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TUBE SHEET ASSEMBLY
ROHRPLATTENANORDNUNG
ENSEMBLE DE PLAQUES TUBULAIRES

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REFERENCES CITED:
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Description

BACKGROUND TO THE INVENTION

[0001] This invention relates to a tube sheet assembly according to the preamble of claim 1. Such a tube sheet assembly is known from EP-A-0 777 098. In particular the invention is concerned with a tube sheet assembly for a waste heat boiler employed in a chemical process plant and which makes use of metal ferrules for protecting the inlets of the exchange tubes of the tube sheet.

[0002] Various types of chemical process plants employ heat exchangers or waste heat boilers for heat recovery and cooling. One example of a chemical process employing a waste heat boiler is a reforming process in which light hydrocarbons are converted into a gas mixture comprising carbon monoxide and hydrogen. In the reforming process the mixture of carbon monoxide and hydrogen is called synthesis gas or syngas. As the syngas is formed at high process temperatures it is necessary to dissipate large amounts of heat. This is often achieved with the use of waste heat boilers.

[0003] A waste heat boiler typically includes an inlet chamber into which a hot syngas stream can be fed from a transfer line. From the inlet chamber the syngas passes through exchange tubes extending between an inlet tube sheet and an outlet tube sheet. The exchange tubes are surrounded by circulating water such that the syngas is cooled as it passes along the exchange tubes. The cooled syngas feeds into an outlet chamber from where it may be fed for further processing or can be subjected to another cooling cycle in a secondary heat recovery system operated in series with the waste heat boiler.

[0004] Due to the fact that the syngas entering the inlet chamber of the waste heat boiler will have a very high temperature, all components in contact with the syngas must be protected with thermal insulation. Accordingly the transfer line, inlet chamber and inlet tube sheet are provided with insulating lining, typically in the form of refractory lining.

[0005] All parts adjacent the joints between the inlet tube sheet and the exchange tubes are subjected to very severe conditions due to the fact that at these positions the syngas stream at its maximum temperature will be in contact with the inner surface of the exchange tubes. For this reason it is conventional practice to protect these parts with tube inserts, also known as ferrules. Generally the ferrules will be inserted into a tube sheet whereafter an insulation layer will be installed around the ferrules as well as on front of the tubesheet in order to provide insulation.

[0006] A problem often encountered with tube sheets is so-called metal dusting which refers to the catastrophic degradation of metals in carbonaceous gases, usually in operating temperatures of between 450°C and 750°C. These high temperatures of tube sheets are of course a result of the high temperatures of the syngas passing therethrough en route to the exchange tubes.

SUMMARY OF THE INVENTION

[0009] According to the present invention there is provided a tube sheet assembly according to claim 1.

[0010] The tube sheet assembly can form part of a waste heat boiler used in a chemical process plant.

[0011] Preferably the tube sheet assembly comprises a plurality of thermal insulators for providing thermal insulation between the tube sheet and a plurality of ferrules conveying hot process fluid to the exchange tubes.

[0012] More preferably the plurality of thermal insulators are secured in position inside the inlet openings with the use of insulation refractory.

[0013] Advantageously the thermal insulator is produced from a ceramic material.

[0014] Preferably, the thermal insulator is in the form of a sleeve having a bore for receiving a ferrule therethrough.

[0015] An annular flange may extend radially outwardly from a first end of the sleeve.

[0016] Typically the insulation material covering the ferrules is a high alumina ceramic fibre.

