Sea-water spray measurement and icebreaking operation during JARE61 Shirase cruise

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Ship icing is a phenomenon in which water droplets attached to the ship are cooled and frozen. Ship icing occurs in cold sea area, and it causes some problems such as a decrease in operation efficiency, a malfunction of deck equipment, increasing risk of falling water, and so on. The main cause of ship icing is generally thought to be sea-water spray generated by the collision of ship and waves. It is, therefore, needed to investigate the condition where a large amount of sea-water spray is generated. In Japanese Antarctic Research Expedition 61st (JARE61), we observed sea-water spray with two types of spray meters installed on Japanese icebreaker Shirase II. One is a spray particle counter (SPC), and the other is a marine rain gauge type spray meter (MRS). SPC measures the spray particles that pass through its sensor area every second, and MRS measures the amount of spray that drops in its cylindrical receptacle every 30 seconds. We installed SPC on the 06 deck and MRS on both sides of the 01 deck (Fig. 1). Through this observation, we acquired continuous data of sea-water spray.

Fig. 1 Position of spray meter on Shirase

Then, we compared sea-water spray data with ship condition data, such as wind direction, significant wave height, mean wave period, and so on. Vessel data interval was united to 1 hour because the used atmospheric analysis data was formed in hourly data. We made minute precipitation data for each sea-water spray meter and compared it with relative wind speed, relative wind direction, significant wave height, and mean period of wave encounter (Fig. 2). As a result, SPC spray volume rate was large in condition that mean period of wave encounter was around 8-10 seconds. This suggests ships might be able to avoid generating much sea-water spray by controlling vessel speed or relative wave direction. However, more study is required on this theme. For example, observing each wave height and direction, comparing with other vessel and cruise data, is needed.

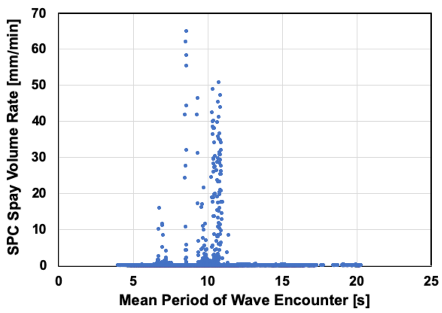

Fig. 2 SPC spray volume rate on mean period of wave encounter

The Shirase II needs to break very thick multiyear landfast ice near Showa station in the Lützow-Holm Bay. In order to improve icebreaking performance, this ship has a water flushing system that decreases the frictional resistance between ship hull and dry snow. This effect was shown in ice tank model test (Yamauchi et. al., 2011; and Yamauchi, 2013). However, it is not clear that the fact can be applied in actual sea ice area. Therefore, we set the test sea area in the route of JARE61 and compared the distance of its advance with and without water flushing.

In the test section, 25 ramming operations which didn't exceed 138m (length of Shirase II) were plotted (Fig.3). The mean ramming distance with and without water flushing are 56 m and 49 m, an increase of about 14%. In JARE61, the fuel consumption during ramming was firstly measured by video recording. The result shows that the increase of fuel consumption due to water flushing is about 4%. This means that the effect of water flushing during ramming is more than its fuel consumption. Figure 3 also suggests that the ramming distance and effect of water flushing increase as the snow becomes thinner. But snow thickness is correlated with ice thickness. Also, the data are highly scattering. We need to further repeat the tests and collect more data to get statistical significance.

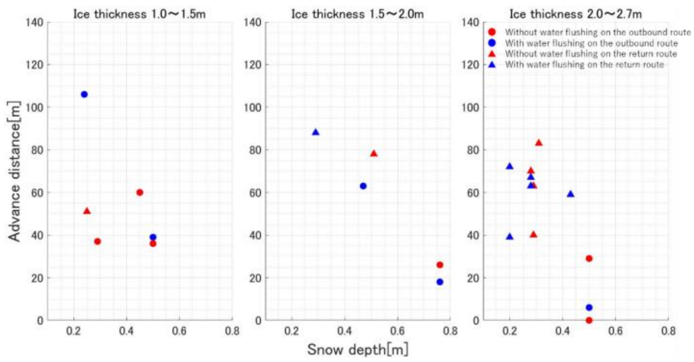

Fig. 3 Comparison of snow depth and advance distance for each ice thickness

References

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