HEAT EXCHANGER USEFUL AS CHARGE-AIR COOLER FOR COMMERCIAL VEHICLES

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ABSTRACT
The invention relates to a heat exchanger, preferably a charge-air cooler for motor vehicles, comprising: first members defining a plurality of passageways for guiding a first fluid in heat exchange relationship with a second fluid flowing over the outside of the members defining the passageways, and at least one second member forming a part of the heat exchanger structure in contact with either the first or second fluid, wherein at least one of the first members and the second member is comprised of a steel strip bearing at least one surface layer of aluminum and/or a brazing material.
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CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] The right of foreign priority under 35 U.S.C. §119(a) is claimed based on Federal Republic of Germany Priority Application 103 28 748-5, filed Jun. 25, 2003, the entire disclosure of which, including the specification, drawings, claims and abstract, is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The invention relates to a heat exchanger, in particular a charge-air cooler for vehicles.

[0003] Known heat exchangers, in particular for motor vehicles, are usually made from aluminum or aluminum alloys. A heat exchanger of this type, as disclosed for example by DE-A 198 57 435, comprises a heat exchanger grid with fins and corrugated or web-like fins which are arranged between the fins and are brazed to the outer surfaces of the tubes, which are generally flat or rectangular tubes. The ends of the tubes themselves are held in header plates of collector tanks and are brazed to the header plates. For the brazing operation, at least a portion of the parts to be brazed is provided with a layer of brazing material or braze cladding comprising a brazing material alloy, e.g., Al—Si. The tubes of the charge-air coolers have hot charge air flowing through them, and after it has been cooled in the charge-air cooler, this air is fed to the internal combustion engine of the motor vehicle. After it has been compressed, the temperature of the charge air may reach 200 to over 300 degrees Celsius before entering the charge-air cooler. The outer side of the tubes, whose exchange surface area is increased by means of the fins, is cooled by ambient air. The strength of aluminum decreases at temperatures over 150 degrees Celsius, which has adverse effects in particular on the components of a heat exchanger that are directly exposed to such a temperature. One way to satisfy these high demands imposed on the temperature resistance of the material, for example, is to increase the wall thickness of the tubes, but this inevitably leads to an increased weight and also to a drop in the heat conduction, and the drop in strength generally cannot be compensated for completely at an economically viable cost. This problem is not restricted to the above-mentioned type of charge-air coolers with flat tubes, but rather also occurs in the case of aluminum heat exchangers of plate-type or stacked design, in which the flow passages or "tubes" are formed by plates or disks, e.g., as described in DE-A 195 11 991 (corresponding to U.S. Pat. No. 5,931,219, the entire disclosure of which is incorporated by reference herein).

SUMMARY OF THE INVENTION

[0004] Therefore, it is one object of the present invention to improve a heat exchanger of the type described in the introduction with regard to its hot strength, in particular the hot strength of the tubes.

[0005] In particular, it is an object of the invention to improve the hot strength of the heat exchanger components without the weight of the heat exchanger increasing significantly as a result, and to provide that the heat exchanger can, if appropriate, be produced using known processes without significant changes.

[0006] In accomplishing the foregoing objects, there has been provided in accordance with one aspect of the invention a heat exchanger suitable for use as a charge-air cooler for a motor vehicle, comprising: a plurality of first members defining a plurality of passageways for guiding a first fluid in heat exchange relationship with a second fluid flowing over the outside of the members defining the passageways, and at least one second member forming a part of the heat exchanger structure in contact with either the first or second fluid, wherein at least one of the first members and the second member is comprised of a steel strip bearing on one or both surfaces at least one layer selected from aluminum and a brazing material.

[0007] Further objects, features and advantages of the present invention will become apparent from the detailed description of preferred embodiments that follows, when considered together with the accompanying figures of drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] An exemplary embodiment of the invention is illustrated in the drawing and described in more detail in the text which follows, in which:

[0009] FIG. 1 is a cross-section through a steel strip which is coated with aluminum on both sides;

[0010] FIG. 2 is a cross-sectional view through a rectangular tube, coated on the inside and outside; and

[0011] FIG. 3 is a perspective view of an illustrative charge air cooler in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] According to the invention, the tubes, header plates, collector tanks and/or turbulence plates of the heat exchanger are made from a steel strip which is clad or coated with aluminum on one or both sides. The core material of the tube therefore consists of steel, i.e., a high-strength material which retains its strength even at relatively high temperatures. One or both outer sides of the steel strip are provided with a layer of aluminum which, on the one hand, protects the core material from corrosion and, on the other hand, allows the tubes to be brazed to the fins and to the header plate. This improvement to the strength and, in particular, the hot strength of the tube material is virtually neutral in terms of weight, i.e., does not result in a greater tube weight compared to aluminum tubes of greater wall thickness.

