

Title of Invention

FLAKE ICE PRODUCTION DEVICE, FLAKE ICE PRODUCTION SYSTEM,
FLAKE ICE PRODUCTION METHOD, AND MOVING BODY

TECHNICAL FIELD

The present invention relates to a flake ice production device, a flake ice production system, a flake ice production method, and a moving body.

BACKGROUND ART

Hitherto, in order to preserve freshness and quality of a fresh marine product, a method of cooling the fresh marine product by means of ice has been employed. For example, when a fishing boat goes out fishing, the fishing boat is loaded with a large amount of ice and stores and transports captured fish in a container filled with ice water (a mixture of ice and sea water). However, if the ice is made from fresh water, melting of the ice causes a decrease in solute concentration of seawater used for freshness preservation. As a result, owing to the osmotic pressure, water infiltrates into the body of the fish soaked in the ice water, thereby raising a problem of deterioration in freshness and taste of the fish. In view of this, for preserving freshness of perishables, Patent Document 1 discloses a production method of ice having a solute concentration of approximately 0.5% to 2.5% acquired by freezing a salt-containing water so as to form the state of

a slurry, wherein a raw water such as filtered and sterilized seawater is adjusted in salinity, and the resultant salt-containing water having about 1.0% to 1.5% solute concentration is rapidly frozen, thereby producing a slurry-state salt-containing ice having the above described solute concentration and an ice point temperature of -5°C to -1°C .

In addition, hitherto, for the purpose of fish freshness preservation and the like, ice is employed to cool a cooled object.

Patent Document 2 discloses a method for preserving freshness of a fish in a manner such that the fish is brought into contact with ice formed from salt water so as to be cooled. Patent Document 2 discloses, as a production method of ice formed from salt water, a method such that an aqueous salt solution is accumulated in a container and cooled from the outside.

In addition, it has been hitherto practiced to cool plants/animals such as fresh marine products or portions thereof with ice water to maintain the freshness thereof. However, in the case of ice formed from fresh water, the salt concentration in seawater used for maintaining the freshness decreases as the ice melts. As a result, there is a problem that water intrudes into the body of the plants/animals or portions thereof immersed in the ice water due to the osmotic pressure and the freshness and the like deteriorate.

In view of this, Patent Document 3 discloses a production method of ice having a solute concentration of approximately

0.5% to 2.5% acquired by freezing a salt-containing water so as to form the state of a slurry, wherein a raw water such as filtered and sterilized seawater is adjusted in salinity, and the resultant salt-containing water having about 1.0% to 1.5% solute concentration is rapidly frozen, thereby producing a slurry-state salt-containing ice having the above described solute concentration and an ice point temperature of -5°C to -1°C .

In addition, Patent Document 4 discloses a method for freezing fresh fish by immersing the fresh fish in a liquid in which bittern is added to 0.2% to 5.0% (w/v) salt water and the water temperature is kept at -3°C to 10°C for a certain period of time.

In addition, in order to maintain the freshness of fresh plants/animals such as fresh marine products or portions thereof, it has been hitherto practiced to produce frozen fresh plants/animals or portions thereof by cooling fresh marine products and the like with ice. For example, a large amount of ice is loaded on a fishing boat when the fishing boat goes fishing and captured fish are placed in a container filled with a mixture of ice and water (ice + seawater) and transported. However, in the case of ice formed from fresh water, the salt concentration in seawater used for maintaining the freshness decreases as the ice melts. As a result, there is a problem that water intrudes into the body of the fish immersed in the mixture of ice and water due to osmotic pressure and the freshness and taste of the fish deteriorate.

In view of this, for preserving freshness of produced plants/animals or portions thereof to be frozen, Patent Document 3 discloses a production method of ice having a solute concentration of approximately 0.5% to 2.5% acquired by freezing a salt-containing water so as to form the state of a slurry, wherein a raw water such as filtered and sterilized seawater is adjusted in salinity, and the resultant salt-containing water having about 1.0% to 1.5% solute concentration is rapidly frozen, thereby producing a slurry-state salt-containing ice having the above described solute concentration and an ice point temperature of -5°C to -1°C .

In addition, Patent Document 4 discloses a method for immersing fresh fish in a liquid in which bittern is added to 0.2% to 5.0% (w/v) saline solution and the water temperature is kept at from -3°C to 10°C for a certain period of time.

Patent Document 1: Japanese Unexamined Patent Application, Publication No. 2002-115945

Patent Document 2: Japanese Unexamined Patent Application, Publication No. 2000-3544542

Patent Document 3: Japanese Unexamined Patent Application, Publication No. 2002-115945

Patent Document 4: Japanese Unexamined Patent Application, Publication No. 2006-158301

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

However, in the prior arts including Patent Document 1, since the moisture in the fresh marine product crystallizes on freezing, the ice crystal in the fresh marine product grows and destroys the cell tissues of the fresh marine product, and there is thus a problem that it is difficult to maintain freshness and taste of the marine product. Also, in the conventional method described in Patent Document 1, since the ice point temperature of the salt-containing ice in the state of a slurry or the water temperature of the immersion liquid is not so low, freshness of the fresh marine product can be maintained only for a short period of time, and the cooling temperature required for each cold storage object cannot be accommodated. Also, in an ice acquired by freezing salt water, the water first begins to freeze from a fresh water part having high freezing point, and the final part to freeze contains a part in which a small amount of salt water is frozen and a part where precipitated salt adheres around ice. As a result, the solute concentration of the ice becomes non-uniform. Also, when melting the ice, since the part that freezes last melts first, high concentration salt water is released. Thus, there has been a technical issue such that the solute concentration greatly changes while melting and the temperature of the melting water increases to 0°C. The present invention has been made in view of the above-described circumstances, and the object of the present invention is to easily produce flake ice having approximately uniform solute concentration. Further, it is possible to provide a

production method of flake ice having excellent cooling capacity, and a production method of flake ice capable of maintaining a non-separating state for a long period of time.

Means for Solving the Problems

In order to achieve the above object, in accordance with an aspect of the present invention, there is provided a flake ice production device that produces flake ice by freezing brine, including: a drum including an inner cylinder, an outer cylinder that surrounds the inner cylinder, and a clearance formed between the inner cylinder and the outer cylinder, a refrigerant supply unit that supplies a refrigerant to the clearance, a rotary shaft that rotates by taking a central axis of the drum as an axis, an injection unit that rotates together with the rotary shaft and injects brine toward an inner peripheral surface of the inner cylinder, and a scraping unit that scrapes off flake ice that is generated as a result of the brine injected from the injection unit being adhered to the inner peripheral surface of the inner cylinder, which has been cooled by the refrigerant supplied to the clearance.

In addition, the brine can include, an aqueous solution that contains a solute satisfying a predetermined condition, and a solid (such as metal) having a thermal conductivity higher than that of an ice formed from a liquid including the aqueous solution.

