The present invention relates to coplanar multi fluid heat exchanger assemblies comprising a heat exchange core, end tanks and in-tank oil coolers. Oil is preheated by coolant by in-tank oil coolers leading to advantages in overall thermal performance.
FIG. 1

PRIOR ART
MULTI FLUID HEAT EXCHANGER ASSEMBLY

FIELD OF THE INVENTION

[0001] This invention relates to heat exchanger assemblies, and methods for forming heat exchanger assemblies, and, particularly, heat exchanger assemblies employing multi-fluid heat exchangers.

BACKGROUND OF THE INVENTION

[0002] It has become increasingly desirable for heat exchangers to exhibit efficient transfer of heat, while remaining relatively easy to make. In the automotive industry, in particular, it has become increasingly necessary to combine multiple functions in a single heat exchanger assembly. In particular, the need to reduce the number of overall components, and to optimize assembly efficiency has driven the need for improved heat exchanger assembly devices that combine increasingly efficient designs and multiple functions in packaging heretofore attainable using plural separate components or devices having inefficient designs. More specifically, there has been a growing need for an improved heat exchanger assembly device, particularly for under the hood automotive vehicle applications, which combines multiple functions, that is efficient to make and operate and that occupies substantially the same or less space than existing heat exchanger assembly devices.

[0003] In prior art heat exchangers, fluid warm up is often needed for specific length of time, and bulky arrangements to provide for in tank oil coolers and separate heat exchangers allowing warm fluid to exchange heat with fluid to be warmed have been used. In all of the cases the arrangement is not compact and heat exchange capacity is limited. For example, traditional systems require additional heat exchanger assembly to cool oil for high performance conditions (trailer tow or high performance engines). The typical solution has been to provide for additional separate heat exchanger assemblies, usually air to oil heat exchanger assemblies, with resultant cost and packaging issues.

[0004] In the automotive industry, there has existed for some time, the need to provide these multiple advantages at reduced service and other operating costs. Prior art multi-fluid heat exchangers, for example, include heat exchangers with in-tank oil coolers, but with a main core area that only handles one fluid, for example, in a radiator, a radiator coolant. There has also been a need for heater exchange assemblies and systems with configurations whereby not only cross-flow but also down flow configurations are both possible and feasible. Additionally, although combo coolers present advantages such as condenser to oil combinations to handle individual heat exchanges in a combined form, it may not meet certain vehicle needs. In automotive applications, fluids such as automotive fluids (oils, coolants, refrigerants, fuels, windshield wiper fluids, brake fluids, air, CO2, exhaust gases and the like) are often used, and have different chemical and thermodynamic characteristics making them useful as heat exchange fluids. Particularly in extreme operating conditions and where a multi-fluid heat exchanger or 'combo cooler' assembly presents advantages, it is seen as particularly attractive to be able to selectively manage heat exchange between the different fluids, especially when the different fluids passed through the heat exchanger assembly have substantially different flow characteristics. The present invention provides solutions for a number of the limitations found in traditional heat exchanger assemblies.

SUMMARY OF THE INVENTION

[0005] The present invention allows coplanar multi fluid heat exchanger assembly and systems to offer higher capacity automotive fluid, including oil cooling option. The present invention solves the problem of the prior art by allowing, for example, for both reduction of cost and simplifying packaging difficulties by providing additional capacity by linking in tank cooler to air to oil cooler as part of a coplanar arrangement.

[0006] The present invention allows one to use a separate radiator with different temperature zones while allowing other fluid to be heated or cooled by a separate in tank or partially integrated heat exchange element. FIGS. 2 and 3 shows the example where first fluid is radiator coolant and second fluid and third fluid, if selected also to be radiator coolant, then the heat exchanger assembly will be a multi zone radiator. This link of both heat exchange functions is often described as a method to provide optimal cooling.

[0007] In preferred embodiments, the present invention allows for the use of a combination cooler (combo cooler) for non-air conditioned cars, as well as air conditioned equipped cars depending on choice and configuration of components and its zones. The present invention also provides for down flow configuration where packaging and layout makes the fluid flow almost in vertical direction.

[0008] The present invention allows in-tank heat exchanger assembly to warm the fluid inside them with radiator coolant. Allows higher capacity to transfer heat for second fluid if needed in a compact coplanar heat exchanger assembly arrangement is provided.

[0009] The present invention allows for the use of a wide variety of fluids and types of fluid for heat exchange in one assembly. By placing a number of fluids or types of fluid in various zones or areas of a heat exchanger assembly, preferably in a coplanar arrangement, fluids in such heat exchanger assemblies such as radiator coolant, transmission oil and power steering oil, and the like, surprisingly provide efficiencies and packaging advantages, as well as yielding combination cooler plus additional heat exchanger assembly (‘tri-cooler’)(three fluid) or dual or multiple combination cooler (combo cooler plus additional heat exchange) features, which were unavailable even with traditional combo cooler technologies.

[0010] The present invention meets the above needs by providing an improved heat exchanger assembly without the same packaging limitations as the condenser and oil cooler combinations of traditional combo cooler by: providing radiator packaging advantages; by having fewer oil cooler line routing limitations; by providing reduced service costs for condenser-oil coolers; by allowing use of combination cooler type technology for non-air conditioned cars; and, by functioning where down-flow configuration needs to be used.

[0011] More specifically the present invention allows for a heat exchanger assembly having more than one ‘zone’ in its various heat exchange areas in order to conduct heat exchange for multiple fluid at different rates. The main ‘core’
area is comprised of a heat exchanger core comprising a plurality of tubes and a plurality of fins disposed between the tubes, wherein at least one fluid, and, in particular, an automotive fluid, flows. The core area conducts heat exchange for one or more fluids at different rates. More preferably, the present invention allows for two or more zones in the main core area of the heat exchanger assembly wherein one or more fluids exchange heat at same or different rates in each zone.

