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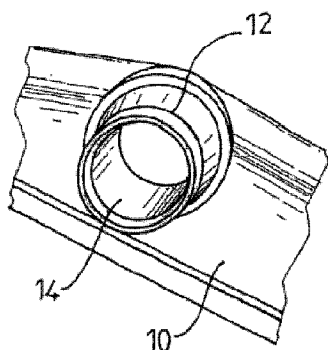
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(54) Title: DEVICE FOR PROTECTING A HEAT EXCHANGER AGAINST CORROSION



(57) Abstract: The invention concerns a device for protecting the aluminum walls of a heat exchanger against corrosion by an aggressive environment to which its walls are subjected. The device comprises at least a renewable sacrificial resist (14) consisting of elements, in particular zinc and/or magnesium elements, adapted to reduce at least locally the electrochemical potential of the aluminum of the heat exchanger walls. The sacrificial resist can be contained either in the heat exchanger or in a fluid circuit comprising the heat exchanger. The invention is particularly applicable to motor vehicle heat exchangers.



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Device for protecting a heat exchanger against corrosion

The invention relates to the field of heat exchangers, in particular for motor vehicles.

It relates more particularly to a device for protecting the aluminum walls of a heat exchanger against corrosion by an aggressive environment to which said walls are subjected.

In this case, the term "walls" is intended to cover various flow channels which include, in a non-limiting manner, the tubes and collector boxes of the exchanger, as well as the connection tubing thereof.

The term "aluminum" is intended to cover both aluminum per se and various alloys thereof.

Heat exchangers of this kind are typically made up of a bundle of tubes connected to one or more collector boxes which define a volume through which a heat transfer fluid passes, most often a liquid which may be or become corrosive.

Liquids, which may be acidic, neutral, or basic, i.e. the pH of which is generally between 2 and 10, typically pass through said exchangers.

This is the case in particular for heat exchangers made of light alloy, used in motor vehicles. In a non-limiting manner, said heat exchangers include engine-cooling radiators, radiators or unit heaters intended for heating the passenger compartment, and, in a more general manner, any heat exchanger in which a liquid flows which may be or become corrosive.

The consequences of such corrosion are particularly damaging when the walls of the exchanger are particularly thin, as is the case in particular for some tubes of the exchanger.

This thus results in risks of leaks which may compromise the functioning of the engine of the vehicle or constitute a danger for the occupants of the vehicle.

Various solutions have already been proposed for solving said problem and protecting the walls, in particular the tubes, made of aluminum, from corrosion.

Up to now, in order to protect the aluminum tubes from corrosion it is necessary to co-laminate, on a strip of aluminum, a protection strip which is capable of protecting the aluminum, and then to form the tubes before brazing them.

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This requires application of another layer of a suitable alloy, i.e. a brazing alloy, onto the other face of the aluminum strip, i.e. onto the face opposite that bearing the protection strip.

Protection of this kind is made possible by modifying the electrochemical potential of the protection strip to below the electrochemical potential of the aluminum, so as to provide cathodic protection. This is generally achieved by introducing zinc or alloys of zinc/aluminum or magnesium/aluminum or zinc/aluminum/magnesium, which reduce (i.e. make more electronegative) the potential of the aluminum alloy of the protection strip from approximately 30 to 200 millivolts.

This known solution requires co-lamination, which complicates the manufacturing methods and increases the thickness of the walls of the tubes. Moreover, this solution requires compatibility between the material of the protection strip and that of the brazing alloy.

Another known solution consists in depositing zinc by thermal spraying directly onto the aluminum strip, which will then be shaped to form a tube.

Another known solution, which is applicable to non-brazed exchangers, consists in co-extruding the aluminum in order to form channels having an interior alloy which will preferably not corrode.

Yet another solution is known which consists in placing a cartridge of silicate-based products either into the heat exchanger itself, or into the circuit of which the heat exchanger is part. Said cartridge can thus be placed either in the engine-cooling radiator or in the cooling circuit itself.

