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Experimental Study on Structure of Flow Pattern of Two-Phase Gas-Liquid Flow in Rectangular Container with Aeration

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Abstract—The flow pattern of the two-phase gas-liquid flow in the rectangular container with aeration was measured by use of the PIV (Particle Image Velocimetry) system. The air was supplied from the center of the bottom at the volume flow rate of 100 mL/min into the water of 60 L filled with the rectangular vessel. As the result, it was found that there exists the large-scale circulating flow in the domain.

Index Terms—**Gas-Liquid Flow, Particle Image Velocimetry, Two-Phase Flow.**

I. INTRODUCTION

This study is focusing on the mass mortality during the initial period in the larviculture, and is an attempt to protect this from the viewpoint of the fish–raising by use of the aquarium design. Considering the life history of the marine piscine, the early period is very crucial for their survival.This period denotes that during which the fish hatch from eggsand the spine is formed. The fish hatches from eggs in two to three days are called the larval fish or fingerling. The fishjust formed the spine are calledjuvenile fish. Although this period is one hundredth of the life of fish, a number of studies have been reportedso far. One of the reasons is that the numerical plummet of the number of fish to first one thousandth or ten thousandth called the mass mortality happens in this very short period.Therefore, the efforts in aquaculture have been doneas seed production since the early 1970s. However, even now, there are no effective strategies to prevent from the mass mortality in the initial period, and many studies have been done from the viewpoint of the aquarium design.The effect of the flow pattern with aeration on the survival rate at 10 days after hatching with the aeration was examined in [1]. And, the effect of rearing–tank proportions on early survival was also examined in [2]. Although there may be a variety of reasons for the mass mortality including rearing environment, there are two persuasive reasons. One is the surfaced death and the other is the sedimentation death. The surfaced death is that the larvae fish are to die of the gathering to the water surface due to the convection with aeration for oxygen supply, light–harvesting and capture by the surface tension of water because of the poor swimming ability. The sedimentation death is that the larvae fish are to die of the settlement at the bottom area of the aquarium. Although the reason of this is not clear yet, this has been illustrated as follows. If the density of the larvae fish becomes larger than that of water asthey grow, the larvae fish will die of the infection bythe bacteria from the scratches due to the rubbingagainst the side walls and the bottom wall of the aquarium. Consequently, the larvae fish are to die of the transfer by sedimentation into the area with the poor oxygen at night. As mentioned above, the mass mortality of the larvae fish is strongly affected by the flow patterns in the aquarium. Accordingly, the investigation on the flow pattern of the two–phase gas–liquid flow is crucial to prevent them from themass mortality. The aim of this study is to investigate on the flow pattern in the aquarium by the experiment, and obtain the fundamental informationas the strategy of this problem. The flow inside the rectangular vessel with the aeration was measured by [3], [4]. However in this study, the schematic flow pattern is provided anew.

II. EXPERIMENTAL METHOD

Fig.1 shows the experimental apparatus in the present study. The volume of the aquarium is almost 60 L with the size of W600(x) × H300 (y) × D300 (z) mm. The aquarium is filled with the city–water with the tracer particles for the visualization with the laser beam sheet. The PIV (particle image velocimetry) system was adopted to measure the velocity fields in the domain. The air was supplied through the commercial airstone located at the center of the bottom, and the two–phase gas–liquid flow was induced within the domain. The flow was visualized in the two–dimensional area using the laser beam sheet, and recorded through the CCD camera and stored into the personal computer. Further, the velocity vectors were calculatedby use of the software provided by Dantec Dynamics. Fig.2 shows the measurement planes. In the present study, the velocity vectors were measured on the four planes using the PIV system. The planes A, B, C and D are the ones at z =150mm, x=550mm, x=450mm, x=350mm, respectively. The obtained velocity vectors were the two–dimensional ones, and the vertical components of the velocity against the plane were not

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obtained in the present experimental system. The general method mentioned above was almost the same as [3], [4]. The volume flow rate of supplied air was set at 100 mL/min in the present study.

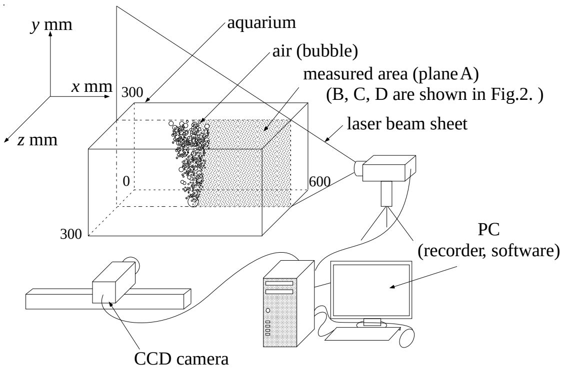


Fig. 1 Experimental apparatus of PIV system

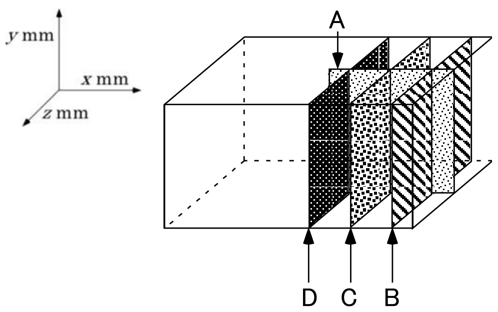
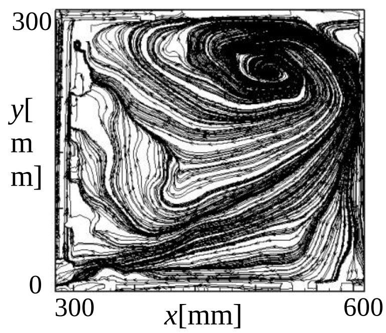


