METHOD FOR MAKING A SHAPED MULTICHANNEL HEAT EXCHANGER

Inventors: Peter J. Breiding, Wichita, KS (US); Charles B. Obosu, Wichita, KS (US); Jeffrey N. Nichols, Wichita, KS (US); Dan R. Burdette, Wichita, KS (US)

Correspondence Address:
Johnson Controls, Inc.
c/o Fletcher Yoder PC
P.O. Box 692289
Houston, TX 77269

Assignee: Johnson Controls Technology Company, Holland, MI (US)

Appl. No.: 12/040,743
Filed: Feb. 29, 2008

Related U.S. Application Data

Continuation of application No. PCT/US07/85291, filed on Nov. 20, 2007.

Provisional application No. 60/909,598, filed on Apr. 2, 2007, provisional application No. 60/882,033, filed on Dec. 27, 2006, provisional application No. 60/867,043, filed on Nov. 22, 2006.

Publication Classification

Int. Cl.
B23P 15/26  (2006.01)
B21D 53/02  (2006.01)

U.S. Cl. 29/726.5; 29/890.03

ABSTRACT

A technique is provided for forming and coating heat exchangers. The heat exchanger may be of any suitable type, such as employing two or more manifolds, with tubes, such as multichannel tubes extending between the manifolds, with fins being provided around or between the tubes. The overall heat exchanger structure is made as a slab that is advanced through an oven, such as in a brazing zone. Heat applied in the brazing zone heats the entire slab to an elevated temperature, and immediately after the brazing zone the slab is hot formed to provide bends or other configurations or contours. A coating is then applied at the elevated temperature, and the heat exchanger may advance through a curing station at which cooling is controlled to promote curing of the coating. The overall process provides a streamlined integrated assembly and manufacturing procedure for formed and coated heat exchangers.
FIG. 10

FIG. 11

FIG. 12

FIG. 13

FIG. 14

1. BRAZE STRUCTURE
2. REMOVE FRAME
3. TRANSFER TO FORMING
4. HOT FORM
5. APPLY COATING
6. CONTROLLED COOLING / CURE
7. TRANSFER TO STOCK / ASSEMBLY
METHOD FOR MAKING A SHAPED MULTICHANNEL HEAT EXCHANGER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from and the benefit of U.S. Provisional Application Ser. No. 60/867,043, entitled MICROCHANNEL HEAT EXCHANGER APPLICATIONS, filed Nov. 22, 2006, U.S. Provisional Application Ser. No. 60/882,033, entitled MICROCHANNEL HEAT EXCHANGER APPLICATIONS, filed Dec. 27, 2006, and U.S. Provisional Application Ser. No. 60/909,598, entitled MICROCHANNEL COIL HEADER, filed Apr. 2, 2007, which are hereby incorporated by reference.

BACKGROUND

[0002] The present invention relates generally to methods for making a shaped multichannel heat exchanger.

[0003] Heat exchangers are used in a variety of settings and for many purposes. For example, liquid-to-air heat exchangers are used throughout industry, and in many heating, ventilating, air conditioning and refrigeration applications. The latter applications include residential, commercial, and industrial air conditioning systems in which heat exchangers serve as both condensers and evaporators in a thermal cycle. In general, when used in an evaporator, liquid or primarily liquid refrigerant enters a heat exchanger and is evaporated to draw thermal energy from an air flow stream that is drawn over the heat exchanger tubes and fins. When used as a condenser, the refrigerant enters in a vapor phase (or a mixed phase) and is de-superheated, condensed and sub-cooled in the condenser.

[0004] Recent developments in heat exchanger designs have included the use of multichannel or multiple channel tubes. These tubes are often generally flat in shape, and include a number of parallel fluid passageways along their width. Current designs include from 16 to 24 passages, although the number of passages may vary, as may their internal configuration. The tubes are generally aligned parallel with one another and in fluid communication with manifolds used to distribute and collect the refrigerant. Heat exchanging fins are disposed between the tubes and aid in transferring heat to or from the fluid flowing through the internal passage ways of the tubes.

