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## Studies on the Ice Accumulation on Ships

### III. On the prevention of icing on ships by membranous water

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#### Abstract

In this paper the author describes that it may be possible to prevent ice accumulation on ships according to the use of a running water film formed on the hull with the warmed cooling water from the main engine.

Two fishing boats were equipped for this basic experiments and the installation was kept throughout the year for that purpose. Sufficient results have been obtained but there remain some problems for a future study.

#### Introduction

A practical way of deicing fishing boats has been needed for a long time. Some practical decicing methods have been investigated and found for several years, but all of them were confined, to a cirtain number of ships and the result was only to reduce or remove partly the accumulated ice on ships.

Consequently, we cannot but accept that is difficut to work out a final solution to that problem except by using heat energy.

In this paper the author describes a project on the prevention of icing by using the water heated by the heating unit of the engine. Namely, this method on the prevention of icing is based on the use of warm water forming a mebranous current on the surface of the hull.

After basic laboratory, the experiment was made on an offshore dragnet boat the No. 35 Benten-maru (124 GT.) and a pelagic trawler the No. 28 Kofuku-maru (349 GT.) this winter in the northen sea.

An attempt to put this method into practical way was made by the joint project of the members of the Hakodate Seimo Sengu Co. LTD. and the Bridge-stone Tire Co. LTD. This study was being continued as the joint research by them and the author.

As a result of the examination, it well be possible in principle to prevent ice accumulation on ships by this method but some problems still remain to be solved.

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### **General idea on this prevention method of icing by membranous water**

It is well known that ice accumulation on ships does not occur on the hull washing always by green water near the water line. That is to say, the sea water, whose temperature falling is confined to 0°C extent is difficult to icing itself on ship for it has nearly an inexhaustible heat capacity against the coldness of the atmosphere. If it is frozen for an instant, it will be thawed immediately by waves and splashes.

Such a method of deicing is examined in view of that fact.

In practice, we have to consider the thin membrane of the water for this purpose. Because not only there are some disagreement as to let hebitually a mass water flow on the decks and the upper structures of fishing boats but by so doing there are anew dengers of the stability of boats at sea.

Therefore the quantity of water is one of the elements of the problems as well as the temperature of the membrane.

If the heat capacity of membranous water, whose quantity and temperature are controled, exceeds the latent heat of the splashes and the snow adhering to the ship, they will flow out of the deck before icing itself. Then, the practical prevention of ice accumulation will be realized as a result of the heat transfered by membranous water and special properties of running water.

### **Characteristic of membranous running water and its effect on deicing**

In general, being either converged or meandered according to its viscosity and surface tension, a small quantity of water flows on the surface of the wall is not diffused as a membrane. The flow has to be increased in a quantity corresponding to the property of the surface so as that to become a flat membranous water film.

Fig. 1, 2 show water being splashed on the upper edge of the test pieces and converged in a downward position.

It is difficut to form a membrane in case of water is lower viscosity but either in a small rate of flow or large flux.

The development of icing is very remarkable<sup>1)</sup> so that an insufficient formation or a partial break of the water film is easy to permits the occurrence of ice and invites the ice accumulation to extend over a wide area. That is to say, it is considered necessary to secure a perfect water membrane.

The selection of a suitable surface material was chosen in order to make on it a flat film however small the flow of water used. A diffusion rubber sheet shown in Fig. 3 has been developed after experimentation.

