



US 20150247658A1

(19) **United States**(12) **Patent Application Publication**
Cosby, II et al.(10) **Pub. No.: US 2015/0247658 A1**(43) **Pub. Date: Sep. 3, 2015**(54) **LOW REFRIGERANT HIGH PERFORMING
SUBCOOLER***F25B 41/00* (2006.01)*F28D 1/053* (2006.01)(71) Applicant: **TRANE INTERNATIONAL INC.**,
Piscataway, NJ (US)(52) **U.S. Cl.**CPC *F25B 39/04* (2013.01); *F28D 1/05325*
(2013.01); *F25B 40/02* (2013.01); *F25B 41/00*
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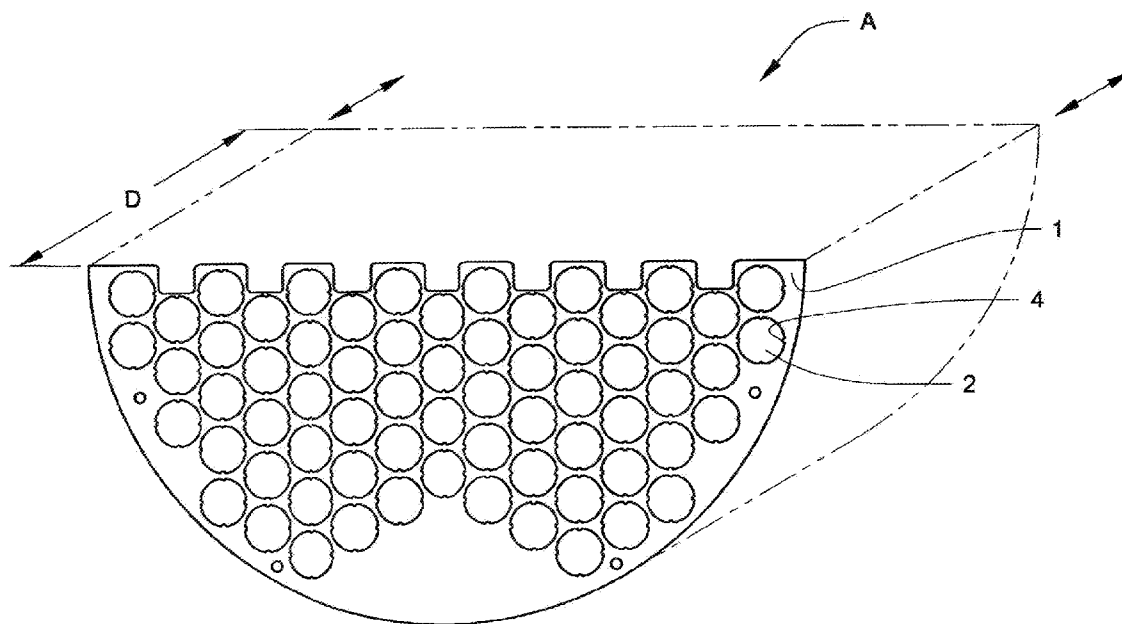
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ABSTRACT(21) Appl. No.: **14/431,078**(22) PCT Filed: **Sep. 26, 2012**(86) PCT No.: **PCT/CN2012/081990**

§ 371 (c)(1),

(2) Date: **Mar. 25, 2015**

A refrigerant displacement device is used to reduce subcooler refrigerant charge while enhancing heat transfer performance, e.g. by maintaining and/or increasing subcooler performance. The refrigerant displacement device physically takes up volume of the subcooler that would normally be occupied by refrigerant. The refrigerant displacement device can be a baffle structure with orifices through which the subcooler's heat exchange tubes are allowed to be inserted. Refrigerant is still allowed, however, to flow through the remaining volume of the subcooler and through openings constructed as, e.g. annuluses, between the tube(s) and the refrigerant displacement device, so as to allow refrigerant flow from an inlet of the subcooler to an outlet of the subcooler.

