(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 583 048 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
18.04.2018 Bulletin 2018/16

(21) Application number: **11770192.0**

(22) Date of filing: **15.06.2011**

(51) Int Cl.:
F28F 19/06 *(2006.01)*

(86) International application number:
PCT/SE2011/050737

(87) International publication number:
WO 2011/159238 (22.12.2011 Gazette 2011/51)

(54) **HEAT EXCHANGER WITH IMPROVED CORROSION RESISTANCE**

KORROSIONBESTÄNDIGER WÄRMETAUSCHER

ÉCHANGEUR DE CHALEUR RESISTANT AU CORROSION

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **15.06.2010 SE 1050608**

(43) Date of publication of application:
24.04.2013 Bulletin 2013/17

(73) Proprietor: **Alfa Laval Corporate AB**
221 00 Lund (SE)

(72) Inventors:
- **NILSSON, Mats**
  S-226 47 Lund (SE)
- **NILSSON, Maribel**
  N-1384 Asker (NO)
- **BERGH, Jesper**
  S-237 41 Bjärred (SE)

(74) Representative: **Alfa Laval Attorneys**
Alfa Laval Corporate AB
Patent Department
P.O. Box 73
221 00 Lund (SE)

(56) References cited:
DE-A1-102008 013 358
GB-A- 933 295
GB-A- 1 202 936
US-A- 4 140 172

EP 2 583 048 B1

Printed by Jouve, 75001 PARIS (FR)

Description

Field of the Invention

[0001] The present invention relates to a plate package for a plate heat exchanger and a plate heat exchanger with improved corrosion resistance.

Background

[0002] WO 96/06705 discloses a plate package having the features in the preamble of claim 1. DE 10 2008 013358 A1 and GB 933295 A disclose plate heat exchangers having coatings. Plate heat exchangers may be used for different types of fluids.

[0003] However, some fluids are considered very corrosive. When heat exchanging at least one corrosive fluid the demands on the heat exchanger increases.

[0004] Today the choice is often between materials which may corrode giving a short life time of the plate heat exchanger with a risk of contaminating the fluid or a heat exchanger made of a more corrosion resistant material, the latter being very expensive in comparison. Unfortunately, several materials that are considered corrosion resistant are not able to be used for all parts of permanently assembled plate heat exchangers since the materials used are unable to give satisfying permanent joining. Brazed plate heat exchangers may be made of a corrosion resistant plate material but the brazing material is a less corrosion resistant material thus constituting an obstacle for the heat exchangers to be used in connection with certain liquids or gases. Then the brazing technique itself may mix plate material and brazing material during assembly of the heat exchanger giving rise to more easily corroding areas.

[0005] Also, corrosion resistant materials that can be applied to the plates of a heat exchanger before assembly can make it difficult or impossible for such a heat exchanger to achieve satisfying permanent joining with good anti-corrosion properties.

[0006] Coating materials like plastics are considered not enough fatigue and corrosion resistant for highly corrosive fluids. The stress put on a plastic coating on a plate of a plate heat exchanger e.g. in the form of high pressures and/or high temperatures also makes the coating degrade and/or lose its adhesion to the plate. Also, high pressure differences and high temperature differences during use of a plastic coated heat exchanger may cause the coating to degrade and e.g. flake. Plastics also exhibit inferior thermal transmittance properties compared to metals which a plate heat exchanger is made of.

[0007] Tantalum is a very corrosion resistant metal towards many fluids and it is known to make heat exchangers of this metal. However, tantalum is an expensive metal and is mechanically considerably weaker than other known materials for use in heat exchangers such as stainless steel. Thus, thicker plates must be used to withstand the mechanical stress put on a heat exchanger made of tantalum.

[0008] WO 92/16310 discloses a method of surface protecting heat transfer plates in a heat exchanger using plastics as a surface protecting material. According to the method a gaseous medium containing the plastics is introduced into the assembled plate heat exchanger which then forms a layer on the surfaces of the heat exchanger plates.

[0009] GB 1,112,265 discloses tubular heat exchangers in contact with highly corrosive media. In the document it is disclosed that mounting plates may be coated or lined with tantalum and the tubes may be made of tantalum.

