MODULAR COMPOSITE INTERCOOLER

A modular heat exchanger assembly comprising: a plurality of interlocking housings each having a heat-exchanging element, a first and second side each having a mating connector and a first end and a second end, wherein the interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core, the first end has a plurality of first end mating connector openings and the second end has a plurality of second end mating connector openings; there may be at least one first-type end cap, at least one second-type end cap and/or at least one third-type end cap for connection to either one of the first end mating connector openings or one of the second end mating connector openings and there is at least one access opening.
COOLANT ROUTING

PARALLEL

Fig. 5A

SERIAL

Fig. 5B

MIXED

Fig. 5C
MODULAR COMPOSITE INTERCOOLER

[0001] This application claims priority to provisional patent application No. 61/760,622 filed Feb. 4, 2013 and entitled “Modular Composite Intercooler,” the entire contents of which are incorporated herein by reference.

[0002] The present invention relates to heat exchangers and in particular to modular heat exchanger assemblies.

[0003] Conventional heat exchangers for use in automobiles utilize heat exchanging core elements which include a series of generally parallel aluminum tubes that are machined to shape and made of aluminum.

[0004] The present invention seeks to provide heat exchanger parts that may be interchanged to provide a modular approach that can be used for every available size and type of heat exchanger including, but not limited to, heat exchangers for cooling incoming air for engines, transmission fluid coolers for vehicle transmissions, radiators for engine coolant. Also, the parts may be of plastic to reduce costs. The plastic also provides for a critical air seal to certain types of tubes (e.g. LAMINOVATM tubes). Another advantage of the present invention is the reduction of, or elimination of, the need for tools to assemble the parts. Many of the parts may snap together without the need for tools.

[0005] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and claims.

SUMMARY OF THE INVENTION

[0006] The present invention relates generally to modular heat exchanger assemblies.

[0007] According to one embodiment, a modular heat exchanger assembly is provided comprising: a plurality of interlocking housings each having a heat-exchanging element, first side having a mating connector and a second side having a mating connector and a first end and a second end, wherein the plurality of interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core and wherein the first end has a plurality of first end mating connector openings and the second end has a plurality of second end mating connector openings; at least one first-type end cap with a plurality of end cap mating connectors for connection to either one of the first end mating connector openings or one of the second end mating connector openings and having one first-type end cap open connector; at least one second-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening; at least one first-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening and having one first-type end cap open connector, wherein at least one first-type end cap open connector is attached to at least one second-type end cap open connectors and wherein at least one of the at least one first-type end caps and the at least one second-type end cap has an access opening (38).

[0008] According to another embodiment, a modular heat exchanger assembly is provided comprising: a plurality of interlocking housings each having a heat-exchanging element, first side having a mating connector and a second side having a mating connector and a first end and a second end, wherein the plurality of interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core and wherein the first end has a plurality of first end mating connector openings and the second end has a plurality of second end mating connector openings; at least one third-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening; at least one first-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening and having one first-type end cap open connector, wherein at least two of the at least one first-type end cap and the at least one third-type end caps have an access opening.

[0009] These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 depicts a portion of the modular heat exchanger assembly according to the present invention;

[0011] FIG. 2 depicts an exploded view of the modular heat exchanger assembly according to the present invention;

[0012] FIG. 3 depicts one coolant flow path according to the present invention;

[0013] FIG. 4 depicts one coolant flow path according to the present invention;

[0014] FIGS. 5A, 5B and 5C depicts coolant flow paths according to the present invention;

[0015] FIG. 6 depicts an end cap according to the present invention;

[0016] FIG. 7 depicts an end cap according to the present invention;

[0017] FIG. 8 depicts an end cap according to the present invention;

[0018] FIG. 9 depicts an end cap according to the present invention;

[0019] FIG. 10 depicts an interlocking housing according to the present invention;

[0020] FIG. 11 depicts interlocking housings and a heat-exchanging element according to the present invention;

[0021] FIG. 12 depicts a portion of the modular heat exchanger assembly according to the present invention;

[0022] FIG. 13 depicts an end cap according to the present invention;

[0023] FIG. 14 depicts a mating connector according to the present invention;

[0024] FIG. 15 depicts a modular heat exchanger assembly according to the present invention;