All these known solutions have drawbacks.

This is the case in particular for solutions in which an alloy, forming a protection, is applied to the aluminum walls. Indeed, said alloys which corrode (purposely) are very often of a thickness that is selected so as to be equal to 10% of that of the aluminum wall. However, in the case where the aluminum wall is thin, said alloy does not constitute a sufficient protection resist. This is in particular the case for environments containing large quantities of chlorides (80 to 1000 ppm), copper (1 to 30 ppm), in a neutral environment, or, even more so, in an acidic environment (pH 2 to 6.5), or indeed alkaline (pH 7.5 to 11).

A response to this problem is to increase the thickness of said sacrificial alloy up to 20 or 30% of the thickness of the aluminum wall. Said solution results in an increase of the overall thickness of the wall, without guaranteeing that this thickness will be sufficient to provide the necessary protection.

Another possible response appears to be that of modifying the content of the sacrificial element, but in this case, too, this is not well controlled, since the percentages, for example of zinc, vary from 0.8% to 5%, indeed 15%. In the case of such percentages, problems arise relating to the diffusion of the zinc in the case of brazed exchangers, and also problems relating to the recyclability of these alloys.

Moreover, lowering the potential of this layer in particular increases the dissolution speed thereof, as soon as it contains cracks, scratches, or other damage which allows for corrosive liquid to come into direct contact.

Furthermore, in the case of cartridges based on silicate products, which are inhibitors of aluminum corrosion, the protection is no longer ensured in acidic environments, since the silicate is unstable and precipitates in the form of inert silica.

The invention in particular aims to overcome the disadvantages above, by proposing an effective device for protecting the aluminum walls of a heat exchanger against corrosion by an aggressive environment.

It aims in particular to provide a device of this kind which prevents recourse to an anticorrosion alloy which is applied, for example co-laminated, onto the walls of aluminum tubes.

It furthermore aims to provide a protection device of this kind which is compatible with all types of heat exchangers, whether these be brazed heat exchangers, or heat exchangers obtained by mechanical assembly.

For this purpose, the invention proposes a protection device of the type defined above, which comprises at least a renewable sacrificial resist formed of elements capable of reducing at least locally the electrochemical potential of the aluminum of the heat exchanger walls.

Said resist is preferably entirely immersed in the aggressive environment, so that the entirety

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of the resist can be consumed.

By way of example, said elements may comprise zinc and/or magnesium.

In one embodiment, the sacrificial resist is contained in the heat exchanger. Said heat exchanger may be formed, for example, by a cooling radiator of a motor vehicle engine.

In another embodiment, the sacrificial resist is contained in a fluid circuit which comprises the heat exchanger. This may for example be the cooling circuit of a motor vehicle engine.

Said renewable sacrificial resist is intended to provide an introduction of elements, for example zinc and/or magnesium, in a quantity much greater than the quantity theoretically required for the protection, such that said elements are sacrificed, i.e. progressively disappear.

In this case, the term "renewable" is intended to refer to a resist which is capable of being recharged with sacrificial elements.

As said elements are present in a largely sufficient quantity, the protection will always be ensured, without risk of exhaustion of the elements making up the resist.

The elements in question advantageously comprise zinc and/or magnesium. In this case they may in particular be zinc alloys, magnesium alloys, or indeed alloys of zinc and magnesium.

The sacrificial resist may be present in different forms.

It may in particular be present in the form of discrete elements, in particular in the form of a powder, granules, pellets, etc.

It may also be present in the form of continuous elements, in particular in the form of plates or inserts, having a thickness of from 0.1 to 30 mm.

The elements of the sacrificial resist are advantageously contained in a receptacle that is permeable to the aggressive environment. As a receptacle in particular a sachet or a cartridge is envisaged, advantageously made of stainless steel and/or plastics material, comprising passage openings for the aggressive environment.