[0010] WO 96/06705 discloses fully brazed heat exchangers which are resistant to corrosive media due to the brazing joints between the plates are protected by a coating resisting the corrosive media. The plates are made of stainless steel, the solder is copper solder and the protective coating intended to cover the brazing joints is a metal such as tin or silver.

[0011] US 2010/0051246 discloses a high-temperature and high-pressure corrosion resistant process heat exchanger, wherein the third system coolant channel surfaces of the heat transmission fin and heat transmission plate, which come in contact with sulphuric acid and/or sulfite, are subjected to ion beam coating and ion-beam mixing using a material having high corrosion resistance such as SiC, Al_2O_3, silicon steel and tantalum.

[0012] JP 4,334,205 discloses a plate heat exchanger with plates made of titanium, stainless steel, copper, nickel or alloys thereof. In order to suppress elution of electrode material from a plate a coating treatment is performed on at least 30% of the heat transfer plate electrode areas by the side of a cooling water passage. The coating may comprise platinum metal oxide, manganese, tantalum, tin etc.

[0013] EP 110,311 discloses a flat heat-exchange plate comprising two plates which may be surface coated with tantalum or a tantalum alloy and at least one duct. The two plates are attached to each other to form the flat heat-exchange plate by use of an adhesive coat.

[0014] It would be desirable to find new ways to ensure more corrosion resistant heat exchangers in order to be able to process highly corrosive media and increase the life time of the heat exchangers. It is also desirable to be able to produce corrosion resistant heat exchangers from cheaper base materials that have good mechanical properties and are easily and effectively permanently assembled. It would also be desirable that all parts of a heat exchanger, e.g. both plates and joints, which are in contact with a highly corrosive fluid are equally highly corrosion resistant. Further, it would be desirable to achieve more fatigue and corrosion resistant internal parts of heat exchangers in contact with highly corrosive fluids. It would also be desirable to find corrosion and fatigue resistant materials applied on the inside of a plate heat exchanger, which materials show good adhesion. Still further, it would be desirable to achieve a good or improved heat transfer in the plate heat exchanger.

Summary of the invention

[0015] It is an object of the present invention to solve the above mentioned problems. Thus, it is an object of the present invention to provide good mechanical properties and high corrosion resistance of all parts of a heat exchanger in contact with highly corrosive fluids. It is also an object of the present invention that good heat transfer is obtained.

[0016] This object is achieved by a permanently joined plate package for a plate heat exchanger being coated with a tantalum containing coating everywhere on the inside, such as both plates and joints, in at least one flow side of the plate package. By applying a coating comprising tantalum highly corrosive media such as hydrochloric acid can be used in a plate heat exchanger without a rapid degradation of the heat exchanger.

[0017] The present invention relates to a permanently joined plate package for a plate heat exchanger made of stainless steel or carbon steel wherein at least all surfaces in contact with media of at least one of the flow sides of the plate package have an alloy bonded coating of a tantalum containing compound. The present invention also relates to a plate heat exchanger comprising said plate package.

[0018] One embodiment of a plate heat exchanger according to the present invention include the heat exchanger having frames and/or mounting plates that are a part of at least one of the flow sides of the heat exchanger and said frames and/or mounting plates are made of tantalum, or stainless steel or carbon steel having an alloy bonded coating of a tantalum containing compound, preferably stainless steel or carbon steel having an alloy bonded coating of a tantalum containing compound, more preferably stainless steel having an alloy bonded coating of a tantalum containing compound.

[0019] Another embodiment of a plate heat exchanger according to present invention is when the plate heat exchanger is permanently joined and is made of stainless steel or carbon steel and all surfaces of at least one of the flow sides of the plate heat exchanger have an alloy bonded coating of a tantalum containing compound.

Detailed description of the invention

[0020] A conventional permanently joined plate package or plate heat exchanger may be made more corrosion resistant than it was from the beginning with the present invention.

