

# Causal Analysis and Countermeasures of Ice Blockage in Seawater Fluid Ice Producing Machine

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**Abstract.** The seawater fluid ice producing machine has a wide application prospect. However, ice blockage often occurs in the machine, which has impeded its popularization and application. In the view of crystallization mechanism, the method of reducing the degree of super-cooling and changing the surface characteristics of the ice cylinder are proposed to solve this problem. In addition, some suggestions are given on the transportation, daily maintenance and operation process. Given the environmental factors, strengthening equipment and adjusting the inlet flow rate of the ice producing machine are adopted to reduce the ice blockage rate of the fluid ice producing machine and smooth the operation of this machine.

## 1. Introduction

Fluid seawater ice has great potential application in the field of fishing and freshness preservation. At present, the spiral scraping machine is the most widely used. However, ice blockage is easy to occur in the ice cylinder and the ice content of seawater fluid ice is low <sup>[1]</sup>. Scholars both at home and abroad have carried out many researches on the spiral scraping ice-producing machine, mainly focusing on improving the efficiency of ice-producing <sup>[2]</sup>, without analysing the causes of ice blockage.

## 2. Preparation of Seawater Fluid Ice and analysis of ice resistance

In this paper, Spiral scraping fluid ice-producing machine working process is analyzed (Fig.1) <sup>[3]</sup>. most of whose heat exchangers are shell-and-tube heat exchangers. In shell-and-tube heat exchangers, the refrigerant outside the tube evaporates and absorbs heat, transferring energy through the shell wall and the water solution inside the tube is condensed and releases heat. The water solution is then cooled down to super-cooled state in the ice cylinder. After ice crystals are formed, the ice crystals adhered to the inner wall of the ice cylinder are peeled off by rotating the spiral blade mounted on the central



power shaft of the tube at a high speed. The scraped ice crystals are mixed with the original solution to form fluid ice. The generated seawater fluid ice flows out of the ice outlet under the transmission of the spiral blade.

Ice crystals are formed when the seawater inside the inner wall of the ice cylinder evaporates and absorbs heat. When the ice layer in the inner wall of the ice cylinder becomes thicker, the heat transfer resistance increases<sup>[4]</sup>, In case of serious, the inside of the ice tube does not work properly. Thicker ice layer on the inner wall of the ice cylinder will bring about abrasion on the scraper. The ice crystals on the wall cannot be peeled off. Finally, the ice maker cannot operate normally.

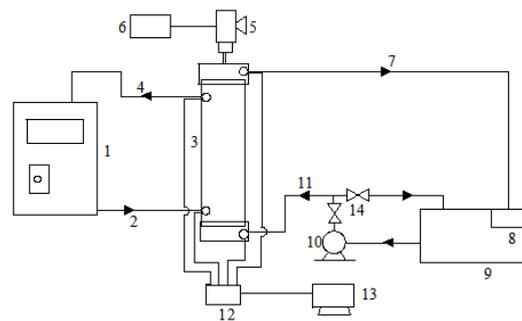


Figure 1. Spiral scraping fluid ice-producing machine working process<sup>[3]</sup>.

1-constant cooling tank; 2-coolant (in); 3-spiral ice slurry generator; 4-coolant(out); 5-drivemotor; 6-speed controller; 7-fluidized ice(out); 8-filter; 9-aqueous storage tank; 10-pump; 11-seawater(in); 12-temperaturecollector; 13-computer; 14-flow regulating valve.

In addition, external vibration and internal fouling of shell-and-tube heat exchangers will lead to the reduction of the speed of the power shaft, the damage of spiral blades and other issues, so that the ice cylinder is blocked by fluid ice.

### 3. Causal analysis and Countermeasures of Ice Blockage of Fluid Ice Producing Machine

#### 3.1 Crystallization Mechanism

Under certain super-cooling circumstances, ice crystals begin to grow once heterogeneous nucleation nuclei are formed. According to the total growth rate of ice layer on the inner wall deduced by Chen Yan et al<sup>[5]</sup>, the growth rate of ice layer is obviously related to the solutes (additives) in the water solution, the inner wall temperature (preparation materials) of heat exchanger and the thickness of ice layer. At the same time, the slower the total rate of ice growth the lower the ice content is, the slower the formation rate of fluid ice per unit time is. Thus this process will increase the energy consumption of scraping ice machine system and worsen the spiral blade abrasion

As for the solute in the solution, the method of adding raw corn flour and nano-nucleating agent to prepare different concentrations of aqueous solution was adopted to promote the crystallization rate<sup>[6,7]</sup>. Under the same conditions, the ice crystal particles produced by adding raw corn flour in seawater were smaller than those produced by seawater<sup>[8]</sup>. In addition, the surface condition of the ice tank affects the contact angle of the sea water, which in turn affects the critical nucleation, the critical nucleation radius. Aiming at the surface characteristics of ice cylinder, ice-thinning materials such as high fluorine coating, FEVE resin and nano-particle polymer were used to reduce the aggregation degree and adhesion strength of ice on the surface<sup>[9-11]</sup>.