[0012] The heat exchanger assembly of the present invention, outside of the core area, also provides for at least one zone of where heat exchange utilizing fluids, and, preferably, automotive fluids, occurs. Most preferably the heat exchanger assembly has at least one, and, preferably, at least two almost parallel end tanks having a heat exchange element in at least one of the end tanks. This in-tank heat exchange element, (e.g. a cooler in the end tank or manifold area of the heat exchanger assembly) provides for at least one heat exchange zone outside of the core area zones, the heat exchange element utilizing a fluid, and, preferably, an automotive fluid, to provide for an exchanging leading to the heat exchange zone.

[0013] The present invention provides for multiple fluids to flow in coplanar arrangement, without the disadvantages of the prior art and with increased efficiency due to the exchange of certain fluids in certain zones of the heat exchanger assembly, and between zones of the heat exchanger assembly, while also reducing packaging volumes, thereby reducing packaging restraints. In preferred embodiments of the present invention, a heat exchanger assembly is provided that comprises at least two zones in the main core area and at least one or more separate exchange elements in at least one end tank (or, likewise known as a manifold) of the heat exchanger assembly. The heat exchanger assembly more preferably has at least two in tank heat exchange elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 shows a schematic view of a multiple fluid heat exchange of the prior art.

[0015] FIG. 2 is a schematic face on view of a heat exchange assembly with in tank heat exchange element in accordance with an aspect of the present invention.

[0016] FIG. 3 is a schematic face on view of a heat exchange assembly with with three core zones and in tank heat exchange element in accordance with an aspect of the present invention.

[0017] FIG. 4 is a schematic face on view of a heat exchange assembly with in tank heat exchange element in one compartment in accordance with an aspect of the present invention.

[0018] FIG. 5 is a schematic face on view of a heat exchange assembly with in tank heat exchange element partially within or integrated into at least one or two compartments in accordance with an aspect of the present invention.

[0019] FIG. 6a is a schematic view of a heat exchange assembly system with heat exchanger assembly and other heat exchanger in accordance with an aspect of the present invention, with heat exchange zones in parallel.

[0020] FIG. 6b is a schematic view of a heat exchange assembly system with heat exchanger assembly and other heat exchanger in accordance with an aspect of the present invention, with heat exchanger assembly and other heat exchanger side by side.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The present invention, therefore, in its preferred embodiments, by providing for at least two or more zones in the main core area and at least one or two more other zones outside of the core area and, in particular, in at least one end tank, and, preferably, in at least one compartment of at least one end tank, provides for a wider application range of for heat exchanger assemblies by providing hereinafter untapped capabilities for heat exchange (and, in particular, ‘cooling’) using three or more different types of fluid, preferentially four or more different types of fluids. In preferred embodiments of the present invention, a zone or zones may be achieved by providing a heat exchanger assembly with at least one heat exchange element in one of or each of the two collecting or ‘end tanks’ of heat exchanger assembly with a core comprising a radiator. In such preferred embodiments by providing a heat exchanger assembly having a heat exchange element in the collecting or end-tank of the heat exchanger, pre heating of the heat exchange fluid, and, particularly automotive fluid, can be achieved through the heating of radiator fluid. Also preferred embodiments of the present invention can provide even more efficiencies by providing for a coplanar heat exchanger assembly in combination with or ‘on top of’ heat exchanger assembly with two collecting tank, whereby additional exchange or ‘cooling’ with one more different fluid occurs. The present invention, therefore, allows for the incorporation of smaller heat transfer capacity heat exchangers in the collector tanks and better (more efficient) (smaller volume) packaging is achieved for an equivalent amount of heat exchanger capacity for the assembly as a whole.

[0022] The zones for heat exchange are generally located in both the core of the heat exchange assembly and in at least one of the end tanks of the assembly. In preferred embodiments of the present invention wherein the heat exchanger assembly is particularly suited for an automotive vehicle, the assembly comprises a first end tank; at second end tank; a core including fins, a least two compartments in the at least one of the end tanks; at least two heat exchange zones the core each including a plurality of spaced apart tubes with fins between the spaced tubes; and at least one heat exchange element in at least one of the end tanks. The heat exchange zones are disposed so that their respective tubes and fins are generally co-planar with each other and are connected to the end tank.

[0023] The present invention, therefore, relates to a heat exchanger assembly and a heat exchanger assembly system employing more than one heat exchange element in the end tank of the heat exchanger assembly. The heat exchanger assembly is a multi-fluid (e.g., 3 or 4 fluid) heat exchanger. More preferably the heat exchanger assembly of the present invention utilizes two or more different types of fluids, more preferably three or more different types of fluids. By different type of fluids, it means fluids with different thermodynamic characteristics of heat transfer useful for different heat applications in an automotive vehicle. The heat
exchanger assembly may also be a one pass per zone or multi-pass heat exchanger. Although the heat exchanger assembly according to the present invention may be used for a variety of articles of manufacture (e.g., air conditioners, refrigerators or the like), the heat exchanger assembly has been found particularly advantageous for use in automotive vehicles. In preferred embodiments of the present invention, the heat exchanger assembly may be used for heat transfer of one or more automotive fluids. More preferably, the heat exchanger assembly may be preferentially used for heat transfer of one or more different types of fluids, and include restriction fluids such outside of the end-tank such as air, oil, transmission oil, power steering oil, radiator fluid, refrigerant, combinations thereof or the like. For example, in a highly preferred embodiment of the present invention there is contemplated a multi-fluid heat exchanger assembly with a heat exchanger core area that includes zones, that due to their heat exchanger characteristics that can be seen as: a radiator in combination with a condenser; a radiator in combination with an oil cooler selected from the group consisting of a power steering oil cooler, a transmission oil cooler and a combination thereof; or a radiator in combination with a condenser and an oil cooler selected from the group consisting of a power steering oil cooler, a transmission oil cooler and a combination thereof.

According to one preferred aspect of the invention, the heat exchanger assembly with a heat exchanger core area provides an improved multi-fluid heat exchanger assembly having features permitting for ease of assembly of the heat exchanger. According to another preferred aspect, the heat exchanger assembly heat exchanger core area is optimized for performance by careful selection of such design criteria as hydraulic diameter, tube configuration or a combination thereof.