[0021] A plate heat exchanger is composed of multiple, thin metal plates that have very large surface areas and fluid flow passages which may enable heat transfer. A heat exchanger is provided with at least two inlets and two outlets for the fluids to be heat exchanged. Additional fluids may be used then requiring additional inlets and out lets of the heat exchanger. Plate heat exchangers comprise a series of heat transfer plates. These heat transfer plates form what is called a plate package in the heat exchanger. The heat transfer plates are made of thin sheets of metal and are often provided with corrugations or other protuberances in their heat transferring portions, which in a heat exchanger abut against each other by a large force at a great number of contact places distributed across the heat transferring portions. Then the heat transfer plates are assembled interspaces are formed between the plates. These plate interspaces are intended for at least one heat exchanging fluid flowing through. In a plate heat exchanger the at least two fluids are flowing through the interspaces next to each other allowing the heat transfer to take place. These interspaces between the plates intended for flow of one of the fluids is in the present application considered as being part of a flow side. In the present application the wording flow side is connected to the construction of a heat exchanger or plate package for the fluids, i.e. the fluid flow passages. Since at least two fluids are used in a plate heat exchanger, it has has at least two flow sides, one flow side for a warm fluid and one flow side for a cold medium. For each flow side, all parts of a plate package or a heat exchanger being in contact with either the warm or cold flowing fluid are considered belonging to that flow side, e.g. plates, plate interspaces, joints, connections, inlet and/or outlet ports in frames or mounting plates. In a plate package or plate heat exchanger according to the present invention at least one of the flow sides is designed for highly corrosive fluids when in use.

[0022] With the present invention simple rigid base materials for heat exchangers such as stainless steel, copper and carbon steel can be used and with a tantalum containing coating be made corrosion resistant to highly corrosive fluids. With the present invention also other parts of the plate package or heat exchanger like the joints which may be more sensitive parts of the plate heat exchanger due to e.g. welding during the assembly of the heat exchanger are coated with a corrosion resistant material. The joints may also be sensitive parts of the heat exchanger due to soldering, fusion bonding or brazing during assembly of the heat exchanger. The term fusion bonding relates to the use of an iron based brazing material in accordance with the disclosures of e.g. EP 1 347 859 B1 and WO 02/098600. Assembly of a heat exchanger using soldering, fusion bonding or brazing the joints may be made of a different material than the plates. During the assembly process the soldering or brazing material is applied to the plates, fully or partially covering the plates, and the soldering or brazing material may during the assembly be mixed with additional coatings on the plate material or in some cases even the plate material itself creating more corrosion sensitive parts of the heat exchanger. Since at least both plates and joints of a plate package or plate heat exchanger according to the present invention are coated the heat exchanger is made more corrosion resistant. Thus, in this way the joints or areas on the plates close to the joints can no more be a weak link for the heat exchanger.

[0023] In one embodiment of the present invention permanently assembled plate heat exchangers or plate packages for plate heat exchangers made of stainless steel or carbon steel are coated with a tantalum containing compound. The plate packages or heat exchangers may e.g. be permanently assembled by welding, soldering, fusion bonding or brazing. A tantalum containing compound is introduced into the heat exchanger in at least those plate interspaces being intended for through flow of one of the two heat exchanger fluids, i.e. at least one of the flow sides designated for being used for highly corrosive fluids when in use. Inside the heat exchanger or plate package, the tantalum containing compound is deposited on all surfaces of at least one of the flow sides of the heat exchanger or plate package, e.g. plates, joints and other parts intended to be in contact with heat exchanger fluids.