[0017] Preferably the insulation material on the ferrules is covered with a waterproof material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings wherein:

Figure 1 shows a diagrammatic representation of a waste heat boiler including a tube sheet assembly in accordance with the present invention;

Figure 2 shows an enlarged cross-sectional view of a portion of the tube sheet assembly of the invention;

Figure 3 shows a cross-sectional view of a thermal insulator for use in the thermal assembly of Figure 2;

Figure 4 shows an enlarged cross-sectional view of
Figure 5 shows the results of a thermal analysis done on the tube sheet assembly in accordance with the invention.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

[0019] Figure 1 shows a diagrammatic representation of a waste heat boiler, generally indicated with the reference numeral 10. The waste heat boiler 10 includes an inlet chamber 12 for providing fluid communication between an inlet tube sheet 14 and a transfer line 16 which can convey hot syngas. A plurality of heat exchange tubes 18 extend between the inlet tube sheet 14 and an outlet tube sheet 20. The outlet tube sheet 20 in turn is fluid communication with an outlet chamber 22. In use the exchange tubes 18 will be surrounded with cooling water which will circulate inside a shell 24.

[0020] In use hot syngas emanating from a chemical process will be fed into the inlet chamber 12 of the waste heat boiler via the transfer line 16. From the inlet chamber 12 the syngas will pass through the inlet tube sheet 14 and into the exchange tubes 18. While passing through the exchange tubes 18 the syngas will be cooled under the influence of the cooling water circulating in the shell 24. Finally, the cooled syngas will exit the exchange tubes 18 at the outlet tube sheet 20 and feed into the outlet chamber 22. From the outlet chamber 22 the syngas can either undergo a further processing cycle or can be subjected to a further cooling process.

[0021] Figure 2 shows an enlarged view of a portion of the inlet tube sheet 14 of a tube sheet assembly in accordance with the present invention, generally indicated with the reference numeral 26. The tube sheet 14 defines an inlet opening 28 through which syngas can pass from the inlet chamber 12 to an exchange tube 18.1. In order to protect the portions of the tube sheet 14 defining the inlet opening 28 against the thermal effects of the hot syngas being fed by the ferrule 30 into the exchange tube 18.1.

[0023] It is pointed out that the thermal insulator 32 need not be confined to the cavity inside the inlet tube sheet 14, but can extend therefrom as shown in Figure 2. It is also envisaged that the thermal insulator can also be located on the face of the tubesheet only.

[0024] Figure 3 provides a cross-sectional view of the thermal insulator 32. The thermal insulator 32 includes a cylindrical section 34 and a tapered section 36. A bore 38, which is suitably sized for accommodating the ferrule 30, extends from the one end of the thermal insulator 32 to the other end as shown. The thermal insulator 32 is here produced from a ceramic material, but it is envisaged that the thermal insulator could also be produced from a range of materials such as graphite and alumina.

[0025] Typical dimensions of the thermal insulator 32 include that it has an overall length of approximately 30mm, a diameter of approximately 50mm while the cylindrical section has a length of approximately 16.3mm. The bore 38 has a diameter of approximately 30mm while the tapered section tapers at an angle of approximately 20°. It will, however, be appreciated that the thermal insulator could have a range of dimensions.

[0026] It is pointed out that the thermal insulator 32 could be installed into the surface of the inlet tube sheet 14 or into the contour of a tube-to-tube joint. The ferrule 30 is further wrapped in an insulation material 40, here provided in the form of high alumina ceramic fibre, typically of the type sold under the trademark Saffil®. The insulation material 40, in turn, is covered with waterproof tape 42.

[0027] The tube sheet assembly 26 also includes a layer of refractory material 44, here having a thickness of approximately 75mm to 100mm, for insulating the inlet tube sheet 14 against the thermal effects of the hot syngas fed to the exchange tubes 18. The refractory material 44 also aids in securing the thermal insulator 32 in position.

[0028] A further embodiment of the tube sheet assembly 26 is shown in figure 4. In this example the thermal insulator 32 includes an annular flange 39 extending radially outwardly from an end of the insulator 32, and in use abuts a face of the tube sheet 14.