[0005] Depending upon the application, heat exchangers may be provided in various forms and shapes. In the simplest applications, a generally planar slab configuration is provided, with all tubes being parallel with one another and in generally the same plane as the manifolds. However, in other applications it is particularly advantageous to bend or wrap the heat exchangers around other equipment to increase the density of the heat exchanger capabilities. For example, in many residential air conditioners, an outside heat exchanger is wrapped around two, three, or even four sides of other system components, and single or multiple fans draw air through the wrapped heat exchanger.

[0006] A difficulty in the manufacturing of such heat exchangers involves processes used to initially form the heat exchanger slabs, followed by processes for bending the slabs and painting or coating the slabs with a desired external coating. Where manufacturing operations occur at different locations, it is most beneficial to form flat slabs and transport these for storage and manufacturing to other locations in this flat configuration. In certain system designs, then, at a second manufacturing location the slabs are cold formed to provide their ultimate wrapped shape. Where paints or coatings are then applied that require curing at elevated temperatures, separate heating arrangements must be provided for the coatings. Current manufacturing techniques do not allow for enhanced integration of these processes.

SUMMARY

[0007] In accordance with aspects of the invention, a method for making a heat exchanger is presented. The method includes conveying through an oven, an assembled heat exchanger including a plurality of multichannel tubes extending between a pair of manifolds, to permanently join the multichannel tubes to the manifolds, and hot forming the multichannel tubes and/or manifolds in a forming station downstream of the oven at least partially utilizing heat energy transmitted to the heat exchanger in the oven.

[0008] In accordance with further aspects of the invention, a method for making a heat exchanger is presented. The method includes conveying through an oven, an assembled heat exchanger including a plurality of multichannel tubes extending between a pair of manifolds, to permanently join the multichannel tubes to the manifolds, and hot forming the multichannel tubes and/or manifolds in a forming station downstream of the oven at least partially utilizing heat energy transmitted to the heat exchanger in the oven, and controlling the temperature of the heat exchanger and the coating to cure the coating and to cool the heat exchanger.

[0009] In accordance with yet further aspects of the invention, a system for making a heat exchanger is provided. The system includes a heat exchanger assembling station at which a plurality of multichannel tubes are assembled between a pair of manifolds, an oven through which the assembled heat exchanger is conveyed to permanently join the multichannel tubes to the manifolds, and a hot forming station downstream of the oven at which the heat exchanger is formed at least partially utilizing heat energy transmitted to the heat exchanger in the oven.

DRAWINGS

[0010] FIG. 1 is a perspective view an exemplary residential air conditioning or heat pump system of the type that might employ a heat exchanger.

[0011] FIG. 2 is a partially exploded view of the outside unit of the system of FIG. 1, with an upper assembly lifted to expose certain of the system components, including a heat exchanger.

[0012] FIG. 3 is a perspective view an exemplary commercial or industrial heating, ventilation, air conditioning, and refrigeration (HVAC&R) system that employs a chiller and air handlers to cool a building and that may also employ heat exchangers.

[0013] FIG. 4 is a perspective view of an exemplary heat exchanger made by the present techniques, presenting two bends that are made during hot forming immediately after assembly.

[0014] FIG. 5 is an exemplary configuration of another heat exchanger made by the present techniques having a single bend.

[0015] FIG. 6 is a partially exploded view of a portion of the heat exchangers of FIGS. 4 and 5, showing the various components that are assembled during the manufacturing process.
FIG. 7 is a more detailed view of one of the heat exchanger tubes shown in the previous figures assembled with a manifold.

FIG. 8 is a diagrammatical representation of manufacturing stations or steps for making a formed, coated heat exchanger.

FIG. 9 is a perspective view of a portion of a manufacturing line in which slab heat exchangers are transferred from an oven in which the assembly is unified or joined, to a transfer conveyor for moving to a hot forming station.

FIGS. 10-13 are diagrammatical perspective views of a slab heat exchanger assembly being progressively formed at a hot forming station to provide heat exchanger structure similar to that illustrated in FIG. 4.

FIG. 14 is a diagrammatical flow chart illustrating key steps in making the formed, coated heat exchangers.

