



Title of the Invention

ICE MAKING METHOD AND ICE MAKING APPARATUS

Background of the Invention

5 1. Field of the Invention

The present invention relates to a method of continuously releasing water from a supercooled state to make ice and not interfering with production of supercooled water for a long time, and an apparatus capable of continuously making ice.

10 2. Description of the Related Art

A general technology of producing supercooled water to make sherbet ice thereof continuously is disclosed, for example, in US Patent No. 4,671,077. Besides, a method is also proposed which continuously releases water in the supercooled state in a closed pipe to make ice.

15 To make ice continuously for a long time, however, it is required to prevent phase change (supercooling release) from propagating from a position where ice crystals exist for making ice, for example, a supercooling releasing device, to a cooler so as to avoid freeze of the cooler.

More specifically, once supercooled water which has been produced
20 in a supercooler starts changing in phase in the supercooling releasing device, ice nuclei sequentially grow on and are removed by water flow from the wall face in the supercooling releasing device, and the process is repeated. Such a phenomenon that growth and removal of ice on and from a surface of a solid substance in contact with the supercooled water propagates to the
25 upstream side, that is, the supercooler, along an inner wall of a connecting pipe which is connected to the inlet of the supercooling releasing device.

The reason why such propagation occurs relates to attachment of ice to the wall face. More specifically, the ice attached to the wall face, even if exposed to the flow at a high velocity, is staying still on the wall of the pipe or is moving downstream at a very low velocity during the attachment, so that
5 phase change proceeds upstream by the growth of ice during the state. Note that even if the ice is removed by the flow, a group of micro crystals remain at a portion of the face where the above ice attached, from where new ice nuclei grow.

In regard of this phenomenon, for example, Japanese Patent No.
10 2806155 discloses a method of preventing propagation of phase change by heating a connecting pipe, and Japanese Patent Laid-Open No. 2000-74532 proposes a method of preventing ice from entering a connecting pipe by providing special processing to an end portion of a connecting pipe on the side of an ice making container to increase the flow velocity to 2.7 m/s.

15 Further, methods for weakening adherence of ice to the wall face in a supercooling releasing device also include a method of using a material having a low heat conductivity for the material of the wall face in itself as disclosed in the 35th Japan Heat Transfer Symposium Transaction (1998, P. 221).

20 The technology disclosed in Japanese Patent No. 2806155, however, requires extra energy for heating, and has a disadvantage that an increase in temperature of the supercooled water unavoidably causes a decrease in the amount of ice production.

The technology disclosed in Japanese Patent Laid-Open No. 2000-
25 74532 requires energy for transferring water and produced ice water more than the case in which the flow velocity is not increased because the increase

in the flow velocity in the connecting pipe increases pipe resistance of the connecting pipe. Moreover, it is necessary to take measures separately against attachment of foreign matter such as minute flaws, scales or the like on the face, which has been provided with the special processing, of the end
5 portion of the connecting pipe in order to keep for a long time the effect of preventing phase change from propagating upstream.

The method of using a material having a low heat conductivity for the material of the wall face in itself cannot bring the adherence of ice to 0 (zero) because there exists no substance having a heat conductivity of 0 (zero), and
10 therefore it is impossible to fully prevent phase change from propagating upstream.

Summary of the Invention

The present invention is developed in consideration of the above-
15 described disadvantages, and it is an object thereof to stably prevent phase change from propagating from a supercooling releasing device to a connecting pipe for a long time without necessity of the above-described extra heating energy or special processing provided to a surface of an end portion of the connecting pipe for preventing the propagation, in making ice
20 by releasing supercooling in a so-called closed system.

In order to attain the above-described object, an ice making method of the present invention is a method for making ice by sending water which has been brought to a supercooled state in a supercooler to a closed-type supercooling releasing device through a connecting pipe without allowing the
25 water to be in contact with air, wherein water at 0°C or higher is supplied to an inner face of the connecting pipe. As the water at 0°C or higher, water

immediately before being introduced into the supercooler or water which has been taken from a heat storage tank and heated, can be used. It is, of course, adoptable to employ water higher than 0°C.

When water at 0°C or higher is supplied to the entire circumference
5 of an inner face of the connecting pipe, a liquid film of the water at 0°C or higher is formed at the entire circumference of the inner face of the connecting pipe downstream from a portion supplied with the water. This liquid film can prevent ice from attaching to an inner wall of the connecting pipe and phase change from propagating upstream. Ice nuclei, even if
10 existing, do not grow but melt in time or are flowed downstream in the liquid film at 0°C or higher formed on the wall face of the connecting pipe, so that phase change never propagates upstream beyond the portion of the connecting pipe which is supplied with the water at 0°C or higher. In order to attain the above-described effect, it is necessary to keep the flow rate from
15 the outlet of the connecting pipe at about 2% to about 3% of the flow rate of water flowing into the supercooling releasing device. The flow velocity in the connecting pipe is only required to be 1 m/s or higher.