In addition, the liquid can further include, oil.

In addition, the solute can include, two or more types of solutes each having a different degree of solidifying point depression.

In addition, the flake ice production device according to an aspect of the present invention can further include a speed control unit that variably controls a rotation rate of the rotary shaft.

In addition, the refrigerant supply unit can supply a liquefied natural gas as the refrigerant to the clearance.

In addition, the flake ice production device according to an aspect of the present invention can be installed on a moving body.

EFFECT OF THE INVENTION

According to the present invention, it is possible to easily produce flake ice having approximately uniform solute concentration. Further, it is possible to provide a production method of flake ice having superior cooling capacity, and a production method of flake ice that is possible to maintain an unseparated state for a long time.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an image view including a partial cross-sectional perspective view showing an outline of a flake ice production device according to an embodiment of the present invention;

Fig. 2 is an image view showing an outline of the entire flake ice production system including the flake ice production device of Fig. 1;

Fig. 3 is an image view showing types of ice slurry which can be produced from the flake ice produced by the flake ice production device of Fig. 1; and

Fig. 4 is a diagram showing an example of using exhaust cold from LNG (Liquefied Natural Gas).

BEST MODE FOR CARRYING OUT THE INVENTION

<Ice>

Ice produced by flake ice production device according to the present invention is an ice (also referred to as "flake ice"), which is formed from a liquid (also referred to as "brine") including an aqueous solution including a solute, that satisfies the following conditions (a) and (b).

(a) The temperature upon complete melting of the ice is lower than 0°C.

(b) A rate of change in solute concentration of an aqueous solution to be generated from the ice in melting process is 30% or less.

It is known that solidifying point depression, in which the solidifying point of the aqueous solution decreases, occurs in a case in which a solute such as common salt is dissolved in water. By the action of solidifying point depression, the solidifying point of an aqueous solution in which a solute such as common salt is dissolved decreases.

This means that ice formed from such an aqueous solution is ice which is solidified at a lower temperature than ice formed from fresh water. Here, the heat required when ice converts to water is called "latent heat", but this latent heat is not accompanied by a temperature change. By the effect of such latent heat, the ice having a lowered solidifying point, as described above, is sustained in a stable state at a temperature equal to or lower than the solidifying point of fresh water at the time of melting and thus a state in which the cold energy is saved is sustained. Consequently, the capacity of the above-described ice to cool the cold storage object is inherently higher than that of ice formed from fresh water. However, the present inventors discovered that when ice produced by the conventional method is used to cool the cold storage object, the temperature of the ice itself rapidly increases, and therefore the cooling capacity thereof is insufficient. The present inventors investigated the reasons for this and discovered that, in the conventional method, even if the ice is from an aqueous solution including a solute such as common salt, actually a solute-free ice is produced before the aqueous solution freezes. As a result, what is produced is a mixture of the solute-free ice and the remaining solute, or otherwise only a slight amount of ice having a lowered solidifying point. Consequently, an ice having high cooling capacity has not been produced.

However, the present inventors have succeeded in producing an ice from a liquid including an aqueous solution

having a decreased solidifying point by a predetermined method (described later). Such ice, which is generated by the flake ice production device according to the present invention, satisfies the above described conditions (a) and (b). Hereinafter, the conditions (a) and (b) will be described.

(Temperature at the Completion of Melting)

With regard to the above (a), since the ice generated by the flake ice production device according to the present invention is the ice formed from the liquid including the aqueous solution including the solute, the temperature of the solidifying point thereof is lower than that of fresh water (solute-free water). Therefore, the ice has a feature that the temperature at the completion of melting is less than 0°C. The "temperature at the completion of melting" is intended to mean the temperature of water obtained by melting the entire amount of ice used for the cold storage unit according to the present invention by leaving the ice under conditions above the melting point (such as room temperature at atmospheric pressure) to start melting.

The temperature at the completion of melting is not particularly limited as long as the temperature is below 0°C, and it can be changed as appropriate by adjusting the type and the concentration of the solute. The temperature at the completion of melting of the ice is preferably lower as the cooling capacity is higher, and specifically, the temperature is preferably -1°C or less (-2°C or less, -3°C or less, -4°C or

less, -5°C or less, -6°C or less, -7°C or less, -8°C or less, -9°C or less, -10°C or less, -11°C or less, -12°C or less, -13°C or less, -14°C or less, -15°C or less, -16°C or less, -17°C or less, -18°C or less, -19°C or less, -20°C or less, or the like). Meanwhile, there is also a case in which it is preferable to bring the solidifying point closer to the freezing point of a cold storage object (such as a case for preventing damage to fresh plant and animal foodstuff). In such a case, the temperature at the completion of melting is preferably not too low, for example, -21°C or higher (-20°C or higher, -19°C or higher, -18°C or higher, -17°C or higher, -16°C or higher, -15°C or higher, -14°C or higher, -13°C or higher, -12°C or higher, -11°C or higher, -10°C or higher, -9°C or higher, -8°C or higher, -7°C or higher, -6°C or higher, -5°C or higher, -4°C or higher, -3°C or higher, -2°C or higher, -1°C or higher, -0.5°C or higher, or the like).

(Rate of Change in Solute Concentration)

With regard to the above (b), the ice generated by the flake ice production device according to the present invention has a feature that the rate of change in solute concentration of the aqueous solution generated from the ice in the melting process (hereinafter, abbreviated as the "rate of change in solute concentration" in some cases in the present specification) is 30% or less. Even in the method described in Patent Document 1, there is also a case in which a small amount of ice having a decreased solidifying point is generated. However, since most of the ice is a mixture of solute-free ice and solute

crystals, cooling capacity thereof is not sufficient. In the above-described case of the ice largely containing the mixture of solute-free ice and solute crystals, when the ice is placed under a melting condition, the elution rate of the solute while melting is not consistent. This means that, at a time close to the start of melting, a large amount of the solute is eluted, as the melting progresses, the elution amount decreases, and at a time close to the completion of melting, a small amount of the solute is eluted. In contrast, the ice generated by the flake ice production device according to the present invention is formed from a liquid including an aqueous solution including a solute, and therefore has a feature that the change is small in elution rate of the solute in the melting process. Specifically, the rate of change in solute concentration of the aqueous solution generated from the ice in the melting process is 30%. Incidentally, the "rate of change in solute concentration of the aqueous solution generated from the ice during the melting process" is intended to mean the proportion of the concentration of the solution at the completion of melting of the ice against the solute concentration of the solution generated at an arbitrary point of time in the melting process. Incidentally, the "solute concentration" is intended to mean the mass concentration of the solute in the aqueous solution.