The heat exchanger assembly may be installed in a variety of locations relative to the article of manufacture to which the heat exchanger assembly is applied. For an automotive vehicle, the heat exchanger assembly is preferably located under a hood of the vehicle, especially in areas where maximum air flow can be experienced in the vehicle (which is usually in the front of the vehicle), but may, in some cases be at the bottom or in the rear, or in electric vehicles in the side of the vehicle. According to one highly preferred embodiment, the heat exchanger assembly may be attached to a radiator of the vehicle. Exemplary methods and assemblies for attaching a heat exchanger assembly to a radiator are disclosed in U.S. Pat. No. 6,158,500 and U.S. Patent Publication WO03/069251 titled “A Method and Assembly for Attaching Heat Exchangers”, filed Feb. 10, 2003, both of which are fully incorporated herein by reference for all purposes.

According to one aspect of the invention, the heat exchanger assembly will comprise a plurality of components that are assembled together by suitable joining techniques. Many techniques may be utilized, including mechanical assemblies and the like. In one preferred embodiment, one or more of the components of the heat exchanger assembly such as the baffles, the end tanks, the tubes, fins, the inlets, the outlets, a bypass or combinations thereof may be attached to each other using brazing. Although various brazing techniques may be used, one preferred technique is referred to as controlled atmosphere brazing. According to one highly preferred embodiment, a brazing alloy may be provided as a cladding on one of the components of the heat exchanger. In such a situation, it is contemplated that the components may be formed of a material such as a higher melting point aluminum alloy while the cladding may be formed of a lower melting point aluminum alloy.

The heat exchanger assemblies of the present invention are useful in automotive or motor vehicle applications. Heat exchangers assemblies of the present invention will typically include core components such as one or more tubes, one or more end tanks, one or more inlets and outlets, one or more baffles and other core components such as one or more fins or a combination thereof. In the present invention, the at least one or more end tanks, have at least one or more heat exchange elements in at least one or more of the end tanks, and, preferably, in at least one or more compartments of at least one or more end tanks. Depending upon the embodiement of the heat exchanger assembly, various different shapes and configurations are contemplated for the components of the assembly. For example, and without limitation, the components may be integral with each other or they may be separate. The shapes and sizes of the components may be varied as needed or desired for various embodiments of the heat exchanger. Additional variations will become apparent upon reading of the following description.

In general, a preferred heat exchanger assembly contemplates at least two spaced apart end tanks bridged together by a core with at least two zones, in at least partial fluid communication by a plurality of generally parallel tubes, with fins disposed between the tubes. Optional end plates, or more preferably, end tubes, enclose the core assembly in a generally co-planar configuration. At least one of the end tanks, and, preferably, both of the end tanks, have at least one heat exchange element wherein heat exchange takes place between two fluids.

The multiple-fluid heat exchanger assembly, due to the inclusion of at least one heat exchange element, and, preferably, more than one heat exchange element within at least one of the end tanks, handles more than one fluid in co-planar arrangement with smaller packaging size than traditional combo coolers and with larger heat exchange capacity.

In preferred embodiments of the present invention, a heat exchanger assembly comprises: a first end tank; a second end tank opposite the first end tank; a plurality of first tubes in fluid communication with the first and second end tanks, the plurality of first tubes adapted to have a first fluid flow therethrough; a plurality of second tubes in fluid communication with the first and second end tanks, the plurality of second tubes adapted to have a second fluid, flow therethrough; a plurality of fins disposed between the first and second tubes, with the first and second tubes and the fins being generally co-planar relative to each other; a heat exchange element adapted to have a third fluid, different from the first or the second fluid, flow therethrough; wherein at least one of the first fluid or second fluid is a radiator fluid, and wherein the third fluid is an automotive fluid. More preferred is when the heat exchange element is located in the first or second end tank and the first end tank and the second end tank each include at least one baffle.

Also preferred are heat exchanger assemblies having at least two separate heat exchange elements in either
one or both of the first or second end tanks. More preferred are heat exchanger assemblies wherein at least one of the separate heat exchange elements is located in the first end tank and at least one of the separate heat exchange elements is located in the second end tank.

[0032] Heat exchangers assemblies as described herein, utilize automotive fluids capable of heat exchange, including cooling. Where third automotive fluids are used, they can, preferably, depending on desired applications, be radiator fluids or oils. The present invention extends the applicability with radiator coolant as one of the fluid in conjunction with transmission oil or power steering oil or engine oil or any other fluid requiring heat transferred.

[0033] In further preferred embodiments of the present invention, the heat exchanger assembly comprises: a first end tank; a second end tank opposite the first end tank; at least one heat exchange element in at least one of the end tanks; a plurality of first tubes in fluid communication with the first and second end tanks, the plurality of first tubes adapted to have an automotive fluid flow therethrough; a plurality of second tubes in fluid communication with the first and second end tanks, the plurality of second tubes adapted to have an automotive fluid, flow therethrough; a plurality of third tubes in fluid communication with the first and second end tanks, the plurality of third tubes adapted to have an automotive fluid, flow therethrough; and a plurality of fins disposed between the first, second and third tubes, with the majority of fins being generally co-planar relative to each other. More preferably, each plurality of tubes and the heat exchange element each form an area or zone of heat exchange of the heat exchange assembly. The these preferred embodiments, at least one automotive fluid flows through the area or zone of the heat exchange assembly, as well as, in preferred embodiments, through the zone of the heat exchange element in the end tank. In even more preferred embodiments, where there is at least one of first, second or third tubes. At least one of the first, second or third tube is adapted to have a radiator fluid flow therethrough.

[0034] The tubes of the core of the heat exchanger assembly can be the same or of different size from one another. Preferred is wherein at least one of the first tubes, second tubes or third tubes is of another size than one of the other tubes. Particularly when at least one of the first, second or third tubes is of another size than one of the other tubes, it is preferred that the first or second tubes have an oil flowing therethrough. Particularly preferred is where first and second tubes are present in the core and the heat exchange element is in the end tank, that in at least one of the first or second tubes and that at least one heat exchange element are adapted to have a radiator fluid flow therethrough.