[0025] FIG. 16 depicts a portion of an interlocking housing according to the present invention;

[0026] FIG. 17 depicts a portion of an interlocking housing according to the present invention;

[0027] FIG. 18 depicts an interlocking housing according to the present invention;

[0028] FIG. 19 depicts a portion of an interlocking housing according to the present invention;

[0029] FIGS. 20A and 20B depicts a modular heat exchanger assembly according to the present invention;

[0030] FIG. 21 depicts an end cap according to the present invention;

[0031] FIG. 22 depicts a coolant inlet/outlet interface;

[0032] FIG. 23 depicts a coolant inlet/outlet interface;

[0033] FIG. 24 depicts a portion of an interlocking housing according to the present invention;

[0034] FIG. 25 depicts a portion of an interlocking housing according to the present invention; and
DetaIed descriptIon of the Invention

The following detailed description is of the best currently contemplated modes of carrying out the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention, since the scope of the invention is best defined by the appended claims.

With reference to FIGS. 1-25, the present invention provides a modular heat exchanger assembly comprising: a plurality of interlocking housings (10, 12, 14, 16) each having a heat-exchanging element (8), first side (18) having a mating connector (20) and a second side (22) having a mating connector (24) and a first end (26) and a second end (28), wherein the plurality of interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core and wherein the first end has a plurality of first end mating connector openings (30) and the second end has a plurality of second end mating connector openings; at least one first-type end cap (32) with a plurality of end cap mating connectors (34) for connection to either one of the first end mating connector openings or one of the second end mating connector openings and having one first-type end cap open connector (36). There may be at least one second-type end cap (40) with a plurality of end cap mating connectors (42) for connection to either a first end mating connector opening (30) or a second end mating connector opening and having at least one second-type end cap open connector (44, 46), wherein at least one first-type end cap open connector (36) is attached to at least one second-type end cap open connectors (44) and wherein at least one first-type end cap and at least one second-type end cap has an access opening (38). At least two end caps have an access opening to permit the flow of coolant through the heat exchanger assembly—in effect, there needs to be one inlet and one outlet for every heat exchanger assembly. In one embodiment, one of the second-type end cap open connectors (44) is an access opening.

In operation, the fluid that passes through the inside of the end caps (e.g. 32, 40) and heat exchanging element (8) (also referred to as tubes) is a water/coolant mix that cools the exterior of the tubes and air is passing over the top and through the tubes. By way of example, the fluid may be air and water coolant, transmission fluid, refrigerant, engine oil, etc. passing both inside the heat exchanging elements and outside and over the heat exchanging elements. The air passing over a heat exchanging element (8) (tubes) is hot and is cooled by the significantly lower temperature water/coolant passing through the heat exchanging element (8) (tubes). Two of the functions of the plurality of interlocking housings are to guide air over the tubes and to permit a means to align and connect the caps to the tubes with a radial seal. The housings were designed in many different configurations without resorting to retooling to permit different juxtapositions of housings to permit different coolant flow methods. The tube is the heat-exchanger body, the assembly taught herein creatively and cost effectively provides a solution for providing a sealed coolant passage through the inside the tubes and an integrated ducting path for air flow over the exterior of the heat-exchangers for removal of heat from the incoming air.

It should be understood that there are many different end caps, which may be designed in a multitude of different ways to accomplish the goals of providing different shapes, configurations and coolant flow paths. FIGS. 6, 7, 8 and 9 depict examples of different end cap configurations. According to one embodiment, the first-type end cap (32) has a plurality of end cap mating connectors (34) for connection to either one of the first end mating connector openings or one of the second end mating connector openings and having one first-type end cap open connector (36). The first-type end cap open connector (36) in the example shown is a male connector. The male connector, according to one embodiment, has a series of concentric protrusions (98) with a raised portion (100) and a circular base (98). The connector may be a snap-fit or a series of cantilever snaps, which permit disassembly. Such a connector requires force to unsnap, but does not break before disassembly. The second-type end cap (40) may have a female connector (46) and a male connector (44). The first-type end cap open connector (36), shown as a male connector, fits into, or connects with/attaches to, the second-type end cap open connector (46).