DETAILED DESCRIPTION

FIGS. 1-3 depict exemplary applications for heat exchangers. Such systems, in general, may be applied in a range of settings, both within the HVAC&R field and outside of that field. In presently contemplated applications, however, heat exchanges may be used in residential, commercial, light industrial, industrial and in any other application for heating or cooling a volume or enclosure, such as a residence, building structure, and so forth. Moreover, the heat exchanges may be used in industrial applications, where appropriate, for basic refrigeration and heating of various fluids. FIG. 1 illustrates a residential heating and cooling system. In general, a residence, designated by the letter R, will be equipped with an outdoor unit OU that is operatively coupled to an indoor unit IU. The outdoor unit is typically situated adjacent to a side of the residence and is covered by a shrub to protect the system components and to prevent leaves and other contaminants from entering the unit. The indoor unit may be positioned in a utility room, an attic, a basement, and so forth. The outdoor unit is coupled to the indoor unit by refrigerant conduits RC that transfer primarily liquid refrigerant in one direction and primarily vaporized refrigerant in an opposite direction.

When the system shown in FIG. 1 is operating as an air conditioner, a coil in the outdoor unit serves as a condenser for recondensing vaporized refrigerant flowing from indoor unit IU to outdoor unit OU via one of the refrigerant conduits. In these applications, a coil of the indoor unit, designated by the reference characters IC, serves as an evaporator coil. The evaporator coil receives liquid refrigerant (which may be expanded by an expansion device described below) and evaporates the refrigerant before returning it to the outdoor unit.

The outdoor unit draws in environmental air through sides as indicated by the arrows directed to the sides of unit OU, forces the air through the outer unit coil by a means of a fan (not shown) and expels the air as indicated by the arrows above the outdoor unit. When operating as an air conditioner, the air is heated by the condenser coil within the outdoor unit and exits the top of the unit at a temperature higher than it entered the sides. Air is blown over inner coil IC, and is then circulated through the residence by means of ductwork D, as indicated by the arrows in FIG. 1. The overall system operates to maintain a desired temperature as set by a thermostat T. When the temperature sensed inside the residence is higher than the set point on the thermostat (plus a small amount) the air conditioner will become operative to refrigerate additional air for circulation through the residence. When the temperature reaches the set point (minus a small amount) the unit will stop the refrigeration cycle temporarily.

When the unit in FIG. 1 operates as a heat pump, the roles of the coils are simply reversed. That is, the coil of the outdoor unit will serve as an evaporator to evaporate refrigerant and thereby cool air entering the outdoor unit as the air passes over the outdoor unit coil. Indoor coil IC will receive a stream of air blown over it and will heat the air by condensing a refrigerant.

FIG. 2 illustrates a partially exploded view of one of the units shown in FIG. 1, in this case outdoor unit OU. In general, the unit may be thought of as including an upper assembly UA made up of a shroud, a fan assembly, a fan drive motor, and so forth. In the illustration of FIG. 2, the fan and fan drive motor are not visible because they are hidden by the surrounding shroud. An outdoor coil OC is housed within this shroud and is generally disposed to surround or at least partially surround other system components, such as a compressor, an expansion device, a control circuit.

FIG. 3 illustrates another exemplary application, in this case an HVAC&R system for building environmental management. A building BL is cooled by a system that includes a chiller CH, which is typically disposed on or near the building, or in an equipment room or basement. Chiller CH is an air-cooled device that implements a refrigeration cycle to cool water. The water is circulated to a building through water conduits WC. The water conduits are routed to air handlers AH at individual floors or sections of the building. The air handlers are also coupled to ductwork DU that is adapted to blow air from an outside intake OL.

Chiller CH, which includes heat exchangers for both evaporating and condensing a refrigerant as described above, cools water that is circulated to the air handlers. Air blown over additional coils that receive the water in the air handlers causes the water to increase in temperature and the circulated air to decrease in temperature. The cooled air is then routed to various locations in the building via additional ductwork. Ultimately, distribution of the air is routed to diffusers that deliver the cooled air to offices, apartments, hallways, and any other interior spaces within the building. In many applications, thermostats or other command devices (not shown in FIG. 3) will serve to control the flow of air through and from the individual air handlers and ductwork to maintain desired temperatures at various locations in the structure.

