DETAILED DESCRIPTION OF DRAWINGS

Referring to Figures 1 to 3, an industrial shell and tube heat exchanger for providing freezing or chilling of brine to produce slurry ice in accordance with a first embodiment of the invention is shown.

Figure 1 shows the following parts with corresponding reference numbers:

11 Motor Drive Arrangement,
12 Refrigerant Out,
13 Spiral (Brine/Tube side),
14 Refrigerant Out,
15 Slurry Ice Out,
16 Bearing/Gland Arrangement,
17 Brine In (Tube Side), and
18 Refrigerant In (Shell Side).

Figure 2 shows a front view of the industrial shell and tube heat exchanger shown in Figure 1 as seen from arrow A, namely a view on A.

Figure 3 shows an enlarged front view of tubes of the industrial shell and tube heat exchanger as seen in Figure 2, namely a tube arrangement.

The industrial shell and tube heat exchanger for providing freezing or chilling of brine to produce slurry ice, includes a shell and tube heat exchanger located in a horizontal position and which includes

(a) At least one tube within the shell and tube heat exchanger; and

(b) At least one rotatable spiral driven in at least one tube, and which is adapted to move or pump the brine and slurry ice through the respective tube to ensure individual supply of brine for the production of slurry ice.

The tubes outer surface on the refrigerant (shell side) of the tubes are specially prepared.

The tubes are fixed in the end plate of the shell and tube heat exchanger.

The spirals are driven inside the tube by mechanical means.

The heat exchanger includes a mechanical drive adapted to drive the spirals and which may be aligned with the centre of the tube and fitted with bearings and shaft seal.

The mechanical drive is directly connected to a motor, or in bundles where the centre tube spiral drive provides the driving pulley for other tube spirals around.

The drive is done with belts to an arrangement of tubes around the centre tube spiral.

There are no bearings in the opposite side of the spirals.

The spirals self centre in the tube with the rotation.

Figures 4 and 5 show an industrial shell and tube heat exchanger for providing freezing or chilling of brine to produce slurry ice in accordance with a second embodiment of the invention.

Figure 4 shows the following parts with corresponding reference numbers:

41 Geared Motor,
42 Driven Shafts,
43 Ammonia Outlet (Shell Side),
44 Tension Rods,
45 Brine/Slurry Outlet (Tube Side),
46 Ammonia Inlet (Shell Side),
47 Spiral In Tube,
48 Brine Inlet (Tube Side),
49 Bearing Plate,
50 Bearing Plate,
51 Shaft Seal, and
52 Drive Shaft.

Figure 5 shows an enlarged front view of tubes of the industrial shell and tube heat exchanger as seen in Figure 4, namely a tube arrangement.

In this embodiment the mechanical drive is done with an arrangement of gears and each gear drives a shaft supported by acetal water lubricated bearings, able to drive inside the water. All the gears mesh and balanced loads ensure easy rotation and the centre drive exist through a shaft seal to be driven by a single geared motor.

The non drive end of the spirals can be tensioned in order to facilitate stability in the spiral operation.

The drive method shown in Figure 4 has a more compact arrangement to allow more tubes in the same shell. The diving loads on the gears and shaft is more balanced and therefore ensures lower friction and lower power consumption.

The brine provides the lubrication and dampening effect of the spiral inside the tube.

The brine is fully flooded and circulated through the heat exchanger tubes.

Ammonia is evaporated in the shell side and absorbs the heat from the brine in order to create ice crystals on the inner tube surface inside the brine stream.

The spirals provide high velocity brine stream on the inner tube surface to provide best heat transfer.

The spirals remove the ice crystals from the inner tube surface with high velocity brine stream created by the rotation of the spiral.

The spirals provide agitation to the brine stream inside the tube and facilitate a super cooling effect, where brine is super cooled and ice crystals forms inside the brine stream.

The spirals provide sufficient vibration in the tube to facilitate the removal of ice crystals from the inner tube surface.

The spirals provide sufficient vibration to improve heat transfer on the refrigerant side with specially prepared surface on the outside of the tube.

PATENT CLAIMS

1. An industrial shell and tube heat exchanger for providing freezing or chilling of brine to produce slurry ice, which includes a shell and tube heat exchanger located in a horizontal position and which includes

(a) at least one tube within the shell and tube heat exchanger; and

(b) at least one rotatable spiral driven in at least the one tube, and which is adapted to move or pump the brine and slurry ice through the respective tube to ensure individual supply of brine for the production of slurry ice~~.~~ ~~,~~

which includes a mechanical drive adapted to drive the spirals and which is aligned with the centre of the tube and fitted with bearings and shaft seal, in which the mechanical drive is operated with belts to an arrangement of tubes around the centre tube spiral.

2. An exchanger as claimed in claim 1, in which the tube(s) is(are) fixed in the end plate of the shell and tube heat exchanger.

3. An exchanger as claimed in claim 1 or claim 2, in which the spiral(s) are driven inside the tube by mechanical means.

~~4. An exchanger as claimed in any one of the preceding claims, which includes a mechanical drive adapted to drive the spirals and which is aligned with the centre of the tube and fitted with bearings and shaft seal.~~

4~~5~~. An exchanger as claimed in claim 1 ~~4~~, in which the mechanical drive is directly connected to a motor and/or in bundles where the centre tube spirals drive provides the driving pulley for other tube spirals around.