An ice making apparatus of the present invention includes: a supercooler for bringing water to a supercooled state; a closed-type
20 supercooling releasing device for releasing the water in the supercooled state; a connecting pipe for connecting an outlet of the supercooler and an inlet of the supercooling releasing device; an outer container for watertightly covering an outer periphery of the connecting pipe; and a water injection pipe for injecting water into the outer container, wherein the connecting pipe is
25 divided over an entire circumference thereof with a gap between divided portions thereof in the outer container.

In the ice making apparatus of the present invention, since the connecting pipe is divided over the entire circumference thereof with a gap between divided portions thereof in the outer container, when water is injected from the injection pipe into the outer container, the water can be supplied through the gap onto the inner wall of the connecting pipe to form a liquid film of the injected water on the inner wall of the connecting pipe downstream from the gap. Therefore, the ice making method of the present invention can be preferably implemented. It should be noted that the division of the connecting pipe slightly relieves the propagation with the gap at the beginning of formation of ice pieces starting from the supercooling releasing device to the connecting pipe, but cannot fully interfere with the propagation upstream because of a bridge operation.

The water injection pipe is designed to branch off from a conduit, which is connected to the supercooler at the inlet side, and bypasses the supercooler to be connected between the conduit and the outer container, thus eliminating necessity to ensure an extra water source and allowing water to be injected to a suitable temperature or just requiring a very small quantity of heat even if heating is required.

Brief Description of the Drawings

FIG. 1 is an explanatory view showing a general configuration of an ice making apparatus according to an embodiment;

FIG. 2 is a partially sectional side view showing an internal appearance of a connecting pipe in the ice making apparatus according to this embodiment;

FIG. 3 is a sectional side view showing another example of divided

end faces of the connecting pipe;

FIG. 4 is a sectional side view showing still another example of the divided end faces of the connecting pipe;

FIG. 5 is a sectional side view showing yet another example of the divided faces of the connecting pipe; and

FIG. 6 is a sectional side view showing another divided faces of the connecting pipe.

Detailed Description of the Invention

Hereinafter, a preferred embodiment of the present invention will be explained based on the drawings to describe the present invention in detail. FIG. 1 shows the whole configuration of an ice making apparatus 1 according to the embodiment, in which a supercooler 2 has, for example, a so-called shell-and-tube configuration. The supercooler 2 has a function of cooling water, which has been introduced thereinto, using brine from a freezer (not shown) to bring the water to a supercooled state, for example, at 0°C or lower.

To an outlet side of the supercooler 2, that is, to a jet port 2a thereof, one end portion of a connecting pipe 3 is connected, and the other end portion of the connecting pipe 3 is connected to a closed-type supercooling releasing device 4. The supercooling releasing device 4 has a function of releasing the supercooled water, which has flowed thereinto through the connecting pipe 3, from its supercooled state for phase change to thereby produce ice in a slurry form and allowing the ice to flow out to the outside. As a trigger for releasing supercooling, for example, ultrasound generated by an ultrasonic vibrator is used, and a well-known ultrasonic vibrator can be

appropriately used for this kind of closed-type supercooling releasing device
4.

To an inlet side of the supercooler 2, a conduit 11 is connected, so that
water taken by a pump 12 from various reservoirs 13 including a heat storage
5 tank is sent into the supercooler 2. Upstream of the pump 12 along the
conduit 11, for example, a preheater 14 is provided to be able to heat water
flowing in the conduit 11, for example, to 0.5°C.

Downstream of the pump 12 along the conduit 11, one end portion of
a water injection pipe 21 is connected, and the other end portion thereof is
10 connected to an outer container 22 which watertightly covers the outer
periphery of the connecting pipe 3. Therefore, part of the water in the
conduit 11 bypasses the supercooler 2 and is sent through this water injection
pipe 21 to the outer container 22. Accordingly, water is sent to the water
injection pipe 21 and to the supercooler 2 by one pump 12.

15 The connecting pipe 3, as shown in FIG. 2, is divided perpendicularly
to an axial direction thereof to create a gap d in the outer container 22, so that
the connecting pipe 3 is divided into an upstream side connecting pipe 3a and
a downstream side connecting pipe 3b. Accordingly, when water is injected
from the water injection pipe 21 into the outer container 22, the water
20 entering the connecting pipe 3 through the gap d flows downstream on a flow
in the connecting pipe 3 along a wall face of the downstream side connecting
pipe 3b, thereby forming a liquid film of the injected water on an inner wall
face of the downstream side connecting pipe 3b.