The rate of change in solute concentration with regard to the ice generated by the flake ice production device according to the present invention is not particularly limited as long

as the rate is 30% or less. However, a small rate of change in solute concentration means a high purity (i.e., a high cooling capacity) of the ice formed from the aqueous solution having the lowered solidifying point. From this viewpoint, the rate of change in solute concentration is preferably 25% or less (24% or less, 23% or less, 22% or less, 21% or less, 20% or less, 19% or less, 18% or less, 17% or less, 16% or less, 15% or less, 14% or less, 13% or less, 12% or less, 11% or less, 10% or less, 9% or less, 8% or less, 7% or less, 6% or less, 5% or less, 4% or less, 3% or less, 2% or less, 1% or less, 0.5% or less, or the like). Meanwhile, the rate of change in solute concentration may be 0.1% or more (0.5% or more, 1% or more, 2% or more, 3% or more, 4% or more, 5% or more, 6% or more, 7% or more, 8% or more, 9% or more, 10% or more, 11% or more, 12% or more, 13% or more, 14% or more, 15% or more, 16% or more, 17% or more, 18% or more, 19% or more, 20% or more, or the like).

(Solute)

The type of solute to be included in the ice generated by the flake ice production device according to the present invention is not particularly limited as long as it is a solute when water is used as a solvent, and can be selected as appropriate according to the desired solidifying point, the application for which the ice is to be used, and the like. Examples of the solute may include a solid solute and a liquid solute, and examples of a typical solid solute may include salts (inorganic salts, organic salts, and the like). Particularly,

among the salts, common salt (NaCl) is preferable since the temperature of solidifying point is not excessively decreased and it is suitable for cooling of fresh plants and animals or portions thereof. In addition, common salt is preferable from the viewpoint of easy procurement as well since it is included in seawater. Examples of the liquid solute may include ethylene glycol. Incidentally, the solute may be included singly, or two or more types thereof may be included.

The concentration of the solute included in the ice generated by the flake ice production device according to the present invention is not particularly limited, and can be selected as appropriate according to the type of solute, the desired solidifying point, the application for which the ice is to be used, and the like. For example, in the case of using common salt as the solute, from the viewpoint of further decreasing the solidifying point of the aqueous solution and thus being able to obtain a high cooling capacity, it is preferable that the concentration of common salt is 0.5% (w/v) or more (1% (w/v) or more, 2% (w/v) or more, 3% (w/v) or more, 4% (w/v) or more, 5% (w/v) or more, 6% (w/v) or more, 7% (w/v) or more, 8% (w/v) or more, 9% (w/v) or more, 10% (w/v) or more, 11% (w/v) or more, 12% (w/v) or more, 13% (w/v) or more, 14% (w/v) or more, 15% (w/v) or more, 16% (w/v) or more, 17% (w/v) or more, 18% (w/v) or more, 19% (w/v) or more, 20% (w/v) or more, or the like). Meanwhile, it is preferable not to excessively lower the temperature of the solidification in the case of using the ice generated by the flake ice production

device according to the present invention for cooling fresh plants and animals or portions thereof, and it is preferable that the concentration of common salt is 23% (w/v) or less (20% (w/v) or less, 19% (w/v) or less, 18% (w/v) or less, 17% (w/v) or less, 16% (w/v) or less, 15% (w/v) or less, 14% (w/v) or less, 13% (w/v) or less, 12% (w/v) or less, 11% (w/v) or less, 10% (w/v) or less, 9% (w/v) or less, 8% (w/v) or less, 7% (w/v) or less, 6% (w/v) or less, 5% (w/v) or less, 4% (w/v) or less, 3% (w/v) or less, 2% (w/v) or less, 1% (w/v) or less, or the like).

The ice generated by the flake ice production device according to the present invention is suitable for use as a refrigerant to cool the cold storage object, since it has an excellent cooling capacity. Examples of a low-temperature refrigerant may include an organic solvent to be used as an anti-freezing solution such as ethanol in addition to ice, but the ice has a higher thermal conductivity and a higher specific heat than these anti-freezing solutions. For this reason, an ice having a lowered solidifying point arising from dissolution of a solute such as the ice generated by the flake ice production device according to the present invention is useful also from the viewpoint of having a cooling capacity superior to other refrigerants at temperatures lower than 0°C such as an anti-freezing solution.

The ice generated by the flake ice production device according to the present invention may or may not include components other than the above-described solute.

In the present invention, the term "ice" refers to one acquired by freezing a liquid including an aqueous solution.

Also, the ice generated by the flake ice production device according to the present invention is sustained in a stable state at a temperature equal to or lower than the solidifying point of fresh water, and thus the ice can be sustained in a non-separating state for a long time. For this reason, for example, in a case in which the liquid constituting the ice generated by the flake ice production device according to the present invention is a liquid that further includes oil in addition to the aqueous solution including the solute, as will be described later, a state in which the oil is uniform lasts for a long time, and thus a non-separating state can be sustained for a long time.

As described above, the liquid constituting the ice generated by the flake ice production device according to the present invention may be a liquid which further includes oil in addition to the aqueous solution including the solute described above. Examples of such a liquid may include raw milk, industrial waste including water and oil (such as waste milk). It is preferable that the liquid is raw milk from the viewpoint that the functionality when eating the ice is improved. It is presumed that the reason for improved functionality is that the oil (fat) included in the raw milk is confined in the ice. Incidentally, the ice generated by the flake ice production device according to the present

invention may be constituted only by ice obtained by freezing the aqueous solution including the solute described above.

In a case in which the liquid constituting the ice generated by the flake ice production device according to the present invention further includes oil, the ratio of water and oil in the liquid is not particularly limited, and is selected as appropriate in a range of, for example, 1 : 99 to 99 : 1 (10 : 90 to 90 : 10, 20 : 80 to 80 : 20, 30 : 70 to 70 : 30, 40 : 60 to 60 : 40, or the like).

In addition, the ice generated by the flake ice production device according to the present invention may be an ice from an aqueous solution including two or more types of solutes each having a different degree of solidifying point depression. In this case, the ice generated by the flake ice production device according to the present invention may be a mixture of ice from an aqueous solution including one solute and ice from an aqueous solution including the other solute. In this case, for example, if ice from an aqueous solution including ethylene glycol as a solute is added to ice from an aqueous solution including salt as a solute having a degree of solidifying point depression different to that of ethylene glycol, it is possible to delay the melting of the ice from the aqueous solution including ethylene glycol. Alternatively, the ice generated by the flake ice production device according to the present invention may be ice from an aqueous solution prepared by dissolving two or more types of solutes in the same aqueous solution. In addition, to concurrently use two

or more types of solutes each having a different degree of solidifying point depression is also useful to decrease the melting point of ice from an aqueous solution including a target solute. For example, in the case of using common salt as a solute, it is possible to decrease the melting point of ice formed from saline solution by concurrently using a solute (ethylene glycol, calcium chloride, or the like) which can decrease the melting point further than common salt, and for example, it is possible to realize a temperature in the vicinity of -30°C , which cannot be realized only by ice formed from saline solution. The ratio of two or more types of solutes each having a different degree of solidifying point depression can be changed as appropriate according to a purpose.