The second-type end cap (40) may have a female connector (46) and a male connector (44). The female connector (46) receives the first-type end cap open connector (36). The term “male” refers to the protruding connector and “female” refers to the recessed or open connector. The “male” part fits into the “female” part and may have a radial seal (102) therebetween. As depicted in FIG. 7, there may be second-type end cap (40) with a coolant flow cavity (110) between a male one way connector (112) and a female connector (114). As depicted in FIG. 6, for a first-type end cap (32) there is a coolant flow cavity (116) between the end cap housing connector opening (106) and a male connector. Of course, as is the very purpose of the invention, the connectors can be changed and adjusted (e.g. a female one-way connector, a male one-way connector, a female connector, a male connector or any connection means) in any way to suit the needs of the user.

The term first-type end cap (32) is intended to refer to an end cap that has one first-type end cap open connector (36). The first-type end cap open connector (36) may be a female connector, a male connector, a female connector, a male connector or any connection means. The term second-type end cap (40) has two second-type end cap open connectors. The second-type end cap open connectors (36) may be female one-way connectors, male one-way connectors, female connectors, male connectors or any connection means known within the art. For example, the second-type end cap open connectors may be one male connector and one female connector. By way of another example, the second-type end cap open connectors may also be two male one-way connectors or two female one-way connectors.

The term third-type end cap (FIG. 3, 50) has no end cap open connectors and only has the end cap housing connector opening (this may be seen in FIG. 9, on a first-type end cap, as end cap housing connector opening (104). FIGS. 6 and 9 depict first-type end caps. FIG. 6 shows end cap housing connector opening (106) for attachment to, or communication with, one of a plurality of interlocking housings (e.g. 10, 12, 14, 16), and in particular to the heat exchanger element (tube). It should be noted, that the end cap mating connectors (34) hold the end cap to either one of the first end mating connector openings or one of the second end mating connector openings and having one first-type end cap open connector (36). This attachment may be seen in FIG. 12. FIG. 9 shows
end cap housing connector opening 104 for attachment to one of a plurality of interlocking housings (e.g. 10, 12, 14, 16).

[0043] According to another embodiment, there may be at least one third-type end cap (50) with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening. As can be seen in FIGS. 3 and 4, the third-type end cap (50) does not allow for coolant flow to the adjacent end cap (52). Instead, the coolant flows directly into or out of the heat-exchanging element (see FIG. 1, heat-exchanging element 8 . . . ). In this way, a series coolant flow path (depicted in FIGS. 3 and 5B) and a mixed parallel and series coolant flow path (depicted in FIG. 5C, 26A, 263 and 26C) may be accomplished. Of course, the male and female connectors may be reversed without departing from the present invention. Also, any configuration and combination of different types of end cap may be used to accomplish the desired configuration. By way of example, the at least one second-type end caps (40) may be two second-type end cap open connectors that provide a parallel coolant flow path. A parallel coolant flow path may also be achieved with at least one first-type end cap (32) attached to at least one second-type end cap (40). See FIG. 4 (and FIG. 5A) depicting a parallel coolant flow path.

[0044] Each of the second-type end caps (40) may also have two second-type end cap open connectors that provide a series coolant flow path. This is depicted in FIG. 3. The plurality of interlocking housings each having a heat-exchanging element may also be connected to provide a mixed parallel and series coolant flow path. Examples of different configurations that provide mixed parallel and series coolant flow path are depicted in FIGS. 26A, 263 and 26C.

[0045] As shown in FIG. 12, there may be a number of o-ring seals (120) interposed between the plurality of end cap mating connectors (34) and at least one of the first end mating connector openings (30) and the second end mating connector openings (not shown in FIG. 12, would be similar to first end mating connector openings (30), except at the other end). There may also be an o-ring seal (122) interposed between a portion of the first-type end cap open connector and the second-type end cap open connectors. FIGS. 13-14 depict one embodiment of the end cap mating connectors (34) and a first end mating connector openings (30). As can be seen, the end cap mating connector (34) has a slanted L-shaped protrusion (130), such that it slides through the first end mating connector opening and once it passes the opening the slanted L-shaped protrusion (130) prevents it from being removed while the part is being assembled into a final end-item, although these protrusions can be serviced without damage if the manufacturers directions are followed. This helps to remove the need for tools and allows for easy snap together fit of the parts.