Referring to FIG. 4, an exemplary heat exchanger 10 is illustrated which may be formed by the described method. The heat exchanger has a pair of manifolds 12 and 14 between which a plurality of horizontal tubes 16 extend. Heat exchanging fins 18 are provided between the tubes and are secured to the tubes during the manufacturing process described below. Similarly, as also described below, the tubes themselves are inserted into the manifolds during assembly and are sealed with respect to the manifolds such that sealed fluid passageways are established between the manifolds and interior passageways of the tubes. An inlet 20 is provided in manifold 12, along with an outlet 22. The heat exchanger of FIG. 4 is therefore a multi-pass heat exchanger, and a baffle (not shown) would be provided in manifold 12 to force fluid from the inlet, through manifold 12 and upper tubes, into manifold 14, and therefrom back to outlet 22 of manifold 12 through lower tubes. Circular (or more generally, arcuate) bends 24 and 26 are formed in heat exchanger 10 to increase the surface area of the overall heat exchanger for the space within which the heat exchanger will be disposed. These
bends are formed in accordance with the techniques described with respect to FIGS. 8-14, particularly by hot forming just after assembly of the heat exchanger.

[0029] It should be noted that, while heat exchanger 10 is illustrated as including multichannel tubes, other tubes could be used in the heat exchanger, and the techniques described below could also be adapted to forming such heat exchangers. The orientation of the tubes and of the manifolds should not be considered as limiting in any way. That is, the manifolds themselves could be bent, with bends in the heat exchanger being made along the direction of the tubes, and the manifolds positioned in upper and lower locations, generally opposite or at right angles to the orientation illustrated in FIG. 4. Other forming configurations could also be used.

[0030] For example, FIG. 5 illustrates an alternative configuration for a heat exchanger, designated generally by reference numeral 28. In this arrangement, manifolds 12 and 14 are provided with tubes 16 and fins 18 extending therebetween, with tubes 16 being in fluid communication with manifolds 12 and 14 as described with reference to FIG. 4. Similar inlet and outlet tubes are provided as indicated by reference numerals 20 and 22, respectively. However, in this design, a single bend 30 is executed that is greater than 90°, to form a generally v-shaped overall heat exchanger design. Multiple bends, including bends greater than or less than 90°, and bends that form serpentine structures may be implemented by the present techniques.

[0031] FIG. 6 is a partial exploded view of one of the manifolds of the heat exchangers of FIGS. 4 and 5, along with tubes and fins that are installed during the assembly process. A cap 32 is designed to be received on an open end of the manifolds 12 which is generally a tubular structure formed of an aluminum alloy. A baffle (not shown) similar to cap 32 may be installed within the manifold, such as by pressing it into the appropriate location during the assembly process. Openings or apertures 34 are formed in the manifold prior to assembly. These may be formed by conventional piercing operations. Tubes 16 are preformed, such as by extrusion. These tubes are then cut to the appropriate length and stacked so that they can be assembled with the manifolds prior to sealing and joining these members together. During the assembly process, ends 36 of the tubes are positioned within respective apertures 34 of the manifolds, such that the tubes extend completely through the apertures and can be sealed at the location where each tube passes through the respective aperture. Thus, following assembly, sealed fluid passage ways are established between the interior volume of the manifolds and the individual fluid passage ways of the tubes. Similarly, during manufacturing, a ribbon or tape is deformed to create fins 18 that are disposed between the tubes. In presently contemplated manufacturing processes, crimps are formed in a thin aluminum alloy tape, and this is disposed between individual tubes 16 along the full length of the heat exchanger between the manifolds.

[0032] FIG. 7 illustrates a somewhat more detailed perspective view of one of tubes 16 sealed to one of the manifolds 12. Tube 16 enters through aperture 34, with end 36 extending into the manifold. Individual fluid pathways 40 in each tube are then in fluid communication with the internal volume of the manifold. The interior portion 42 of each tube may be of various lengths, or may be contoured for particular purposes, depending upon the heat exchanger design and its mode of operation. In general, however, all such tubes will be sealed at an interface 38 by an appropriate sealing agent, such as a brazing compound applied as described below.