(Refrigerant to Cool Cold Storage Object (Also Referred to as "Ice Slurry"))

The present invention includes a refrigerant, including the above-described ice, to cool the cold storage object. As described above, the ice generated by the flake ice production device according to the present invention is suitable for a refrigerant to cool a cold storage object, since it has an excellent cooling capacity. Incidentally, in order to avoid confusion between the refrigerant to cool the cold storage object and a refrigerant to cool the inner cylinder 22 (see Fig. 1), the refrigerant to cool the cold storage object will be referred to as "ice slurry" hereinafter.

The ice slurry generated by the flake ice production device according to the present invention may include a component other than the above-described ice. For example, the ice slurry may be constituted by a mixture of ice and water by including water in addition to the above-described ice. In a case in which the ice slurry further includes water including the same solute as the solute included in the ice, the solute concentration of the ice is preferably close to the solute concentration of the water, the reason for which is as follows.

In a case in which the solute concentration of the ice is higher than the solute concentration of the water, the temperature of the ice is lower than the saturated freezing point of the water, and thus the moisture freezes immediately after the water having a lower solute concentration is mixed with the ice. On the other hand, in a case in which the solute concentration of the ice is lower than the solute concentration of the water, the saturated freezing point of the water is lower than the saturated freezing point of the ice and thus the ice melts and the temperature of the refrigerant composed of the mixture of ice and water decreases. This means that, in order not to change the state of the mixture of ice and water (state of ice slurry), as described above, it is preferable to set the solute concentrations of ice and water to be mixed to be about the same. In addition, in a case in which the refrigerant is in the state of a mixture of ice and water, the water may be one generated as

the ice melts or one separately prepared, but the water is preferably one generated as the ice melts.

Specifically, in the case of constituting the ice slurry generated by the flake ice production device according to the present invention by a mixture of ice and water, the ratio of the solute concentration in the ice and the solute concentration in the water is more preferably 75 : 25 to 20 : 80, still more preferably 70 : 30 to 30 : 70, yet more preferably 60 : 40 to 40 : 60, yet still more preferably 55 : 45 to 45 : 55, particularly preferably 52 : 48 to 48 : 52, and most preferably 50 : 50. Particularly in the case of using common salt as the solute, it is preferable that the ratio of the concentration of the solute in ice to the concentration of the solute in water is in the above range.

Water to be a raw material of the ice generated by the flake ice production device according to the present invention is not particularly limited, but it is preferable that the ice is an ice from seawater, water prepared by adding salt to seawater, or diluted seawater in the case of using a common salt as the solute. Procurement of seawater, water prepared by adding salt to seawater, or diluted seawater is easy, thereby enabling cost reduction.

Although the ice slurry generated by the flake ice production device according to the present invention may or may not further include a solid having a thermal conductivity higher than that of the ice generated by the flake ice production device according to the present invention, it is

preferable to further include the solid. It is possible to achieve quick cooling of a target of cooling in a short time by utilizing a solid having a high thermal conductivity, but in this case, the solid itself also loses cold energy in a short time and the temperature thereof is likely to increase and the solid is thus unsuitable for long-term cooling. Meanwhile, it is suitable not to utilize a solid having a high thermal conductivity for long-term cooling but it is unsuitable not to utilize the solid for quick cooling of a target of cooling. However, the ice generated by the flake ice production device according to the present invention has a high cooling capacity as described above, and is thus useful from the viewpoint that long-term cooling is also possible while obtaining a quick cooling capacity by the solid having a high thermal conductivity. Examples of the solid having a thermal conductivity higher than that of the ice generated by the flake ice production device according to the present invention may include metals (aluminum, silver, copper, gold, duralumin, antimony, cadmium, zinc, tin, bismuth, tungsten, titanium, iron, lead, nickel, platinum, magnesium, molybdenum, zirconium, beryllium, indium, niobium, chromium, cobalt, iridium, palladium), alloys (steel (carbon steel, chromium steel, nickel steel, chromium nickel steel, silicon steel, tungsten steel, manganese steel, and the like), nickel chrome alloy, aluminum bronze, gunmetal, brass, Manganin, nickel silver, constantan, solder, alumel, chromel, monel metal, platinum iridium, and the like), silicon, carbon, ceramics

(alumina ceramics, forsterite ceramics, steatite ceramics, and the like), marble, brick (magnesia brick, Corhart brick, and the like), and the like each having a thermal conductivity higher than that of the ice generated by the flake ice production device according to the present invention are employed. In addition, the solid having a thermal conductivity higher than that of the ice generated by the flake ice production device according to the present invention is preferably a solid having a thermal conductivity of 2.3 W/m K or more (3 W/m K or more, 5 W/m K or more, 8 W/m K or more, or the like), more preferably a solid having a thermal conductivity of 10 W/m K or more (20 W/m K or more, 30 W/m K or more, 40 W/m K or more, or the like), still more preferably a solid having a thermal conductivity of 50 W/m K or more (60 W/m K or more, 75 W/m K or more, 90 W/m K or more, or the like), yet more preferably a solid having a thermal conductivity of 100 W/m K or more (125 W/m K or more, 150 W/m K or more, 175 W/m K or more, or the like), still yet more preferably a solid having a thermal conductivity of 200 W/m K or more (250 W/m K or more, 300 W/m K or more, 350 W/m K or more, or the like), particularly preferably a solid having a thermal conductivity of 400 W/m K or more (410 W/m K or more, or the like).

In a case in which the ice slurry generated by the flake ice production device according to the present invention includes the above-described solid having a thermal conductivity higher than that of the ice generated by the

flake ice production device according to the present invention, the ice slurry is suitable for long-term cooling even when a large amount of the solid is included, as described above. For example, the ratio of the mass of the solid having a thermal conductivity higher than that of the ice generated by the flake ice production device according to the present invention to the mass of the ice, which is included in the ice slurry, generated by the flake ice production device according to the present invention (or a total mass of the liquid including the aqueous solution and the ice, which is included in the ice slurry, used for the cold storage unit according to the present invention) may be 1/100000 or more (1/50000 or more, 1/10000 or more, 1/5000 or more, 1/1000 or more, 1/500 or more, 1/100 or more, 1/50 or more, 1/10 or more, 1/5 or more, 1/4 or more, 1/3 or more, 1/2 or more, and the like).

