Performance of a double gimbal system for an acoustic sub-bottom probe for Mn crust thickness measurements

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Abstract

This paper evaluates the performance of a double gimbal system for an acoustic sub-bottom probe for measuring crust thickness in practical Mn crusts surveys. To increase the sampling rate for thickness measurement of Mn crusts obtained by sampling, an acoustic sub bottom probe was made capable of in-situ measurements. However, it was shown in lab experiments that the acoustic reflection intensity of the probe was severely affected by the angle of incidence of the acoustic beam. Since Mn crusts are found abundantly on the slopes of underwater seamounts, a double gimbal system was made to orient the beam parallel to the seafloor using a slope measuring algorithm. The system has been implemented on the AUV BOSS-A and used for obtaining measurements of Mn crust thickness at No. 5 Takuyo seamount in Northwest Pacific. The performance of the gimbal system during sea trials is evaluated to demonstrate how it can significantly improve the quality of acoustic reflections obtained from the probe.

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Index Terms

Acoustic mapping, Sub-bottom, Double gimbal, Mn crusts, Real-time control

I. Introduction

Exploration of Manganese crusts (Mn crusts) has gained signifant importance in recent years for their economic and scientific value.

Mn crusts are found abundantly along the slopes of underwater seamounts.

For thorough understating of these crusts, estimating their volume and distribution is important.

This is usually carried out by using camera systems mounted on Remotely Operated Vehicles (ROVs) and sampling using cutting tools mounted on manipulators.

The spatial resolution obtained from sampling does not provide enough details for volumetric estimation.

For this, an acoustic sub-bottom probe was developed by our group for in-situ continuous measurements of Mn crusts thickness.

The acoustic probe focuses a 200 kHz acoustic beam with a diameter of 20 mm at a target 1.5 m away.

Using the reected acoustic signal from the surface and the back face of the crust, the thickness of crusts is calculated from the time difference between the two reections.

Previous experiments performed by our group in a tank showed that the quality of acoustic reection is signicantly affected by the angle of incidence of the acoustic beam as seen in Figure 1.

To make practical use of the probe during surveys, an actively controlled double gimbal system was made with a control algorithm which uses the seaoor slope to align the probe parallel to the seaoor.

The system has been implemented on the survey class Autonomous Underwater Vehicle (AUV) BOSS-A which is a payload oriented vehicle with sensors built specically for Mn crust surveys. It is equipped with the acoustic probe mounted on a double gimbal system as its main payload. A high resolution mapping system, capable of centimeter order seaoor reconstructions in color, is implemented on the AUV based on light sectioning.

These reconstructions can be used to measure accurate slopes of the seaoor.

However, for actively controlling the gimbals in real-time, a simplied algorithm is made which calculates the plane made by two points on the laser line and range to seaoor measured using the Doppler Velocity Log (DVL).

The performance of this system during sea trials is elaborated in this paper

Organisation of the paper:

Section 2: Describes the problem with angular reflection

Section 3: Describes the hardware associated. The acoustic probe, gimbal mechanism, visual mapping system and the control mechanism.

Section 4: Describes the method of analysis of the performance of the system

Section 5: Describes the survey performed in the ocean using this system and analyses the performance of the system.

Section 6: Provides conclusions to the performance of the system.

II. Conclusions

Acoustic probe was developed for continuous measurements of the Mn crust. Previous results have showed the effect of angle of incidence on the intensity of the acoustic reflection. The system was gimbaled to align the probe parallel to the seafloor AUV was developed using this concept and deployed at an underwater seamount Results from the trials showed the necessity for such a system to obtain Mn crust thickness measurements.

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References

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