Note that since a pressure applied by the pump 12 to the water
25 flowing in the water injection pipe 21 is maintained until the water reaches
the outer container 22, there is no trouble to force the water into the

connecting pipe 3 through the later-described gap d.

The ice making apparatus 1 according to the embodiment has the above-described configuration, and an example of the operation thereof is explained next. For example, when water at 0°C is taken from the reservoir 13, the water is increased in temperature to 0.5°C by the preheater 14. The water at 0.5°C is cooled into a supercooled state of, for example, -2°C in the supercooler 2, and is sent, as it is, to the supercooling releasing device 4, where the water is released from the supercooled state to form ice in a slurry form, for example, at 0°C which is continuously flowed out to the outside.

Meanwhile, the water at 0.5°C branching off from the conduit 11 and flowing into the water injection pipe 21 is injected into the outer container 22 to enter the connecting pipe 3 through the divided portion of the connecting pipe 3, that is, the gap d, and flows downstream, as it is, on the flow of the supercooled water. In this event, since the gap d is provided at the entire circumference of the connecting pipe 3, the aforementioned water at 0.5°C flows along the wall face of the inner wall of the downstream side connecting pipe 3b, resulting in a liquid film of the water at 0.5°C formed at the entire circumference of the wall face, that is, the inner face.

It should be noted that a junction point (an injected water spouting/receiving opening) between the water injection pipe 21 and the outer container 22 is set in such a manner to have an axis offset from the gap d and a predetermined distance therefrom. This is a configuration for the purpose of uniform injection of water from the entire circumference of the wall face.

Consequently, even if the supercooling release, which is implemented in the supercooling releasing device 4, will propagate upstream along the

wall face, the upstream propagation is prevented because the liquid film at 0°C or higher is formed on the inner wall face of the downstream side connecting pipe 3b. In addition, ice nuclei, even if existing, do not grow but melt in time or are flowed downstream by the flow of water in the supercooled state in the liquid film at 0°C or higher formed on the wall face, and as a result, phase change never propagates upstream beyond the outlet of the connecting pipe 3. This prevents freeze in the connecting pipe 3 and at the outlet of the supercooler 2, thus making it possible to stably make ice in a slurry form.

10 In contrast to the prior art, it is unnecessary to provide special processing such as application of a resin or the like onto the surface of the wall face, and the stable propagation preventing effect can be obtained for a long time. The water for forming the liquid film is heated to 0.5°C by the preheater 14 in this embodiment, but the heating requires only very little energy which is much smaller than that in a method of preventing freeze by directly heating the connecting pipe and the like as in the prior art.

Further, since part of the water flowing in the conduit 11 is branched off to be injected into the outer container 22 in this embodiment, it is unnecessary to ensure separately a water source of water to be injected into the outer container 22.

Note that while the preheater 14 is installed to heat the water flowing in the conduit 11 in this embodiment, an appropriate temperature regulator such as a heater in which, for example, a sensor and a controller are combined may be provided to individually heat the water flowing in the water injection pipe 21. Thereby, water to be injected can be individually set to suitable temperatures. The water injection pipe 21 is not necessarily drawn

from the branching off portion of the conduit 11, but water may be directly taken from the water source such as the reservoir or the like, or a public water supply and the outer container 22 may be connected to each other through a valve and a temperature regulator.

5 The divided end faces of the connecting pipe 3, that is, an end face of the upstream side connecting pipe 3a and an end face of the downstream side connecting pipe 3b preferably employ shapes of respective examples shown in FIG. 3 and thereafter.

10 The example shown in FIG. 3 has a shape in which the end face of the upstream side connecting pipe 3a is in a tapered shape projecting downstream on an inner wall 31 side, and the end face of the downstream side connecting pipe 3b is in a tapered shape projecting upstream on an outer wall 32 side.

15 The example shown in FIG. 4 has a shape in which the end face of the upstream side connecting pipe 3a is in a tapered shape projecting downstream on an inner wall 31 side as in the example in FIG. 3, but the end face on the downstream side connecting pipe 3b projects upstream on an outer wall 32 side, and an end face 33 itself of the downstream side connecting pipe 3b is in a shape curved convex toward upstream.

20 The example shown in FIG. 5 has a configuration in which the end face of the upstream side connecting pipe 3a projects downstream on an inner wall 31 side farther than on an outer wall 34 side, the end face of the downstream side connecting pipe 3b projects upstream on an inner wall 35 side farther than on an outer wall 32 side, and a tip 36 of the end face of the upstream side connecting pipe 3a and a tip 37 of the end face of the
25 downstream side connecting pipe 3b have faces which are cut perpendicularly to respective axial directions.