The above-described solid according to the present invention may have any shape, but has preferably a particulate shape. In addition, the solid may be included in a state of being included inside the ice generated by the flake ice production device according to the present invention or in a state of being included outside the ice, but the cooling capacity is higher when the solid is included in a state of being included outside the ice since the solid is likely to come into direct contact with the target of cooling. For this reason, it is preferable that the solid is included in a state of being included outside the ice. In addition, in a case in which the ice slurry generated by the flake ice production

device according to the present invention includes the above described solid, the solid may be mixed in the ice after the ice is produced according to the production method, which will be described later, of the ice generated by the flake ice production device according to the present invention, or the ice may be produced in a state in which the solid is mixed with water to be a raw material of the ice in advance.

Hereinafter, a description will be given of an embodiment of the present invention with reference to the accompanying drawings.

[Flake Ice Production Device]

It is impossible to generate the ice generated by the flake ice production device according to the present invention even when a liquid that includes an aqueous solution and is in a state of being accumulated in a container is cooled from the outside. It is considered that this is due to insufficient cooling rate. However, a flake ice production device 10 according to an embodiment of the present invention enables an unprecedented rapid cooling in a manner such that a liquid including an aqueous solution including a solute is sprayed so as to be atomized and in direct contact with a wall surface maintained at a temperature equal to or lower than the solidifying point of the aqueous solution. It is considered that, as a result of this, the ice having a high cooling capacity that satisfies the above-described conditions (a) and (b) can be produced.

Examples of the wall surface may include an inner wall surface of a cylindrical structure such as a drum 11 in Fig. 1, which will be described later. However, the wall surface is not particularly limited as long as the wall surface can be kept at a temperature equal to or lower than the solidifying point of the aqueous solution. The temperature of the wall surface is not particularly limited as long as it is kept at a temperature equal to or lower than the solidifying point of the aqueous solution, but it is preferable that the temperature is kept at a temperature lower than the solidifying point of the aqueous solution by 1°C or more (2°C or more, 3°C or more, 4°C or more, 5°C or more, 6°C or more, 7°C or more, 8°C or more, 9°C or more, 10°C or more, 11°C or more, 12°C or more, 13°C or more, 14°C or more, 15°C or more, 16°C or more, 17°C or more, 18°C or more, 19°C or more, 20°C or more, 21°C or more, 22°C or more, 23°C or more, 24°C or more, 25°C or more, or the like) from the viewpoint of being able to produce an ice of high purity including the ice that satisfies the conditions (a) and (b).

A method for spraying is not particularly limited, but it is possible to spray, for example, by injecting from an injection hole 13a provided to an injection unit such as an injection unit 13 in Fig. 1, which will be described later. In this case, a water pressure at the time of injection may be, for example, 0.001 MPa or more (0.002 MPa or more, 0.005 MPa or more, 0.01 MPa or more, 0.05 MPa or more, 0.1 MPa or more, 0.2 MPa or more, or the like) and may be 1 MPa or less (0.8

MPa or less, 0.7 MPa or less, 0.6 MPa or less, 0.5 MPa or less, 0.3 MPa or less, 0.1 MPa or less, 0.05 MPa or less, 0.01 MPa or less, or the like.

In addition, as shown in Fig. 1, which will be described later, spraying of the liquid may be conducted through continuous spraying in which a rotating means such as a rotatable rotary shaft 12 is provided on a central axis of the vertical drum 11 and spraying is conducted while rotating the rotating means.

(Collection Step)

After the above-described ice generating step, the present invention includes a step of collecting the ice generated on the wall surface.

A method for collecting is not particularly limited. For example, the ice on the wall surface may be scraped off by means of a unit such as a blade 15 as shown in Fig. 1, which will be described later, and the ice which has fallen may be collected.

Incidentally, when the ice is produced, ice-making heat is generated, but there is a possibility that an actual melting completion temperature is affected as the ice exposed to this ice-making heat. Therefore, it is considered that the melting completion temperature is affected by, not only the type and concentration of the solute, but also the ice-making heat. Accordingly, it is possible to adjust the actual melting completion temperature, by adjusting the amount of the ice-making heat remaining in the ice. It is possible to

adjust the ice-making heat by adjusting the retention time of the ice on the wall surface in the collection step according to the present invention.

Fig. 1 is an image view including a partial cross-sectional perspective view showing an outline of a flake ice production device 10 according to an embodiment of the present invention.

As shown in Fig. 1, the flake ice production device 10 includes the drum 11, the rotary shaft 12, and the injection unit 13, a scraping unit 14, the blade 15, a flake ice discharge port 16, an upper bearing member 17, a heat insulating protective cover 19, a geared motor 20, a rotary joint 21, a refrigerant clearance 24, a bush 28, a refrigerant supply unit 29, and a rotation control unit 27. The drum 11 is configured by an inner cylinder 22, an outer cylinder 23 which surrounds the inner cylinder 22, the refrigerant clearance 24 formed between the inner cylinder 22 and the outer cylinder 23. An outer peripheral surface of the drum 11 is covered by the heat insulating protective cover 19 in a cylindrical shape. Although material of the inner cylinder 22 and the outer cylinder 23 is not particularly limited, steel is employed in the present embodiment. To the refrigerant clearance 24, a refrigerant is supplied via a refrigerant tube 35 from the refrigerant supply unit 29, thereby cooling an inner peripheral surface of the inner cylinder 22.

The rotary shaft 12 is disposed on the central axis of the drum 11 and rotates around the material axis by taking the

central axis as the axis and using the geared motor 20 installed above the upper bearing member 17 as a power source. A rotation rate of the geared motor 20 is controlled by the rotation control unit 27, which will be described later. In addition, the rotary joint 21 is attached to the top portion of the rotary shaft 12. On an upper portion of the rotary shaft 12, a vertical hole 12a is formed, extending in the material axis direction in communication with each pipe of the injection unit 13 (see Fig. 2).

The injection unit 13 is constituted by a plurality of pipes each provided at a tip portion with an injection hole 13a for injecting the brine toward the inner peripheral surface of the inner cylinder 22, and rotates together with the rotary shaft 12. The brine injected through the injection hole 13a adheres to the inner peripheral surface of the inner cylinder 22, which has been cooled by the refrigerant, and is quickly frozen without being provided with time for separation. The plurality of pipes constituting the injection unit 13 radially extend from the rotary shaft 12 in a radial direction of the drum 11. Although installation height of each pipe is not particularly limited, in the present embodiment, each pipe is installed at an upper position of a height of the inner cylinder 22 of the drum 11. Incidentally, a spray nozzle or the like may be employed in place of the pipe.