Publication Classification(51) **Int. Cl.***F25B 39/04* (2006.01)*F25B 40/02* (2006.01)

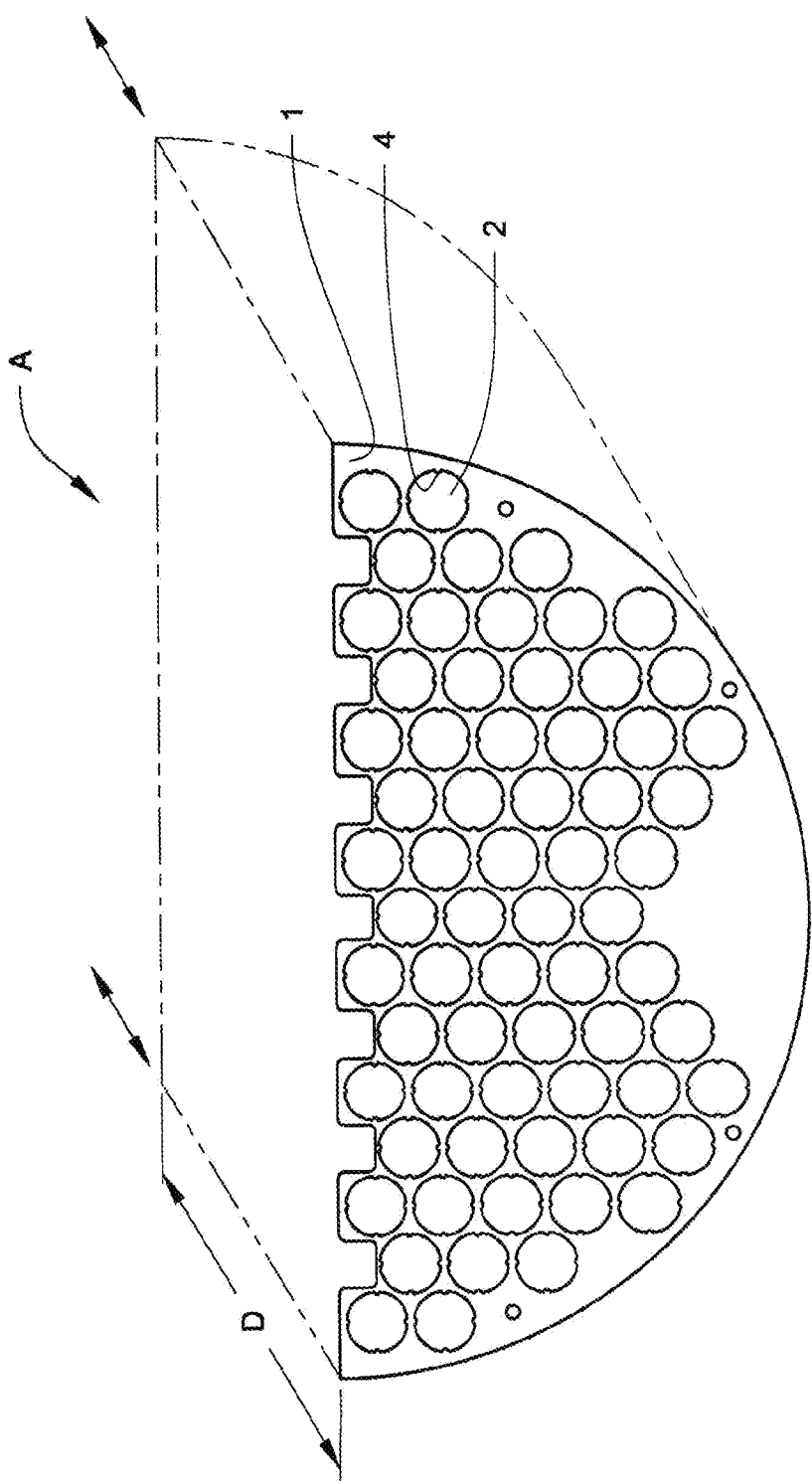


Fig. 1

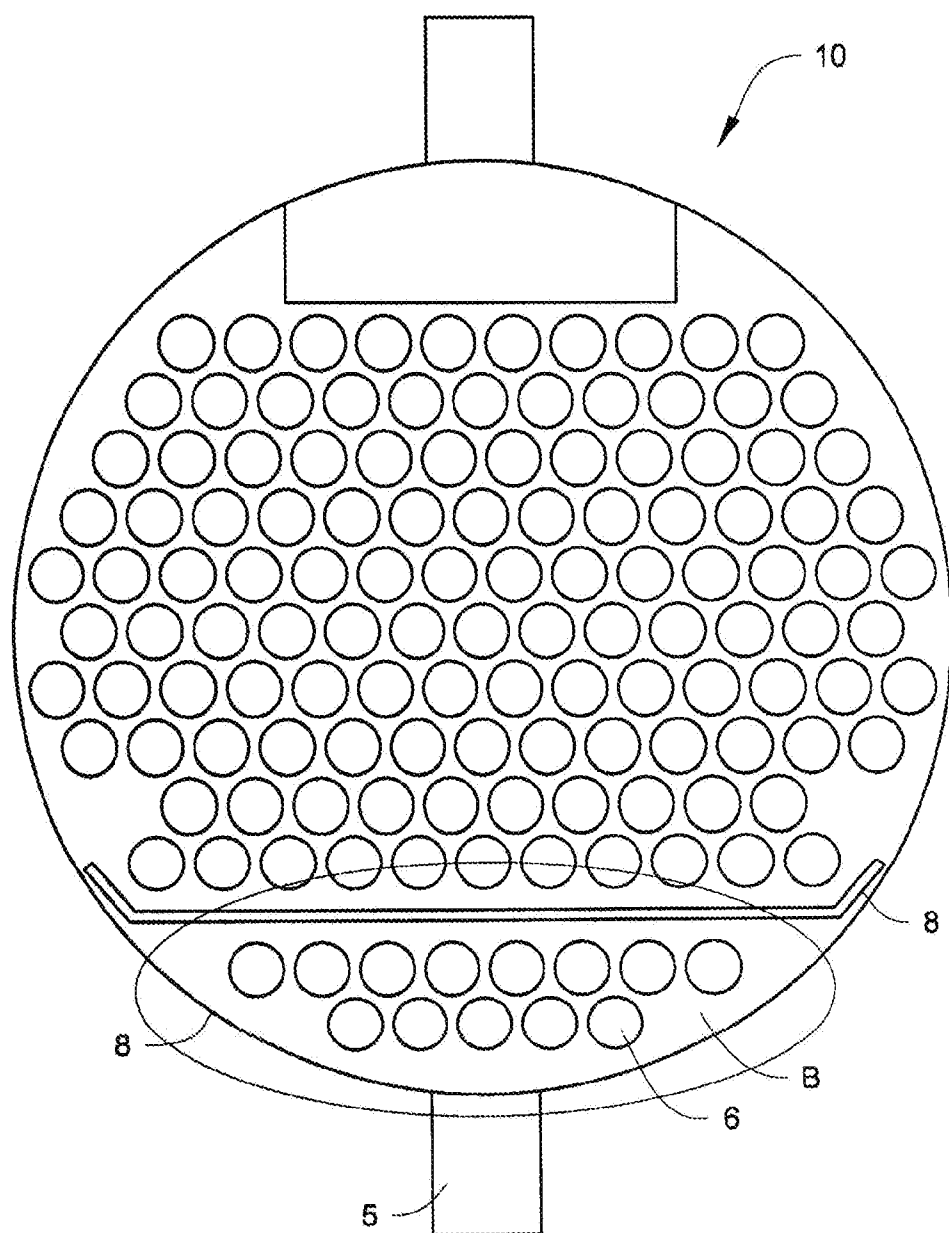


Fig.2

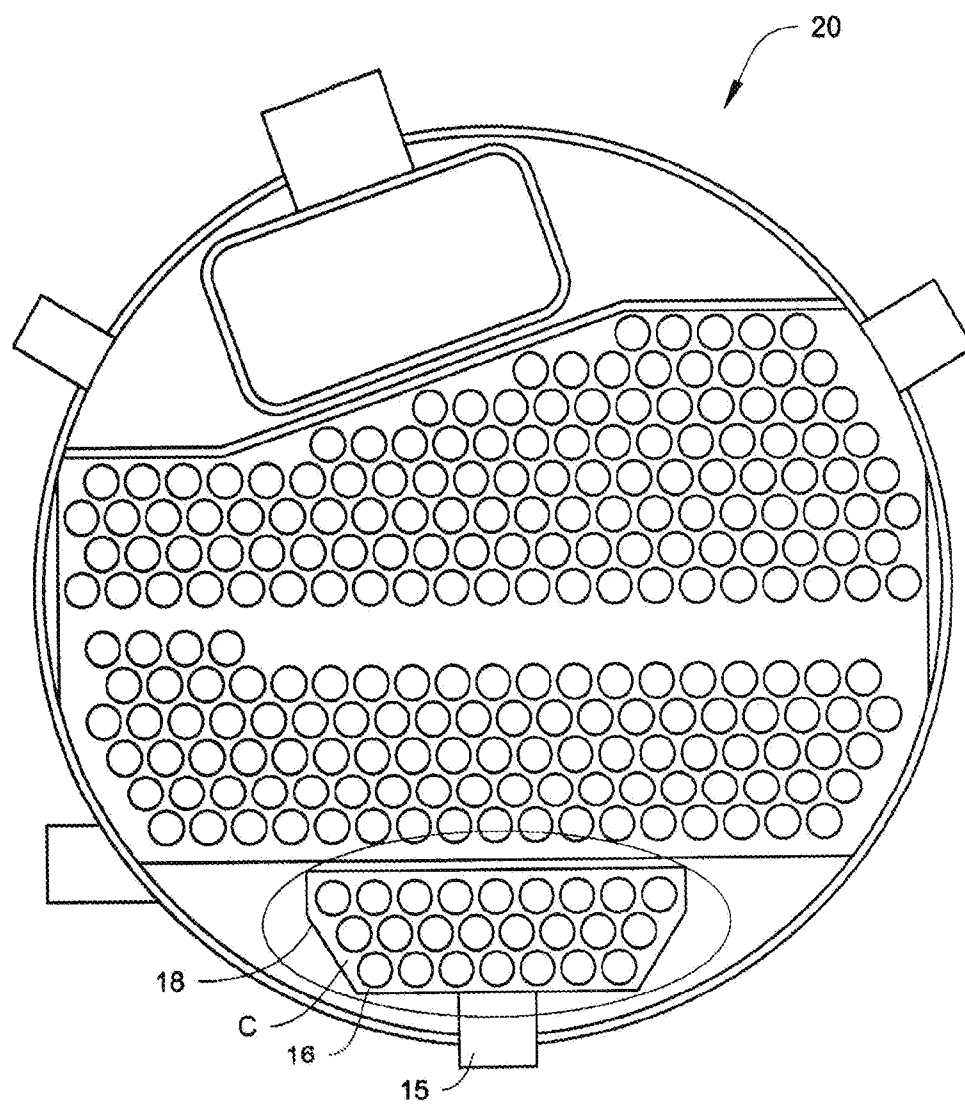


Fig.3

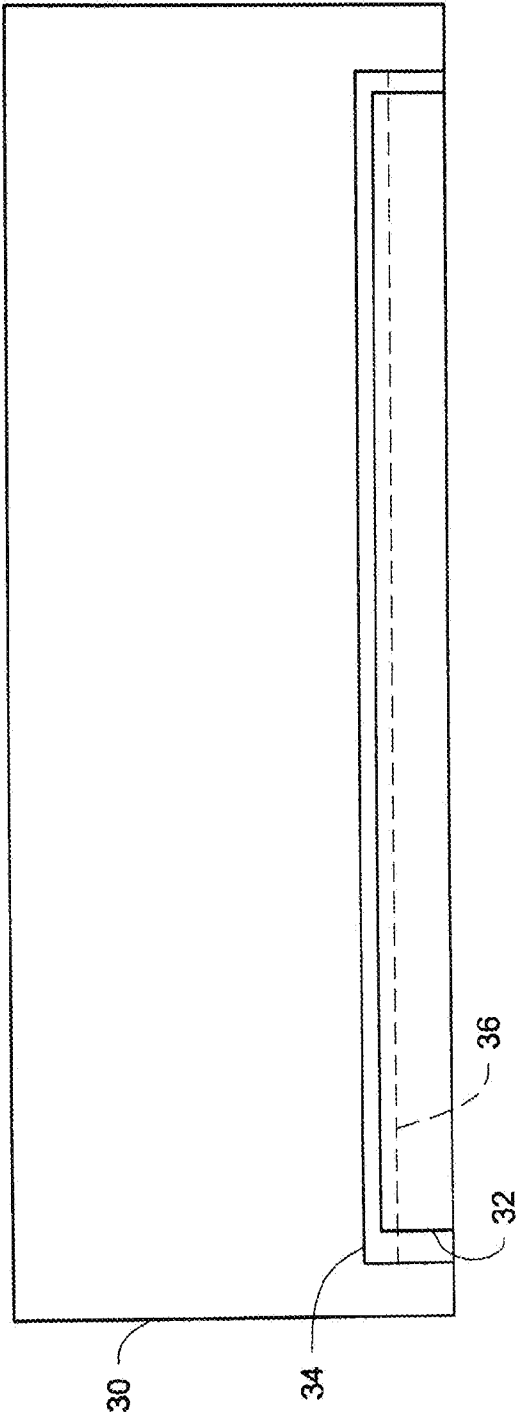


Fig.4

LOW REFRIGERANT HIGH PERFORMING SUBCOOLER

FIELD

[0001] The disclosure herein relates to heating, ventilation, and air-conditioning (“HVAC”) applications, systems and methods, and more particularly to a subcooler with a refrigerant displacement device that can be suitable for use with a condenser in HVAC components, units, and systems.

