METHOD FOR BONDING AN ALUMINUM RIB TO A STEEL PIPE AND HEAT EXCHANGER HAVING A UNIT PRODUCED IN THIS WAY

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ABSTRACT
The invention relates to a method for bonding an aluminum rib to a steel pipe, a surface coating material of the steel pipe being used as the bonding material, so that supplying a separate soldering material, for example, may be dispensed with. The invention additionally relates to a heat exchanger which comprises a unit made of steel pipe and aluminum rib produced according to the method.
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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority document 07020245.2 filed in Europe on Oct. 16, 2007, the entire contents of which are incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention
[0003] The invention relates to a method for bonding an aluminum rib to a steel pipe. Furthermore, the invention relates to a heat exchanger, preferably a condenser and in particular an air-cooled condenser, for industrial facilities and in particular for power plants, which comprises a unit or module produced according to the method.

[0004] 2. Description of Related Art
[0005] Heat exchangers of the relevant type typically have, as described, for example, in EP 1 553 379 A1, a distributor pipe (preferred embodiment as a single-pipe system; SPS), whose external surface is at least partially provided with cooling ribs. The heat exchange (energy exchange process) occurs in that a first medium (or fluid) flowing through the distributor pipe and cooling down dissipates its heat into the cooling ribs surrounding the distributor pipe, which have a second medium or fluid, such as coolant air or coolant gas in particular, flowing around them, the heat being discharged to this second medium. A heat exchange is also possible in the reverse direction, of course.

[0006] If the first medium to be cooled is in a gaseous state upon entry into the heat exchanger, depending on the cooling gradient, condensation thereof may be achieved. Therefore, heat exchangers of this type are also used as condensers. In power plants, such condensers are used to condense the exhaust steam of steam turbines. Increasing water shortages and/or rising costs for the purchase and provision of coolant water have had the result that air-cooled condensers (ACC) are used ever more frequently in power plants in particular. However, using such heat exchangers in cooling devices in industrial facilities of the chemical and food industries is also known.

[0007] The distributor pipe (only pipe hereafter) is typically a steel pipe. This steel pipe is typically implemented as coated with a metal having good heat conduction, such as aluminum in particular. The cooling ribs themselves also essentially comprise aluminum. In addition to the good heat conductivity already mentioned, this offers the further advantage of saving weight, because the air-cooled heat exchangers or condensers, which are typically quite large, would otherwise be too heavy, which would result in disadvantages for transport and mounting.

[0008] The bond between pipe and aluminum cooling ribs is produced in a soldering process. For this purpose, the pipe is aluminum plated (typically already at the producer) and bonded to the aluminum ribs at a soldering temperature of approximately 600°C. For this purpose, the pipe must be heated up and cooled down again after the soldering procedure, however. Such a method therefore has a high power demand and/or power consumption. Furthermore, the different coefficients of thermal expansion are also problematic, which may result in warping tensions, whose prevention requires a complex process control.

DE 100 57 180 A1 makes suggestions to solve some of these problems. The provided suggestions result in heat exchangers having poor efficiencies, however.

BRIEF SUMMARY OF THE INVENTION

[0010] The object of the invention is to specify a method for bonding an aluminum rib to a steel pipe, which has a lower power demand. It is also the object of the invention to specify a heat exchanger (of the type cited at the beginning) having high efficiency, for whose production a lower power demand is required than in the prior art. Both the method and also the heat exchanger are additionally to allow cost-effective maintenance of the manufacturing.

[0011] This object is achieved by a method according to Claim 1, by a heat exchanger according to the first concurrent claim, and by the specified use according to the second concurrent claim. Advantageous refinements and embodiments are the subject matter of the particular dependent claims.