~~6. An exchanger as claimed in claim 4 or claim 5, in which the mechanical drive is operated with belts to an arrangement of tubes around the centre tube spiral.~~

~~7. An exchanger as claimed in any one of the preceding claims, which includes no bearings in the opposite side of the spirals.~~

~~8. An exchanger as claimed in any one of the preceding claims, in which the spirals are self-centred in the tube with the rotation.~~

~~9. An exchanger as claimed in claim 1 or claim 2, in which an arrangement of gears drive each spiral.~~

~~10. An exchanger as claimed in any one of claims 1 to 4 and 9, in which the gears are driven with a single geared drive outside through a shaft seal assembly.~~

5~~11~~. An exchanger as claimed in any one of claims 1 to 3~~ 4 and 9 to 10~~, in which the spiral is tensioned to facilitate stability in spiral operation.

~~12. An exchanger as claimed in any one of the preceding claims, in which the brine provides the lubrication and dampening effect of the spiral inside the tube.~~

6~~13~~. An exchanger as claimed in any one of the preceding claims, in which the brine is fully flooded and circulated through the heat exchanger tubes.

~~14. An exchanger as claimed in any one of the preceding claims, which is adapted to allow Ammonia to be evaporated in the shell side and which absorbs the heat from the brine in order to create ice crystals on the inner tube surface inside the brine stream.~~

~~15. An exchanger as claimed in any one of the preceding claims, in which the spirals are adapted to provide high velocity brine stream on the inner tube surface to provide best heat transfer.~~

~~16. An exchanger as claimed in claim 14 or claim 15, in which the spirals are adapted to remove the ice crystals from the inner tube surface with high velocity brine stream created by the rotation of the spiral.~~

~~17. An exchanger as claimed in any one of claims 14 to 16, in which the spirals are adapted to provide agitation to the brine stream inside the tube and facilitate a super-cooling effect, where brine is super-cooled and ice crystals forms inside the brine stream.~~

~~18. An exchanger as claimed in any one of claims 14 to 17, in which the spirals provide sufficient vibration in the tube to facilitate the removal of ice crystals from the inner tube surface.~~

~~19. An exchanger as claimed in any one of the preceding claims, in which the spirals are adapted to provide sufficient vibration to improve heat transfer on the refrigerant side with specially prepared surface on the outside of the tube.~~

~~20. An exchanger as claimed in any one of the preceding claims, in which the inner tube surface is prepared to facilitate the removal of ice crystals.~~

~~21. An exchanger as claimed in any one of the preceding claims, in which the overall flow rate is controlled with a pump to ensure the ice concentration required.~~

7~~22~~. A method of producing slurry ice, which includes the steps of moving or pumping brine and slurry ice through at least one tube to ensure individual supply of brine for the production of slurry ice~~.~~, in which the brine is fully flooded and circulated through the heat exchanger tubes.

8~~23~~. A method as claimed in claim 7~~22~~, in which the tubes are fixed in the end plate of the shell and tube heat exchanger.

9~~24~~. A method as claimed in claim 7~~22~~ or claim 8~~23~~, which includes the step of driving spirals inside the tube by mechanical means.

10~~25~~. A method as claimed in any one of claims 7~~22~~ to 9~~24~~, which includes the step of self-centring the spirals in the tube with the rotation.

11~~26~~. A method as claimed in any one of claims 7~~22~~ to 10~~25~~, in which the brine provides the lubrication and dampening effect of the spiral inside the tube.

~~27. A method as claimed in any one of claims 22 to 26, in which the brine is fully flooded and circulated through the heat exchanger tubes.~~

~~28. A method as claimed in any one of claims 22 to 27, which includes the step of allowing Ammonia to be evaporated in the shell side which~~

~~absorbs the heat from the brine in order to create ice crystals on the inner tube surface inside the brine stream.~~

~~29. A method as claimed in any one of claims 22 to 28, in which the spirals provide high velocity brine stream on the inner tube surface to provide best heat transfer.~~

~~30. A method as claimed in claim 28 or claim 29, in which the spirals remove the ice crystals from the inner tube surface with high velocity brine stream created by the rotation of the spiral.~~

~~31. A method as claimed in any one of claims 25 to 27, in which the spirals provide agitation to the brine stream inside the tube and facilitate a super cooling effect, where brine is super cooled and ice crystals forms inside the brine stream.~~

~~32. A method as claimed in any one of claims 22 to 31, in which the spirals provide sufficient vibration in the tube to facilitate the removal of ice crystals from the inner tube surface.~~

~~33. A method as claimed in any one of claims 22 to 32, in which the spirals provide sufficient vibration to improve heat transfer on the refrigerant side with specially prepared surface on the outside of the tube.~~

~~34. A method as claimed in any one of claims 22 to 33, which includes the step of preparing the inner tube surface to facilitate the removal of ice crystals.~~

~~35. A method as claimed in any one of claims 22 to 34, which includes the step of controlling the overall flow rate with a pump to ensure the ice concentration required.~~

~~36. An industrial shell and tube heat exchanger for providing freezing or chilling of brine to produce slurry ice substantially as hereinbefore described with reference to the accompanying drawings.~~

~~37. A method of producing slurry ice substantially as hereinbefore described with reference to the accompanying drawings.~~