BACKGROUND

[0002] Subcoolers are known to be used in shell and tube heat exchangers, such as in condensers of water cooled HVAC chillers and that operate under the condensing temperature. Subcooler design is typically dictated by heat exchange tube geometry size and shell size allowance within the shell and tube heat exchanger.

[0003] Existing subcooler designs can be separate enclosures ranging from, for example discrete envelopments within a condenser shell, to separate welded enclosures within the condenser shell.

[0004] Other subcooler designs that may not utilize a separate enclosure, and may instead use part of the condenser shell walls as part of the subcooler enclosure.

SUMMARY

[0005] Such subcooler designs that may be discrete envelopments as described above are often welded enclosures to prevent leakage and bypass. The costs of such subcooler designs can be high. Such subcooler designs described above that may utilize the condenser shell walls as part of the subcooler enclosure can have relatively more refrigerant charge than discrete envelopment designs, and can have significantly more flow area/reduced flow velocities. Also, future refrigerant taxes and/or higher prices with new alternative refrigerants may restrict the construction of such designs that utilize portions of the condenser shell wall. Additionally, where there may be reduced flow velocities, subcooler performance may suffer and require additional tube surface area to accommodate the lack of heat transfer performance.

[0006] A refrigerant displacement device as described herein and shown in the Figures can address performance and cost issues that may be associated with such existing subcooler designs as described above, by not only minimizing refrigerant charge through the subcooler, but also minimizing the free flow area to increase flow velocity over the subcooler tubes.