[0029] A tube sheet assembly in accordance with the above description will ensure that in use the temperature on the surface of the inlet tube sheet remain below the metal dusting range, provided the refractory installation is installed correctly. One example of a thermal analysis, showing the above tendency (which has also been proven in practice), is shown in Figure 5. Zone 1-2 represents the refractory material (in this example having a thickness of 60mm), Zone 2-3 represents the thermal insulator (having a thickness of 15mm) and Zone 3-4 represents the tube sheet. It is clear from the temperature distribution that the surface of the tube sheet is sufficiently below the
metal dusting range, and that the thermal insulator (Zone 2-3) plays a fundamental role in achieving this goal.

Claims

1. A tube sheet assembly including:

   a tube sheet (14) for holding a plurality of heat exchange tubes (18), the tube sheet having a plurality of inlet openings (28) through which a process fluid can pass into the heat exchange tubes;
   the tube sheet assembly including a plurality of ferrules (30), each being intended, in use, to extend through an inlet opening into a respective heat exchange tube;
   each ferrule being covered by an insulating material (40), and characterised in that a thermal insulator (32) is at least partially located inside an inlet opening of the tube sheet for covering a portion of a respective ferrule extending through the inlet opening, thereby providing thermal insulation between the tube sheet and the ferrule.

2. The tube sheet assembly of claim 1 wherein the tube sheet forms part of a waste heat boiler used in a chemical process plant.

3. The tube sheet assembly of claim 1 or claim 2 wherein the tube sheet assembly includes a plurality of thermal insulators for providing thermal insulation between the tube sheet and a plurality of ferrules conveying hot process fluid to the exchange tubes.

4. The tube sheet assembly of any one of claims 1 to 3 wherein the or each thermal insulator is secured inside the inlet openings by way of a layer of refractory material abutting against an end of the thermal insulator.

5. The tube sheet assembly of any one of the preceding claims wherein the thermal insulator is made of a ceramic material.

6. The tube sheet assembly of any one of the preceding claims wherein the thermal insulator is in the form of a sleeve having a bore for receiving a ferrule theretrough.

7. The tube sheet assembly of claim 6 wherein an annular flange extends radially outwardly from a first end of the sleeve, and abuts an outer face of the tube sheet.

8. The tube sheet assembly of any one of the preceding claims wherein the insulating material covering the ferrules is a high alumina ceramic fibre.

9. The tube sheet assembly of claim 8 wherein the insulating material on the ferrules is covered with a waterproof material.

10. A heat exchanger including a tube sheet assembly as claimed in any one of claims 1 to 9.

Patentansprüche

1. Rohrbodenanordnung, umfassend:

   einen Rohrboden (14) zum Halten einer Mehrzahl von Wärmetauscherrohren (18), wobei der Rohrboden eine Mehrzahl von Einlassöffnungen (28) aufweist, durch die ein Prozessfluid in die Wärmetauscherrohre gelangen kann, wobei die Rohrbodenanordnung eine Mehrzahl von Hülsen (30) umfasst, die eingerichtet sind, sich im Gebrauch durch eine Einlassöffnung in ein entsprechendes Wärmetauscherrohr zu erstrecken, wobei jede Hülse von einem isolierenden Material (40) umgeben ist und dadurch gekennzeichnet, dass ein thermischer Isolator (32) zumindest teilweise in einer Einlassöffnung des Rohrbodens angeordnet ist, um einen Anteil einer entsprechenden Hülse, die sich durch die Einlassöffnung erstreckt, zu umgeben, und so für eine thermische Isolation zwischen dem Rohrboden und der Hülse zu sorgen.

2. Rohrbodenanordnung nach Anspruch 1, wobei der Rohrboden einen Teil eines Abhitzekessels bildet, der in einer chemischen Prozessanlage verwendet wird.

3. Rohrbodenanordnung nach Anspruch 1 oder Anspruch 2, wobei die Rohrbodenanordnung eine Mehrzahl von thermischen Isolatoren umfasst, um eine thermische Isolation zwischen dem Rohrboden und einer Mehrzahl von Hülsen zu erreichen, die ein heißes Prozessfluid zu den Tauscherrohren leiten.