The example shown in FIG. 6 has a shape in which the end face of the upstream side connecting pipe 3a projects downstream on an inner wall 31 side farther than on an outer wall 34 side, the end face of the downstream side connecting pipe 3b projects upstream on an inner wall 35 side farther than on an outer wall 32 side, and an end face 38 of the upstream side connecting pipe 3a and an end face 39 of the downstream side connecting pipe 3b themselves are in a shape curved convex to the outside of the connecting pipe 3.

The employment of the above-described shapes of the divided faces of the connecting pipe 3 as shown in FIG. 3 to FIG. 6 allows water entering the connecting pipe 3 through the gap d to flow more preferably along the inner wall 35 of the downstream side connecting pipe 3b to thereby form a liquid film of the water more preferably on the surface of the inner wall 35 of the downstream side connecting pipe 3b. It should be noted that an aspect shown in FIG. 4 exhibited the best effect in the results of the experiment the present inventor carried out through the use of the shapes of the divided end faces shown in FIG. 3 to FIG. 6.

In addition to the above-described embodiment, for example, a plate-type heat exchanger can be used in place of the shell-and-tube type heat exchanger (supercooler).

Besides, as well as the box-shaped outer container, an annular-shaped outer container with a diameter larger than that of the connecting pipe 3 can also be used as the outer container 22.

According to the present invention, in making ice by releasing supercooling in a so-called closed system, it is possible to stably prevent phase change from propagating from the supercooling releasing device to the

connecting pipe for a long time without necessity of extra heating energy or special processing provided to the surface of the end portion of the connecting pipe. This makes it possible to continuously release the water from its supercooled state to make ice and to stably implement this operation
5 for a long time.

What is claimed is:

1. A method for making ice by sending water which has been brought to a supercooled state in a supercooler to a closed-type supercooling releasing device through a connecting pipe without allowing the water to be in contact
5 with air, wherein
water at 0°C or higher is supplied to an inner face of said connecting pipe.
2. The method as set forth in claim 1, wherein
as said water at 0°C or higher, water immediately before being
10 introduced into the supercooler is used.
3. The method as set forth in claim 1, wherein
said water at 0°C or higher is water which has been taken from a heat storage tank and heated.
4. An apparatus for making ice, comprising:
15 a supercooler for bringing water to a supercooled state;
a closed-type supercooling releasing device for releasing the water in the supercooled state;
a connecting pipe for connecting an outlet of said supercooler and an inlet of said supercooling releasing device;
20 an outer container for watertightly covering an outer periphery of said connecting pipe; and
a water injection pipe for injecting water into said outer container,
wherein said connecting pipe is divided over an entire circumference thereof with a gap between divided portions thereof in said outer container.
- 25 5. The apparatus as set forth in claim 4, wherein
said water injection pipe branches off from a conduit, which is

connected to said supercooler at the inlet side and bypasses said supercooler to be connected between said conduit and said outer container.

6. The apparatus as set forth in claim 4, wherein

5 said connecting pipe has divided end faces, the end face of an upstream side connecting pipe being in a tapered shape projecting downstream on an inner wall side and the end face of a downstream side connecting pipe being in a tapered shape projecting upstream on an outer wall side.

7. The apparatus as set forth in claim 4, wherein

10 said connecting pipe has divided end faces, the end face of an upstream side connecting pipe being in a tapered shape projecting downstream on an inner face side, the end face of a downstream side connecting pipe projecting upstream on an outer wall side, and the end face itself of the downstream side connecting pipe being curved convex toward
15 upstream.

8. The apparatus as set forth in claim 4, wherein

said connecting pipe has divided end faces, the end face of an upstream side connecting pipe projecting downstream on an inner wall side farther than on an outer wall side, the end face of a downstream side
20 connecting pipe projecting upstream on an inner wall side farther than on an outer wall side, and each of said end faces having a face perpendicular to an axial direction at a tip on the inner wall side.

9. The apparatus as set forth in claim 4, wherein

said connecting pipe has divided end faces, the end face of an
25 upstream side connecting pipe projecting downstream on an inner wall side farther than on an outer wall side, the end face of a downstream side

connecting pipe projecting upstream on an inner wall side farther than on an outer wall side, and each of the end faces itself being curved convex to the outside of said connecting pipe.

10. The apparatus as set forth in claim 4, further comprising:

5 a temperature regulator for regulating a temperature of water flowing in said water injection pipe.

11. The apparatus as set forth in claim 5, further comprising:

a heater for heating, upstream of a connecting portion of the water injection pipe along said conduit, water flowing in said conduit.