[0046] As shown in FIGS. 10, 11, 15 and 16, the plurality of interlocking housings may have outer squared off corners to form a planar seal surface for mating parts. FIG. 15 also depicts that the end caps (whether it is a first-type end cap, second-type end cap or third-type end cap) may also have a square shaped base (124) and a planar edge (126) and although this surface is not used for sealing, it may permit advantages in the assembly process. The planar seal surfaces for the mating parts allow for easy alignment and for sealing of air to make the heat-exchanger efficiency improved when the assembly is used as in the function of an intercooler. The plurality of interlocking housings have a planar surface that permits the resulting surface to have an elastomeric element push against them forming a torturous path against external airflow leakage around the tubes/housings, which if the leakage occurred would make the heat-exchanger tubes less efficient. FIG. 11 is intended to show that the plurality of interlocking housings may be of any desired length.

[0047] The plurality of interlocking housings, the at least one first-type end caps, the at least one second-type end cap and the at least one third-type end cap may be formed in a single piece or in multiple pieces. Each piece in the modular heat exchanger assembly of the present invention may be made of thermoplastic or thermoset materials and can be formed/made by injection molding, blow molding, casting, extrusion and/or compression molding. As shown in FIG. 16, the inside of the housing can be pulled from both ends in the injection mold tool for optimized shape control. The opening is drafted, except for this window (200), which is draft free to block air from bypassing the heat-exchanging element (8) (which may be, by way of an example, a LAMINOVÁ™ tube). The draft free window is tolerated so that it is always in contact with the tube fins (202). FIG. 24 depicts the interlocking housing formed in a single piece. FIG. 25 depicts the interlocking housing formed in two pieces.

[0048] According to another embodiment, a modular heat exchanger assembly is provided comprising: a plurality of interlocking housings each having a heat-exchanging element, a first side having a mating connector and a second side having a mating connector (24) and a first end (26) and a second end, wherein the plurality of interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core and wherein the first end has a plurality of first end mating connector openings and the second end has a plurality of second end mating connector openings; at least one third-type end cap (50) with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening; at least one first-type end cap (32) with a plurality of end cap mating connectors (34) for connection to either a first end mating connector opening or a second end mating connector opening and having one first-type end cap open connector (36), wherein at least two of the at least one first-type end cap and the at least one third-type end caps have an access opening (38). There may also be at least one second-type end cap (40) with a plurality of end cap mating connectors (42) for connection to either a second end mating connector opening or a second end mating connector opening and having one second-type end cap open connector (44, 46), wherein at least one first-type end cap open connector (36) is attached to at least one second-type end cap open connectors (44, 46). Note that a second-type end cap cannot be connected to a third-type end cap, as a third-type end cap is closed on all sides and must be adjacent to either another third-type end cap or a first-type end cap. Accordingly, in any combination that includes a third-type end cap and a second-type end cap, there must also be a first-type end cap interposed between the third-type end cap and the second-type end cap.

[0049] The plurality of interlocking housings each having a heat-exchanging element may be connected to provide at least one of a parallel coolant flow path, a series coolant flow path and a mixed parallel and series coolant flow path. There may be o-ring seals interposed between the plurality of end cap mating connectors and at least one of the first end mating connector openings and the second end mating connector openings.
openings. FIGS. 20A and 20B depict an assembly sequence of the parts. First the plurality of interlocking housings (10, 12, 14, 16) are attached to one another, then the end caps (e.g. 32, 40) are attached. Of course, any type of end cap may be used.

FIGS. 21-23 depict an access opening with a coolant interface. The access opening of the end cap has pipe threads (208) which accept the threaded pipe (206). FIG. 23 depicts one example of a hose interface (210).

It should be understood that the foregoing relates to preferred embodiments of the invention and that modifications may be made without departing from the spirit and scope of the invention as set forth in the following claims.

We claim:

1. A modular heat exchanger assembly comprising:
   a plurality of interlocking housings each having a heat-exchanging element, a first side having a mating connector and a second side having a mating connector and a first end and a second end, wherein the plurality of interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core and wherein the first end has a plurality of first end mating connector openings and the second end has a plurality of second end mating connector openings;
   at least one first-type end cap with a plurality of end cap mating connectors for connection to either one of the first end mating connector openings or one of the second end mating connector openings and having one first-type end cap open connector;
   at least one second-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening and having at least one second-type end cap open connector;
   wherein at least one first-type end cap open connector is attached to at least one second-type end cap open connector; and
   wherein at least one of the at least one first-type end caps and the at least one second-type end cap has an access opening.