[0013] The term "tubes" is in general to be understood as meaning flow passages which can be produced from the aluminum-clad steel strip according to the invention, i.e., for example flat tubes or pairs of disks or plates that form fluid flow passageways between them. The term "steel" is also to be understood as encompassing any equivalent material with a high hot strength. The term "turbulence plate" is also to be understood as meaning a fin, such as, for example, a corrugated fin. The term "header plate" is to be understood as meaning that part of a collection vessel which has openings for receiving the tubes, so that the tubes can be
connected so as to communicate with the collection vessel. The term “aluminum” is intended to include layers of pure aluminum as well as the usual aluminum alloys used to make heat exchangers.

[0014] According to a further independent and advantageous feature to the invention, the core material of the tubes, header plates, collector tanks and/or turbulence plates is likewise steel, coated on both sides with an aluminum brazing material, e.g., clad with an Al—Si alloy. In this case too, the brazing material cladding protects the base material from corrosion and allows it to be brazed to fins and header plates, while at the same time the strength of the tubes is increased.

[0015] According to a further advantageous embodiment of the invention, the layer of aluminum is applied to both sides of the core material. In this context, it is advantageous that the inner side of the tube can also be brazed to further parts, e.g., turbulence inserts. It is therefore possible to produce the same type of heat exchanger or charge-air cooler even though the core material for the tubes has been changed.

[0016] According to a further advantageous embodiment of the invention, the material of the tubes, header plates, collector tanks and/or turbulence plates is produced from a cold strip, i.e., a cold-rolled steel sheet, which has been clad with aluminum on both sides, i.e., the base material and the clad layers are, as it were, produced in a single operation.

[0017] According to a further advantageous embodiments of the invention, the tube can be welded or brazed along a longitudinal seam. This reduces the production costs, for example, compared to extruded tubes.

[0018] According to a further advantageous embodiment of the invention, a layer of brazing material, e.g., a known Al—Si, (aluminum-silicon, alloy) is additionally applied to the layer of aluminum. This allows fins and plates to be brazed to the tubes without the fins and tubes themselves having to be brazed material-clad. It is therefore sufficient for the layer of brazing material to be arranged either on the tubes or on the fins and the header plate to ensure that there is a sufficient supply of brazing material available in the brazing process. Of course, this also applies to the inner sides of the tube and to the brazing of turbulence plates.

[0019] According to a further advantageous embodiment of the invention, the thickness of the layer of aluminum is approximately 4 to 40%, in particular, approximately 8%, of the thickness of the core material, i.e., of the steel strip. This is sufficient for the intended functions, such as corrosion prevention and brazing. A thickness of the aluminum layer of from 0.005 to 0.5 mm, in particular 0.01 to 0.2 mm, is preferred.

[0020] According to an advantageous general aspect of the invention, the composite material that has been coated in accordance with the invention is used to produce heat exchangers, in particular its tubes, header plates, collector tanks and/or turbulence plates. Whereas the majority of the components can be produced from lightweight, brazable or weldable material, a core material with a high hot strength and a corrosion-resistant, brazable or weldable covering is used for the highly stressed components. The overall heat exchanger can therefore be produced in lightweight form with a high hot strength.

[0021] Turning now to the drawings, FIG. 1 shows a cross-section through a coated steel strip 1 which has a relatively thick core layer 2 of steel or a similar material, i.e., a material with similar properties. An aluminum layer or coating 3, 4 is applied on the top surface and also on the bottom surface of the steel strip, i.e., is fusedly joined to the core layer 2. This composite material can be produced by rolling, for example, as a cold strip clad with aluminum on both sides, i.e., a steel sheet is cold-rolled and clad with the layer of aluminum, which may amount to approximately 4 to 40%, in particular 8%, of the wall thickness of the steel strip. In addition, it is also possible for braze cladings, which likewise consist of an aluminum alloy, but alloyed with Si (silicon) or other additives which reduce the melting point, to be applied to one or both of the two layers of aluminum or to one or both sides of the steel strip.

[0022] FIG. 2 shows a tube 5 for a heat exchanger (not shown in more detail), preferably a charge-air cooler, comprising the strip material shown in FIG. 1. The aluminum-coated strip 1 shown in FIG. 1 is shaped in a manner known per se on a roll-forming device to form a tube section, as diagrammatically illustrated in the drawing, and is closed off at its narrow side 5a by a longitudinal weld seam 6 or prepared for subsequent brazing by forming a local overlap in the wall. FIG. 2 uses the same reference numerals as FIG. 1 for corresponding elements.

[0023] It can be seen that the tube 5 is provided with a layer of aluminum 3, 4 on both the inner side and the outer side. In addition, layers of brazing material 7, 8, which may consist of an Al—Si alloy and which are applied by cladding prior to welding of the tube, are preferably, for some uses, applied to both the outer side and the inner side of the tube 5. The tube 5 is used for the grid of the charge-air cooler. Charge air flows through the internal cross section 9 of the tube 5, and ambient air flows on its outer side. Air fins (not shown) are arranged at the longitudinal sides 5b, 5c of the tube 5 and brazed to the tube, which is made possible by the brazing coating 7. The fins, which are made from aluminum, therefore do not themselves have to be provided with a cladding of brazing alloy.