[0007] In one embodiment, a refrigerant displacement device is a baffle structure that includes a main body that is suitable to be placed into a subcooler, for example along the direction that heat exchange tubes extend, e.g. in an end to end or lengthwise direction/arrangement. The main body physically displaces refrigerant from volume or free flow areas within the enclosure of the subcooler that would otherwise be occupied by refrigerant. The main body has a number of orifices through the main body, and through which heat exchange tubes may be suitably inserted. The orifices have a standoff(s) to create space between an outer diameter of the heat exchange tubes and surfaces on the baffle created by the orifices. During unit, system, component operation, refrigerant is allowed to flow through the orifices between the baffle and the heat exchange tubes, and refrigerant is directed to flow proximate the heat exchange tubes.

[0008] In one embodiment, the displacement device can be a series of baffles, where each of the baffles may have a different depth (e.g. dimension along the tube length), or in some embodiments can be one extrusion or a few larger extruded pieces. In some embodiments, whether there is a series of baffles, extruded pieces, or single extrusion, the refrigerant displacement device can extend along a majority or about all of the heat exchange tube length running through subcooler.

[0009] In one embodiment, the refrigerant displacement device can be suitably incorporated into HVAC system, for example into a condenser. In some embodiments, the refrigerant displacement device can be suitably incorporated into a subcooler with a dedicated, discrete envelopment. In some embodiments, the refrigerant displacement device the refrigerant displacement device can be suitably incorporated into a subcooler that utilizes a portion of the condenser shell walls.

[0010] In one embodiment, a method of operating a subcooler in a condenser of an HVAC unit or system includes: causing refrigerant to enter an inlet of a subcooler; causing the refrigerant to flow through orifices of a refrigerant displacement device; causing the refrigerant to be directed by the refrigerant displacement device to flow proximate the heat exchange tubes in areas between surfaces of the baffle created by the orifices and the outer surface of the heat exchange tubes; causing refrigerant to not be physically present at areas in the subcooler that are away from the heat exchange tubes and toward the enclosure of the subcooler, and not proximate the heat exchange tubes; and subcooling the refrigerant, while reducing refrigerant charge through the subcooler and increasing flow velocity proximate the heat exchange tubes.

[0011] In some embodiments, the method further comprises causing the refrigerant to flow through annularly shaped spaces created by standoffs on the orifices of the baffle, so that refrigerant flows between the orifices of the baffle and heat exchange tubes inserted therein.

[0012] Other features and aspects of the systems, methods, and control concepts will become apparent by consideration of the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Reference is now made to the drawings in which like reference numbers represent corresponding parts throughout.

[0014] FIG. 1 is an end view one embodiment of a refrigerant displacement device, and schematically showing a depth from end to end that can vary.

[0015] FIG. 2 is an open end schematic view of a condenser of an HVAC system with a subcooler utilizing a portion of the condenser shell walls as the subcooler enclosure.

[0016] FIG. 3 is an open end schematic view of another condenser of an HVAC system with a subcooler as a separate discreet enclosure.

[0017] FIG. 4 shows a schematic side view of a refrigerant displacement device installed in a subcooler.

DETAILED DESCRIPTION

[0018] A refrigerant displacement device is described and shown in the Figures that can address performance and cost issues that may be associated with such existing subcooler designs as described above, by not only minimizing refrigerant charge through the subcooler, but also minimizing the free flow area to increase flow velocity over the subcooler tubes.

Generally, the refrigerant displacement device is a baffle structure or construction and arrangement of a series of baffles that are suitable for use in a subcooler.

[0019] The utilization of one or more refrigerant displacement baffles allows for minimization of refrigerant but also helps to focus high velocity refrigerant flow proximate to and around the heat exchange tubes to conduct heat away from the refrigerant into the cooling fluid inside the heat exchange tubes. Refrigerant charge can be reduced, and/or chiller efficiency can increase, and/or copper tubing costs can be saved. The refrigerant displacement device herein can allow for the flexibility in any type of subcooler, e.g. discrete envelope designs and designs that use a portion of the condenser shell wall as the subcooler enclosure, by utilizing a refrigerant displacement device, such as baffle(s), to reduce refrigerant charge through displacement. The refrigerant displacement device can also enhance heat transfer performance within the subcooler by minimizing flow areas and focusing refrigerant flow within a flow annulus around the subcooler tubing.