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It is also conceivable for the elements of the sacrificial resist to be contained in a recess of the heat exchanger which is exposed to the aggressive environment.

In another embodiment, the elements of the sacrificial resist are contained in a paint that is applied to an inside wall of the heat exchanger. A paint of this kind advantageously contains more than 80 wt. % of dry extracts of elements, in particular zinc and magnesium.

According to one embodiment, the sacrificial resist is placed in a selected location of the heat exchanger. It can be contained in a reservoir, in particular in a collector box, of the heat exchanger. It can also be contained in tubing of the heat exchanger.

According to another embodiment, the sacrificial resist is contained in a fluid circuit which comprises the heat exchanger.

The device of the invention offers various advantages compared with the known solutions of the prior art.

One of these advantages is to not cause any problem during manufacture of heat exchangers requiring a brazing operation and/or mechanical assembly.

Another advantage is associated with the fact that the more aggressive the environment, in particular in the case of an acid or alkaline pH, the more the sacrificial resist will corrode and will bring ions of elements, for example zinc and/or magnesium, to the surface of the aluminum, where it is necessary to protect it.

Without wishing to be bound to a particular theory, the presence of the sacrificial resist means that said resist corrodes, firstly bringing ions of elements, for example zinc and/or magnesium, to the surface of the aluminum, where it is necessary to protect it.

Another advantage of the invention is that all the ions which form mini-cathodes on the aluminum, i.e. which accelerate the corrosion speed thereof, in particular in the form of pittings, will be trapped by the sacrificial resist, because this has a much more electronegative potential than the alloys described above used as a protection strip on the aluminum tubes.

The ions which form micro-cathodes are, in a non-limiting manner, iron, copper, tin, silver,

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etc.

According to another aspect, the invention relates to a heat exchanger comprising a protection device as defined above. It also relates to a fluid circuit comprising a heat exchanger and a protection device as defined above.

In the following description, given merely by way of example, reference is made to the accompanying drawings, in which:

- Fig. 1 shows a collector box of a heat exchanger provided with tubing in which a protection device according to the invention is placed;
- Fig. 2 shows a portion of a collector box of a heat exchanger comprising a device according to the invention designed in the form of an insert or a cartridge;
- Fig. 3 is a cross-sectional view of a collector box of a heat exchanger in which a protection insert or cartridge is placed; and
- Fig. 4 is a cross-sectional view of a collector box of a heat exchanger comprising a protection device according to the invention designed in the form of a paint applied to the inside wall of the collector box.

Reference is first made to Fig. 1 which shows a collector box 10 of a heat exchanger, in particular of a motor vehicle, to which tubing 12 intended for inlet or outlet of a heat transfer fluid is connected.

By way of example, the collector box 10 may form part of a cooling radiator of a motor vehicle engine, through which the engine-cooling liquid passes. Said radiator forms part of a fluid circuit, in this case a cooling circuit, through which the above-mentioned cooling liquid passes.

In order to avoid any risk of corrosion, a sacrificial resist 14, in this case in the form of a tubular insert applied against the inside wall of the tubing 12, is provided inside the tubing 12. Given the location thereof, the insert is completely soaked by the cooling liquid.

Said insert is formed of a renewable sacrificial resist made up of elements capable of reducing at least locally the electrochemical potential of the aluminum of the heat exchanger walls. By way of example, said insert may be formed of zinc and/or magnesium. It may in particular be a zinc alloy, a magnesium alloy, or indeed an alloy of zinc and magnesium.

Reference is now made to Fig. 2 which shows a collector box 10 of an elongate design, in

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which another sacrificial resist 16 according to the invention is placed. Said resist 16 may be formed as an insert that is applied against the inside wall of the collector box, or indeed in the form of a cartridge that is filled with discrete elements, for example granules.

In the case of zinc and/or magnesium elements it is possible to use either a zinc and/or magnesium insert, or a cartridge filled with zinc and/or magnesium granules.