[0024] The use of a tantalum containing compound according to the present invention provides a plate package or plate heat exchanger with very good properties. Tantalum shows better heat transfer properties then plastics which are not considered thermally conductive materials. According to the present invention it is important to be able to present a coating or layer which does not impair the heat transfer. Tantalum shows good heat transfer properties. Further, the tantalum containing coating according to the present invention is chemically bonded to the materials of the plate package and plate heat exchanger. The tantalum containing compound is bonded by alloying to said materials. In this context an alloy bonding is a metallic solid solution composed of two or more elements from two or more different metal bodies composed of different materials, in the present invention tantalum and the plate material, e g stainless steel, copper or carbon steel, in an interface layer between the bodies. Such an alloying bonding give rise to more fatigue resistant plate packages and heat exchangers compared to e. g. heat exchangers coated with plastic materials. Since the tantalum is partially alloyed to the material the adhesion is superior. This makes it easy for the tantalum containing coating to follow the plate and joint materials movements due to thermal and pressure changes within the plate heat exchanger when going form out of use to use and also during use. The tantalum containing coating has a gradual transition of compounds within itself. When looking at the tantalum containing coating in a cross cut view, the intermediate phase closest to the heat exchanger material, e.g. a plate, show an alloy of tantalum containing compound and the plate material, a gradual transition is thereafter made to only the tantalum containing compound, which thereafter is gradually transferred into tantalum oxide since the outer surface of the tantalum containing compound is oxidized. Thus, since not all of the tantalum containing coating applied to parts of a heat exchanger is an alloy with said parts it is considered that the tantalum containing compound is partially alloyed to the heat exchanger parts.

[0025] The film thickness of the tantalum coating must not be too high because that would influence the heat transfer properties in a negative way since an enlarged barrier, an increased plate thickness, between the heat transferring fluids decreases the heat transfer. If the film thickness is to low the effect of the coating may not last as long as suspected when in contact with a highly corrosive fluid.

[0026] According to the present invention a tantalum containing compound is coated on the inside of a plate package or heat exchanger using a deposition process with chemical reactants in fluid form. The method of coating a permanently joined plate package or heat exchanger in accordance with the present invention, comprises the steps: 1) introducing gas or vapor phase chemical reactants into said plate package or heat exchanger in at least one of the flow sides of the heat exchanger, wherein at least one of the reactants is a reactant comprising tantalum, 2) formation of a solid film comprising a tantalum containing compound on the surfaces of said plate package or heat exchanger from the reaction of the gas or vapor phase chemical reactants.

[0027] The application process relates to formation of a non-volatile solid film on a substrate, in the present case parts of a plate package or heat exchanger, from the reaction of gas or vapor phase chemical reactants, wherein at least one reactant is a reactant comprising tantalum. A reaction chamber is used for the process, into which the reactant gases or vapors are introduced to decompose and react with the substrate or in the case of multiple applications the previously applied layer to form the film. Inside the reaction chamber the reactants are forced into the plate package or heat exchanger. In one embodiment the reactant comprising tantalum in fluid form is tantalum pentachloride.

[0028] The application process disclosed above could also be used for parts of a heat exchanger such as frames or mounting plates not part of a permanently joined heat exchanger. Such coated frames or plates may then be used together with a permanently joined plate package coated in accordance with the present invention.

[0029] The application process of the tantalum containing composition is preferably done by Chemical Vapor Deposition (CVD) or Atomic Layer Deposition (ALD), preferably by CVD.

[0030] A basic CVD process consists of the following steps: 1) a predefined mix of reactant gases and diluent inert gases are introduced at a specified flow rate into the reaction chamber; 2) the gas species move to the substrate; 3) the reactants get adsorbed on the surface of the substrate; 4) the reactants undergo chemical reactions with the substrate to form the film; and 5) the gaseous by-products of the reactions are desorbed and evacuated from the reaction chamber.

[0031] The growth of material layers by ALD consists of repeating the following characteristic four steps: 1) Exposure of the first precursor. 2) Purge or evacuation of the reaction chamber to remove the non-reacted precursors and the gaseous reaction by-products. 3) Exposure of the second precursor - or another treatment to activate the surface again for the reaction of the first precursor. 4) Purge or evacuation of the reaction chamber. Each reaction cycle adds a given amount of material to the surface, referred to as the growth per cycle. To grow a material layer, reaction cycles are repeated as many as required for the desired film thickness.

