1. INTRODUCTION

Two phase flow phenomena play an important role in many aspects of science and industrial fields. It can be found frequently such as in oil and gas industries, power plants, chemical processes, and so on. One of the example is the sub-cooled water injection in the cold leg of the nuclear power plant. This case is strongly connected with the emergency core cooling (ECC) and may be activated during loss of coolant accident (LOCA). This scenario leads to the liquid-liquid mixing where the two phase flow complex phenomena due to the bubbles induced turbulence occur. In oil and gas well intervention, gas/water always appears after perforation job and again, the two phase flow phenomena take place. These practical issues lead to the rapid development of two phase flow knowledge. From these examples, deep understanding of this field is very necessary especially in determination of the velocity and two phase regimes. It should become a fundamentals objective in two phase flow study.

Currently, two phase flow research is still in intensive development both numerically and experimentally. These tools become a common method in various cases of two phase flow phenomena. In the case of bubbly flow, several investigations have carried out in order to obtain radial gas volume fraction, bubble rising path, velocity profile, turbulent parameters, and so on. Antal et al (1991) conducted a numerical simulation to predict the void fraction profiles for both co-current upward and downward flow. The two-fluid model was implemented where a set of continuity and momentum equations applied for each phase. The drag force from Ishii and Mishima (1984) was used as well as the general lift force with a positive coefficient range from 0.01 – 0.5 was also applied for the model. The new model for wall forces was introduced and derived in detail. For upward flow, the results shown that the small bubbles have a strong tendency to collect near the wall while the large bubble moves toward the center of the duct. In the other hand, flat profile was observed in the pipe center and no bubbles found near the wall. Then, they used experimental data for upward flow from Nakoryakov et al (1986) to compare their results, and it gives a good agreement. Although there is no available data for downward flow, but the similar trends are expected.

Tomiyama et al (1995) carried out an experimental study and numerical simulation on the lateral migration of a single bubble in the stagnant and laminar surrounding liquid. In their experiment, a glycerol solutions were used as a working fluid. This work concerned in the dependence of Eotvos number (Eo) and dimensionless liquid volumetric flux to the lateral behavior of the single bubble. In this experiment, Eotvos number (Eo) and liquid volumetric flow (J_L^*) were taken as parameter while Morton number (Mo) was kept constant. The test section was a square duct of 30 mm and 400 mm in width and length, respectively. Bubbles trajectory was obtained for several volumetric flux ranges from -0.25 up to 0.25 and Eo was increased number from 2.2 – 21.7 while *log* (Mo) was kept constant in -2.8. Here, a negative value for volumetric flux indicates a downward flow, zero value for stagnant liquid and a positive value for upward flow. As the results for negative J_L^*, bubble rose up rectilinearly along the wall for high Eo number and migrate to the center of the duct at low Eo number. In contrary, when J_L^* is positive, and under a decrease of Eo number, it was observed that the bubble moves in rectilinearly path along the wall. These characteristic of bubble lateral migration allow that the lift force acting on the bubble is proportional to the liquid velocity gradient, since it increases with $|J_L^*|$.

Nakoryakov et al, (1996) carried out an experimental study on the downward and upward bubbly flow. A fully developed turbulent downward flow was observed in 42.3 mm diameter pipe while the 14.8 mm diameter pipe was used for upward laminar flow. The velocity profiles as well as the turbulent parameters were measured by electrodiffusional method. The result shows that the value of single phase turbulent intensity is higher than gas-liquid flow as it close to the wall (at dimensionless value of about 100). The reduction of turbulent intensity was occurred in the free bubbles region and as it close to the wall, the value of turbulent intensity falls in the same curve and it is not affected by gas flow rate.

Shawkat et al, (2008) conducted an experimental investigation relates to bubble and liquid turbulent characteristic in a 200 mm inner diameter pipe. The liquid turbulent parameter was measured by using hot film anemometry while the bubble characteristics were measured by a dual optical probe. The core peak was observed for all flow condition (J_L ranging from 0.2 – 0.68 m/s) except for the low void fraction regions ($\alpha \leq 4\%$). In general, the turbulence intensity increases when the bubbles enter the flow. The bubble migration in radial position was characterized by the ratio between turbulent dispersion force and lift force.

In determination of liquid velocity profile, Ishikawa et al (2009) conducted upward flow experiment in contraction channel by using a PIV technique. They focused on micro bubble tracer while particle tracer was also used for validate its traceability. The total length of vertical upward flow facility was 1700 mm and the contraction channel was set 1000 mm from the bottom with width of contraction channel varies from 50 mm to 20 mm, linearly. For the PIV and visualization, they used a high speed video camera while YAG laser (250 mW, wavelength 532 nm) was coupled with a cylindrical lens to obtain a laser sheet with an appropriate thickness, 1 mm. Average micro bubble diameter was observed of 50 µm and high-porous polymer (60 µm diameter, 1.02 SG) was used as particle tracer. In comparison both these tracers, micro bubbles tracer cannot obtain enough number of density but the instantaneous velocity and mean velocity vector obtained by these tracers show almost the same results.

PIV measurement for three dimensional two phase bubbly flow was performed by Hassan et al (1997). This work was aimed to study the turbulence structure in a co-current bubbly flow. A stereoscopic PIV was used to obtain a three dimensional (3D) velocity vector as well as the radial distribution of volume averaged turbulence intensities, and Reynolds stresses were calculated. Small polystyrene particle with a density of 1050 kg/m^3 and diameter of 40 µm was used as tracer particle.

Three experimental conditions were carried out. The first was the injection of a single bubble in stagnant fluid, then single phase liquid upward flow with volumetric rate of 9.7 x 10^{-7} m^3/s and the third was the injection of a single bubble into upward liquid flow with the same volumetric rate with the second ones. Bubble diameter was assumed as sphere equivalent volume and the average's bubble volume was obtained by dividing constant gas flow rate (m^3/s) with formation of bubble's frequency (bubbles/min) which comes in the viewing volume. In this case, bubble shape was oblate spheroid with a helical trajectory and as mentioned in previous works, bubble shape and size become an important thing because they present the dynamic changes in pressure inside the bubble and surrounding liquid as well as the liquid velocity field is changed also. The radial distribution of mean velocity, turbulent intensity, and Reynolds stress were successfully presented for all schemes (before, present and after entire viewing volumes). For the case before and when the bubble presents in the viewing volume, small fluctuation of the radial and angular velocities are obtained. After the bubble leaves the viewing volume, its wake produces higher turbulent condition. The magnitude of the radial and angular velocities increased considerably.

Lucas et al (2000) conducted the numerical investigations to determine the radial gas void fraction distribution of the bubbles and compare the result with their experimental database. This works allowed a prediction whether wall peaking or core peaking occurs in dependence of bubble size distribution as well as the gas and liquid volume flow rate.

This author's study about the experimental investigation of the bubble behavior in a turbulent downward flow was aimed to obtain a better understanding of turbulent parameters in the dependence to single bubble fluctuation. The velocity profile inside the channel will be presented also as a first step in analyzing this phenomenon. The correlations between these parameters will be an expecting output from this study and the implementation in numerical or CFD codes were expected as well.