If a fluid is hindered in its falling progress by some resistance it will simply

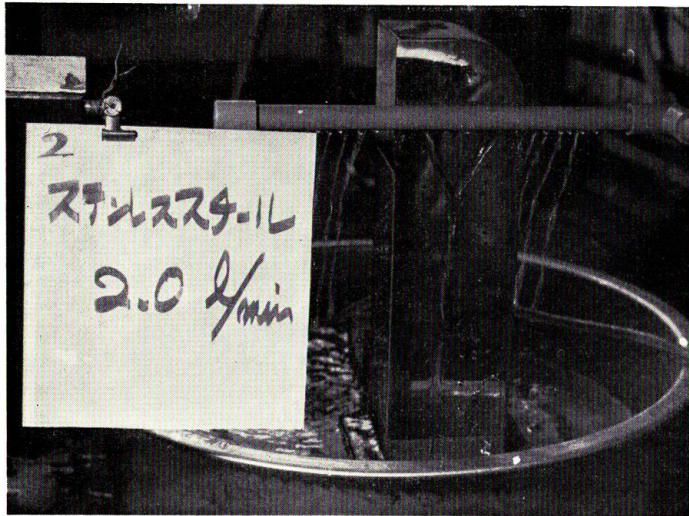


Fig. 1. General property of running water being converged on the surface of a stainless steel.



Fig. 2. General property of running water being meandered on the surface of a regular rubber sheet.



Fig. 3. Water film consists of running water on the surface of the diffusive rubber.

form a diffusive film due to the resistance.

A neoprene rubber sheet with a loose texture surface was used. It is clear that the spray water is spouting from the upper edge of the sheet and spread on the surface as shown in Fig. 3. The water film in this figure is about 1 mm thick.

### The collection and the use of the cooling water coming from an engine

If the latent heat of a water film is not superior to the external cooling atmosphere, the water flow will freeze in the future, however complete the running water film is formed. But, it is difficult under existing circumstances, on fishing vessels, to produce artificially the heat energy to counterbalance the external condition in the northern sea.

The effective use of the warmed cooling water coming from the cooling system for an engine has been examined under these conditions.

It is too regrettable to waste the enormous heat of an engine as it is well

Table 1. Outline of Cooling Water.

Fishing boat	Horse power of the main engine	Quantity of the cooling water	Rising temperature of the cooling water
type 124 tons	1000~1300 HP	20~30 tons/horu	15~20°C
type 349 tons	2000~2500 HP	40~60 tons/horu	20~25°C



known in mechanical engineering. The amount of cooling water used on an off-shore dragnet fishing boat of the 124 GT. type and a pelagic trawler of the 349 GT. type is shown in Table 1.

This method of deicing comes on the assumption that the thermal capacity of the cooling water may be exploited.

### **Physical conditions of a water film and its effect on the prevention of icing**

The fundamental experiments on the subject were made in three steps.

The formation of a water film and its effect to prevent ice adhesion on itself was observed at the start in our laboratory with some test models in the airconditioning duct consisting of a section 500 mm square had been preapred<sup>2)3)</sup> in order to carry out effectively the experiment, Then the stability of a running water film in high wind and the thermal transfer from that water surface was measured at sea as shown Fig. 4 on the Oshima-maru (4075 GT.) Seikan ferry boat of the National Railways. Finally the characteristic of membranous running water in its life-size in condition of a low temperature was investigated at The Institute of Low Temperature Science, Hokkaido University for estimation so far.

It was found that the prevention of ice accumulation on ships may be possible

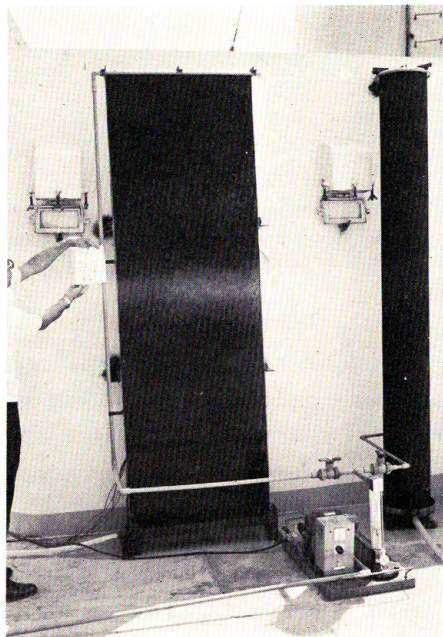


Fig. 4. View of the experience on the Oshima-maru.

with a condition of 10 m/sec wind velocity,  $-18^{\circ}\text{C}$  atmospheric and  $0^{\circ}\text{C}$  sea water temperature. The result of that examination complies with the aforesaid conception.