[0032] In one embodiment the method of coating a permanently joined heat exchanger made of stainless steel, copper or carbon steel comprises the steps: 1) introducing gas or vapor phase chemical reactants into said heat exchanger in at least one of the flow sides of the heat exchanger, wherein at least one of the reactants is a compound comprising tantalum, 2) formation of a solid film comprising tantalum on the surfaces of said heat exchanger from the reaction of the gas or vapor phase chemical reactants, is for the steps 1) and 2) preferably carried out at a temperature of 600-1000°C, more preferably 700-900°C.

[0033] In another embodiment of the present invention steps 1) and 2) are carried out at atmospheric pressure, subatmospheric pressure or at very low pressure.

[0034] According to the present invention it is important that the heat exchange plates of a plate package or plate heat exchanger not only are permanently joined to each other along their peripheral portions, it is also important that at a variety of areas of contact in their heat exchange portions are permanently joined. If plates are only joined along their peripheral portions other areas of contact may move/be dislocated during use. If only contact surfaces along their peripheral portions are permanently joined the plates may separate at some areas of contact which are not permanently joined during use when the plate heat exchanger is e.g. pressurized on one of the fluid flow sides. In the case of areas of contact shifting due to e.g. pressurizing, a coated heat exchanger which is not joined at all areas of contact within the fluid flow would then have areas not coated exposed to the fluid in the heat exchanger and thus resulting in corroding areas if the fluid used is corrosive. Thus, it is important that all areas of contact between plates, where the areas of contact are in contact with or surrounded by corrosive fluid, are permanently joined by welding, soldering, fusion bonding or brazing.

[0035] A permanently joined plate package for a plate heat exchanger as disclosed herein is to be interpreted as a non-accessible plate package wherein at least all areas of contact between plates in contact with corrosive fluid are permanently joined. Thus, since the plate package is non-accessible it is to be interpreted that the complete plate package may not be disassembled in any way. Such a plate package according to the present invention can be used in a plate heat exchanger having e.g. frames and/or mounting plates of any material, as long as they are not in contact with the corrosive fluid in at least one of the flow sides. If e.g. frames or mounting plates are a part of at least one of the flow sides of the heat exchanger and is in contact with a highly corrosive fluid said frames and/or mounting plates preferably are made of tantalum, or stainless steel or carbon steel having an alloy bonded coating of a tantalum containing compound on at least the parts of the at least one of the flow sides of the heat exchanger. For such frames and/or mounting plates preferably stainless steel or carbon steel having an alloy bonded coating of a tantalum containing compound are used, more preferably stainless steel having an alloy bonded coating of a tantalum containing compound.

[0036] A permanently joined plate heat exchanger as disclosed herein is to be interpreted as a non-accessible heat exchanger comprising a permanently joined plate package wherein at least all areas of contact between plates in contact with corrosive fluid are permanently joined. Thus, since the plate heat exchanger is non-accessible it is to be interpreted that the plate heat exchanger may not be disassembled. For a plate heat exchanger this means that not even any frames or mounting plates that are located around a plate package and are to be in contact with at least one corrosive heat exchange fluid can be removed. The permanently joined plate heat exchanger according to the present invention is for the parts in contact with at least one fluid, e.g. a corrosive fluid, impossible to disassemble in any way. The wordings permanently joined and permanently assembled in view of plate packages and plate heat exchangers are regarded as being interchangeable in the present application.

[0037] The present invention relates to application of a solid film of a tantalum containing coating onto surfaces within a permanently joined plate package or plate heat exchanger. The tantalum containing compound used as coating, preferably metal tantalum, tantalum oxide and/or tantalum nitride, applied on the surfaces of the heat exchangers to be in contact with highly corrosive fluid. In a preferred embodiment the tantalum containing compound is metal tantalum and/or tantalum oxide, preferably metal tantalum. If the tantalum coating is made of metal tantalum naturally the uppermost part of the coating is oxidized and thus is tantalum oxide, and the nethermost part of the coating is then alloyed with the materials of a permanently joined plate package or plate heat exchanger.

[0038] The permanently joined plate package and permanently joined heat exchanger coated in accordance with the present invention is made of stainless steel or carbon steel. Stainless steel and carbon steel are considered materials with good mechanical properties. The permanently joined plate package or permanently joined heat exchanger is assembled using welding, soldering, fusion bonding or brazing, preferably using welding fusion bonding or brazing. Brazing is preferably done by use of copper as brazing material. Preferably the heat exchanger is made of stainless steel and was assembled using welding, fusion bonding or brazing, preferably fusion bonding or copper brazing.