[0035] As mentioned, one advantageous feature of the present invention is the ability to integrate a plurality of different fluid heat exchange functional elements. Though the specification will make apparent that alternatives are possible (e.g. side by side), one particularly preferred configuration for the components of the assembly is to effectively stack a first fluid heat exchanger element or area upon at least a second fluid heat exchanger element or area in a single generally co-planar assembly. In another particularly preferred approach a first fluid heat exchanger element or area is stacked upon at least a second fluid heat exchange element or area and a third fluid heat exchanger. More preferred is that the at least first, second and third heat exchange elements or areas are in a single generally co-planar assembly. Also more preferred is a stacked at least first, second and third heat exchange element or area in a crossflow or horizontal assembly. In more preferred embodiments of the present invention, the heat exchange zones may be described by the functions that they perform. For example, where automotive fluids such as oils pass or flow therethrough they are referred to oil heat exchange zones, where condenser or related coolant fluids pass or flow are referred to as condenser zones, where radiator fluids pass or flow as radiator zones. In more preferred embodiments of the present invention, the heat exchange zones are selected from the group consisting of an oil heat exchange zone, a condenser zone, a radiator zone or combinations thereof. For example, in preferred embodiments of the present invention, at least one of the heat exchange zones functions as a radiator.

[0036] Another advantageous feature of the present invention is the ability to present the integration of the plurality of different fluid heat exchange elements or areas with zones as a heat exchanger assembly system. Particularly preferred is a heat exchanger assembly system wherein one heat exchange element or area is adapted to have a fluid selected from the group of radiator coolant and an automotive fluid and the other heat exchanger assembly is adapted to have a fluid selected from the group of automotive fluids. Another particularly preferred embodiment is a heat exchange element or area wherein the heat exchangers are arranged essentially in parallel. Another particularly preferred embodiment is a heat exchange element or area wherein the heat exchange elements or areas are arranged side by side.

[0037] In particularly preferred embodiments of the heat exchanger assembly of the present invention, both cross flow or horizontal and down flow fluid direction may occur. Even more particularly preferred embodiments of heat exchanger assemblies of the present invention are those wherein the fluid flow direction is vertical or ‘down flow’ from top to bottom or bottom to top.

[0038] Referring to FIG. 1, a prior art heat exchanger is shown with arrows indicating fluid flows.

[0039] Referring to FIGS. 2 and 3, a heat exchanger assembly 200 or 300 is shown with two separate in-tank heat exchange elements (203/204 or 304/305) with a core area (201/202 or 301/302/303) having at least two zones in coplanar arrangement.

[0040] Referring to FIG. 2 heat exchanger assembly 200 has a one piece or multiple piece first tank 221; a second tank 222 comprises one piece or multiple pieces opposite the first tank; a plurality of first tubes 201 is in fluid communication with the first and second end tanks 221, 222, the plurality of first tubes adapted to have first fluid flow there-through, for example, between ports 205 and 206; a plurality of second tubes 202 is adapted to have a second fluid, different from the first fluid or the same fluid in embodiments with cores such as those found in ‘combinations’ such as low temperature or high temperature radiators, flow there-through, for example, ports 207 and a plurality of fins disposed between the first and second tubes, with the first and second tubes and the fins being generally co-planar relative to each other.

[0041] The first tank 221 and second tank 222 each have two compartments 218 and 216 for tank 221 created by
separation 213. Compartments 219 and 217 for second tank 222 are created by separation 214. Compartments 216 and 217 are in fluid communication for first fluid. Compartments 218 and 219 are in fluid communication with second fluid.

[0042] Compartment 219 is further separated by a separation 215 to create compartment 220 and 223. The second fluid is in fluid communication with compartment 220-218 and 218-223. The second fluid is externally communicated through port or manifold type 208 or regulator type device 207.

[0043] The first tank 221 incorporates heat exchange element (in tank cooler) 203 inside forming a zone in tank 221 in compartment 216 and third fluid flows inside heat exchange element 203 and third fluid is either cooled or heated by the first fluid flowing in the first tank in communication with second tank 222. Similarly second tank 222 also incorporates or houses in tank cooler 204 forming a zone in compartment 217, and fourth fluid flows in communication between first tank 221 and second tank 222 to exchange heat with the inside heat exchange element 204 and the fourth fluid is either cooled or heated by the first fluid flowing in the second tank 222 in communication with first tank 221. FIG. 2 shows four different heat exchange element arranged to manage at least four fluids.

[0044] It is understood that in some applications at least one of the in tank oil coolers can be removed thereby leaving only one tank housing in tank oil cooler (preferably the tank which is downstream of the fluid which is heating or cooling the in tank cooler fluid).

[0045] The same arrangement as was discussed above is in FIG. 2 can be envisioned in downflow arrangement if rotated 90 degrees.

[0046] Referring to FIG. 3 more than four fluids are present through the heat exchanger assembly design and FIG. 3 shows an arrangement where 5 different fluids are present.

[0047] Heat exchanger assembly 300 comprises one piece or multiple piece first tank 329; a second tank 328 comprising one piece or multiple pieces opposite the first tank; a plurality of first tubes 301 in fluid communication with the forming a zone in compartment 330 of the first tank 329 and zone in compartment 331 of the second end tank 328, the plurality of first tubes adapted to have first fluid flow there-through, for example between ports 307 and 306; a plurality of second tubes 302 adapted to have a second fluid there-through, the second fluid the same as, or preferably different from, the first fluid, and a plurality of fns disposed between the first and second tubes, with the first and second tubes and the fns being generally co-planar relative to each other.

[0048] The first tank 329 and second tank 328 each have at least three compartments with at least zones in respective compartments. Zones are in compartments 330 and 331, compartments 320, 330 and 326 for first tank 329 created by separations 315 and 318, and compartments 321, 331 and 327 for second tank 328 are created by separations 314 and 317.

[0049] Compartments 330 and 313 are in fluid communication for fluid one. Compartments 320 and 321 are in fluid communication with second fluid. Compartments 326 and 327 are in fluid communication for fluid three.

[0050] Compartments 320 and 321 are in fluid communication with second fluid. Compartment 321 is further separated by a separation 316. The separation 316 creates sub compartments 322 and 323 in compartment 321. Second fluid is in fluid communication between compartment 322 and 320 and also between zone 323 and 320. The second fluid is externally communicated through port or manifold type 333 or regulator type devise 313.

