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Density Measurement of Underexpanded Jet Using Stripe Patterned Background Oriented Schlieren Method

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Abstract : The Schlieren method, which has been conventionally used to visualize high-speed flows, has disadvantages such as the complexity of the experimental setup and the inability to quantitatively analyze the amount of refraction of light. The Background Oriented Schlieren (BOS) method proposed by Meier is one of the measurement methods that solves the problems, as mentioned above. The refraction of light is used for BOS method same as the Schlieren method. The BOS method is characterized using a digital camera to capture the images of the background behind the observation area. The images are later analyzed by a computer to quantitatively detect the amount of shift of the background image. The experimental setup for BOS does not require concave mirrors, pinholes, or color filters, which are necessary in the conventional Schlieren method, thus simplifying the experimental setup. However, the defocusing of the observation results is caused in case of using BOS method. Since the focus of camera on the background image leads to defocusing of the observed object. The defocusing of object becomes greater with increasing the distance between the background and the object. On the other hand, the higher sensitivity can be obtained. Therefore, it is necessary to adjust the distance between the background and the object to be appropriate for the experiment, considering the relation between the defocus and the sensitivity. The purpose of this study is to experimentally clarify the effect of defocus on density field reconstruction. In this study, the visualization experiment of underexpanded jet using BOS measurement system with ronchi ruling as the background that we constructed, have been performed. The reservoir pressure of the jet and the distance between camera and axis of jet is fixed, and the distance between background and axis of jet has been changed as the parameter. The images have been later analyzed by using personal computer to quantitatively detect the amount of shift of the background image from the comparison between the background pattern and the captured image of underexpanded jet. The quantitatively measured amount of shift have been reconstructed into a density flow field using the Abel transformation and the Gradstone-Dale equation. From the experimental results, it is found that the reconstructed density image becomes blurring, and noise becomes decreasing with increasing the distance between background and axis of underexpanded jet. Consequently, it is cralified that the sensitivity constant should be greater than 20, and the circle of confusion diameter should be less than 2.7mm at least in this experimental setup.

Keywords : BOS method, underexpanded jet, abel transformation, density field visualization
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