An experimental result about the radiation of running water film corresponds to the relation between the relative wind velocity and the service quantity of the cooling water as analyzed in Fig. 5. It will help in the search for a practical planning of the installation to prevent ice accumulation. The coefficient of thermal

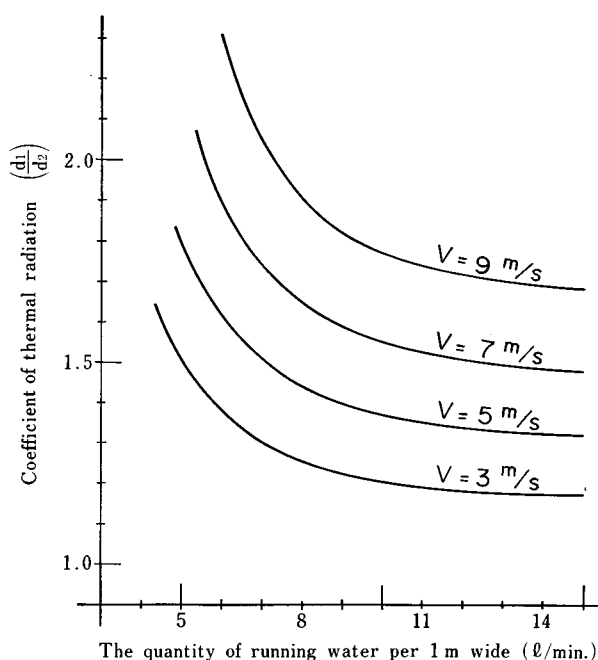


Fig. 5. A coefficient of thermal radiation.

$d_1$ , temperature difference upper edge of the water film and outside  
 $d_2$ , temperature difference lower edge of the water film and outside  
 $V$ , wind velocity

radiation shown in Fig. 5 equals to the ratio of each temperature difference from the temperature of upper or lower edge of the wall when the cooling water is being flown to the outside, when the wall height of the deck house of a fishing vessel is assumed to be about 2.4 m high.

A deicing plant was designed according to these analyzes on the precondition that the temperature of the supply water must not fall below the freezing point while the water is running on a deck or walls. For example, in case of the No. 35 Benten-maru on which the experiment has been made off the coast of Wakkanai in this winter, the quantity of cooling water consumed has been calculated to be

about 25 tons per hour to deice the deck house (the front and the side parts) and the outside of the bulwarks in front of the midship.

We observed that during the sea trials splashes of warm water were accidentally carried out for deicing of the around due to their heat capacity but they were blown somewhat away rearward on the deck by the misguided action of wind velocity exceeding 15 m/sec, even if the stability of running water film under such a strong wind was feared.<sup>4)</sup>

### The result of the sea trial and its problems

As aforesaid, the trial was based on the method applied to two fishing boats. The result so far were very favorable on this icing phenomenon with which each vessels have met off the Maritime Provinces, the Sakhalin and the Kurile Islands.

That is the reason why the latent heat of the cooling water was so abundant that at any time we had not to fear the freezing of the supply water.

On the No. 28 Kofuku-maru, it is reported that the running water area was kept to a complete safety degree from icing under the condition of  $-5^{\circ}\text{C}$  air temperature,  $0^{\circ}\text{C}$  sea water temperature and 4 in the Beauforts wind scale. The supply water temperature on the upper edge of the diffusive rubber sheet for prevention of ice adhesion was  $35^{\circ}\text{C}$  and even at the lower edge the water was kept at as much as  $27^{\circ}\text{C}$  during that time.

Here are a list of the necessary precautions taken and the problems encountered through the sea trials.