Reference is now made to Fig. 3 which shows another collector box 10, having a generally U-shaped cross section, of a heat exchanger. A sacrificial resist 18 according to the invention is placed inside the collector box. In the example, said resist is formed as an insert or a cartridge containing discrete elements, in particular granules. As is the case in Fig. 2, the insert may in particular be based on zinc and/or aluminum, and the cartridge may in particular contain zinc and/or aluminum granules.

Reference is now made to Fig. 4 which shows another collector box 10 of a heat exchanger, also having a generally U-shaped cross section.

A paint 20 preferably containing more than 80% dry extracts of sacrificial resist elements, for example zinc and/or magnesium elements, is applied to the inside of the U-shaped wall.

In the case of a cartridge as shown in Fig. 2 and 3, said cartridge will be made of a stainless material, for example stainless steel and/or plastics material, and will comprise passage openings for the aggressive environment.

It must be understood that, in place of using a cartridge, it is possible to use any other form of receptacle, for example a sachet, providing passage openings for the aggressive environment.

Likewise, the sacrificial resist may be placed at any other location of the heat exchanger, for example in reservoirs, protrusions, or other recesses which a heat exchanger may define.

In a variant, the sacrificial resist may be placed in a circuit comprising the heat exchanger.

Whatever the location thereof, the sacrificial resist is capable of being completely immersed in the aggressive environment.

The invention will now be described with reference to the following comparative tests.

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Comparative tests were carried out on a test loop in which a heat exchanger made of aluminum alloy and comprising thin-walled channels (in particular tubes) was inserted. These comparative tests have been carried out with and without the device of the invention.

A heat transfer liquid flowed in the test loop, at a temperature of approximately 90°C and containing approximately 200 mg per liter (200 ppm) chloride ions, 1 ppm copper ions, and sufficient ferrite ions to reduce the pH to approximately 3.

A protection device according to the invention in the form of granules of approximately 3 to 5 mm length and 1.5 to 3 mm width, contained in a sachet made of stainless steel and having meshes of approximately 1 mm opening was used.

Said sachet was placed in an appropriate location of the heat exchanger, preferably in a collector box.

The test was carried out over 500 hours. After this testing time had expired, no piercing of the heat exchanger was identified. Inspection of the exchanger made it possible to demonstrate attacks of which the depth was less than a micrometer, i.e. not capable of compromising the proper functioning of the heat exchanger.

The same test, carried out using a heat exchanger without the device of the inspection, had to be stopped after approximately 100 hours on account of leaks due to piercing.

Claims

1. Device for protecting the aluminum walls of a heat exchanger against corrosion by an aggressive environment to which said walls are subjected, characterized in that it comprises at least a renewable sacrificial resist (14, 16, 18, 20) formed of elements capable of reducing at least locally the electrochemical potential of the aluminum of the heat exchanger walls.
2. Device according to claim 1, characterized in that the elements comprise zinc and/or magnesium.
3. Device according to either claim 1 or claim 2, characterized in that the sacrificial resist is present in the form of discrete elements, in particular in the form of a powder, granules or pellets.
4. Device according to either claim 1 or claim 2, characterized in that the sacrificial resist is present in the form of continuous elements, in particular in the form of plates or inserts.
5. Device according to either claim 3 or claim 4, characterized in that the elements of the sacrificial resist are contained in a receptacle that is permeable to the aggressive environment.
6. Device according to claim 5, characterized in that the receptacle is a sachet or a cartridge, advantageously made of stainless steel and/or plastics material, comprising passage openings for the aggressive environment.
7. Device according to either claim 3 or claim 4, characterized in that the elements of the sacrificial resist are contained in a recess of the heat exchanger which is exposed to the aggressive environment.
8. Device according to claim 1, characterized in that the elements of the sacrificial resist are contained in a paint that is applied to an inside wall of the heat exchanger.
9. Device according to claim 8, characterized in that the paint contains more than 80 wt.% of dry extracts of elements, in particular zinc and magnesium.

