Slurry ice cooling has great potential, according to study

Slurry ice-based cooling systems promise significant environmental and cost advantages, says Zafer Ure following a fresh study of their potential

The growth in environmental concern and the resultant phaseout of CFC/HCFCs has prompted a search for acceptable alternative cooling technologies.

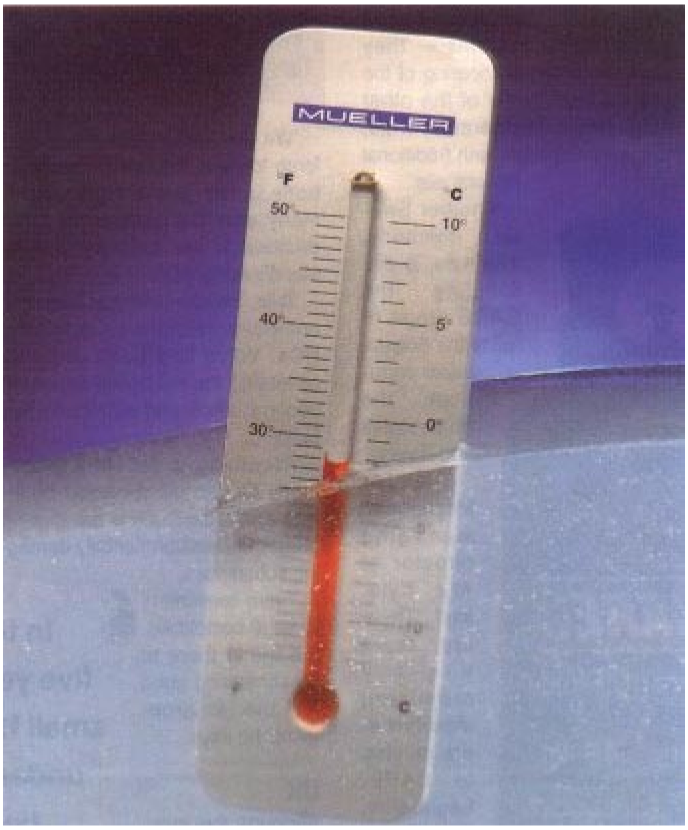
One solution that is receiving attention is slurry ice-based systems. Slurry ice has the potential to achieve considerable environmental as well as economic benefits, for both central cooling systems and direct ice production for the ever expanding demand for ‘ice applications.

Capacity

The cooling capacity of slurry ice can be four to six times higher than that of conventional chilled water, depending on the ice fraction. Any of the currently available range of primary refrigerants can be used for the production of slurry ice.

The characteristics of the binary (crystal) ice formation allows end users to pump the ice, hence providing easy handling and full contact with the product for higher chilling efficiencies.

It can be applied in a very wide range of applications, including quick chilling and freezing, batch cooling, process machinery cooling, supermarket refrigeration and air conditioning, fast indirect cooling of products such as milk, beer and oil, and special applications such as marine and mine cooling.



Cooling capacity of slurry ice *can be four to six times higher than chilled water*

There are several approaches to slurry ice technology. I have carried out a study, highlighting the advantages and disadvantages of using various ice slurry cooling systems.

The important physical properties and behaviour of ice slurries are presented in a form that will help practising engineers and consultants develop an effective and efficient slurry icebased cooling system.

The extracts here are intended to provide a flavour - rather than a comprehensive summary - of the contents of the study.

Ice production techniques can be divided into two main groups, dynamic and static systems. The ice produced can be used either directly or indirectly to cool the product or system.

Production

Static ice production systems have probably been in use longest. In general, the ice formation takes place without any physical removal of the ice. The most common techniques are ice on coil, ice banks and encapsulated ice storage.

In contrast, slurry ice employs dynamic production techniques, and offers the vital pumpable characteristic.

At 20 to 25 per cent ice concentration, slurry ice flows like conventional chilled water while pro-

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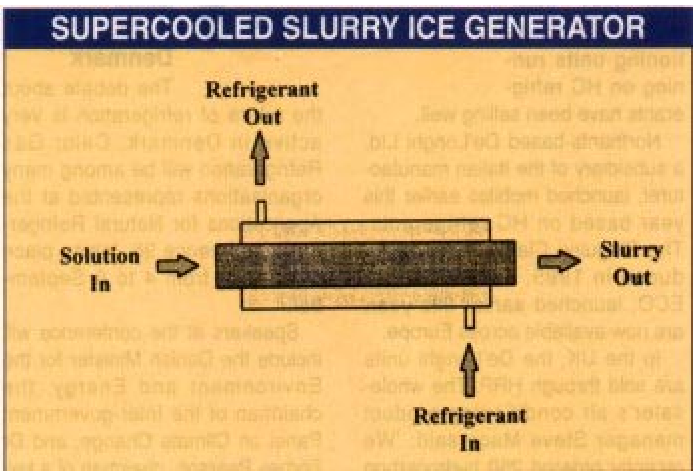