[0020] The refrigerant displacement device can be utilized in a subcooler, for example in a condenser of a water cooled chiller or HVAC unitary product, where the refrigerant displacement device is a physical structure, such as one or more displacing baffles.

[0021] FIG. 1 is an end view one embodiment of a refrigerant displacement device, and also schematically showing a depth from end to end that can vary.

[0022] The refrigerant displacement device may be one or more baffles. An exemplary baffle “A” is shown in FIG. 1 that may be used in a refrigerant displacement device. The baffle A is shown for example from a side as if it were inserted into a chiller and if the view of the chiller was taken from an end. The baffle A has a structure 1 that physically prevents refrigerant from occupying certain spaces inside the subcooler when the baffle A is installed. As shown, the baffle A has a number of orifices 2 through which heat exchange tubes can be inserted. The orifices have protrusions or standoffs 4 that allow for space, such as an annulus or annular shape, to be present between an outer surface of a heat exchange tube that may be inserted through the orifices 2 and the inner diameter or circumferential-like wall of the orifices 2. The protrusions 4 define the amount of space between orifice and the heat exchange tubes and could be modified as appropriate to achieve certain flow velocities and amount of subcooling needed/desired. The shape, geometry, and actual dimensions of the baffle A, its orifices 2, its protrusions 4, or its overall structure 1 are not meant to be limiting. One or more of baffles A can be inserted within the subcooler as an array to provide displacement of refrigerant (to minimize dead space, decrease free flow area within the subcooler) and to focus refrigerant flow proximate and around the heat exchange tubes to help with heat exchange performance, e.g. by increasing flow velocities near and around the heat exchange tubes, which can increase the refrigerant side heat transfer coefficient and decrease the amount of subcooler heat transfer that may be required, which can reduce copper tube surface area.

[0023] The refrigerant displacement device can be a series or array of baffles, where each baffle has a depth from end to end, e.g. such as when viewing perpendicularly into the page of FIG. 1. In some embodiments, depth “D” (see also e.g. dashed lines and double arrows in FIG. 1) can be varied to achieve the desired, needed size of the baffle along the length of the heat exchange tubes. The depth “D” that is shown is

merely illustrative and not meant to be limiting. It will be appreciated that the depths can be varied. It will also be appreciated that the baffle could be a single extruded piece, rather than a series of baffles, that spans much of the tube length within the subcooler (see e.g. FIG. 4 further described below). It will also be appreciated that the baffle does not have to be a single extrusion, but could be a dual extrusion or just a few extruded pieces to account for other subcooler structures, e.g. the position of inlet/outlet structures into/out of the subcooler. It will further be appreciated that the baffles pieces that may be used could have common interlocking structures to allow baffles to be linked together and to create multiple subcooler cross sectional geometries, for example by having suitable press fit structures, or suitable fastening capability, or may be connected by epoxy or using interlocking modules similar to e.g. LEGO toys. And it will also be appreciated that not all of the tubes in the subcooler must be inserted through the baffle as it may be desired and/or necessary. One example of the baffle material could be a composite or plastic material, such as polypropylene. The material of the refrigerant displacement device is generally not meant to be limiting, although HVAC system friendly and refrigerant friendly, non-corrosive materials may be preferred. A screen may also be used to block debris from flowing through the subcooler, such as on an inlet and/or outlet of the subcooler.

[0024] FIG. 2 shows one type of condenser 10 with a subcooler “B” that has heat exchange tubes 6 where its enclosure 8 is formed by utilizing the wall(s) of the condenser shell and perhaps other pieces of the condenser, such as a drain pan and/or inlet/outlet structures. An outlet 5 from the subcooler B is also shown. It will be appreciated that a suitable inlet into the subcooler B would be employed to allow refrigerant to flow inside the subcooler B, for example from the bottom or on sides of the subcooler B.