[0033] FIG. 8 represents an exemplary manufacturing installation diagrammatically in accordance with aspects of the present technique. It should be noted that the overall integrated manufacturing process may be adapted to include various sub-processes that are generally conventional in nature. The manufacturing installation 44 begins with an assembly station 46 which itself may be generally similar to those used in conventional manufacturing processes, for example. In particular, at assembly station 46, the manifolds, any baffles required in the manifolds, and tubes and fins are fitted to one another. These components are somewhat loosely fitted to one another, and then are held in an assembly by a framework, sometimes referred to as a braze frame. At station 48, then, this braze frame is installed. This installation, also, may be generally similar to that performed in existing heat exchanger manufacturing operations. Typically, the braze frame will mechanically hold the various components of the heat exchanger together in a flat slab configuration. The braze frame itself will be processed along with the heat exchanger, and will ultimately be removed after sealing and joining of the components to one another as described below. Such braze frames are typically made of metals that can undergo many cycles of heating and cooling during manufacturing, such as stainless steel. Moreover, the braze frames may be cleaned from time to time to remove flux and brazing materials, although such operations are beyond the scope of the present discussion.

[0034] At a flux station 50, material is sprayed or otherwise applied to the assembled heat exchanger that will serve to join the components together and to seal locations at which the tubes and manifolds are joined. While these materials may be generally described as a “flux”, those skilled in the art will appreciate that the particular compositions of the materials may vary widely, depending upon the materials used for the heat exchanger itself and the conditions under which the heat exchanger is to operate, as well as those conditions under which the heat exchanger is manufactured. In general, the flux will completely coat the components described above, and will remain on the heat exchanger following manufacturing. A drying or degassing station 52 may then be provided at which the flux is dried and any gasses contained within the heat exchanger, tubes, and any other internal interstices are allowed to or encouraged to escape. In certain applications, this drying may occur at atmospheric pressures and temperatures.

[0035] Once the heat exchanger is assembled, held in the braze frame, and coated with a joining and sealing material (referred to generally herein as a flux), the entire assembly may enter a brazing zone, as indicated by reference numeral 54 in FIG. 8. This brazing zone will generally include an oven maintained at an elevated temperature, through which the assembled heat exchanger will be passed at a controlled speed. The temperature reigning in the oven and the speed at which the assembled heat exchanger is conveyed through the brazing zone will vary, depending upon the heat exchanger design and size, the materials used to fabricate the heat exchanger, and the flux used to join the components to one another. In general, however, for heat exchangers made of aluminum alloys, the temperature of the brazing zone may be on the order of 1,000°F, below the melting point of the heat exchanger materials, but above the temperature at which the brazing materials are re-flow to join and seal the components.
to one another. Immediately upon exiting the brazing zone 54, then, the heat exchanger slab enters a forming station 56. As described more fully below, the heat exchanger may transit through the brazing zone in any desired position, although in a presently contemplated embodiment, the slab is positioned generally horizontally. Prior to exiting the brazing zone 54, the braze frame is removed or falls away from the assembled heat exchanger, and the heat exchanger may exit the zone on a slowly moving conveyor as described more fully below.

[0036] The forming station 56 performs hot forming of the heat exchanger slab to arrive at a desired formed shape, typically the final shape of the heat exchanger itself. Progressive forming may be performed at this forming station, and the temperature to which the heat exchanger is raised in the brazing zone serves to facilitate hot forming of the structure. While additional heat may be added in the forming station 56, in a presently contemplated embodiment, the temperature at which the heat exchanger exits the brazing zone is sufficient to facilitate this hot forming.

[0037] Following forming of the heat exchanger, a coating or paint is applied at a coating station as indicated by reference numeral 58 in FIG. 8. Various materials may be used to paint or coat the heat exchanger, depending upon the environmental conditions in which it will be used and the particular esthetic appearance desired. For example, cured coatings such as acrylics or epoxies may be employed. The coatings may be corrosion inhibitors. Such coatings may be applied by various processes, such as spraying, dipping, and so forth, generally dictated by the type of coating used and the procedures recommended by the coating supplier. It should be noted that coating station 58 also benefits from the elevated temperature of the heat exchanger as it exits the brazing zone and forming station. Additional heat may be input into the system to maintain the heat exchanger at the desired temperature for coating, depending upon such factors as the throughput of the system, the time that it is required for the coating operation, and the nature of the coating provided (e.g., the temperature at which the coating is intended to be applied).