[0012] The method according to the invention for bonding an aluminum rib to a steel pipe comprises at least the following steps:

[0013] providing at least one first component in the form of a surface-coated steel pipe,
[0014] providing at least one second component in the form of an aluminum rib,
[0015] bringing these components into contact, and
[0016] heating these components to a temperature between 470°C and 590°C, preferably to a temperature between 550°C and 585°C, and subsequently holding at this temperature (solder persistence temperature) and/or in this temperature range for a predefined period of time, a permanent bond, more precisely a soldered bond occurring on at least one contact point of the components, in which the material of the surface coating of the first component is used as a bonding material, more precisely as a soldering material.

[0017] An aluminum rib is understood in the meaning of the invention as a flat element formed from aluminum, which is capable of or suitable for heat discharge to a medium flowing past. Concretely, this may be a cooling rib of a typical construction.

[0018] The method according to the invention is based on the finding that the persistence temperature, which corresponds to the soldering temperature and/or solder persistence temperature, may significantly decrease, i.e., by at least approximately 10%, if the surface coating of the first component has a melting temperature which is below the currently typical soldering temperature of 600°C. An advantageous increase of the temperature interval to the softening temperature of the aluminum thus results.

[0019] Upon heating of the components brought into contact with one another, the surface coating already begins to melt at least partially significantly below the currently typical soldering temperature of 600°C, it being provided according to the invention that the molten surface coating is then used as a soldering material. This offers the advantage that a separate supply of a soldering material may be dispensed with. Because of the lower soldering temperature, there are also power consumption savings, which are accompanied by lower costs (cost-effectiveness aspect) and a lower environmental strain (the power consumption is in direct correlation to the persistence temperature). In addition, improved dimen-
sional accuracy may thus be achieved, because fewer warping tensions are caused due to the lower temperatures. In addition, a shortening of the actual soldering time or the holding time has resulted as a further advantage, by which the output of the furnace (soldering furnace) may be increased.

According to the invention, the surface coating is only to be applied to the first component (pipe) and not to the second component (aluminum rib).

The range for the soldering temperature and/or the concrete soldering temperature is oriented depending on the surface coating material for the first component. A higher aluminum proportion in the coating material does require a high soldering temperature, but then also results in improved heat conduction at the contact points (lower heat conduction resistance). It is therefore preferably provided for the method according to the invention that the surface coating for the first component has an aluminum proportion of greater than 20 wt.-%. Furthermore, it is preferably provided that the second component (aluminum rib) is formed from pure aluminum. This ensures good heat conduction and high efficiency for the heat transfer. Pure aluminum is understood in the meaning of the invention as an aluminum component of at least 99.5 wt.-%.

In such a preferred method design, the advantages accompanying the invention arise particularly clearly. At reduced power demand (in relation to the prior art), especially good heat conduction is achieved between first component and second component, which results in a high efficiency for the heat transfer between the media.

An advantageous refinement of the method provides that a flux is applied at least in the area of the contact point. This is preferably a flux based on cesium and in particular a flux based on cesium-aluminum-fluoride (CaAlF). The flux is to ensure optimum flow and wetting properties upon heating, in that it prevents the oxidation of the surfaces of the joint partner and the solder on the one hand and decreases the surface tension of the liquid solder and/or the molten surface coating on the other hand. The flux is preferably applied before the heating.

Another refinement of the method provides that the components are cooled in a controlled way after the bonding or joining, i.e., as predefined by a time-temperature curve. The above-mentioned warping tensions may thus be reduced, which result in heat warping and disadvantageously impair the dimensional accuracy of the produced unit or module. Alternatively, removal and cooling at room temperature are also possible, in particular if the soldering temperature is comparatively low.

According to an especially preferred refinement, the coating for the first component has an aluminum proportion of greater than 30 wt.-%, preferably greater than 40 wt.-%, and in particular a proportion of 55 wt.-% and the remaining proportion is essentially zinc (Zn). The soldering temperature (or heating or solder persistence temperature) is between 550°C and 585°C in these cases, and is 575°C in particular.