[0039] According to the present invention the coating comprising tantalum applied onto the surfaces in at least one of the flow sides designated for being used for highly corrosive fluids has preferably a film thickness of about 1-300 μm, preferably 1-125 μm, more preferably 1-50 μm, even more preferably 10-40 μm and most preferably 15-25 μm.

Examples

[0040] Two copper brazed stainless steel units, CB14, and two Alfa Fusion stainless steel units, AN14, from Alfa Laval have been processed with the CVD process to coat with tantalum. Conventional Alfa Fusion units, AN14, were used as reference. All units contained plates of stainless steel but in CB14 they were copper brazed and in AN14 they were fusion bonded together.

Process:

[0041] Tantalum reacts with chlorine gas to form $TaCl_5$. The gas is led into an vacuum oven at 850 °C were the $TaCl_5$ will react with available surfaces (stainless steel, copper, carbon steel, graphite etc) to form a CVD coating of tantalum. The pressure of the gas is about 25 mB, and the process is running for about 8 hours.

[0042] The chorine released during the process will react with hydrogen to form hydrochloric gas which is led out of the process and neutralized with sodium hydroxide.

[0043] $TaCl_5$ gas is led from the centre pipe to the units. The small, hanging spacers attached to the inlet and outlet are used for evaluation of the thickness of the tantalum layer. According to weight measuring of the spacers before and after process the average thickness of the tantalum layer is about 45 μm in the inlet and 38 μm in the outlet.

Analysis:

[0044] The tantalum CVD processed units (CB 14 and AN 14 units) were corrosion tested with 75 °C hydrochloric acid during 48 h. The hydrochloric acid used for the test showed almost no change in color after recirculation in the tantalum treated units. The tantalum coated CB 14 and AN 14 units showed no without leaking or other signs of corrosion damages during or after the corrosion test. After the corrosion test the units were pressure tested with compressed air at 8 bar. No external or internal leaks were found in the units.

[0045] A conventional AN14 unit was corrosion tested in hydrochloric acid as well. For the conventional AN14 unit the hydrochloric acid reacted strongly with the stainless steel surfaces under emission of hydrogen gas, the acid had to be replaced a couple of times because of depletion. A strong green colorization from iron chloride was found in the acid from the standard unit. The conventional AN14 unit showed no leakage after 90 minutes, but after 6 hours numerous large leaks were detected.

[0046] After the corrosion tests the units were cut up and cross cuts of the surfaces were metallograhipcally prepared and examined with microscope. The tantalum treated units were cut up and four cross cuts were examined from each unit. The CB 14 unit showed very good adhesion between the copper and tantalum in all investigated locations. The CB 14 unit showed slightly better adhesion between the copper and tantalum than the stainless steel and tantalum in the AN 14 unit. A reason for this might be that the surface of the AN 14 unit may have been contaminated or, to a lower extent, be because of the higher surface roughness in the AN 14 unit.

[0047] The thickness of the tantalum layer varies from about 105-125 μm in the areas around the inlet to just over 10 μm at the diagonal maximum distance from inlet on the AN 14 unit.

[0048] The thickness of the tantalum layer varies from about 150 μm in the inlet to thin, most probably less than 5 μm at the diagonal maximum distance from inlet on the CB 14 unit.

Claims

1. A permanently joined plate package for a plate heat exchanger made of stainless steel, copper or carbon steel, **characterised in that** at least all surfaces in contact with media of at least one of the flow sides of the plate package have an alloy bonded coating of a tantalum containing compound, wherein the coating has a thickness of about 1-300 μm, and that the coating has been applied after the plate package has been permanently joined.

2. A permanently joined plate package according to claim 1, wherein the tantalum containing compound is metal tantalum, tantalum oxide and/or tantalum nitride, preferably metal tantalum and/or tantalum oxide, more preferably metal tantalum.

