An evaporator includes a manifold receiving a distributor insert. The distributor insert receives the flow of refrigerant to be delivered into the manifold, and has openings to communicate this refrigerant into a plurality of chambers which are defined between adjacent dividing elements of the distributor insert within the manifold. In this manner, these chambers are each associated with distinct heat transfer tubes and such that these chambers are isolated from each other.
MICROCHANNEL HEAT EXCHANGER WITH ENHANCED REFRIGERANT DISTRIBUTION

RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/053,677, which was filed May 16, 2008.

BACKGROUND OF THE INVENTION

[0002] This application relates to heat exchangers of refrigerant systems that utilize a distributor insert mounted within a manifold, and incorporating dividing elements separating the manifold into a plurality of chambers, each associated with at least one heat exchange tube.

[0003] In recent years, much interest and design effort has been focused on the efficient operation of heat exchangers (and condensers and evaporators in particular) of refrigerant systems. One relatively recent advancement in the heat exchanger technology is the development and application of parallel flow, or so-called microchannel or minichannel, heat exchangers (these two terms will be used interchangeably throughout the text), as the condensers and evaporators. Also, throughout the text, the reference will be made to a heat rejection heat exchanger as a condenser, with the understanding that the heat rejection heat exchanger may operate as a gas cooler, at least for a portion of the time.

[0004] Such microchannel heat exchangers are provided with a plurality of parallel heat exchange tubes, among which refrigerant is distributed and flown in a parallel manner. The heat exchange tubes are orientated generally substantially perpendicular to a refrigerant flow direction in the inlet, intermediate and outlet manifolds that are in flow communication with the heat exchange tubes. When utilized in condenser and evaporator applications, these heat exchangers may be designed in multi-pass configuration, typically with a plurality of parallel heat exchange tubes within each refrigerant pass, in order to obtain superior performance by balancing and optimizing heat transfer and pressure drop characteristics. Single-pass configurations are typically more desirable in the evaporator applications, since the refrigerant pressure drop plays a dominant role in the evaporator performance.

[0005] However, there have been some obstacles to the use of the microchannel heat exchangers within a refrigerant system. In particular, a problem, known as refrigerant maldistribution, typically occurs in the microchannel heat exchanger manifolds when the two-phase flow enters the manifold. A vapor phase of the two-phase flow has significantly different properties, moves at different velocities and is subjected to different effects of internal and external forces than a liquid phase. This causes the vapor phase to separate from the liquid phase and to flow independently. The separation of the vapor phase from the liquid phase has raised challenges, such as refrigerant maldistribution in parallel flow heat exchangers.

[0006] It is known in certain refrigerant systems to utilize a distributor insert for delivering refrigerant into an evaporator manifold. Such systems have been employed in refrigerated merchandisers, such as refrigeration display cases. The proposed inlet distributor insert utilized in refrigerant display cases would not solve the problem of refrigerant maldistribution mentioned above.

[0007] Another proposed heat exchanger is constructed of a plurality of plates. The heat exchange refrigerant channels are formed of spaced plates, and remote ends of those spaced plates provide inlet plenums for each refrigerant channel. The plates separate adjacent plenums, and an insert tube extends through the plates and into the plenums. This tube includes a plurality of orifices which direct refrigerant into the individual plenums. This arrangement would not be practical for microchannel heat exchangers, and would only be a practical construction for the one type of heat exchanger formed of the spaced plates.

SUMMARY OF THE INVENTION

[0008] In the disclosed embodiments of this invention, a manifold for a heat exchanger incorporates a distributor insert positioned within a manifold cavity. The distributor insert has multiple refrigerant distribution orifices of a small size projecting through the distributor walls, and also has dividing elements located on its periphery. Upon positioning the distributor insert within the heat exchanger manifold, the dividing elements act as manifold separation members by defining separate chambers within the manifold cavity, with each chamber fluidly communicating with at least one heat exchange tube positioned downstream, with respect to refrigerant flow.

[0009] In one embodiment, the heat exchanger manifold is an inlet manifold of an evaporator and, in another embodiment, the heat exchanger manifold is an intermediate manifold of a condenser or an evaporator.

[0010] While all separation chambers may be of an identical size and the distributor dividing elements uniformly spaced, in one embodiment, they are of a variable size to further fine tune refrigerant distribution. Although the invention is disclosed in relation to a two-phase refrigerant, it is also applicable to a single-phase refrigerant and refrigerant-oil mixtures.

[0011] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 schematically shows a basic exemplary refrigerant system.

[0013] FIG. 2 shows a portion of an inlet manifold of an inventive heat exchanger.

[0014] FIG. 3 shows a portion of an intermediate manifold of an inventive heat exchanger.

[0015] FIG. 4 shows an exemplary design of a distributor insert.

[0016] FIG. 5A shows a cross-sectional view of an exemplary heat transfer tube.

[0017] FIG. 5B shows a cross-sectional view of an exemplary dividing element.

[0018] FIG. 5C shows a side view of an exemplary dividing element of FIG. 5B.

