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RESEARCH ARTICLE

Measurement of liquid sheet using laser tagging method by photochromic dye

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Abstract Liquid atomization system has been extensively applied as the most significant process in many industrial fields. In the internal combustion engine, the combustion phenomenon is strongly influenced by the spray characteristics of the fuel given by the atomization process. In order to completely understand the whole atomization process, a detail investigation of relations between the liquid jet characteristics and the breakup phenomenon is required. In this study, a non-intrusive method called as laser tagging method by photochromic dye has been developed with aim to study the breakup process of liquid sheet in detail, covering from the behavior in film until disintegrated into ligament and droplets. The laser tagging method by photochromic dye is based on a shift in the absorption spectrum of photochromic dye molecules tagged by ultraviolet laser. The shift results a color change at the tagged region of liquid containing the dye. In this study, the motions of the dye traces were analyzed as the liquid surface velocity. As a result, liquid sheet was found to keep its velocity constantly in film before suddenly increase around broken point. However, it then decreased after broken into droplets. By forming a set of four points of dye traces on the liquid sheet, the change of relative position of the set enabled the measurement of deformation and rotational motion of the liquid sheet. As a result, the normal strain of the liquid sheet parallel to the flow direction depended on the flow behavior of ligament formation.

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1 Introduction

Liquid atomization presents in many industrial fields. From pesticides spray in agricultural to internal combustion engine in transportation and power generation industry, liquid atomization system has been extensively applied as the most significant process to ensure their continuous operations.

In the internal combustion engine, for example, the fuel combustion of diesel engine plays an important role in the engine performance. However, the combustion phenomenon is strongly influenced by the spray characteristics of the fuel given by the atomization process. This has attracted attention from researchers to clarify the spray flow behavior. However, most of the studies carried out by the researchers merely described the spray characteristics caused by the atomization process. Therefore, in order to completely understand the whole atomization process, a detail investigation of relations between the liquid jet characteristics and the breakup phenomenon is required.

Various measurement methods on the breakup process of the spray flow have been developed in the past. However, the methods sometimes present performance limitations when applied to certain flow fields. For instance, laser Doppler velocimetry (LDV) and particle image velocimetry (PIV) are limited to precisely evaluate the spray flows which presents liquid sheet, since the irregular refraction of laser light will appear when it enter the liquid. Therefore, a proper measurement method is required to provide appropriate assessment for such spray flow.

In this paper, we applied a non-intrusive method called as laser tagging method by photochromic dye for measuring velocity distribution in liquid sheet. This technique is based on a shift in the absorption spectrum of photochromic dye molecules tagged by ultraviolet (UV) laser. The

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