3. A permanently joined plate package according to claims 1 or 2, wherein the plate package was assembled using welding, fusion bonding or brazing, preferably fusion bonding or copper brazing.

4. A permanently joined plate according to any one of claims 1-3, wherein the plate package is made of stainless steel and was assembled using welding, fusion bonding or brazing, preferably fusion bonding or copper brazing.

5. A permanently joined plate package according to any one of claims 1-4, wherein the coating of tantalum containing compound has a thickness of about 1-125 μm, preferably 1-50 μm, more preferably 10-40 μm and most preferably 15-25 μm.

6. A plate heat exchanger **characterised in that** it comprises a plate package of the kind as defined in any one of claims 1-5.

7. A plate heat exchanger according to claim 6, wherein said heat exchanger has frames and/or mounting plates that are a part of at least one of the flow sides of the heat exchanger and said frames and/or mounting plates are made of tantalum, or stainless steel or carbon steel having an alloy bonded coating of a tantalum containing compound, preferably stainless steel or carbon steel having an alloy bonded coating of a tantalum containing compound, more preferably stainless steel having an alloy bonded coating of a tantalum containing compound.

8. A plate heat exchanger according to claim 7, wherein the plate heat exchanger is permanently joined and is made of stainless steel or carbon steel and all surfaces of at least one of the flow sides of the plate heat exchanger have an alloy bonded coating of a tantalum containing compound.

Patentansprüche

1. Dauerhaft gefügtes Plattenpaket für einen Plattenwärmetauscher, bestehend aus rostfreiem Stahl, Kupfer oder Karbonstahl, **dadurch gekennzeichnet, dass** mindestens alle Flächen in Kontakt mit Medien von mindestens einer der Strömungsseiten des Plattenpaketes eine legierungsgebondete Beschichtung aus einer tantalhaltigen Verbindung besitzen, wobei die Beschichtung eine Dicke von ungefähr 1 bis 300 μm besitzt, und die Beschichtung aufgebracht wurde, nachdem das Plattenpaket dauerhaft gefügt wurde.

2. Dauerhaft gefügtes Plattenpaket nach Anspruch 1, bei welchem die tantalhaltige Verbindung metallisches Tantal, Tantaloxid und/oder Tantalnitrid, vorzugsweise metallisches Tantal und/oder Tantaloxid, jedoch noch bevorzugterweise metallisches Tantal ist.

3. Dauerhaft gefügtes Plattenpaket nach Anspruch 1 oder 2, bei welchem das Plattenpaket unter Zuhilfenahme von Schweißen, Schmelzbonden oder Löten, jedoch vorzugsweise von Schmelzbonden oder Kupferlöten montiert wurde.

4. Dauerhaft gefügtes Plattenpaket nach einem der Ansprüche 1 bis 3, bei welchem das Plattenpaket aus rostfreiem Stahl besteht und unter Zuhilfenahme von Schweißen, Schmelzbonden oder Löten, jedoch vorzugsweise Schmelzbonden oder Kupferlöten, montiert wurde.

5. Dauerhaft gefügtes Plattenpaket nach einem der Ansprüche 1 bis 4, bei welchem die Beschichtung aus tantalhaltiger Verbindung eine Dicke von ungefähr 1 bis 125 μm, vorzugsweise 1 bis 50 μm, jedoch noch bevorzugterweise 10 bis 40 μm und besonders bevorzugterweise 15 bis 25 μm besitzt.

6. Plattenwärmetauscher, **dadurch gekennzeichnet, dass** er eine nach einem der Ansprüche 1 bis 5 definierte Art von Plattenpaket beinhaltet.

7. Plattenwärmetauscher nach Anspruch 6, bei welchem der Wärmetauscher Rahmen und/oder Montageplatten besitzt, welche Bestandteil von mindestens einer der Strömungsseiten des Wärmetauschers sind und wobei die Rahmen und/oder Montageplatten aus Tantal oder aus rostfreiem Stahl oder aus Karbonstahl bestehen und eine legierungsgebondete Beschichtung aus einer tantalhaltigen Verbindung besitzen, vorzugsweise aus rostfreiem Stahl oder Karbonstahl, welcher eine legierungsgebondete Beschichtung aus einer tantalhaltigen Verbindung besitzt, und noch bevorzugterweise aus rostfreiem Stahl, welcher eine legierungsgebondete Beschichtung aus einer tantalhaltigen Verbindung besitzt.