[0019] FIG. 5D shows a cross-sectional view of another exemplary dividing element.

[0020] FIG. 5E shows a side view of an exemplary dividing element of FIG. 5D.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0021] A basic exemplary refrigerant system 20 is illustrated in FIG. 1 including a compressor 22 compressing a refrigerant and delivering it downstream into a condenser 24.
From the condenser 24 the refrigerant passes through an expansion device 26 into an inlet refrigerant pipe 28 leading into an evaporator 30. From the evaporator 30, the refrigerant is returned to the compressor 22 to complete the closed-loop refrigerant circuit.

As mentioned above, a plurality of small refrigerant distribution orifices 42 is provided to direct the refrigerant from the distributor insert 34 into a plurality of separation chambers 46 defined by adjacent dividing elements 44 of the distributor insert 32 within the cavity of the inlet manifold 34. The distance between the dividing elements 44 can be uniform or can be adjusted to control the ultimate size of the separation chambers 46 associated with any particular cluster of heat transfer tubes 36. This distance between the dividing elements 44 may vary from one cluster of heat transfer tubes 36 to another, or in an extreme case, from one heat transfer tube 36 to another. As an example, for a single inlet refrigerant pipe 28 located at the end of the inlet manifold 34, the size of the chambers 46 may be uniform along the longitudinal axis of the manifold 34 or, for instance, may decrease from the manifold inlet end to its remote end, where refrigerant velocity is expected to be lower. Any particular configuration of the dividing elements 44 could depend on operational parameters and particular application.

As shown in FIG. 2, the inlet refrigerant pipe 28 fluidly communicates with a distributor insert 32, which provides a refrigerant flow path along its longitudinal axis. An inlet manifold 34 of the evaporator 30 receives the distributor insert 32, and in turn fluidly communicates with a plurality of heat exchange tubes 36 positioned generally perpendicular to and downstream, with respect to the direction of refrigerant flow, of the inlet manifold 34. The inlet refrigerant pipe 28 may be positioned at the end of the inlet manifold 34, in the middle of the inlet manifold 34 or at any intermediate location in-between. Further, the inlet refrigerant pipe 28 may comprise two inlet refrigerant pipes connected at the opposite ends of the inlet manifold 34 or at any intermediate locations. Obviously, more than two inlet refrigerant pipes can be utilized, but all of them need to be fluidly connected and provide refrigerant paths into the distributor insert 32.

As known, a plurality of heat transfer fins 38 may be disposed between and rigidly attached, usually by a furnace braze process, to the heat exchange tubes 36, in order to enhance external heat transfer and provide structural rigidity for the heat exchanger 30. Also, as known, each heat exchange tube 36 of a microchannel heat exchanger (evaporator) 30 typically has a plurality of small internal channels 41 providing multiple parallel refrigerant flow paths along longitudinal axis of each heat exchange tube 36 (see FIG. 5A). The internal channels 41 enhance internal heat transfer and also provide structural rigidity for the heat exchanger 30.

As also illustrated in FIG. 2, a plurality of refrigerant distribution orifices 42 of a small size are formed to protrude through the walls of the distributor insert 32 and to provide the refrigerant paths from an internal cavity of the distributor insert 32 into the inlet manifold 34. The distribution orifices 42 can be, for instance, of a round shape, rectangular shape, oval shape or any other shape. Furthermore, the distributor insert 32 has dividing elements 44 located on its periphery and rigidly attached to the outside walls of the distributor insert 32. Upon positioning the distributor insert 32 within the inlet manifold 34 of the evaporator 30, the dividing elements 44 form refrigerant separation chambers 46 within the internal cavity of the inlet manifold 34, with each chamber communicating refrigerant downstream to at least one heat exchange tube 36. Typically, each separation chamber would be fluidly connected to several refrigerant distribution orifices 42 and several heat exchange tubes 46.

Similarly, an inner periphery of the dividing elements 44 is tightly received within an inner wall of the inlet manifold 34. Similarly, an inner periphery of the dividing elements 44 is closely received on an outer wall of the insert 32. In this manner, adjacent separation chambers 46 are maintained predominantly isolated from each other preventing refrigerant migration from one separation chamber 46 to another. Therefore, the overall characteristics of the refrigerant flow into the heat exchange tubes 36 can be controlled such that the effects of phase separation and/or refrigerant migration can be eliminated or minimized.

FIG. 3 shows another embodiment 300, wherein the manifold 301 is an intermediate manifold, downstream of heat exchange tubes 302, and feeding the refrigerant into heat exchange tubes 312. As shown, the distributor insert 306 has...
The dividing elements 44 can be of any shape and form, such as, for instance, flat plates (see FIG. 5E), as long as they do not drastically block refrigerant flow into the heat exchange tubes 36 and isolate one separation chamber 46 from another (e.g. by a small clearance or mechanical chemical bonding). Furthermore, dividing elements 44 may have cutouts 202 in case the heat exchange tubes 36 penetrate inside the inner manifold 34 (see FIGS. 5D and 5E). The dividing elements 44 may be attached to the distributor insert 32 mechanically (e.g. snapped into place into small grooves manufactured on the outer wall of the distributor insert 32), or by brazing, welding or soldering. The dividing elements 44 may be also attached to the inner wall of the inner manifold 34 (e.g. by furnace brazing). Both attachment processes can be performed, for instance, during furnace brazing of the entire heat exchanger 30.