[0051] Compartment 326 and 327 are in fluid communication for fluid three. Compartment 326 is further separated by a separation 319. The separation 319 creates sub compartments 324 and 317 in compartment 326. Third fluid is in fluid communication between compartment 326 and 324 and also between compartment 326 and 325. The second fluid is externally communicated through port or manifold type or regulator type devise 312.

[0052] In one embodiment of the present invention, first tank 329 incorporates another heat exchange element 304 forms a zone in compartment 330, and fourth fluid flows inside heat exchanger assembly 304 which allows fourth fluid to exchange heat with first fluid. Heat exchange elements (in tank coolers) are similarly illustrated in second tank 328 which incorporates or houses in tank cooler 305 which allows fifth fluid to exchange heat with first fluid. FIG. 3 shows heat exchange elements yielding heat exchanger assembly capable of handling at least 5 five fluids.

[0053] Preferred embodiments of the present invention, therefore, can achieve, also with the arrangements per this inventions warm up of desired fluid along with cooling at higher capacities.

[0054] Heat exchanger assembly for multiple fluids is provided to give larger heat transfer capability and with warm up capabilities is illustrated in FIG. 4.

[0055] Heat exchanger assembly 400 comprises one piece or multiple piece first tank 420; a second tank 421 one piece or multiple piece, opposite the first tank; a plurality of first tubes 401 in fluid communication with the compartment 418 of the first tank 420 and zone in compartment 419 of the second end tank 421, the plurality of first tubes adapted to have first fluid flow there-through, for example between ports 403 and 404. A plurality of second tubes 402 is adapted to have a second fluid, different from the first fluid, flow there-through, and a plurality of fns disposed between the first and second tubes, with the first and second tubes and the fns being generally co-planar relative to each other.

[0056] The first tank 420 and second tank 421 each have at least two compartments. Compartments 418 and 412 for first tank 420 created by separation or baffle 411. Compartments 419 and 414 for second tank 421 are created by separations baffles 413.

[0057] Compartments 418 and 419 are in fluid communication for fluid one. Compartments 414 and 412 are in fluid communication with second fluid.

[0058] Second tank 421 incorporates another heat exchange element 423 in compartment 419 and second a fluid flows inside heat exchange element (in tank cooler) 425 which allows second fluid to exchange heat with first fluid.
The second fluid flows through in tank cooler 423 and exchanges heat with first fluid in zone in compartment 419 and communicates through port 406. Port 406 is either part of in tank cooler 423 or separate part or part of the tank 421. The port 406 is in communication with regulator device with manifold 410. The regulator devise is equipped sensors for temperature or pressure or both.

When second fluid communicates between port 406 and 407 the second fluid is in warm up mode. Thus second fluid exchanges heat with fluid one in compartment with zone 419 through in tank cooler 423 and warms up, then second fluid passes through port 406, and depending on the regulator settings, exits out of port 407.

The second fluid flowing through in tank cooler 423 and after exchanging heat with fluid one; comes out at port 406 which is in communication with regulator devise with manifold 410. Depending upon the regulator temperature or pressure setting or both, the second fluid passes through the manifold (end tank) and enters or communicates with compartment 414. The second fluid passes through a plurality of second tubes 402 which are in fluid communication with zone 412 and exits at port 409. In this mode the second fluid is being cooled. The second fluid cools down through heat exchange with first fluid and is further cooled by external fluid, for example, air, when it flows through a plurality of second tubes 402. Higher capacity heat exchange is possible for the second fluid as it has two different cooling fluids to exchange the heat, first with fluid one in the zone 419 and then with a third fluid, preferably air, when flowing through a plurality of tubes 402.

In a particular preferred embodiments of the present invention, the first fluid is preferably radiator coolant, the second fluid is preferably a transmission or engine oil.

416 and 422 are mounting pins crimped to the side plate 417, for later brazing. 415 is a drain cock in this embodiment.

Referring to FIGS. 4 and 5, a heat exchanger assembly is shown with 423 and 523 providing for a zone in end tank compartment 419 wherein a selected automotive fluid, such as transmission oil or engine oil, can be pre-warmed using heat exchange with fluid such as radiator coolant prior to entering in to compartment 414. This pre-warmed fluid goes back to the system. While, at the same time, once the fluid is warmed up to predetermined temperature the cooling of the fluid is required and the cooling takes place in zone in compartment 419 and the regulator device with manifold 410 allows the fluid to pass through and enter the compartment 414 and further through core section 402 and gets cooled further prior to exit to return to system through 409.

FIG. 5 provides for a heat exchanger assembly for multiple fluids to give larger heat transfer capability.

Heat exchanger assembly 500 comprises a one piece or multiple piece first tank 520; a second tank 521 comprising of one piece or multiple piece, opposite the first tank; a plurality of 419 first tubes 501 in fluid communication with the compartment 518 of the first tank 520 and zone in compartment 519 of the second end tank 521, the plurality of first tubes adapted to have first fluid flow there-through, for example between ports 503 and 504; a plurality of second tubes 502 adapted to have a second fluid, different from the first fluid, flow there-through, and a plurality of fins disposed between the first and second tubes, with the first and second tubes and the fins being generally co-planar relative to each other.

The first tank 520 and second tank 521 each have at least two compartments, 518 and 512 for first tank 520 created by separation 511. Zone in compartment 519 and 514 for second tank 421 are created by separation 513. The separation 513 is provided such that it isolates first fluid from second fluid but has opening where heat exchanger assembly 523 can be positioned such that second fluid is in direct fluid communication with 514.

Compartments 518 and 519 are in fluid communication for first fluid. Compartments 514 and 512 are in fluid communication with second fluid.

The second tank 521 incorporates heat exchange element 523 (in tank cooler) and a second fluid flows inside in tank cooler 523 which allows second fluid to exchange heat with first fluid.