#### 1. *Strength of the diffusive rubber sheet*

The outside of bulwark gets a terrific shock when a vessel comes and leaves the quay or the like. The face of such a rubber sheet is impinged upon a quay or scoured by wire ropes. It was protected with metalworking in this examination, as it is difficult to make rubber counteract that sort of external forces with no thought of profit.

The rubber on the outside of the bulwark has been partially damaged in the 4 months through the sea trial in spite of the precautions taken but is discharged its duties on the part of the deck house just as expected.

#### 2. *On setting up the equipment*

The diffusive rubber sheet in general has to be installed not only a rough construction with a solid paint coating on an untidy deck during a casual day in the fishing season except for a newly-built fishing vessel, but also skillfully applied in the autumnal cold preceding the icing season.

Accordingly, the equipments need to be prefabricated as soon as possible.





Fig. 6. No. 35 Bente-marui being equipped with the diffusive rubber sheet.

In this trial, the rubber sheets were plastered with FRP or light aluminium frames constructed in the appearance of a grille.

In dispensable projection of the hull was disposed lest its function should be spoiled. From this result there were kinds of weak points as for the position of the windows and such things. Thought it seems to be a matter of time to solve this problem.

### 3. *Piping of water spray and its prevention from freezing*

As, a spray pipe supplies the warm water to make a membrane on the hull, it is exposed to a low temperature at all times alike the water film itself, the cooling water also may get cool inside the pipe. Moreover, it dose not always follow that the cooling water in the piping is exhausted before it freezes when the water service is cut off, in case of stop engine and so on, because the bore of the spray nozzles is too small.

Needless to say, if every nozzles are frozen it will not be able to keep the deicing device going.

In this trials the piping was kept warm with a plane heater to avert such a misgiving. It was consequently required to use a 150-Watt per meter length of a 1 inch inside diameter steel pipe to keep the surface temperature at 3°C with a 8 m/sec wind velocity and a -15°C atmospheric temperature.

The plane heater graft carbon shielded with a plastic film was too feeble in comparison with external precaution taken to keep the elctric insulation for the

occasion fastened round the pipe as in the original experiment. But the present result is therefore good since the heater was fastened inside the pipe.

#### 4. *The machinery equipment of the water supply*

There must be no hindrance on the smooth operation of the main engine from which the warmed cooling water is used.

It must be designed so as to give a reasonable capacity. Then it is necessary to have a system to renew the used warm water.

A suitable expansion tank should keep a normal flow into the cooling system of the machines. The capacity of each tank was fixed at 0.4 tons of the amount used for the cooling water which is 25 tons per hour in case of the No. 35 Benten-maru and at 0.7 tons for the 40 tons per hour in the No. 28 Kofuku-maru.

If the warm water exceeds the required quantity for our purpose it overflows out of the ship through the tank.

These tanks proved to be working well. Especially the utilization of the waste heat in the No. 28 Kofuku-maru has heightened the effect of the cooling water of the recalesced tank having been placed in a funnel.

In addition, piping, pumps and others will have to be designed to comply with the characteristics of each vessel.

### Conclusion

The methods of deicing have been mostly used to suggest as the tests proved, that the various observations were not to prevent the quick freezing of the splashes but to get off the accumulated ice on ships.

We aimed only to prevent icing by using a running water film from the cooling water of engine. And it proved that this method was practical in principle. Its achievements will become a center of interest after solving its pendings.

Well, such a method has been tried together with the use of water film on the deck house so as to obtain the same result of deicing as the warm water into the handrail put remodeled as piping on the No. 28 Kofuku-maru instead of the rubber sheet which proved insufficient in strength on the outside of the bulwark relatively low in quantity of ice accumulation.

The result so far is satisfactory and great hopes are entertained in the use of this method.

It seems to be a matter of time to reach the final aim on these subjects.

I wish to thank Dr. Ono for his helpful advice and my many colleagues with whom I have discussed this problem.

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