4. Rohrbodenanordnung nach einem der Ansprüche 1 bis 3, wobei der oder jeder thermische Isolator in den Einlassöffnungen durch eine Schicht eines hitzebeständigen Materials geschüttet ist, die an ein Ende des thermischen isolators angrenzt.

5. Rohrbodenanordnung nach einem der Ansprüche 1 bis 3, wobei der oder jeder thermische Isolator in Form eines keramischen Materials hergestellt ist.

6. Rohrbodenanordnung nach einem der vorstehenden Anspruch, wobei der thermische Isolator aus einem keramischen Material hergestellt ist.
weist, um dadurch die Hülse aufzunehmen.

7. Rohrbodenanordnung nach Anspruch 6, wobei ein ringförmiger Flansch sich nach radial außen von einem ersten Ende der Hülle erstreckt und an der äußeren Fläche des Rohrbodens anliegt.

8. Rohrbodenanordnung nach einem der vorstehenden Ansprüche, wobei das isolierende Material, das die Hülsen umgibt, eine Tonerde-Keramitfaser ist.


10. Wärmetauscher, der eine Rohrbodenanordnung gemäß einem der Ansprüche 1 bis 9 umfasst.

Revendications

1. Assemblage de plaque tubulaire, comprenant :

   une plaque tubulaire (14) pour maintenir une pluralité de tubes échangeurs de chaleur (18), la plaque tubulaire comportant une pluralité d’ouvertures d’entrée (28) par lesquelles un fluide de traitement peut passer dans les tubes échangeurs de chaleur ; l’assemblage de plaque tubulaire comprenant une pluralité d’embouts (30), chacun d’eux étant destiné, en utilisation, à s’étendre dans une ouverture d’entrée dans un tube échangeur de chaleur respectif ; chaque embout étant recouvert d’un matériau isolant (40), et caractérisé en ce qu’un isolant thermique (32) est au moins partiellement présent à l’intérieur d’une ouverture d’entrée de la plaque tubulaire pour recouvrir une partie d’un embout respectif s’étendant dans l’ouverture d’entrée, assurant ainsi une isolation thermique entre la plaque tubulaire et l’embout.

2. Assemblage de plaque tubulaire selon la revendication 1, dans lequel la plaque tubulaire fait partie d’une chaudière à récupération de chaleur utilisée dans une usine de traitement chimique.

3. Assemblage de plaque tubulaire selon la revendication 1 ou 2, l’assemblage de plaque tubulaire comprenant une pluralité d’isolants thermiques pour assurer une isolation thermique entre la plaque tubulaire et une pluralité d’embouts transportant du fluide de traitement très chaud vers les tubes échangeurs.

4. Assemblage de plaque tubulaire selon l’une quelconque des revendications 1 à 3, dans lequel l’isolant thermique, ou chacun des isolants thermiques, est fixé dans les ouvertures d’entrée au moyen d’une couche de matériau réfractaire s’appuyant contre une extrémité de l’isolant thermique.

5. Assemblage de plaque tubulaire selon l’une quelconque des revendications précédentes, dans lequel l’isolant thermique est en un matériau de céramique.

6. Assemblage de plaque tubulaire selon l’une quelconque des revendications précédentes, dans lequel l’isolant thermique a la forme d’un manchon comportant un alésage pour y recevoir un embout.

7. Assemblage de plaque tubulaire selon la revendication 6, dans lequel une collerette annulaire s’étend radialement vers l’extérieur à partir d’une première extrémité du manchon, et s’appuie sur une face externe de la plaque tubulaire.

8. Assemblage de plaque tubulaire selon l’une quelconque des revendications précédentes, dans lequel le matériau isolant recouvrant les embouts est en fibre céramique à haute teneur en alumine.

9. Assemblage de plaque tubulaire selon la revendication 8, dans lequel le matériau isolant sur les embouts est recouvert d’un matériau imperméable.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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