Motion Analysis of Towed Vehicle on Survey System for Deep Sea

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***Abstract*:** The aim of this paper is to develop a survey system for deep sea with high accuracy and speed. The proposed survey system consists of tow ship and towed underwater vehicle equipped with sensors. A towed underwater vehicle is thought of as an effective method to survey the bottom of the seabed at large depths.In order to develop the system, motion analysis of towed vehicle for survey system is carried out in this paper.

Keywords: Underwater vehicle, BELUGADEEP

I. Introduction

It is necessary to survey an exact depth when land reclamation works are carried out in the ocean. The sonar equipped on the ship is used in ordinary survey. However, reclamation area has been expanded and deeply in recent years. The ordinary survey method cannot provide the required accuracy. Therefore, a new survey method that using an underwater robot equipped with sensor is proposed. Underwater robots are divided into Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs) and Towed Vehicles. When underwater towed vehicle compared to other underwater robots can obtain advantages such as:

(I) Vehicle position can be obtained easily.

(II) Vehicle can operate for a long time, because power can be transmitted through the cable.

(III) The data can be transmitted in real time.

(IV) High accurate data can be obtained because there is no screw-noise.

In the use of the towed vehicle, keeping position and stable movement are required. The shape of towed vehicle is important for keeping position and stable movement.

In this study, fluid analysis of the towed vehicle is carried out. The effect of the change of body shapes and the effect of the change of attachment position are analyzed. Solidworks and Flowworks including Solidworks are used for analysis.

Fig. 1 shows survey method using underwater towed vehicle.

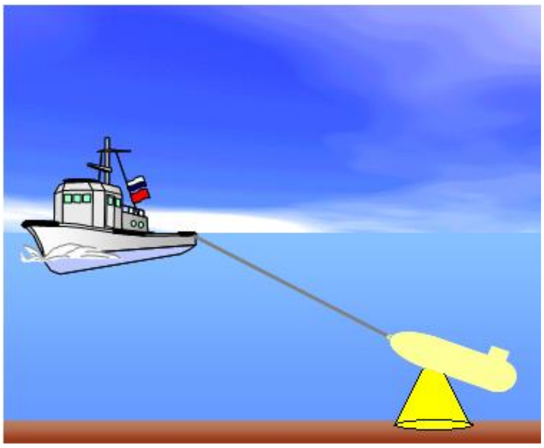


Fig. 1 Survey method

II. Analysis model

1. Body

The model created in Solidworks is shown in Fig. 2. The origin of the analyzed model is BELUGA DEEP shown in Fig. 3, which is developed by TOA-CORPOLATION. Table. 1 shows summary of the vehicle.

Table. 1 Summary of the BELUGADEEP

Size	1.45[m]*0.74[m]*0.84[m] (L*W*H)
Mass	140[kg]
Depth rating	150[m]
Towed Speed	3[knot]
Multibeam Echosounder	Seabat 8101(RESON) 1～400[m],0.01[m]
Attitude and Heading	AHRS440(Crossbow) ±0.1[deg]
Depth Navigation	Micro P(Applied Microsystems) 0.05% of depth 6000[m]

Fig. 2 BELUGADEEP

2. Rear attachment

Fig. 4 shows a rear attachment for vehicle. Attachment is set up in rear of BELUGA DEEP. Rear attachment can change each angle in a perpendicular plane or horizontal plane. The effect of attachment is to stabilize posture of vehicle and the effect like rudder. And them, the attachment changes each angle, a flexible action can be done in a changeable real sea area. And, when the ship turns, it is possible to follow quickly.

In this time, the angle changes in only a perpendicular plane. The role like rudder is given to attachment.

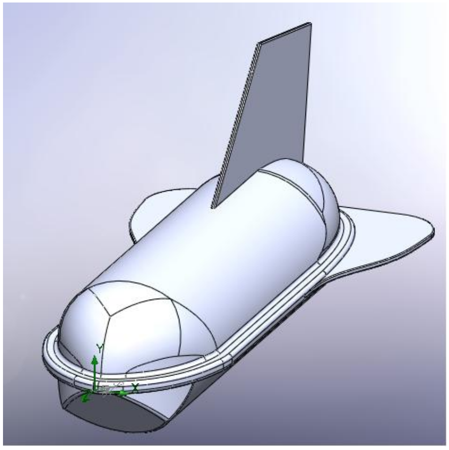


Fig. 3 analyzed model

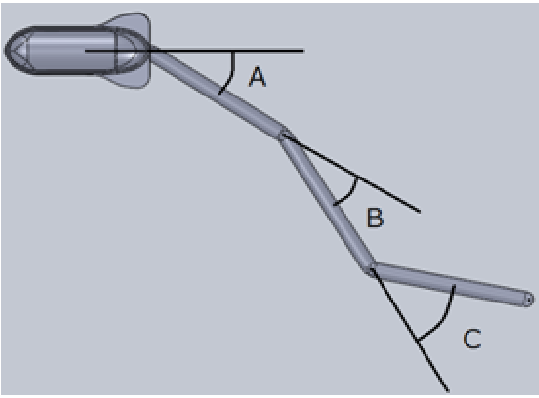


Fig. 4 Vehicle and attachment

Ⅲ. Fluid analysis

1. Analysis condition

The model is analyzed on the condition that Table. 2. Condition other than Table. 2 are defaults condition. When analyzing it, A, B, C in Fig. 4 is changed, and each result is considered.