8. Plattenwärmetauscher nach Anspruch 7, bei welchem der Plattenwärmetauscher dauerhaft gefügt ist und aus rostfreiem Stahl oder aus Karbonstahl besteht und alle Oberflächen von mindestens einer der Strömungsseiten des Plattenwärmetauschers eine legierungsgebondete Beschichtung aus einer tantalhaltigen Verbindung besitzen.

Revendications

1. Ensemble de plaques assemblées de manière permanente pour un échangeur de chaleur à plaques en acier inoxydable, en cuivre ou en acier au carbone, **caractérisé en ce qu'**au moins toutes les surfaces en contact avec des supports d'au moins un des côtés de circulation de l'ensemble de plaques ont un revêtement lié par un alliage d'un composé contenant du tantale, dans lequel le revêtement a une épaisseur d'environ 1-300 μm, et **en ce que** le revêtement a été appliqué après que l'ensemble de plaques a été assemblé de manière permanente.

2. Ensemble de plaques assemblées de manière permanente selon la revendication 1, dans lequel le composé contenant du tantale est le métal tantale, un oxyde de tantale et/ou du nitrure de tantale, de préférence le métal tantale et/ou un oxyde de tantale, plus préférablement le métal tantale.

3. Ensemble de plaques assemblées de manière permanente selon les revendications 1 ou 2, dans lequel l'ensemble de plaques a été assemblé en utilisant la soudure, la liaison par fusion ou le brasage, de préférence la liaison par fusion ou le brasage au cui-

vre.

4. Ensemble de plaques assemblées de manière permanente selon l'une quelconque des revendications 1-3, dans lequel l'ensemble de plaques est en acier inoxydable et a été assemblé en utilisant la soudure, la liaison par fusion ou le brasage, de préférence la liaison par fusion ou le brasage au cuivre.

5. Ensemble de plaques assemblées de manière permanente selon l'une quelconque des revendications 1-4, dans lequel le revêtement du composé contenant du tantale a une épaisseur d'environ 1-125 µm, de préférence 1-50 µm, plus préférablement 10-40 µm et le plus préférablement 15-25 µm.

6. Echangeur de chaleur à plaques **caractérisé en ce qu'**il comprend un ensemble de plaques du type tel que défini dans l'une quelconque des revendications 1-5.

7. Echangeur de chaleur à plaques selon la revendication 6, dans lequel ledit échangeur de chaleur a des cadres et/ou des plaques de montage qui font partie d'au moins un des côtés de circulation de l'échangeur de chaleur et lesdits cadres et/ou plaques de montage sont en tantale, ou en acier inoxydable ou en acier au carbone ayant un revêtement lié par un alliage d'un composé contenant du tantale, de préférence de l'acier inoxydable ou de l'acier au carbone ayant un revêtement lié par un alliage d'un composé contenant du tantale, plus préférablement de l'acier inoxydable ayant un revêtement lié par un alliage d'un composé contenant du tantale.

8. Echangeur de chaleur à plaques selon la revendication 7, dans lequel l'échangeur de chaleur à plaques est assemblé de manière permanente et est en acier inoxydable ou en acier au carbone et toutes les surfaces d'au moins un des côtés de circulation de l'échangeur de chaleur à plaques ont un revêtement lié par un alliage d'un composé contenant du tantale.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 9606705 A **[0002] [0010]**
- DE 102008013358 A1 **[0002]**
- GB 933295 A **[0002]**
- WO 9216310 A **[0008]**
- GB 1112265 A **[0009]**
- US 20100051246 A **[0011]**
- JP 4334205 B **[0012]**
- EP 110311 A **[0013]**
- EP 1347859 B1 **[0022]**
- WO 02098600 A **[0022]**