Numerical Study on Estimation of Hydrodynamic Performance for Open-Frame Underwater Vehicle using CFD

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ABSTRACT

In deep sea exploration, AUVs, especially working/hovering type AUVs, having open-frame structure, are developed and operated. It is necessary to be optimally designed to adapt the environments and missions. However, deriving optimal designs by conducting scale model experiments, a lot of time and cost are consumed. Therefore, the hydrodynamic performance estimation by using CFD is used in recent years. But it has not reached the perfect estimation range for such AUVs. In this study, several mesh system and turbulence models are examined to evaluate the accuracy of the computed hydrodynamic performance of such AUV by comparing the measured data.

KEY WORDS: CFD; Open-frame underwater vehicle; Hydrodynamic Performance; Turbulence model;

INTRODUCTION

Important rolls such as marine survey and research and so on are provided for Underwater Vehicles (UVs) in recent years. Generally, UVs should have optimum design, equipment arrangement, etc. based on the operational environments and missions to be given to certain UVs. To estimate the hydrodynamic performance of UVs which is suitable for the environments and missions, CFD has been widely used as well as the other fluid mechanics (for example; Bienz C. et.al. 2008).

From the viewpoint of CFD application for UVs, it is no exaggeration to say that the CFD against the cruising type AUV (Autonomous Underwater Vehicle) has reached completion. In reality, many CFD applications are reported previously (for example; Tae-Hwan Jun, 2012).

On the other hand, CFD applications for so-called ROV (Remotely Operated Vehicle) and working/hovering type AUV does not reached to the same level as for the cruising type AUV.

Since they have open-frame structure and observation devices and operating equipment are exposed to the water, the flow in the fuselage of such UVs is so complicated. To estimate the hydrodynamic performance applying CFD, the flow described above should be expressed adequately. But the turbulence models and/or computational mesh system has not been examined much. This is because few measured hydrodynamic force acting on the body of ROV and/or working/hovering type AUV are exist in reality (for example: Nomoto et.al. 1986). Furthermore, especially for working/hovering type AUVs, there is the case that observation devices are changed according to the mission. In this case, it is considered that the hydrodynamic performance would change. Then, CFD will be a useful tool to estimate the hydrodynamic performance.

In these circumstances, we started research project to investigate the efficacy of CFD for the open-frame type UVs. 1/4 scale model of certain AUV were made and measured the hydrodynamic force acting on the body. The same CAD data when the model was constructed was used to generate the computational mesh system and solved the flow field by CFD. Several mesh system and turbulence models were examined to evaluate the accuracy of the computed hydrodynamic performance by comparing the measured data. In this paper, a part of these results are presented.

DESCRIPTION OF “OTOHIME”

Outline of open-frame type AUV “OTOHIME”

Easy to replace of the observation devices and balance weight is the largest feature of open-frame type AUV. In this study, “OTOHIME” is considered as the sample open-frame type AUV. “OTOHIME” is developed by JAMSTEC. The overview of “OTOHIME” is shown in Fig. 1 and principle particulars are shown in Table 1. It has Inertial Navigation System (INS), Doppler Velocity Log (DVL) and Global Positioning System (GPS) as navigation equipment, and satellite communication device, wireless LAN, optical cable communication device and acoustic communication device as communication equipment.

In addition, it has laser scanner, CTD measurement device, pH-CO₂ hybrid sensor, still camera, side scan sonar and stereo camera as observation equipment. By equipping the skid at the bottom of the vehicle, it is possible to add various observation instruments and a