FGS. 5D and 5E show another embodiment, wherein the dividing elements 44 do not include the cutout 200, but do include a groove or indentation 202. The purpose of this indentation is to provide a holding cavity for brazing flux such that the distributor insert can be inserted into a manifold and brazed upon construction of the overall heat exchanger.

In general, each of the disclosed embodiments teaches a distributor insert which will receive refrigerant, and distribute refrigerant through a plurality of orifices into separation chambers defined between dividing elements. Since the insert and the dividing elements are attached to each other as a rigid sub-assembly, the entire assembly can be inserted into a manifold. This will allow the use of this feature without requiring any specific heat exchanger design, as has been the case in the prior art.

Although an embodiment of this invention has been disclosed, a worker of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content.

What is claimed is:

1. A heat exchanger comprising:
   a plurality of heat transfer tubes;
   a manifold for communicating refrigerant into said plurality of heat transfer tubes, and a distributor insert connected to a source of refrigerant and having a plurality of orifices in an outer periphery of said distributor insert and dividing elements on an outer wall of said distributor insert such that a plurality of distribution chambers are defined and associated with said plurality of heat transfer tubes.

2. The heat exchanger as set forth in claim 1, wherein the heat exchanger is an evaporator, and said manifold is an inlet manifold.

3. The heat exchanger as set forth in claim 1, wherein said distributor insert and said dividing elements improve refrigerant distribution in said heat exchanger.

4. The heat exchanger as set forth in claim 1, wherein said manifold is an intermediate manifold.

5. The heat exchanger as set forth in claim 1, wherein said distributor insert extends along only a portion of said manifold, and is not aligned with heat transfer tubes communicating into said manifold, but is aligned with heat transfer tubes communicating out of said manifold.

6. The heat exchanger as set forth in claim 1, wherein said dividing elements are spaced uniformly along a length of said distributor insert.

7. The heat exchanger as set forth in claim 1, wherein said dividing elements are attached to said distributor insert by one of mechanical attachment and chemical bonding.

8. The heat exchanger as set forth in claim 1, wherein said dividing elements are flat plates having a cutout portion at an outer periphery to provide clearance for said heat transfer tubes.

9. The heat exchanger as set forth in claim 1, wherein the distributor insert has a round cross-sectional shape.

10. The heat exchanger as set forth in claim 1, wherein said manifold has an internal bore of a round cross-sectional shape.

11. The heat exchanger as set forth in claim 1, wherein the refrigerant passing through said distributor insert is a two-phase refrigerant.

12. The heat exchanger as set forth in claim 1, wherein the heat exchanger is a microchannel heat exchanger.

13. A refrigerant system comprising:
   a compressor, said compressor for compressing a refrigerant and delivering it downstream into a condenser, refrigerant from said condenser passing through an expansion device and then into an evaporator;
   at least one of said condenser and evaporator including a plurality of heat transfer tubes for receiving a refrigerant, and passing the refrigerant along a path from an inlet end to an outlet end, and a manifold for communicating with an inlet end of said heat transfer tube, said manifold receiving a distributor insert, connected to a source of refrigerant and having a plurality of orifices at an outer periphery and a plurality of dividing elements between an outer wall of said distributor insert and an inner wall of said manifold to define a plurality of separation chambers within said manifold, with at least some of said heat transfer tubes being associated with different ones of said separation chambers and isolated from others of said separation chambers by said dividing elements.

14. The refrigerant system as set forth in claim 13, wherein said distributor insert extends from an upstream end of said manifold toward a downstream end of said manifold, and the size of said separation chambers defined between adjacent ones of said dividing elements is determined to optimize the flow of refrigerant within the plurality of heat transfer tubes.

15. The refrigerant system as set forth in claim 13, wherein said plurality of heat transfer tubes, each including a plurality of channels, spaced generally perpendicularly to an upstream to downstream direction of said distributor insert.

16. The refrigerant system as set forth in claim 13, wherein the heat exchanger is an evaporator, and said manifold is an inlet manifold.

17. The refrigerant system as set forth in claim 13, wherein said manifold is an intermediate manifold.

18. The refrigerant system as set forth in claim 17, wherein said distributor insert extends along only a portion of said manifold, and is not aligned with heat transfer tubes communicating into said manifold, but is aligned with heat transfer tubes communicating out of said manifold.

19. The refrigerant system as set forth in claim 13, wherein the heat exchanger is a microchannel heat exchanger.

20. The refrigerant system as set forth in claim 13, wherein said dividing elements are flat plates having a cutout portion at an outer periphery to provide clearance for said heat transfer tubes.