[0024] The internal cross section 9 of the flat tube 5 may be filled by a turbulence plate (not shown) which is brazed to the inner sides of the flat tube by means of the brazing material coating 8. A turbulence plate of this type is advantageous with a view to increasing the heat transfer and the ability to withstand internal pressure (anchoring function) in particular for charge-air tubes. The use of aluminum-coated steel strip for these turbulence plates is likewise advantageous with a view to increasing the ability to withstand internal pressure.

[0025] FIG. 3 shows, in a perspective, partially broken-away view, one preferred embodiment of a heat exchanger suitable for use as a charge air cooler, in accordance with the present invention. The heat exchanger 610 comprises a tank 620 formed from a header plate 630 and a tank cover 640, whereby a chamber 650 for distribution of a first fluid to be cooled, e.g., air, is arranged inside the tank 620. Tubes 670 are inserted through holes 660 of the header plate 630, the tube ends 680 of said tubes illustrating the plural layer structure according to the invention. Via the tube ends 690 opposite said tube ends 680, the tubes 670 discharge into a second tank indicated by a header plate 700, for collection
of the fluid to be cooled. A cooling fluid, e.g. also air, flows through the spacings between the tubes, corrugated fins 710 being arranged in the spacings in order to increase the amount of transferred heat.

[0026] As has already been mentioned, the composite material according to the invention can also be used for any high temperature heat exchanger, as well as for other types of heat exchangers, e.g., for plate-type or (stacked) disk-type heat exchangers. The flow passages are in this case formed by pairs of plates or disks which are brazed to one another on the peripheral side and on the inside are brazed to turbulence inserts and on the outside to fins made from aluminum.

[0027] The foregoing description of preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and modifications and variations are possible and/or would be apparent in light of the above teachings or may be acquired from practice of the invention. The embodiments were chosen and described in order to explain the principles of the invention and its practical application to enable one skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and that the claims encompass all embodiments of the invention, including the disclosed embodiments and their equivalents.

What is claimed is:

1. A heat exchanger suitable for use as a charge-air cooler for motor vehicles, comprising: a plurality of first members defining a plurality of passageways for guiding a first fluid in heat exchange relationship with a second fluid flowing over the outside of the members defining the passageways, and at least one second member forming a part of the heat exchanger structure in contact with either the first or second fluid, wherein at least one of the first members and the second member is comprised of a steel strip bearing on one or both surfaces at least one layer selected from aluminum and a brazing material.

2. A heat exchanger as claimed in claim 1, wherein the first members comprise tubes for guiding the first fluid, and the at least one second member is at least one selected from fins arranged between the tubes and connected to the tubes in a thermally conductive manner, at least one header plate for the tubes, at least one collector tank attached to the header plate, and a turbulence plate.

3. A heat exchanger as claimed in claim 1, wherein the steel strip bears at least one layer of aluminum.

4. A heat exchanger as claimed in claim 3, wherein the layer of aluminum is applied to both sides the steel strip.

5. A heat exchanger as claimed in claim 4, wherein the steel strip is formed as a cold strip clad with Al on both sides.

6. A heat exchanger as claimed in claim 1, wherein the steel strip bears a layer of aluminum and a layer of brazing material applied to the layer of aluminum.

7. A heat exchanger as claimed in claim 1, wherein the thickness of the layer of Al is approx. 4 to 40% of the thickness of the steel strip.

8. A heat exchanger as claimed in claim 7, wherein the thickness of the layer of Al is approx. 8% of the thickness of the steel strip.

9. A heat exchanger as claimed in claim 1, wherein the thickness of the layer of Al is approx. 0.005 to 0.5 mm.

10. A heat exchanger as claimed in claim 9, wherein the thickness of the layer of Al is approx. 0.01 to 0.2 mm.

11. A heat exchanger as claimed in claim 2, wherein the tube is designed as a flat tube and is welded with a longitudinal seam.

12. A heat exchanger as claimed in claim 2, wherein the tube is brazed by means of a longitudinal seam.

13. A heat exchanger as claimed in claim 1, wherein the first members comprise a stack of plates or disks.

14. A heat exchanger as claimed in claim 2, wherein the second member comprises a plurality of fins, and the fins are brazed to the outer sides of the tubes.

15. A heat exchanger as claimed in claim 2, wherein the second members comprise turbulence inserts positioned in the internal cross section of the tubes and which are brazed to the inner side of the tube.

16. A heat exchanger as claimed in claim 1, comprising a charge air cooler for a vehicle.

17. In a motor vehicle of the type embodying a charge air cooler, the improvement comprising the charge air cooler comprising a charge air cooler as defined in claim 16.