The second fluid flowing through in tank cooler 523 and after exchanging heat with fluid one, comes out at port 506 which is in direct communication with zone 514. The second fluid passes through a plurality of second tubes 502 which are in fluid communication with zone 512 and exits at port 509. In this mode the second fluid is being cooled. The second fluid cools down through heat exchange with first fluid and it further gets cooled by external fluid which is usually air when it flows through a plurality of second tubes 502. Higher capacity heat exchange is possible for second fluid as it has two different cooling fluids to exchange the heat, first with fluid one in the zone 519 and then with fluid 3, preferably, usually air when flowing through a plurality of tubes 502.

In preferred embodiments of the present invention, preferred first fluid is radiator coolant, and a preferred second fluid is transmission or engine oil.

516 and 522 are mounting pins crimped to the side plate 517, which later are brazed. Item 515 is a drain cock.

FIG. 6 illustrates preferred embodiments where heat exchange elements or areas or zones can be arranged in the vehicle parallel to each other or side by side. In FIGS. 6 a and b, heat exchanger assembly 1000 is shown in combination with other heat exchanger 1000 to form heat exchanger systems.

In more preferred embodiments of the present invention, the heat exchanger assembly may be used in conjunction or in combination with another heat exchanger or heat exchanger assembly. The at least one other heat exchanger or heat exchanger assembly may be a single fluid or a multiple fluid heat exchanger or heat exchanger assembly, and collectively, for the purpose of the invention, is described as a heat exchanger assembly system. Preferably the heat exchanger assembly system comprises a heat exchanger assembly and at least one other heat exchanger.

As described herein, preferred embodiments of the present invention, and, in particular those involving heat exchanger assembly systems wherein at least one zone of the heat exchanger assembly is adapted to have a fluid selected from the group of radiator coolant and an automotive fluid,
the at least one other zone the other heat exchanger assembly is preferably adapted to have a fluid selected from the group of automotive fluids. In preferred heat exchanger assembly systems, as in the preferred heat exchanger assembly of the system, the heat exchange zones are preferably arranged in parallel. Also in preferred heat exchanger assembly systems, preferred heat exchanger or heat exchange assemblies of such a system, are arranged so as the heat exchanger or exchangers and the heat exchanger assembly are arranged side by side.

[0076] In preferred embodiments of the present invention it is contemplated that the fluid flow direction in normal operational position of the heat exchanger assembly will be vertical or downflow from top to bottom or bottom to top. Also preferred are embodiments wherein the heat exchange elements is partially within or integrated into at least one of the compartments. Where heat exchange elements are partially within or integrated into at least one of the compartments, it is preferred that at least two separate heat exchange elements be integrated into at least two compartments.

[0077] Preferred embodiment of heat exchanger assemblies described in the present invention use end tanks which are designed to handle automotive fluid, and, preferably, radiator fluid, and associated features for example inlet and outlet sizes, attachment features etc. The shape and the type of the end tanks can be circular, rectangular and any other shape and not limited to circular and rectangular as shown in this invention. The size and design will be dependent on radiator flow requirements and maximum oil pressure limit. Baffles to diverting the flow of same fluid are described in combo coolers, as well as baffles separating two fluids. The baffles in the heat exchanger assemblies (end tanks) meet the needs of specific cross section of the end tanks.

[0078] The fins between the tubes can preferably be of the same type in the heat exchanger core area and is preferred most simplistic manufacturing scenario. In the event where different fins are required to meet individual heat exchanger assembly needs such arrangement also can be used in the present invention.

[0079] It is contemplated that a heat exchanger assembly formed in accordance with the present invention may include a core one or more tubes having various different internal configurations for defining passageways within the tubes. They may also have different external configurations defining one or more outer peripheral surfaces of the tubes. Further it is possible that the internal configurations, external configuration or both vary along the length of the tube.

[0080] The internal configuration of a tube may be the same or different from the external configuration. For instance, the walls of the tubes may have opposing sides that are generally parallel to or otherwise complement each other. Alternatively, they may have a different structure relative to each other. The external configuration of the tube may include grooves, ridges, bosses, or other structure along some or all of its length for assisting in heat transfer. Likewise, the internal configuration may include grooves, ridges, bosses or other structure. It is also possible that the structure is provided for generating turbulence within the fluid, or for otherwise controlling the nature of the flow of fluid there-through or for strength.

[0081] The passageways of the tubes may be provided in a variety of shapes such as square, rectangular, circular, elliptical, irregular or the like. In preferred embodiments, the passageways of tubes may include one or more partitions, fins or the like. As used herein, a partition for a passageway in a tube is a structure (e.g., a wall) that substantially divides at least part of the passageway into a first and second portion. The partition preferably is continuous (but may be non-continuous) such that the partition completely separates the first portion from the second portion or the partition may include openings (e.g., through-holes, gaps or the like) connecting the first and second portion.

[0082] As used herein, a fin for a passageway in a tube is intended to encompass nearly any structure (e.g. a protrusion, a coil, a member or the like), which is located within the passageway of the tube and is physically connected (e.g., directly or indirectly) to an outer surface of the tube that engages in heat exchange. The shape of each of the fins may be the same or different relative to each other. Further, the pitch angle of each fin may be the same or different relative to each other. It will also be appreciated that the configuration of a tube may vary along its length. One or both tube ends may be provided with fins but the central portion left un-finned. Likewise, the central portion may be provided with fins but one or both of the tube ends are left un-finned. Fin spacing may be constant within a passageway or may be varied as desired.

[0083] It is contemplated that various numbers of partitions and fins may be used depending upon the size, shape, configuration or the like of the passageways, tubes or both. The fins may be any desirable shape, for instance they may have a sectional profile that is rectangular, rounded or the like. Preferably, the partitions can divide the passageways into various numbers of portions of various different sizes and shapes or of substantially equivalent sizes and shapes. As examples, the portions may be contoured, straight, rectangular or otherwise configured.

[0084] For certain applications, and particularly for lower viscosity fluids, it can be advantageous to have substantially equally sized passageways such that flow through each of the passageway is substantially equivalent and promotes higher amounts of heat transfer. In alternative embodiments, a tube may be divided into one or more of a plurality of first passageways having a first sectional area and one or a plurality of second passageways having a second sectional area (e.g. larger, smaller of different shape relative to the first passageways). Additionally, the partitions of the tube may extend horizontally, vertically, diagonally, combinations thereof or otherwise.