[0038] Following coating station 58, the formed and coated heat exchanger then passes through a controlled cool-down zone as indicated at reference numeral 60 in FIG. 8. This cool-down zone will advance the heat exchanger, such as on a conveyor, and will typically include closed-loop control of the temperature as the heat exchanger advances through the zone. In presently contemplated embodiments, for example, the coating cures at approximately 475°F, with the curing process generally being a “time at temperature” process such that the controlled cool-down zone 60 is sufficiently long and the speed at which the heat exchangers are advanced in their zone is calculated to provide the desired cure of the paint or coating. Ultimately, the cool-down zone will allow heat exchangers to exit at a reduced temperature, with the paint or coating sufficiently cured for subsequent handling, storage, or assembly of a system in which the heat exchanger is to be installed. Generally, however, the heat exchangers will then be capable of being handled and stored at ambient temperature.

[0039] FIG. 9 illustrates an exemplary arrangement for conveying an assembled slab heat exchanger from the brazing zone 54 described above to a hot forming station 56. As illustrated in FIG. 9, and a presently contemplated embodiment, the heat exchanger slab 62, including manifolds, tubes, fins, and so forth, advances on a conveyor 64 designed to carry the heat exchanger slab through and from the brazing zone 54. The slab is positioned lengthwise on the conveyor, and proceeds through the oven 66 of the brazing zone in this orientation. However, other orientations may, of course, be used for processing the heat exchanger through the brazing zone.

[0040] The slab 62, exits at an elevated temperature and is then transferred to a transfer conveyor 68 to the hot forming station 56. At the hot forming station 56, and with the heat exchanger slab still hot from the oven 66, the slab is formed by mechanical means as generally illustrated in FIGS. 10-13.

[0041] The arrangement of FIGS. 10-13 is diagrammatical in nature. However, it is believed that, given the present discussion, those skilled in the art can adapt and implement the forming operation without undue experimentation. Beginning with FIG. 10, slab 62 carried by conveyor 68, approaches locations at which forming tools 70 and 72 are located. These forming tools, which may be varied in design, particularly based upon the type of materials used for the heat exchanger, the radius of bends to be executed in the forming process, and so forth, may be manually, automatically, or semi-automatically actuated. In general, conveyor 68 may stop in the location desired within the forming station, such as by means of feedback from position indicators (not shown). At the appropriate location in the forming station, then, lower forming tools 70 rise on either side of the conveyor 68 as indicated by arrows 74 in FIG. 10. At the same time, forming tools 72 may begin descending toward the heat exchanger as indicated by arrows 76. Presently contemplated embodiments for implementing the forming station would call for forming tools made of durable metals, such as stainless steel, that can be displaced by activation of a hydraulic power system (not represented). Support structures, hydraulic cylinders, hydraulic pressure units, and appropriate valving may be implemented to displace forming tools 70 and 72. Other mechanical support and actuation arrangements may, of course, be envisaged. Moreover, the entire structure may be oriented vertically or at any other suitable angle for entering the forming station and for being bent or formed in the forming station. The arrangements illustrated in FIGS. 10-13 should be understood as exemplary only.

[0042] Continuing with the illustrated example, FIG. 11 illustrates a stage in forming at which the lower forming tools 70 have moved the heat exchanger slab upwards slightly from the conveyor 68. At this point, the slab is supported on the forming tools 70. Stops, positioning dogs, positioning clamps, or any other suitable structures may be included for appropriately positioning the heat exchanger slab on these forming tools, either automatically or in a manually-assisted manner. With lower forming tools 70 spacing the slab from the conveyor by a slight distance as indicated by reference numeral 78, then, upper forming tools 72 may continue to descend as indicated by arrows 80.