The scraping unit 14 is constituted by a plurality of arms each equipped at a tip portion with the blade 15 adapted to scrape off the brine adhered in a frozen state to the inner

peripheral surface of the drum 11. The scraping unit 14 extends in the radial direction of the drum 11, and rotates together with the rotary shaft 12. The plurality of arms constituting the scraping unit 14 are mounted so as to be symmetrical with respect to the rotary shaft 12. Although a number of arms is not particularly limited, in the present embodiment, the number of arms is set to two. Size and material of the blade 15 mounted on the tip portion of each arm are not particularly limited as long as the blade can scrape off the frozen brine. In the present embodiment, each blade 15 is made of stainless steel plate material having a length approximately equal to the entire length (entire height) of the inner cylinder 22, and formed on an end surface facing the inner cylinder 22 with a plurality of serrations 15a. Flake ice is obtained as the frozen brine is scraped off by the blade 15, and the flake ice falls through the flake ice discharge port 16. The flake ice fallen through the flake ice discharge port 16 is stored in a flake ice storage tank 34 (Fig. 2) disposed immediately below the flake ice production device 10.

The upper bearing member 17 having the shape of a pot, is inverted and seals the upper surface of the drum 11. The bush 24 for supporting the rotary shaft 12 is fitted at the central portion of the upper bearing member 17. The rotary shaft 12 is supported only by the upper bearing member 17, and a lower end of the rotary shaft 12 is not pivotally supported. This means that, there is no obstacle at the lower place of the

drum 11 for the flake ice scraped by the blade 15 to fall down, and thus the lower plane of the drum 11 serves as a flake ice discharge port 16 for discharging the flake ice. The refrigerant supply unit 29 supplies to the refrigerant clearance 24 the refrigerant for cooling the inner peripheral surface of the inner cylinder 22 via the refrigerant tube 35. The refrigerant to be supplied by the refrigerant supply unit 29 is not particularly limited as long as being able to cool the inner peripheral surface of the inner cylinder 22. Specifically, for example, LNG (Liquefied Natural Gas) can be employed as the refrigerant. The method for using LNG as the refrigerant will be described later with reference to Fig. 4. In the present embodiment, the refrigerant to be supplied to the refrigerant clearance 24 can be circulated between the refrigerant clearance 24 and the refrigerant supply unit 29 via the refrigerant tube 35. As a result of this, it is possible to maintain the refrigerant supplied to the refrigerant clearance 24 in a state of having a high cooling function. The rotation control unit 27 adjusts the rotation rate of the geared motor 20, thereby adjusting a rotation rate of the injection unit 13 and the scraping unit 14 rotating together with the rotary shaft 12. A method for the rotation control unit 27 to control the rotation rate is not particularly limited. Specifically, for example, a control method using an inverter may be employed.

[Flake Ice Production System]

Fig. 2 is an image view showing an outline of an entire flake ice production system 60 including the flake ice production device 10 of Fig. 1.

The flake ice production system 60 is provided with the flake ice production device 10, a brine storage tank 30, a pump 31, a brine tube 32, a brine tank 33, the flake ice storage tank 34, the refrigerant tube 35, and a freezing point adjusting unit 36. The brine storage tank 30 stores the brine to be raw material of the flake ice. The brine stored in the brine storage tank 30 is fed to the rotary joint 21 via the brine tube 32 by operating the pump 31, and becomes the flake ice by the flake ice production device 10. This means that, the brine fed to the rotary joint 21 is fed to the vertical hole 12a formed in the rotary shaft 12 and the rotary joint 21, and further fed from the vertical hole 12a to each pipe constituting the injection unit 13.

The brine tank 33 supplies the brine to the brine storage tank 30 in a case in which the brine in the brine storage tank 30 has decreased. Incidentally, the brine which has not been frozen on the inner peripheral surface of the inner cylinder 22 but has flowed down is stored in the brine storage tank 30 and is again fed to the rotary joint 21 via the brine tube 32 by operating the pump 31. The flake ice storage tank 34 is disposed immediately below the flake ice production device 10 and stores flake ice which has fallen through the flake ice discharge port 16 of the flake ice production device 10.

The freezing point adjusting unit 36 adjusts the freezing point of the brine to be supplied to the brine storage tank 30 from the brine tank 33. For example, in a case in which the brine is salt water, since the freezing point of the salt water varies depending on the concentration, the freezing point adjusting unit 36 adjusts the concentration of the salt water stored in the brine storage tank 30. A method for adjusting the freezing point of the brine is not particularly limited. For example, it is also possible to employ the following method. That is, there are provided a plurality of brine storage tanks 30, and a plurality of types of brine each having a different freezing point are stored in respective brine storage tanks 30. Thereafter, the brine freezing point adjusting unit 36 selects a predetermined type of brine based on a required temperature of the flake ice (for example, a cooling temperature required for a conveyed article to be conveyed by the flake ice) and supplies the brine to the flake ice production device 10. Thus, by adjusting the freezing point of the brine, it is possible to adjust the temperature of the flake ice to be produced.

In the following, on a premise that the brine is salt water, a description will be given of the operation of the flake ice production system 60 including the flake ice production device 10 having the above-described configuration. First, the refrigerant supply unit 29 supplies the refrigerant to the refrigerant clearance 24 and sets the temperature of the inner peripheral surface of the inner cylinder 22 to be

lower than the freezing point of salt water by approximately -10°C. This makes it possible to freeze the salt water adhered to the inner peripheral surface of the inner cylinder 22.

When the inner peripheral surface of the inner cylinder 22 is cooled, the rotation control unit 27 drives the geared motor 20 so as to rotate the rotary shaft 12 around the material axis. When the rotary shaft 12 rotates, the pump 31 supplies salt water, which is brine, from the brine storage tank 30 to the rotary shaft 12 via the rotary joint 21. When the salt water is supplied into the rotary shaft 12, the injection unit 13 rotating together with the rotary shaft 12 injects the salt water toward the inner peripheral surface of the inner cylinder 22. The salt water injected from the injection unit 13, on contacting the inner peripheral surface of the inner cylinder 22, instantly freezes to ice. At this time, the rotation control unit 27 controls the rotation rate of the rotary shaft 12 so as to be 2 to 4 rpm. Incidentally, in a case in which a spray nozzle is employed in place of the pipe as a constituent of the injection unit 13, the rotation control unit 27 controls the rotation rate of the rotary shaft 12 so as to be 10 to 15 rpm. The ice generated on the inner peripheral surface of the inner cylinder 22 is scraped off by the scraping unit 14 rotating together with the rotary shaft 12. The ice scraped by the scraping unit 14 falls through the flake ice discharge port 16 as the flake ice. The flake ice which has fallen through the flake ice discharge port 16 is stored in the flake ice storage tank 34 disposed immediately

below the flake ice production device 10. As described above, the salt water which has not converted to ice but has flowed down on the inner peripheral surface of the inner cylinder 22 is stored in the brine storage tank 30, and is fed again via the brine tube 32 to the rotary joint 21 by operating the pump 31. In a case in which the salt water in the brine storage tank 30 has decreased, the brine tank 33 supplies the salt water stored in itself to the brine storage tank 30.