Table. 2 Analysis condition

The fluid liquid	Water
Temperature of liquid	280[K]
Water pressure	1114.575[kPa]
Type of analysis	External flow
The velocity of a moving fluid	2[knot],5[knot]
Resolution level of the result	level 3 of 8 level
The degree of A,B,C in Fig .4	each angle is 10[deg] or 20[deg] or 30[deg]

2. Simulation result

The angle and the speed are changed, 24 patterns in total are simulated. Distribution of the pressure and path of particle are calculated.

The sub title (a), (b) of Fig. 5 and Fig. 6 mean "velocity [degree of A/ degree of B/ degree of C]".

A. Distribution of the pressure

The distribution of the pressure that hangs to the vehicle and the attachment is displayed in Fig. 5.

From the pressure that hangs to the tow body and the pressure that hangs to the attachment, it is possible that the attachment functions enough as a rudder. Because, the pressure that hangs to the attachment is larger than the pressure that hangs to the tow body. This is the same also in the simulation by 2[knot] and 5[knot].

If the angle of 20[deg] attaches to the flow in the speed of 2[knot], forecasting the behavior is difficult because the pressure in front of the stick distributes like spots. If the angle of 30[deg] attaches to the flow, because the differential pressure on the front side and the back of the stick, stability will be ruined.

When the angle of 10[deg] attaches to the flow. There is no large difference in the pressure distribution that hangs to the stick. From this, the attachment will be not likely to ruin stability though keeps the function of the rudder.

It is preferred that the applied angle of the attachment is about between from 10[deg] to 20[deg] to the flow.

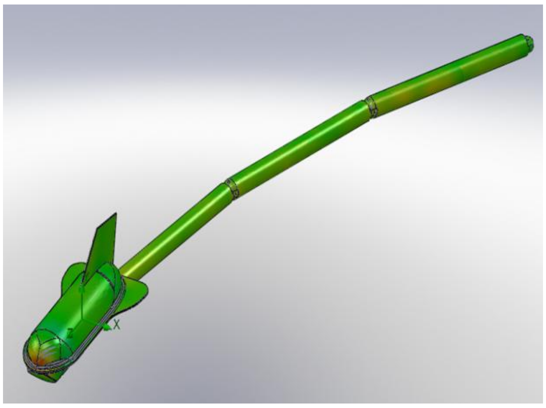
For the simulation by 5[knot], it is roughly consideration similar to the case of simulating it by 2[knot]. However, the influence with the attachment grows because the difference of the pressure distribution is large for simulating it by 2[knot].

B. Path of particle

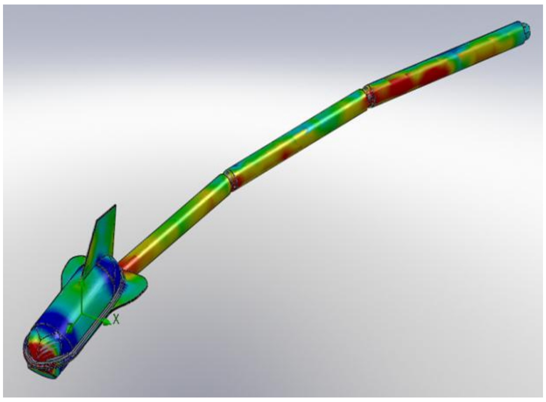
The path of particle around the vehicle and attachment is displayed in Fig. 6.

There is no difference in the shape of the path of particle when 2[knot] and 5[knot] are compared. It is thought that tracks of the fluid do not change depending on the speed. The path of particle changes greatly by angle about the attachment large to the flow. Stability will be ruined by the large change of the path of particle. Therefore, it is necessary not to change the angle of the attachment too much greatly.

Moreover, when the angle of A of fig. 4 changes. The fluid flows into the joining section of the tow body and the attachment. The whirlpool occurs if the fluid flows in the small place. The existence of the whirlpool will ruin the stability of the tow body. Therefore, A of Fig. 4 should be 0[deg]. It is necessary to get the effect as rudder by changing B and C.



(a)2knot[-10/-10/-10]



(b)5knot[-10/-10/-10]

Fig. 5 Distribution of the pressure

(a) (b)

Fig. 6 Path of particle

((a)5knot[-30/0/0],(b)5knot[-10/0/0])

Ⅳ. Conclusion

In this paper, the survey system for deep sea with high accuracy and speed was developed. The proposed survey system consists of tow ship and towed underwater vehicle.

The following results were obtained.

The attachment is effective, and carries out the function as the rudder. However, ruining the stability of the vehicle is predictable under a specific situation.

Reference

[1] 3DCAD system practical guide Solidworks (In Japanese)

[2] Solidworks simulation Tutorial (in Japanese)

[3] http://www.toa-const.co.jp/