[0043] As illustrated in FIG. 12, by progressively moving forming tools 72 in a downwardly, and where desired an arcuate or diagonal movement, as indicated by arrows 82, the final shape of the heat exchanger is provided, by bending the heat exchanger assembly around forming tools 70. The interior shape of the bends formed in the heat exchanger will generally conform to the outer profile of forming tools 70. Any desired radius can be provided by altering the design of the forming tools. It is believed that the present technique, however, will enable even tighter (i.e., smaller radius) bends than are currently available for heat exchanger designs that are cold form tubes and/or manifolds. It should also be noted that in presently contemplated configurations, separate tool-
ing may be provided for different manifold designs (e.g., radius of bends), or the tooling may be designed to allow distances between the forming tools to be adjusted. Such adjustability may allow for different sizes and configurations of heat exchangers to be made using the same tooling and assembly line, adding even further to the flexibility of the integrated manufacturing system. As illustrated in FIG. 13, then, the formed heat exchanger may be lowered back to conveyor 68 by withdrawing forming tools 70 in a linear, arcuate or diagonal motion as indicated by arrows 84. Tools 72 are withdrawn upwardly as indicated by arrows 86. With the tools appropriately repositioned, the heat exchanger may be advanced on conveyor 68 to the coating station as described above. The tools are repositioned to receive and form the next heat exchanger.

[0044] FIG. 14 represents the process described above in the form of steps or phases. The process, designated generally by reference numeral 88, begins with brazing the structures indicated at step 90. Although the term “brazing” is used throughout the present description, it is intended that this term be interpreted to generally mean joining and sealing the assembly by use of an agent or composition that refloows, fuses, or otherwise suitably joins the components to one another. At step 92, the frame member is formed and transferred to the forming station. In particular, the forming is performed hot, preferably using heat still contained by the heat exchanger slab as it exits the brazing zone. However, as also noted above, additional heat may be applied at this step, such as by direct or indirect means, radiation, convection, or any other heating technique. The forming culminates at step 96 where one or more bends are formed in the assembly heat exchanger, such as by mechanical force using hydraulics, mechanical, or other means that may be devised by those skilled in the art without undue experimentation.

[0045] Following forming the heat exchanger at step 96, then, a paint or coating is applied at step 98. This coating may be applied by any suitable mechanism, and will typically be applied in conformance with specifications for the coating provided by the coating supplier. At step 100, then, the formed and coated heat exchanger is cooled at a controlled rate to allow for curing of the coating. Following such curing, the formed and coated heat exchanger may be cooled to any temperatures and transferred to stock or directly to downstream assembly processes, as indicated generally by reference numeral 102. Such processes will typically include mounting the heat exchanger in an air conditioning system, a heat pump system, a chiller, or any other application. The ultimate application in which the heat exchanger is used is not limited to air conditioners, heat pumps, chillers or even to the heating, ventilating, air conditioning and refrigeration context.

[0046] The methods described herein may find application in making any type of heat exchanger. However, the methods are particularly well-suited for making multichannel designs. The methods may be used with any form of heat exchanger, including those in which manifolds or headers are unibent, or designs in which these components are bent. Furthermore, the methods may be adapted for single, or multiple bends in a heat exchanger depending upon the physical configuration of the system. The methods are intended to streamline manufacturing and provide much greater efficiency in the use of thermal energy for the assembly process, hot forming, coating, and curing of coatings.

[0047] It should be noted that the present discussion makes use of the term “multichannel” tubes or “multichannel heat exchanger” to refer to arrangements in which heat transfer tubes include a plurality of flow paths between manifolds that distribute flow to and collect flow from the tubes. A number of other terms may be used in the art for similar arrangements. Such alternative terms might include “microchannel” and “micropart.” The term “microchannel” sometimes carries the connotation of tubes having fluid passages on the order of a micrometer and less. However, in the present context such terms are not intended to have any particular higher or lower dimensional threshold. Rather, the term “multichannel” used to describe and claim embodiments herein is intended to cover all such sizes. Other terms sometimes used in the art include “parallel flow” and “braided aluminum.” However, all such arrangements and structures are intended to be included within the scope of the term “multichannel.” In general, such “multichannel” tubes will include flow paths disposed along the width or in a plane of a generally flat, planar tube, although, again, the invention is not intended to be limited to any particular geometry unless otherwise specified in the appended claims.