[0025] FIG. 3 is an open end schematic view of another condenser of an HVAC system with a subcooler as a separate discreet enclosure. FIG. 3 shows condenser 20 with a subcooler “C” that has heat exchange tubes 16 where its enclosure 18 formed as a separate discreet enclosure that may be welded to the condenser shell. An outlet 15 from the subcooler C is also shown. It will be appreciated that a suitable inlet into the subcooler C would be employed to allow refrigerant to flow inside the subcooler C, for example from the bottom or on sides of the subcooler C.

[0026] It will be appreciated that the refrigerant displacement device may be incorporated into either of the subcooler designs B and/or C from FIGS. 2 and 3.

[0027] FIG. 4 shows a schematic side view of a condenser 30 that has a subcooler 34, with a refrigerant displacement device 32 installed in the subcooler 34. Heat exchange tubes or tube bundle 36 (see dashed line) can be inserted through the refrigerant displacement device 32, e.g. through orifices and protrusions similarly constructed as in FIG. 1. FIG. 4 is to schematically show an example of the relative area and coverage of the refrigerant displacement device 32 inside the subcooler 34. For example using one or more pieces, such as extrusion(s), the refrigerant displacement device 32 can extend the majority or almost the entire length of the subcooler 34 and have coverage on most of the tube bundle 36. It will be appreciated that the refrigerant displacement device A can be constructed and arranged as that in FIG. 4.

[0028] Although the refrigerant displacement device is discussed in the context of a condenser, it will be appreciated that

it may be useful for any shell and tube subcooler design, and any HVAC unit and/or system as appropriate, and which may not include a condenser.

[0029] With regard to the foregoing description, it is to be understood that changes may be made in detail, without departing from the scope of the present invention. It is intended that the specification and depicted embodiments are to be considered exemplary only, with a true scope and spirit of the invention being indicated by the broad meaning of the claims.

1. A refrigerant displacement device suitable for use in a subcooler of an HVAC unit, comprising one or more baffles, each baffle includes:

a main body suitable to be placed inside a subcooler, along a direction that heat exchange tubes would extend inside the subcooler, the main body is configured to physically prevent refrigerant from occupying volume or free flow areas within the subcooler that would otherwise be occupied by refrigerant;

a number of orifices extending through the main body, and through which heat exchange tubes may be suitably inserted; and

one or more standoffs to create space between an outer diameter of heat exchange tubes inserted through the orifices and surfaces on the baffle created by the orifices, wherein during unit, system, and/or component operation, refrigerant is allowed to flow through the orifices between the baffle and the heat exchange tubes, and refrigerant is directed to flow proximate the heat exchange tubes.

2. The device of claim 1, wherein the device is constructed and arranged as a series of baffles, each of the baffles had the same or different depth.

3. The device of claim 1, wherein the baffle is a single extrusion that extends along a majority of the length through subcooler.

4. An HVAC system comprising: a condenser; a subcooler as part of the condenser; and the refrigerant displacement device of claim 1 suitably incorporated inside the subcooler, wherein the subcooler is constructed as a discrete envelopment inside the condenser or is constructed by utilizing a portion of the condenser shell walls.

5. (canceled)

6. A method of operating a subcooler in an HVAC unit or system, comprising:

causing refrigerant to enter an inlet of a subcooler;

causing the refrigerant to flow through orifices of a refrigerant displacement device;

causing the refrigerant to be directed by the refrigerant displacement device to flow proximate the heat exchange tubes in areas between surfaces of the baffle created by the orifices and the outer surface of the heat exchange tubes;

causing refrigerant to not be physically present at areas in the subcooler that are away from the heat exchange tubes and toward the enclosure of the subcooler, and not proximate the heat exchange tubes; and

subcooling the refrigerant, while reducing refrigerant charge through the subcooler and increasing flow velocity proximate the heat exchange tubes.

7. The method of claim 6, further comprises causing the refrigerant to flow through annularly shaped spaces created by standoffs on the orifices of the baffle, so that refrigerant flows between the orifices of the baffle and heat exchange tubes inserted therein.

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