[0085] Advantageously, tubes with passageways divided into larger and smaller sub-passageways, such as those above, have the ability to effectively perform a passive bypass function particularly for the cooling of relatively high viscosity fluids flowing through the tubes. In particular, a higher viscosity fluid will typically be more viscous at lower temperatures and, consequently, more of the fluid will flow through the larger sub-passageways and bypass the smaller sub-passageways resulting in less heat transfer from the fluid. In contrast, as the temperature of the fluid elevates, the fluid will become less viscous and, consequently, the rate will increase at which the fluid is able to flow through the smaller sub-passageways. Thus, the diverse passageway structure tube facilitates, flow of the high viscosity fluid through the tube at cooler temperatures.
In other alternative embodiments, surfaces defining the internal portions of any of the internal passageways of the tubes may be smooth or planar or may be contoured such as corrugated (e.g., including several patterned ridges), ribbed (i.e., including several protrusions), dimpled (e.g., including several depressions) or another suitable fin structure. Spiral or helical grooves or ridges may be provided. In still other alternative embodiments, the tubes may include one or more internal inserts, which are fabricated separately from the tubes but subsequently assembled together. It is contemplated that inserts may be formed in a variety of configurations and shapes for insertion into passageways or portions of passageways of tubes. For example, and without limitation, inserts may be members (e.g., straight or contoured members) with complex or simple configurations. Alternatively, inserts may be coils, springs or the like.

Formation of tubes according to the present invention may be accomplished using several different protocols and techniques. As examples, tubes may be drawn, rolled, cast or otherwise formed. Additionally, tubes according to the present invention may be formed of a variety of materials including plastics, metals, carbon, graphite, other formable materials or the like. Preferably, however, the tubes are a metal selected from copper, copper alloys, low carbon steel, stainless steel, aluminum alloys, titanium alloys or the like. The tubes may be coated or otherwise surface treated over some or all of its length for locally varying the desired property.

In the tubes of the heat exchangers of the present invention, a hydraulic diameter in the range of desired hydraulic diameters is preferred to obtain maximum effectiveness of the exchanger.

As used herein, hydraulic diameter (DH) is determined according to the following equation:

\[ D_h = 4A_p/P_w \]

wherein

\[ A_p \] = wetted cross-sectional area of the passageway of a tube; and

\[ P_w \] = wetted perimeter of the tube.

Each of the variables (\(P_w\) and \(A_p\)) for hydraulic diameter (\(D_h\)) are determinable for a tube according to standard geometric and engineering principles and will depend upon the configuration of a particular tube and the aforementioned variables for that tube (i.e., the number of partitions, the number of portions, the size of the portions, the size of the passageways or a combination thereof).

Heat transfer and pressure drop for a fluid flowing through the tubes can be determined for a range of hydraulic diameters using sensors such as pressure gauges, temperature sensors or the like.

For a multi-fluid heat exchanger, it may be desirable for the tubes designed to transport one of the fluids to be sized, dimensioned or both relative to the tubes that are designed to transport the other fluid(s). In particular, for a multi-fluid heat exchanger assembly designed to handle a first fluid such as a radiator coolant and a second fluid such as an oil (e.g., transmission oil, power steering oil or the like), and a third fluid such as a refrigerant, it is desirable for the internal and external surface areas of the various tubes to be sized, dimensioned or both relative to each other to provide for greater amounts of heat transfer to and/or from the fluids.

According to a preferred aspect of the present invention, a multi-fluid heat exchanger assembly includes tubes for transporting a first fluid such as a radiator coolant and tubes for transporting a second fluid such as an oil (e.g., transmission oil, power steering oil or the like) and tubes for transporting a third fluid such as condenser fluid (e.g., refrigerant, CO₂, etc.). For the tubes transporting the radiator fluid, a large amount of thermal resistance to heat exchange is produced at the external surface of the tube relative to any amount of thermal resistance produced at the internal surface of the tube. However, for the tubes transporting the oil, a large amount of thermal resistance is produced at the internal surface of the tube relative to the any amount of thermal resistance produced at the external surface of the tube. As a result, it is generally desirable for the tube transporting the radiator fluid to have a larger external surface area relative to its internal surface area while it is generally desirable for the tube transporting the oil to have a larger internal surface area relative to its external surface area.

In certain embodiments of the invention, it is preferable for the heat exchanger assembly to include one or more end plates on the core for providing protection to the tubes of the heat exchanger. The end plates may be provided in various different configurations and may be substantially planar or contoured, continuous or non-continuous or otherwise configured. Additionally, the end plates may be provided as separate units that may be connected or attached to one or more of the components (e.g., the end tanks) of the heat exchanger. Alternatively, the end plates may be provided as integral with one or more of the components (e.g., the end tanks) of the heat exchanger.

According to one highly preferred embodiment, one or both of the end plates are omitted. The function of end plates is the end plates is provided by end tubes instead. For example, the end tubes are substantially identical to one or more of the fluid carrying tubes of the heat exchanger.

The invention has been illustrated herein generally by reference to a three, four or five fluid heat exchanger. However, it is not intended to be limited thereby. It is clearly contemplated that the inventive features are adapted for providing even a heat exchanger assembly for fluids in addition to three fluids.

In one particular aspect of the present invention, it is preferable that any baffle employed be generally disk-shaped (or otherwise conforms generally with an interior of the section in which it is introduced) with a first substantially planar outwardly facing surface opposite (either in spaced or in contacting relation with) a second substantially planar outwardly facing surface. Preferably, the baffle includes a central portion and a flanged peripheral portion. More preferably is a baffle system including a baffle or baffles with a central portion and (at least one) flanged peripheral portion, the flanged peripheral portion having a peripheral channel. Even more preferably, the baffle system comprises double baffles, i.e., a first and a second baffle being assembled back to back with a common center contact portion.

