reduction (SCR) dosing systems are widely used in aftertreatment systems of diesel engine for worldwide emission standards. In this system, improving the atomization of urea aqueous solution is important for purifying Nitrogen oxides (NOx). In this paper, surface textures are verified as a new atomization method.

2. Methods

2.1. Test pieces

Figure 1 shows the actual images of test pieces (Base, Dimple 1 and Dimple 2) used in this experiment and the three-dimensional images from the white interference microscope. The textures were dimpled, and the diameter of the holes were 60 μm and the depths were 5 μm and 10 μm.

2.2. Experimental equipment

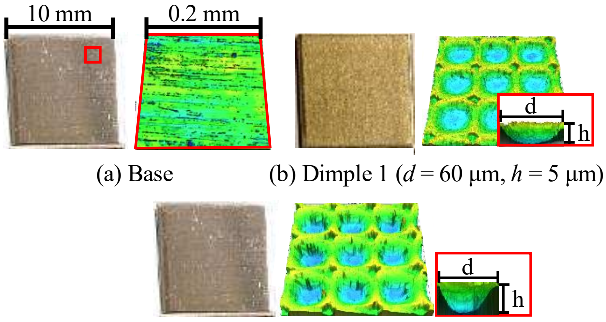
Figure 2 shows the schematic diagram of the experiment equipment for visualizing the impingement behavior. Test pieces were heated at 270 degree Celsius using the hot plate. The behavior of the sprayed droplets upon impact with the wall was visualized by the backlight method. The photography speed was set 300,000 fps.

3. Test results and Discussion

Figure 3 shows the visualization results of the droplet behavior on each test piece. In the case of Base, they bounced back without atomizing, while it was observed that the droplet was violently blown up and atomized at 6.7 μs after the impingement in the case of Dimple 1. However, in the case of Dimple 2, which had a depth of 10 μm, did not show the similar behavior. We estimated that the droplet would have entered into the cavity of Dimple 1, then generated vapors atomized the droplet by blowing up. However, in the case of dimple 2, the droplet would not have blown up because air prevented the droplet from entering the dimple [1].

4. References

[1] Nobuyuki Moronuki, Akinori Takayama, Arata Kaneko, "Design of Surface Texture for the Control of Wettability", Transactions of the JSME, 70, 693, 2004, 126-131.



(a) Base (b) Dimple 1 (d = 60 μm, h = 5 μm)

(c) Dimple 2 (d = 60 μm, h = 10 μm)

Figure 1: Test pieces.

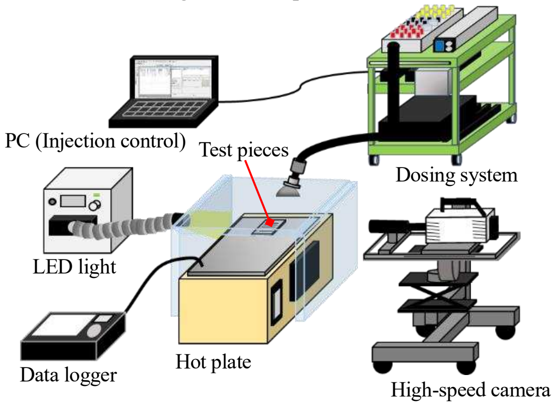
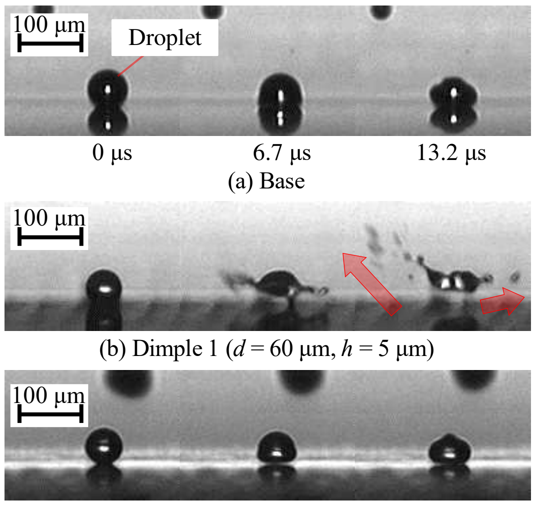


Figure 2: Schematic diagram of the experiment.



(a) Base

(b) Dimple 1 (d = 60 μm, h = 5 μm)

(c) Dimple 2 (d = 60 μm, h = 10 μm)

Figure 3: Visualization results for each test piece.