Fig. 1

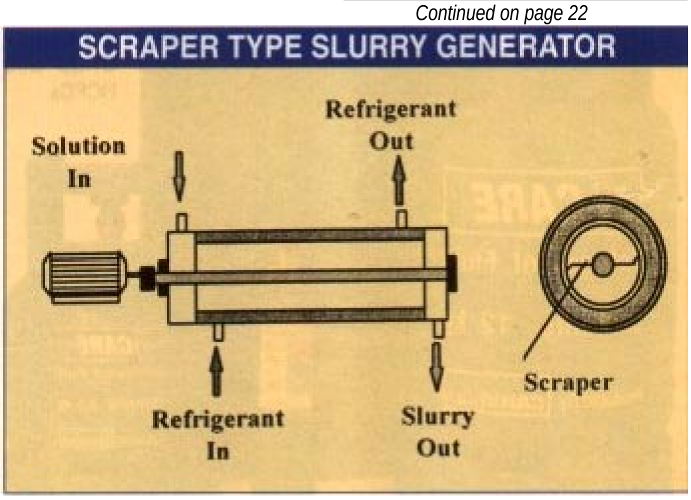

Fig. 2

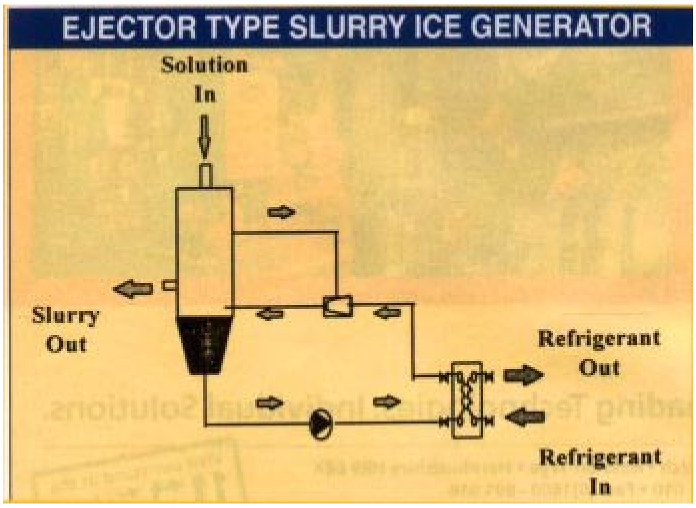

Fig. 3

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viding five times the cooling capacity. At 40 to 50 per cent ice concentration, it demonstrates thick slurry characteristics, and at 65 to 70 per cent concentration, slurry ice has the consistency of ice cream.

Compact equipment design and the pumpable characteristic offer tremendous flexibility for the location of the storage tank(s), and the most economical capacity and duty balancing for any given application.

The storage tank can be placed: under, beside, inside, or on top of a building, and can be in any shape and size to match the building and architectural requirements. Also, multiple small storage tanks may be used instead of single large static type units.

Advantages

A further advantage of slurry ice is that it does not suffer from the static type disadvantages of ice bridging, and ice insulation effects. As it is composed of microscopic crystals of ice, the total surface area for heat exchange is very large, and ice melts quickly to meet varying cooling loads.

Hence, steady and accurate system leaving temperatures.

There are a several types of slurry ice production systems commercially available. These include:

- Supercooled slurry ice production
- Scraper type systems
- Ejector systems
- Vacuum type systems
- Failing film systems

The supercooling concept has an evaporator which operates on the principle of supercooling of water. A stream of water, when cooled slowly, can be supercooled by several degrees without ice forming on the wall.

Before leaving the evaporator, the flow of the supercooled water is physically disturbed in order to generate ice crystals. The ice fraction depends on the supercooling of the liquid leaving the evaporator. The ice fraction increases by around 1.24(C for each 1 (C of supercooling.

Scraper type slurry generators produce ice in a brine solution at various temperature ranges, depending on the solution concentration. The freeze point depressant prevents ice formulation on the evaporator wall.

As the liquid is cooled, ice crystals are formed in the bulk of the liquid. An agitator system is used to move the cold water from the vicinity of the wall to the bulk of the liquid. The increase in the ice fraction for each pass depends on the mass flowrate through the chiller.

The ejector system relies on a heat exchange process with two different fluids. A non-miscible fluid, heavy than water, is cooled below water freezing temperature via a conventional secondary refrigeration chiller. Fluid passes through an ejector system, which uses the high pressure from the fluid to draw water from the tank circuit; the ejector system creates sufficient turbulence and cooling effect to turn ordinary water to ice crystals.

Once the mixture reaches the settling tank, the lighter ice crystals float to the top of the tank and the heavier heat transfer fluid settles at the bottom of the tank for recirculation.

Steady

The settling tank requires careful design in order not to disturb the heat transfer fluid, water and ice levels. In addition, with ice floating at the top of the tank it is difficult to maintain steady ice concentration levels for the supply line.

Vacuum type slurry ice production depends on the principle that the behaviour of water changes with pressure, as exploited in absorption chillers. The concept can be best described as flash evaporation. This requires vapour removal by means of a mechanical or thermal compressor. The compressed vapour is later liquified in the condenser to complete the loop.

This type of system operates at sub-atmospheric pressure, and therefore non-condensable gases must be removed, in similar fashion to absorption refrigeration machines.

Falling film slurry ice generators are based on conventional vertical flooded type shell and tube heat exchangers. The internal failing film process is based on super cooling the solution, which is dis turbed by a spinning rod in orde to overcome the formation of solid ice.

Once the solution is super cooled and disturbed, it forms microscopic fine binary ice crystals, which are collected at the bot tom of the vessel for distribution The essential ice concentration and capacity control can be adjusted by means of either individually controlling the suction pressure and solution flow rates or a combination of both.

In principle, there is negligible friction between the rod and the tube wall, and the slurry ice solution acts like a lubricant. Therefore, the energy required to drive the rod, and the lower maintenance requirements, offer efficient and economical operation.

Chapters

Following sections of the study look in detail at the characteristics of slurry ice, its cooling capacity and behaviour, and the pumping requirements for systems.

There are also chapters on distribution systems, storage, recovering stored cooling, and control strategy.

If you would like to receive a copy of the study, entitled Slurry ice-based cooling systems, contact the author on 01753 866525 (Fax: 01753 620061)