Here, the rotation control unit 27 can change the temperature of the flake ice produced by the flake ice production device 10 by changing the rotation rate of the geared motor 20. For example, it is assumed that salt water is employed as the brine. In this case, it has been hitherto considered that the freezing point at which the salt water freezes depends on the solute concentration thereof alone. For example, if the solute concentration is 0.8%, it has been hitherto considered that the salt water freezes at -1.2°C in any case. However, when the applicant of the present invention, employing salt water as the brine, changed the rotation rate of the rotary shaft 12 using the flake ice production device 10 according to the present embodiment, the applicant of the present invention discovered that the temperature of the flake ice to be produced from salt water of the same concentration changes depending on the rotation rate, and particularly, the temperature decreases when the rotation rate decreases. The reason for this is because a state of the flake ice storing the ice-making heat is maintained until

completion of melting. Thus, it is possible to adjust the temperature of flake ice, while fixing the concentration of brine to a desired value according to targets of refrigeration and freezing.

Fig. 3 is an image view showing types of ice slurry which can be produced from the flake ice produced by the flake ice production device 10 of Fig. 1.

As shown in Fig. 3, if salt water is employed as the brine, the flake ice production device 10 can produce a flake ice (salt ice) in a range of -1°C to -21.3°C by freezing salt water in a range of 1% to 23.2% solute concentration.

Fig. 4 is a diagram showing an example of using exhaust cold from LNG.

Hitherto, imported LNG is stored in an LNG storage tank in a state of liquid of -160°C . The LNG at -160°C is vaporized until reaching ambient temperature, undergoes calorific value adjustment and odorization, and is delivered as city gas or for gas turbine power generation. As a method for effective use of exhaust cold from LNG, in an LNG base, the exhaust cold from LNG at -160°C until the temperature increases to ambient temperature is used for production of liquid oxygen and liquid nitrogen, a cold storage warehouse, cold-energy power generation, and ORV type LNG vaporization using seawater as a heat source. However, by using LNG as a refrigerant of the flake ice production device 10 described above, it becomes possible to easily heat LNG up to ambient temperature without need of the conventional apparatus, energy, or the like.

Moreover, by utilizing the LNG at -160°C as the refrigerant of the flake ice production device 10, it is possible to produce an ultralow temperature flake ice by instantaneously freezing the brine having a freezing point down to approximately -150°C . If the brine is salt water (sodium chloride solution), it is possible to produce a flake ice of -21.2°C at saturation, and if the brine is magnesium chloride aqueous solution, it is possible to produce a flake ice of -26.27°C at saturation. Even a substance, which has a freezing point lower than ethylene glycol salt water and magnesium chloride aqueous solution, being hitherto called "antifreeze" and unable to be used as the brine, can be instantaneously frozen and used as flake ice. Specifically, for example, it is possible to produce a flake ice using ethylene glycol as the brine.

Thus, by utilizing the ultralow temperature refrigerant such as the LNG at -160°C , it becomes possible to produce ultracold flake ice having a temperature of approximately -150°C . Each cold storage object requires a different cold storage temperature depending on a type thereof. For example, there is an object suiting -1°C , and there is an object suiting -150°C . According to the present invention, by utilizing an ultralow temperature refrigerant such as the LNG at -160°C , it is possible to easily produce a flake ice that can meet a wide variety of required cold storage temperatures.

Embodiments of the present invention have been described above, but the present invention is not in any way limited to the configurations described in the above-mentioned

embodiments, and the present invention also includes other embodiments and modifications that can be considered within the scope of the matters described in the claims. In addition, various modifications and combinations of the above-mentioned embodiments may be applied as long as they do not deviate from the gist of the present invention.

For example, in the above-described embodiments, the brine has been described to be salt water (sodium chloride aqueous solution). However, the brine is not particularly limited thereto. Specifically, for example, a calcium chloride aqueous solution, a magnesium chloride aqueous solution, ethylene glycol, and the like may be employed. Thus, it is possible to prepare a plurality of types of the brine each having a different freezing point according to a difference of a solute and concentration.

Further, the ice produced by the ice production device according to the present invention, although being desirable to be an ice from a liquid including an aqueous solution including a solute that satisfies the above-described conditions (a) and (b), may be an ice that does not satisfy either or both of the conditions (a) and (b). This means that, ice slurry including ice and water each having a different solute concentration may be used to cool a cold storage object.

Also, if the above described ice slurry contains a solid having a thermal conductivity higher than that of the ice, in the process of cooling, the solid having the thermal conductivity higher than that of the ice is preferably

interposed between the cold storage object and the ice included in the ice slurry. Thus, long-term cooling becomes possible, while having a quick cooling capacity in a short time due to the solid having the high thermal conductivity. In such a case, depending on purpose, another substance may be interposed among the ice, the solid having the thermal conductivity higher than that of the ice, and the cold storage object. For example, in a case in which the ice slurry includes a substance that is not preferable to directly contact the cold storage object (for example, a solid such as metal having a thermal conductivity higher than that of the ice or the like, which is not desirable to directly contact the cold storage object from a viewpoint of safety), the cold storage object may be cooled in a manner such that either one of the ice slurry and the cold storage object is confined in a bag so as to avoid direct contact between the ice slurry and the cold storage object.

Further, according to the flake ice production device 10 according to an embodiment of the ice-making device of the present invention, since it is possible to efficiently produce flake ice of any temperature, it is possible to reduce the size of the flake ice production device 10 itself. Thus, for example, a moving body such as a vehicle, a ship, an aircraft, and the like for conveying the cold storage object can install the flake ice production device 10 having a small volume compared to the entire volume of the cold storage object to be loaded. Transportation of the cold storage object requires

ice slurry to cool the cold storage object in proportion to the amount of the cold storage object to be transported, but of course, a vehicle, a ship, and an aircraft for conveying the cold storage object has own maximum load capacity. In order to maximize the load capacity of the cold storage object within the maximum load capacity, it is required to minimize the amount of the ice slurry within the range so that the cooling effect is maintained. Here, since the compactified flake ice production device 10 occupies only a small volume compared to the entire volume of the cold storage object to be loaded, it becomes possible to maximize the load capacity of the cold storage object within the range of the maximum load capacity.