[0048] While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention. Furthermore, in an effort to provide a concise description of the exemplary embodiments, all features of an actual implementation may not have been described. It should be appreciated that in the development of any such actual implementation, as in any engineering design project, numerous implementation specific decisions must be made. Such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

1. A method for making a heat exchanger comprising: conveying through an oven, an assembled heat exchanger including a plurality of multichannel tubes extending between a pair of manifolds, to permanently join the multichannel tubes to the manifolds; and hot forming the multichannel tubes and/or the manifolds in a forming station downstream of the oven at least partially utilizing heat energy transmitted to the heat exchanger in the oven.

2. The method of claim 1, comprising applying a brazing material to the assembled heat exchanger prior to entry into the oven, the brazing material at least partially melting in the oven to join the multichannel tubes to the manifolds.

3. The method of claim 1, comprising applying a coating to the heat exchanger after hot forming.

4. The method of claim 3, comprising controlling the temperature of the heat exchanger and the coating to cure the coating and to cool the heat exchanger.

5. The method of claim 1, comprising transferring the heat exchanger from an oven conveyor to a forming station via a forming station conveyor.
6. The method of claim 1, wherein the heat exchanger is hot formed by a mechanical forming tool that bends the multi-channel tubes and/or the manifolds around one or more forms.

7. The method of claim 1, wherein the assembled heat exchanger is generally planar and is conveyed in a generally horizontal position through the oven.

8. The method of claim 7, wherein the heat exchanger is hot formed from the generally horizontal position in which it is conveyed through the oven.

9. The method of claim 1, wherein hot forming includes forming at least one bend in the multi-channel tubes and/or the manifolds.

10. The method of claim 9, wherein hot forming includes forming two bends in the multi-channel tubes and/or the manifolds.

11. A method for making a heat exchanger comprising: conveying through an oven, an assembled heat exchanger including a plurality of multi-channel tubes extending between a pair of manifolds, to permanently join the multi-channel tubes to the manifolds; hot forming the multi-channel tubes and/or the manifolds in a forming station downstream of the oven at least partially utilizing heat energy transmitted to the heat exchanger in the oven; applying a coating to the heat exchanger after hot forming; and controlling the temperature of the heat exchanger and the coating to cure the coating and to cool the heat exchanger.

12. The method of claim 11, comprising applying a brazing material to the assembled heat exchanger prior to entry into the oven, the brazing material at least partially melting in the oven to join the multi-channel tubes to the manifolds.

13. The method of claim 11, comprising transferring the heat exchanger from an oven conveyor to a forming station via a forming station conveyor.

14. The method of claim 11, wherein the heat exchanger is hot formed by a mechanical forming tool that bends the multi-channel tubes and/or the manifolds around one or more forms.

15. The method of claim 11, wherein the assembled heat exchanger is generally planar and is conveyed in a generally horizontal position through the oven.

16. The method of claim 15, wherein the heat exchanger is hot formed from the generally horizontal position in which it is conveyed through the oven.

17. The method of claim 11, wherein hot forming includes forming at least one bend in the multi-channel tubes and/or the manifolds.

18. A method for making a heat exchanger comprising: conveying through an oven, an assembled heat exchanger including a plurality of multi-channel tubes extending between a pair of manifolds, to permanently join the multi-channel tubes to the manifolds; applying a coating to the heat exchanger utilizing heat energy transmitted to the heat exchanger in the oven; and controlling the temperature of the heat exchanger and the coating to cure the coating and to cool the heat exchanger.

19. The method of claim 18, wherein the heat exchanger is hot formed following exit from the oven and prior to applying the coating.

20. A system for making a heat exchanger comprising: a heat exchanger assembling station at which a plurality of multi-channel tubes are assembled between a pair of manifolds; an oven through which the assembled heat exchanger is conveyed to permanently join the multi-channel tubes to the manifolds; and a hot forming station downstream of the oven at which the heat exchanger is formed at least partially utilizing heat energy transmitted to the heat exchanger in the oven.

21. The system of claim 20, comprising a coating station downstream of the hot forming station, the coating station applying a coating to the formed heat exchanger while the heat exchanger is hot.

22. The system of claim 21, comprising a controlled cool down zone downstream of the coating station for controlling cool down of the heat exchanger and curing of the coating.

* * * * *