2. A modular heat exchanger as in claim 1, wherein each of the at least one second-type end caps has two second-type end cap open connectors that provide a parallel coolant flow path.

3. A modular heat exchanger as in claim 1, wherein the plurality of interlocking housings each having a heat-exchanging element are connected to provide a parallel coolant flow path.

4. A modular heat exchanger as in claim 1, wherein the plurality of interlocking housings each having a heat-exchanging element are connected to provide a series coolant flow path.

5. A modular heat exchanger as in claim 1, wherein each of the at least one second-type end caps has two second-type end cap open connectors that provide a series coolant flow path.

6. A modular heat exchanger as in claim 1, wherein the plurality of interlocking housings each having a heat-exchanging element are connected to provide a mixed parallel and series coolant flow path.

7. A modular heat exchanger as in claim 1, further comprising an o-ring seal interposed between the plurality of end cap mating connectors and at least one of the first end mating connector openings and the second end mating connector openings.

8. A modular heat exchanger as in claim 1, further comprising an o-ring seal interposed between a portion of the first-type end cap open connector and the second-type end cap open connectors.

9. A modular heat exchanger as in claim 1, wherein at least one of the first-type end cap open connectors is a female connector.

10. A modular heat exchanger as in claim 1, wherein at least one of the first-type end cap open connectors is a male connector.

11. A modular heat exchanger as in claim 1, wherein the at least one second-type end cap open connectors are one male connector and one female connector.

12. A modular heat exchanger as in claim 1, wherein the plurality of interlocking housings have outer squared off corners to form a planar seal surface for mating parts.

13. A modular heat exchanger as in claim 1, wherein the plurality of interlocking housings, the at least one first-type end caps and the at least one second-type end cap are formed by injection molding.

14. A modular heat exchanger as in claim 1, wherein at least one of the plurality of interlocking housings, the at least one first-type end caps and the at least one second-type end cap are formed in multiple pieces.

15. A modular heat exchanger as in claim 1, wherein at least one of the plurality of interlocking housings, the at least one first-type end caps and the at least one second-type end cap are formed in a single piece.

16. A modular heat exchanger as in claim 1, further comprising at least one third-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening.

17. A modular heat exchanger assembly comprising:
   a plurality of interlocking housings each having a heat-exchanging element, a first side having a mating connector and a second side having a mating connector and a first end and a second end, wherein the plurality of interlocking housings interlock to each other by the second side having a mating connector interlocking with the first side having a mating connector to provide a heat exchanger core and wherein the first end has a plurality of first end mating connector openings and the second end has a plurality of second end mating connector openings;
   at least one third-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening;
   at least one first-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening;
   at least one second-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening;
   wherein at least two of the at least one first-type end cap and the at least one second-type end cap have an access opening.

18. A modular heat exchanger as in claim 17, wherein the plurality of interlocking housings each having a heat-exchanging element are connected to provide at least one of a parallel coolant flow path, a series coolant flow path and a mixed parallel and series coolant flow path.
19. A modular heat exchanger as in claim 17, further comprising an o-ring seal interposed between the plurality of end cap mating connectors and at least one of the first end mating connector openings and the second end mating connector openings.

20. A modular heat exchanger as in claim 17, wherein at least one of the first-type end cap open connectors is either a female connector or a male connector.

21. A modular heat exchanger as in claim 17, wherein the plurality of interlocking housings have outer squared off corners to form a planar seal surface for mating parts.

22. A modular heat exchanger as in claim 17, further comprising at least one second-type end cap with a plurality of end cap mating connectors for connection to either a first end mating connector opening or a second end mating connector opening and having at least one second-type end cap open connector, wherein at least one first-type end cap open connector is attached to at least one second-type end cap open connectors.

23. A modular heat exchanger as in claim 22, further comprising an o-ring seal interposed between a portion of the first-type end cap open connector and the second-type end cap open connectors.

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