Summarizing the above, the flake ice production device and the flake ice production system to which the present invention is applied can take various embodiments as long as it has the following configuration. The flake ice production device (for example, the flake ice production device 10 of Fig. 1) to which the present invention is applied includes, a drum (for example, the drum 11 of Fig. 1) including an inner cylinder (for example, the inner cylinder 22 of Fig. 1), an outer cylinder (for example, the outer cylinder 23 of Fig. 1) surrounding the inner cylinder, and a clearance (for example, the refrigerant clearance 24 of Fig. 1) formed between the inner cylinder and the outer cylinder, a refrigerant supply unit (for example, the refrigerant supply unit 36 of Fig. 2) that supplies a refrigerant (for example, LNG of Fig. 4) to

the clearance, a rotary shaft (for example, the rotary shaft 12 of Fig. 1) that rotates by taking a central axis of the drum as an axis, an injection unit (for example, the injection unit 13 of Fig. 1) that rotates together with the rotary shaft and injects a brine toward an inner peripheral surface of the inner cylinder, and a scraping unit (for example, the scraping unit 14 of Fig. 1) that scrapes off a flake ice generated as a result of the brine, having been injected from the injection unit, attaching to the inner peripheral surface of the inner cylinder, having been cooled by the refrigerant supplied to the clearance. As a result of this, it is possible to easily produce the flake ice by freezing the brine.

In addition, the brine can include, an aqueous solution that includes a solute and satisfies predetermined conditions, and a solid (for example, metal) having a thermal conductivity higher than that of an ice formed from a liquid including the aqueous solution. As a result of this, it is possible to increase the cooling capacity.

In addition, the liquid can further include oil. In addition, the solute can include two or more types of solutes each lowering the solidifying point to a different degree. As a result of this, it is possible to provide a production method of the flake ice having excellent cooling capacity, and a production method of the flake ice capable of maintaining a non-separating state for a long period of time.

In addition, the flake ice production device can further include a speed control unit (for example, the rotation

control unit 27 of Fig. 2) for variably controlling the rotation rate of the rotary shaft. As a result of this, it is possible to slow down the rotation rate of the geared motor 20, thereby enabling to produce a flake ice having a temperature lower than usual.

In addition, the refrigerant supply unit can supply liquefied natural gas as the refrigerant to the clearance.

In addition, a flake ice production system (for example, the flake ice production system 60 of Fig. 2), to which the present invention is applied, for producing a flake ice by freezing a brine includes, a spray unit (for example, the injection unit 13 of Fig. 1) for spraying the brine, a member (for example, the flake ice production device 10 of Fig. 1) for producing the flake ice, in a state in which the member is cooled at a temperature equal to or lower than the freezing point of the brine by a predetermined refrigerant (for example, LNG of Fig. 4), by having the sprayed brine adhered to the member so as to freeze, and a refrigerant supply unit (for example, the refrigerant supply unit 36 of Fig. 2) that supplies to the member a liquefied gas (for example, LNG of Fig. 4) that can cool the member at a temperature equal to or lower than the freezing point of the brine as the predetermined refrigerant.

In addition, the refrigerant supply unit can supply LNG to the member as the predetermined refrigerant. As a result of this, it is possible to effectively utilize the exhaust

cold from LNG, thereby enabling a more ecological production of the flake ice.

In addition, the flake ice production device 10 to which the present invention is applied can be installed on a moving body. As a result of this, since it is possible to efficiently produce a flake ice of any temperature, it is possible to further reduce the size of the flake ice production device itself. Thus, for example, a vehicle, a ship, and an aircraft for conveying the cold storage object can install the flake ice production device having a small volume compared to the entire volume of the cold storage object to be loaded.

EXPLANATION OF REFERENCE NUMERALS

1, 2: Cold Storage Unit, 3: Ice Slurry, 4: Casing, 5: Cold Storage Space, 6: Partition Wall, 7: Heat Insulator, 8: Heat Insulating Sheet, 9: Ice Slurry Storage, 10: Flake Ice Production Device, 11: Drum, 12: Rotary Shaft, 12a: Vertical Hole, 13: Injection Unit, 13a: Injection Hole, 14: Scraping Unit, 15: Blade, 15a: Serrations, 16: Flake Ice Discharge Port, 17: Upper Bearing Member, 19: Heat Insulating Protective Cover, 20: Geared Motor, 21: Rotary Joint, 22: Inner Cylinder, 23: Outer Cylinder, 24: Refrigerant Clearance, 27: Rotation Control Unit, 28: Bush, 29: Refrigerant Supply Unit, 30: Brine Storage Tank, 31: Pump, 32: Brine Pipe, 33: Brine Tank, 34: Flake Ice Storage Tank, 35: Refrigerant Tube, 36: Freezing Point Adjusting Unit, 40: Ice Slurry Supply Port, 41: Ice

Slurry Discharge Port, 42, 43: On-off Valve, 44: Cold Storage
Moving Body, 45: Distribution Base, 46: Ice Slurry Supply
Apparatus, 47: Ice Slurry Supply Adjusting Unit, 50: Gap, 60:
Flake Ice Production System, 70 : Ice Slurry Supply System,
81: Blower Clearance

CLAIMS

1. A flake ice production device for producing a flake ice by freezing a brine, comprising:
a drum including an inner cylinder, an outer cylinder surrounding the inner cylinder, and a clearance formed between the inner cylinder and the outer cylinder,
a refrigerant supply unit that supplies a refrigerant to the clearance,
a rotary shaft that rotates by taking a central axis of the drum as an axis,
an injection unit that rotates together with the rotary shaft and injects the brine toward an inner peripheral surface of the inner cylinder, and
a scraping unit that scrapes off a flake ice generated as a result of the brine, having been injected from the injection unit, attaching to the inner peripheral surface of the inner cylinder, having been cooled by the refrigerant supplied to the clearance.
2. The flake ice production device according to Claim 1, wherein the brine includes,
an aqueous solution that contains a solute and satisfies predetermined conditions, and
a solid having a thermal conductivity higher than that of an ice produced from a liquid containing the aqueous solution.

3. The flake ice production device according to Claim 1 or 2, wherein the liquid further includes oil.

4. The flake ice production device according to any one of Claims 1 to 3, wherein the solute includes, two or more types of solutes each having a different degree of solidifying point depression.

5. The flake ice production device according to any one of Claims 1 to 4, further comprising: a speed control unit for variably controlling the rotation rate of the rotary shaft.

6. The flake ice production device according to any one of Claims 1 to 5, wherein the refrigerant supply unit supplies liquefied natural gas as the refrigerant to the clearance.

7. A flake ice production method using the flake ice production device according to any one of Claims 1 to 6.

8. A flake ice production system for producing a flake ice by freezing a brine, comprising:
a spray unit for spraying the brine,
a member for producing the flake ice, in a state in which the member is cooled at a temperature equal to or lower than the solidifying point of the brine by a predetermined refrigerant,

by having the sprayed brine attached to the member so as to freeze, and

a refrigerant supply unit that supplies to the member a liquefied gas that can cool the member to a temperature equal to or lower than the solidifying point of the brine as the predetermined refrigerant.

9. The flake ice production system according to Claim 8, wherein the refrigerant supply unit supplies LNG to the member as the predetermined refrigerant.

10. A flake ice production method using the flake ice production system according to Claim 8 or 9.

11. A moving body equipped with any one of the flake ice production devices according to Claims 1 to 6.