Effects of Liquid Physical Properties for Liquid Bubble Breakup Due to Airstreams

Teruhiko Yoshida*1
*1: Department of Mechanical and Precision System Engineering, Teikyo University, Utsunomiya, Japan
yoshida@uccl.teikyo-u.ac.jp

Abstract

To reduce the greenhouse gases, bio fuels are developing as an alternative fuel instead of fossil fuels. As carbon dioxide and so on are the causes of global warming, low carbon combustion is one of the crucial issues to conserve the global environment. Liquid atomization technology should contribute to the field of fuel combustion and others, such as the cooling of exhausted warm water at geothermal power plants.. A liquid bubble contains gas in a liquid drop. So, it has a larger surface area than a liquid drop of the same mass. It could have the advantage for fuel combustion and cooling of exhausted warm water. In order to apply it in these areas, effects of liquid physical properties for liquid bubble breakup due to airstreams were investigated. Experiments were conducted using a horizontal air-suction-type wind tunnel. Uniformly sized liquid bubbles were produced. The breakup processes were precisely observed using a digital high-speed video camera.

Introduction

The liquid bubble has many important scientific applications such as the cooling of warm exhaust water, fuel combustion and flow visualization. If liquid bubbles are used to combust bio-ethanol fuel, biodiesel fuel (BDF), and glycerin which is a by-product of BDF, more effective combustion could be obtained than in the case of liquid droplets.

Effects of liquid physical properties for liquid bubbles breakup due to airstreams are investigated. The breakup pattern is impacted due to surface tension, viscosity. Several characteristic deformation and breakup patterns are observed. Some of deformations and breakups are never observed for liquid drops. Breakup ratio in the transition breakup and the breakup time were measured by analyzing the breakup processes recorded by the digital high-speed camera. As the airstream velocity increases, the number of broken-up liquid bubbles increase. And finally at a certain airstream velocity, all the liquid bubbles breakup. The breakup pattern that some liquid bubbles break but others do not is defined as a transition breakup. The relationship between airstream velocities and the breakup ratio is investigated for some liquid bubble sizes.

Results and Discussion

In Fig.1, one of the characteristic figures for liquid bubble deformation and breakup is shown. A small droplet is separated from a main liquid bubble, but a main body continues to keep a liquid bubble. The liquid of the liquid bubble is ethanol in water solution. This phenomenon, the separation of a small droplet from around a stagnation point of a main body, cannot be observed for a water liquid bubble. In the author's experiment on the droplet breakup, the phenomenon of a small droplet separation from a main liquid drop has not been observed. Other characteristic deformation and breakup types are observed. It is revealed that the deformation and breakup pattern of liquid bubbles differs greatly on the physical properties of liquid.

Figure 2 shows the relationship between time and normal diameter of liquid bubble. In one case, a liquid bubble repeats its expansion and depression with time like a sinusoidal wave but eventually it tends to return to its original shape. In another case, a liquid bubble continues to expand its size and finally breaks up.

Breakup conditions with airstream velocity and bubble diameter are investigated. Breakup conditions with Weber number and equivalent liquid bubble diameter are investigated as well. As the equivalent liquid bubble diameter increase, critical Weber number decreases.

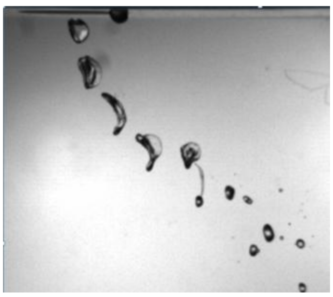

Fig.1 Separation of a small droplet from around a stagnation point of a main body

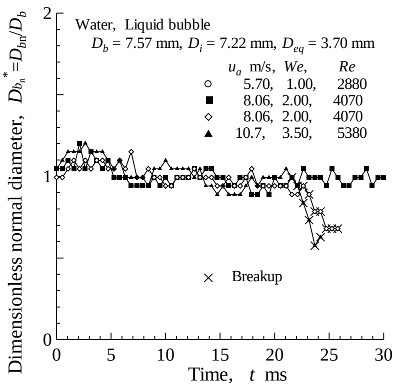

Fig.2 Relationship between time and normal diameter of liquid bubble