10. Device according to any of claims 1 to 9, characterized in that the sacrificial resist is contained in a reservoir, in particular in a collector box (10), of the heat exchanger.
- 5 11. Device according to any of claims 1 to 9, characterized in that the sacrificial resist is contained in tubing (12) of the heat exchanger.
12. Device according to any of claims 1 to 6, characterized in that the sacrificial resist is contained in a fluid circuit comprising the heat exchanger.
- 10 13. Device according to any of the preceding claims, characterized in that the sacrificial resist is entirely immersed in the aggressive environment, so that the entirety of the resist can be consumed.
- 15 14. Heat exchanger, in particular for a motor vehicle, comprising a protection device according to any of claims 1 to 11 and 13.
15. Fluid circuit, in particular cooling circuit for a motor vehicle, comprising a heat exchanger and a protection device according to any of claims 1 to 6 and 12 to 13.

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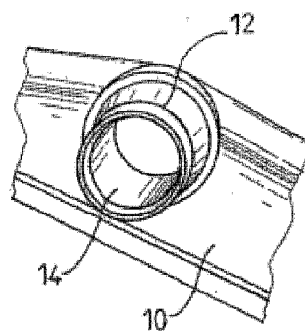


FIG. 1

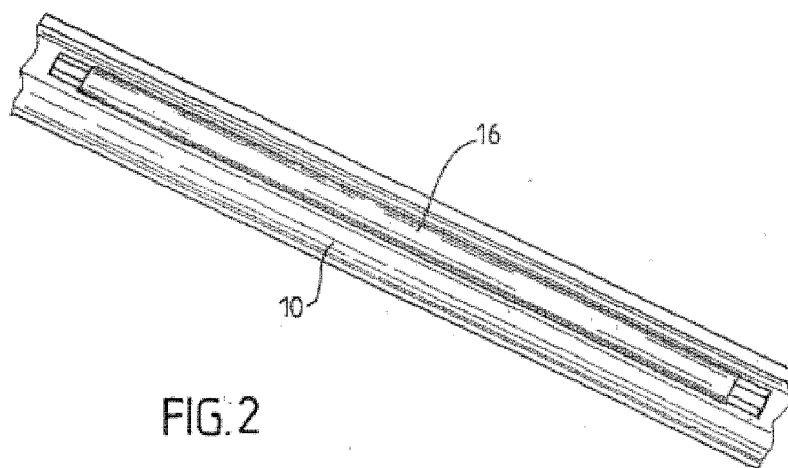


FIG. 2

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FIG. 3

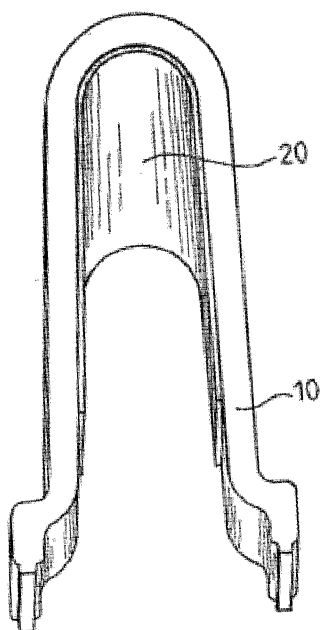
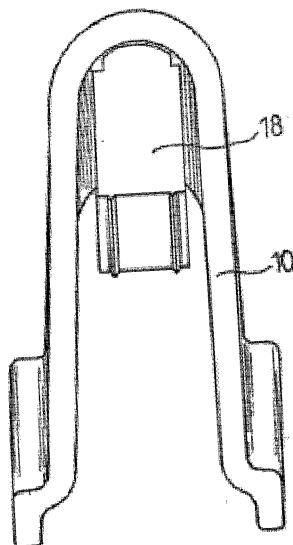


FIG. 4