Unless stated otherwise, dimensions and geometries of the various structures depicted herein are not intended to be restrictive of the invention, and other dimensions or geometries are possible.
What is claimed is:

1. A heat exchanger assembly comprising:
   a first end tank;
   a second end tank opposite the first end tank;
   a plurality of first tubes in fluid communication with the first and second end tanks, the plurality of first tubes adapted to have a first fluid flow therethrough;
   a plurality of second tubes in fluid communication with the first and second end tanks, the plurality of second tubes adapted to have a second fluid flow therethrough;
   a plurality of fins disposed between the first and second tubes, with the fins being generally co-planar relative to each other;
   a heat exchange element adapted to have a third fluid, different from the first or second fluid, flow therethrough,

   wherein at least one of the first fluid or second fluid is a radiator fluid, and wherein the third fluid is an automotive fluid.

2. A heat exchanger assembly as in claim 1 wherein the heat exchange element is located in the first or second end tank and the first end tank and the second end tank each include at least one baffle.

3. A heat exchanger assembly as in claim 2 having at least two separate heat exchange elements.

4. A heat exchanger assembly as in claim 3 wherein the two separate heat exchange elements are located in one or both of the first or second end tanks.

5. A heat exchanger assembly as in claim 3 wherein at least one of the separate heat exchange elements is located in the first end tank and at least one of the separate heat exchange elements is located in the second end tank.

6. A heat exchanger assembly as in claim 2 wherein the third fluid is an oil.

7. A heat exchanger assembly comprising:
   a first end tank;
   a second end tank opposite the first end tank;
   at least one heat exchange element in at least one of the end tanks;
   a plurality of first tubes in fluid communication with the first and second end tanks, the plurality of first tubes adapted to have an automotive fluid flow therethrough;

   a plurality of second tubes in fluid communication with the first and second end tanks, the plurality of second tubes adapted to have an automotive fluid flow therethrough;

   a plurality of third tubes in fluid communication with the first and second end tanks, the plurality of third tubes adapted to have an automotive fluid flow therethrough;

   a plurality of fins disposed between the first, second and third tubes, with the majority of fins being generally co-planar relative to each other;

   wherein each plurality of tubes and the heat exchange element each form an area or zone of heat exchange of the heat exchange assembly; and,

   wherein at least one of the first, second or third tubes has a radiator fluid flowing therethrough.

8. A heat exchanger assembly as in claim 7 wherein the at least one heat exchange element has an automotive fluid flowing therethrough.

9. A heat exchanger assembly as in claim 8 wherein the automotive fluid of at least one heat exchange element is an oil.

10. A heat exchanger assembly as in claim 6 wherein at least one of the first tubes, second tubes or third tubes is of another size than one of the other tubes.

11. A heat exchanger assembly as in claim 7 wherein the first or second tubes have an oil flowing therethrough.

12. A heat exchanger assembly as in claim 7 wherein the first or second tubes and the at least one heat exchange element have a radiator fluid flowing therethrough.

13. A heat exchanger assembly for an automotive vehicle, comprising:
   a first end tank;
   at second end tank;
   a least two compartments in the at least one of the end tanks;
   a core;
   fins;

   at least two heat exchange zones in the core each including a plurality of spaced apart tubes with fins between the spaced tubes;

   at least one heat exchange element in at least one of the end tanks;

   the heat exchange zones being disposed so that their respective tubes and fins are generally co-planar with each other and are connected to the end tank; and the heat exchange zones being selected from the group consisting of an oil heat exchange zone, a condenser zone, a radiator zone or combinations thereof.

14. A heat exchanger assembly as in claim 13 wherein at least one of the heat exchange zones functions as a radiator.

15. A heat exchanger assembly system comprising a heat exchanger assembly as in claim 1 and at least one other heat exchanger.

16. A heat exchanger assembly system comprising a heat exchanger assembly as in claim 7 and at least one other heat exchanger.
17. A heat exchanger assembly system comprising a heat exchanger assembly as in claim 13 and at least one other heat exchanger.

18. A heat exchanger assembly system as in claims 15, wherein at least one zone of the heat exchanger assembly is adapted to have a fluid selected from the group of radiator coolant and an automotive fluid and at least one other zone of the heat exchanger assembly is adapted to have a fluid selected from the group of automotive fluids.

19. A heat exchanger assembly system as in claim 18, wherein the heat exchange zones are arranged in parallel.

20. A heat exchanger assembly system as in claim 18, wherein the heat exchanger assembly and the at least one other heat exchanger are arranged side by side.

21. A heat exchanger assembly as in claim 1 wherein the fluid flow direction is vertical or downflow from top to bottom or bottom to top.

22. A heat exchanger assembly as in claim 7 wherein the fluid flow direction is vertical or down flow from top to bottom or bottom to top.

23. A heat exchanger assembly as in claim 7 wherein the fluid flow direction is vertical or down flow from top to bottom or bottom to top.

24. A heat exchanger assembly as in claim 1, wherein the end tank having the at least one heat exchanger element has at least two compartments and wherein the at least one heat exchange element is found in at least one of the compartments.

25. A heat exchanger assembly as in claim 24, wherein at least one of the fluids is preheated by heat exchange with the second fluid.

26. A heat exchanger assembly as in claim 24, wherein at least one of the fluids is preheated by heat exchange with the third fluid.

27. A heat exchanger assembly as in claim 1, wherein the first end tank and the second end tank both have at least two compartments and wherein the heat exchange element is partially within or integrated into at least one compartment.

28. A heat exchanger assembly as in claim 1, wherein the first end tank and the second end tank both have at least two compartments and wherein the heat exchange element is partially within or integrated into at least two compartments.

29. A heat exchanger assembly as in claim 25, wherein one of the fluids which is being preheated is controlled by a control device for its flow within the heat exchanger.

30. A heat exchanger assembly as in claim 26, wherein one of the fluids which is being preheated is controlled by a control device for its flow within the heat exchanger.

31. A heat exchanger assembly as in claims 29, wherein the control device controls fluid access to more than one zone to increase exchange cooling capacity.

32. A heat exchanger assembly with more than one zone, wherein at least one of the fluids of the heat exchanger exchanges heat in multiple zones to exchange heat at higher capacity.

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