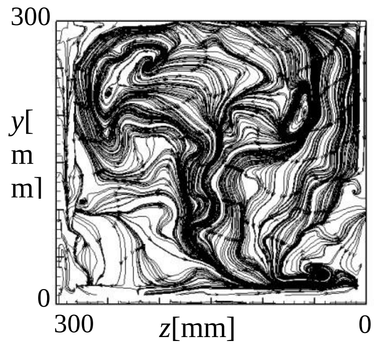
Fig. 2 Measurement planes in the aquarium

III. RESULTS AND DISCUSSION

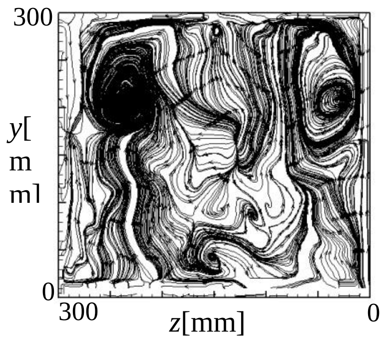
Fig.3 (a) – (d) show the particle trajectories on each plane. The particle trajectories were calculated from the velocity vectors measured by the PIV system. Fig.3 (a) is the particle trajectories on the plane A at *z*=150mm. This plane is the center within the range ofz axis. The measured area is the right half part of the domain. There seems one circulating flow on the plane induced by the aeration from the center of the bottom in the rectangular container. The two dead water regions are also observed on the corner of the upper right and lower right regions of the domain. Fig.3 (b) is the particle trajectories on the plane B at *x*=550mm. There seems the outermost flow region of the circulating flow. Accordingly, the direction of the fluid flow of the great part of this area is downward. Fig.3 (c) is the particle trajectories on the plane C at*x*=450mm. There seem two small–scale vortices in the domain. Fig.3 (d) is the particle trajectories on the plane D at *x*=350mm. In this figure, there also seem two small–scale vortices in the domain as in Fig. 3 (c). However, the scale of the vortices is larger than that of the vortices in Fig.3 (c).



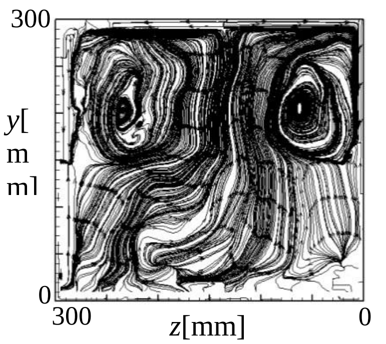
(a) Particle trajectories on plane A at *z*=150mm



(b) Particle trajectories on plane B at *x*=550mm



(c) Particle trajectories on plane C at*x*=450mm



(d) Particle trajectories on plane D at *x*=350mm

Fig. 3. Flow patterns of each plane

From these figures, it is concluded that there exists the large–scale three–dimensional circulating flow inside the vessel induced by the aeration from the center of the bottom. Fig. 4 shows the schematic of this flow. Considering the cross section with the dotted lines, the two kinds of the two–dimensional circulating flow exist, and their aspect

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ratios defined as differ from each other. Here, the aspect ratio is definedas the vertical scale of the circulating flow divided by the horizontal scale of that. Accordingly, one is the circulating flow with the aspect ratio of almost 1 as in Fig. 3 (a). The other is the one with aspect ratio of almost 2 (longitudinal) as in Fig.3 (c) or (d). As for the speed of the fluid, it wasalmost 0.2 m/s at $(x,y) = (308, 12)$ in the present study.

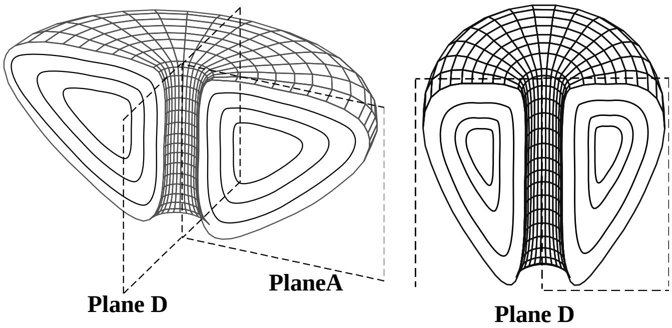

Fig. 4Schematic of flow pattern inducedin container

IV. CONCLUSION

The flow pattern, which is inducedby the two–phase gas–liquid flow due to aeration through the air stone located at the center of the bottom of the aquarium, was measured by the PIV system. As the result, it was obtained experimentally that there exists the three–dimensional circulating flow inside the region.

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