#### 3.2 Operation Suggestions

There are fine and precise instruments in the fluid ice-producing machine. If the operation process is not proper, the fluid ice-producing machine will oscillate and the instrument will be damaged. The ice-producing machine may be blocked and cannot operate normally. After the long-term use of the

machine, the impurities such as scales? are often left inside. If maintenance personnel do not regularly inspect and repair the inside of the ice maker, the worn spiral blade in the ice drum cannot be replaced in time, and the ice crystals in the inner wall cannot be peeled off, thus, the ice jam phenomenon of the ice drum is very easy to occur; if the operator does not know the operation process and common conditions, the ice blockage of the fluid ice-producing machine will also occur.

With respect to the instrumental damage caused by oscillation in the transportation process of the ice maker, the main instrumentation was disassembled to carry out a separate method of anti-oscillation protection. In addition, the production materials of the fluidized ice maker should be studied in depth to find better anti-vibration, cold resistance and plasticity materials. When the thermal resistance increases and the spiral blade wears out, the spiral blade should be checked and cleaned regularly and

replaced. As for the ice jam caused by the operator's improper behavior, the correct operation procedure should be taught beforehand and the corresponding measures should be taken when the common problems occur. The operation requirements of the fluid ice-producing machine should be borne in mind, as is shown in (Table.1).

Table 1. Operation requirements of ice maker

Serial number	Pre-operation check items	Runtime considerations
1	The surrounding environment of the unit should be cleaned regularly	Is there any abnormal noise during compression operation?
2	Clean the condenser	Is the compressor running high and low pressure normal?
3	Cleaning the inlet pipe of the ice machine	Condensation fan motor with or without vibration

### 3.3 Environmental Factors

The seawater fluid ice-producing machine can be used in fishing vessels. During the fishing boat sailing, the sea surface condition often changes. Whether the fishing boat sails smoothly or not has an important influence on the normal operation of the ice-producing machine. In case of wind and wave, the unsteady fishing boat resulted in the oscillation of the fluid ice machined and the spiral blade (Fig.2) is damaged, besides, the inner ice layer cannot be thinned by the spiral scraper and ice blockage will occur in the ice maker.

When the ice water ice generator is applied to fishing vessels, it can draw materials locally and save fresh water resources. However, there is a temperature difference between the two seasons in summer and winter, and the temperature in different sea areas is also different. If the inlet flow rate does not change with it, the ice outlet speed will also change. When the ice outlet speed decreases, it is easy to cause ice blockage, which is not conducive to continuous operation.

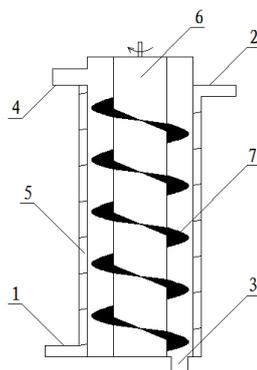


Figure 2. Schematic diagram of the spiral ice slurry generator.

1-Refrigerant inlet; 2-Refrigerant outlet; 3-Seawater inlet; 4-Seawater fluidized ice outlet;  
5-Refrigerant passage; 6-Rotary shaft; 7-Spiral blade.

Due to the damage of the internal parts of the ice maker caused by the swing of the fishing vessel, the base

of the fluidized ice maker should be fixed and the outer protective film should be added to the fishing vessel; in view of the seasonal sea water temperature difference, the sea water flow is adjusted according to the different sea

water temperature, and the sea water temperature is above 20°C. In order to ensure the ice content of the fluidized ice, the inlet flow rate should be adjusted below 60 L/h., and the minimum inlet flow rate should be regulated below 20L/h when the sea water temperature is below 20°C. In addition, when fishing in different sea areas, due to the different salinity of seawater in different sea areas, the import flow needs to be changed. When fishing vessels operate in high salinity sea areas, the import flow is unified below 60L/h.

#### 4. Conclusions

The causes of ice blockage in seawater fluidized ice machine were analyzed. The conclusions could be drawn as follows:

(1) To decrease energy consumption of ice-producing machine and abrasion of spiral blade caused by super-cooling degree, we could add raw corn flour and nanometer nucleating agents to reduce the super-cooling degree.

(2) In view of the instrumental damage caused by oscillation in the transportation process of the ice-producing machine, the main instrumentation was disassembled, the instrumentation was separately protected against oscillation, and the better production materials were found. As for the improper behavior of the operators, we should take measures to teach the correct operation process and the common problems in advance, and be familiar with the operation requirements of the fluid ice-producing machine.

(3) With regard to the damage of the internal parts of the ice-producing machine caused by the swaying of fishing vessel, the method of increasing the fixed base of the fluid ice-producing machine and the outer protective film of the machine was adopted, and the method of adjusting the inlet flow was adopted according to the different salinity and seasonal temperature difference of sea water in different sea areas.

#### Acknowledgement

The authors are grateful for the financial supports of the Zhejiang Provincial Public Projects of China (No. 2017C31008), Zhejiang Provincial Natural Science Foundation of China (No. LY18E060007), National Sparking Plan Project (No. 2013GA700254), Zhoushan Science and Technology Plan Project (No. 2016C41004), the National Natural Science Foundation of China (No. 51606168).

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