Investigation on the Effect of Venturi Geometry Variation on Microbubble Generation

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Abstract. Venturi nozzle is the simplest method in generating microbubble (MB). However, direct relation between venturi geometry variation and generated bubbles properties namely, bubble mean diameter (BMD) and dissolved oxygen (DO) level remains ambiguous. Thus, this study investigates the effect of outlet angle variation, gas intake and water flowrate on the BMD and DO level. Visualization experiments were performed on six geometry variant of venturi nozzles with fixed inlet angle (19°) and outlet angle of 8°,10° and 12° for Venturi with air intake and 5°, 12° and 45° for Venturi without air intake condition. In addition, the venturi nozzles also tested in varied flowrate of 13, 33 and 66 litre per minute (LPM). As the results, with the increment of outlet angle, the BMD decreases while the DO level increases in all nozzles. The presence of air intake in the nozzles produces larger MBs. Furthermore, The BMD and DO level is proportional to the water flowrate. Overall, the varied geometry parameters induce a difference in BMD which affects the DO level.

INTRODUCTION

Microbubbles (MBs) are one of the new technologies that have been discovered to be beneficial to the environment and humanity. Although the definition of MB size range is controversial [1], in general, MB can hardly be seen through naked eyes, and the size is reported between 1 to 200 µm [2]–[4]. In addition, MBs also exhibit many unique characteristics and behaviors such as excellent solubility, slow rise velocity, high dissolution rate, self-compression effect, surface adsorption, and acoustic properties [5]–[8]. These characteristics are being utilized in various fields, such as agriculture [9], aquaculture [10], medical treatment [11], and the automotive industry [7].

Among various MB generation methods, the venturi type is the most economical generator in terms of cost, design, and energy consumption [12]–[14]. It is a hydrodynamic cavitation device consisting of smooth converging and diverging sections connected by a throat, as shown in Figure 1. A small area at the throat induces a higher flow velocity and, thus, pressure drop across it [15], [16]. This generator is also able to produce MBs with sizes ranging from 10µm to millimeters [17], [18]. The role of geometry and flow parameters on the performance of venturi generators has been studied extensively in the past. Primarily, on the effect of convergent angle (α), divergent angle (β), throat length (l), throat diameter (d), outlet diameter (D), and gas feeding hole diameter (dg) variation on the bubble size distribution in venturi. Among all parameters, divergent or also known as outlet angle, is one of the key parameters in controlling MB size distribution. According to several studies, the MB size reduces as the outlet angle increases. This phenomenon occurs because a larger outlet angle induces bubbles to decelerate over a shorter distance and time. Consequently, it provides a strong gas-liquid interaction that aids in collapsing larger MBs into smaller sizes [2], [17], [19].