Study on Two-Phase Velocity Field of a Steady Hydraulic Jumps Using PIV and BIV

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Abstract: The flow structure in a steady hydraulic jump in both the non-aerated and aerated regions was measured using the image-based particle image velocimetry (PIV) and bubble image velocimetry (BIV) techniques, respectively. Three highly aerated jumps with Froude numbers between 4.5 and 5.4 were tested. Mean velocities and turbulence properties were obtained by ensemble averaging the repeated velocity measurements. Based on the mean velocities, the flow structure in the jumps was classified into four regions to distinguish their distinct flow behavior; they are the potential core region, the boundary layer region, the mixing layer region, and the recirculation region.

In addition, spatial variations of mean velocities, turbulence intensity, and Reynolds stresses were also presented. It was observed that the maximum horizontal bubble velocity and maximum horizontal water velocity occur at the same location in the overlapping regions of potential core and mixing layer. The ratio between the maximum bubble velocity and maximum water velocity is between 0.6 and 0.8, depending on the Froude number. Examining the mean horizontal bubble velocities in the mixing layer, a similarity profile was revealed with the mixing layer thickness as the characteristic length scale and the difference between the maximum positive and maximum negative velocities as the characteristic velocity scale. It was also found that the mean horizontal water velocities in the near wall region are self-similar and behave like a wall-jet.

Keywords: Hydraulic jump; Particle image velocimetry; Bubble image velocimeter; Flow similarity.