According to another preferred refinement, the first component is zinc electroplated or hot-dip galvanized. In this case, the aluminum proportion is approximately 4 to 5 wt.-%. The main component of the coating is then formed by zinc (in addition to small quantities of lanthanum, silicon, and the like). In this case, the soldering temperature is in the lower range of the claimed temperature scale, i.e., at approximately 470°C. Very good results may also be achieved at 450°C.

The object is also achieved by a heat exchanger according to the features of the first concurrent claim.

The heat exchanger according to the invention comprises a unit made up first and second components, produced according to the method according to the invention. The first component (steel pipe) is implemented for this purpose as a flat pipe, preferably a sheet steel flat pipe.

In particular, the heat exchanger according to the invention has at least one first component made of a steel material in the form of a surface-coated flat pipe, the surface coating preferably having an aluminum proportion of greater than 20 wt.-%, especially preferably greater than 40 wt.-%, and in particular a proportion of exactly 55 wt.-% (plus a typical tolerance range). Furthermore, the heat exchanger according to the invention has at least one second component in the form of an aluminum rib, this preferably being an aluminum rib made of pure aluminum. The two components are permanently materially bonded to one another on at least one contact point, the surface coating of the first component being used as the bonding or soldering material.

In a preferred refinement, the second component (aluminum rib) is bonded to the flat pipe along a flat section thereof.

According to another preferred refinement, the second component at least sectionally encloses, preferably completely encloses the flat pipe around its circumference. In this way, in addition to the material bond between the components, a form fit is also provided, so that the produced unit or module has a high mechanical stability in spite of light construction.

In another preferred refinement, the heat exchanger is a condenser.

According to the second concurrent claim, the object is additionally achieved by the use of a unit produced according to the method according to the invention for a heat exchanger, preferably for an air-cooled heat exchanger, especially preferably for an air-cooled condenser, which is implemented in particular as a single-pipe system, for use in power plants. The unit produced according to the method according to the invention proves to be especially advantageous for such a use in particular. In this way, a heat exchanger may be provided which on the one hand has a high efficiency (as a result of the aluminum ribs and the higher aluminum proportion in the bonding material) and on the other hand is producible in a power-saving and cost-effective manner.

1. A method for bonding an aluminum rib to a steel pipe comprising the following steps:
   - providing at least one first component in the form of a surface-coated steel pipe, the surface coating preferably having an aluminum proportion of greater than 20 wt.-%,
   - providing at least one second component in the form of an aluminum rib,
   - which preferably comprises pure aluminum, bringing these components into contact, heating and subsequently holding these components in a temperature range between 470°C and 590°C, preferably in the range between 550°C and 585°C, a permanent bond occurring on at least one contact point of the components, in which the material of the surface coating of the first component is used as a bonding material.

2. The method according to claim 1, characterized in that, preferably before the heating, a flux is applied at least in the
area of the contact points, this being a flux based on cesium and in particular a flux based on cesium-aluminum-fluoride.

3. The method according to claim 1, wherein the unit formed by the joining of the components is cooled down in a controlled manner after the joining.

4. The method according to claim 3, wherein the coating for the first component has an aluminum proportion of greater than 30 wt.-%, preferably greater than 40 wt.-%, and in particular a proportion of 55 wt.-%, and the remaining proportion is essentially zinc.

5. The method according to claim 4, wherein the heating temperature for bonding is 575°C.

6. A heat exchanger having a unit produced according to a method according to claim 5, wherein the first component is a flat pipe.

7. The heat exchanger according to claim 6, wherein the second component is connected to the flat pipe along a flat section thereof.

8. The heat exchanger according to claim 6, wherein the second component at least sectionally encloses, preferably completely encloses the flat pipe around its circumference.

9. The heat exchanger according to claim 8, wherein it is a condenser.

10. A use of a unit produced according to the steps according to claim 1 for a heat exchanger, preferably for an air-cooled heat exchanger, especially preferably for an air-cooled condenser, which is implemented in particular as a single pipe system, for use in power plants.

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