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(54) SUPPLY AND EXTRACTION OF TUBE FLOWS AT INTERMEDIATE TEMPERATURE IN HELICALLY COILED HEAT EXCHANGERS

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(57) **ABSTRACT**

A heat exchanger for the indirect exchange of heat between a first fluid and a second fluid, the heat exchanger having a casing surrounding a casing chamber that accommodates the first fluid. A core tube may extend within the casing. A tube bundle is arranged in the casing chamber and has multiple tubes to accommodate the second fluid. The tubes are helically wound around a longitudinal axis of the chamber or around the core tube in a coil region extending from a lower coil end to an upper coil end. At least one tube is coiled only in a section of the coil region. Outside of the section of the coil region the at least one tube extends as a straight tube to the lower coil end, the upper coil end, or to both the lower coil end and the upper coil end.

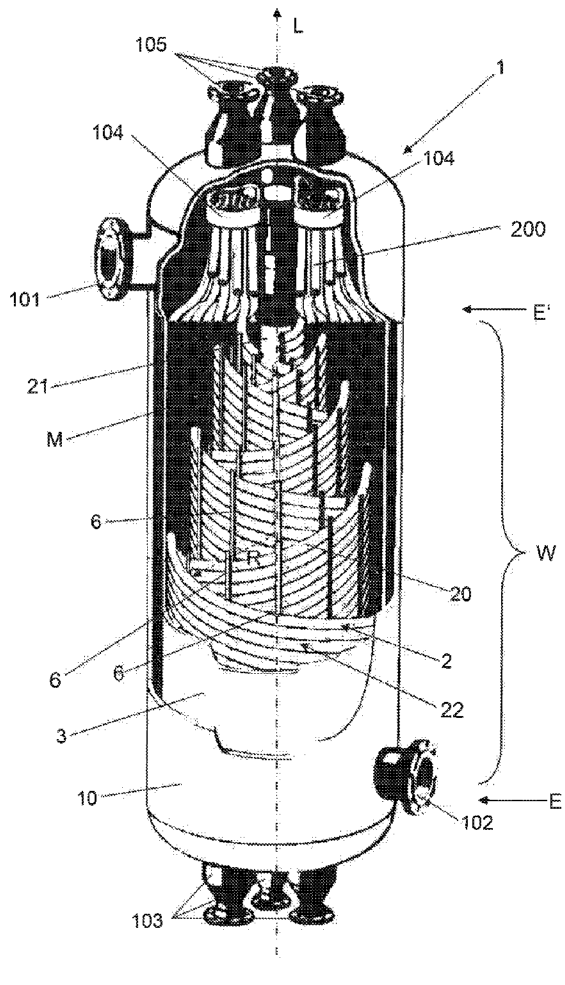


Fig. 1

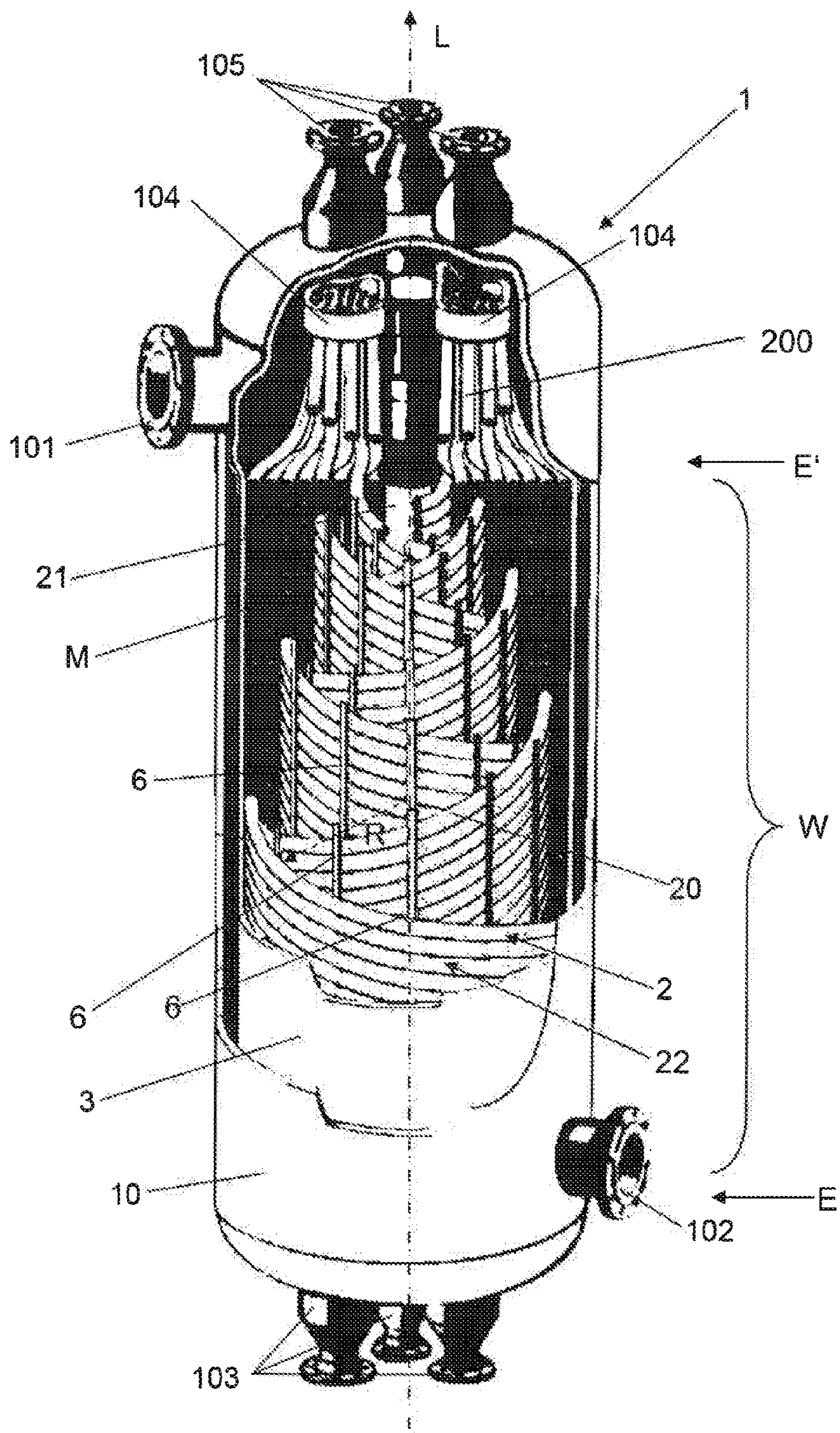
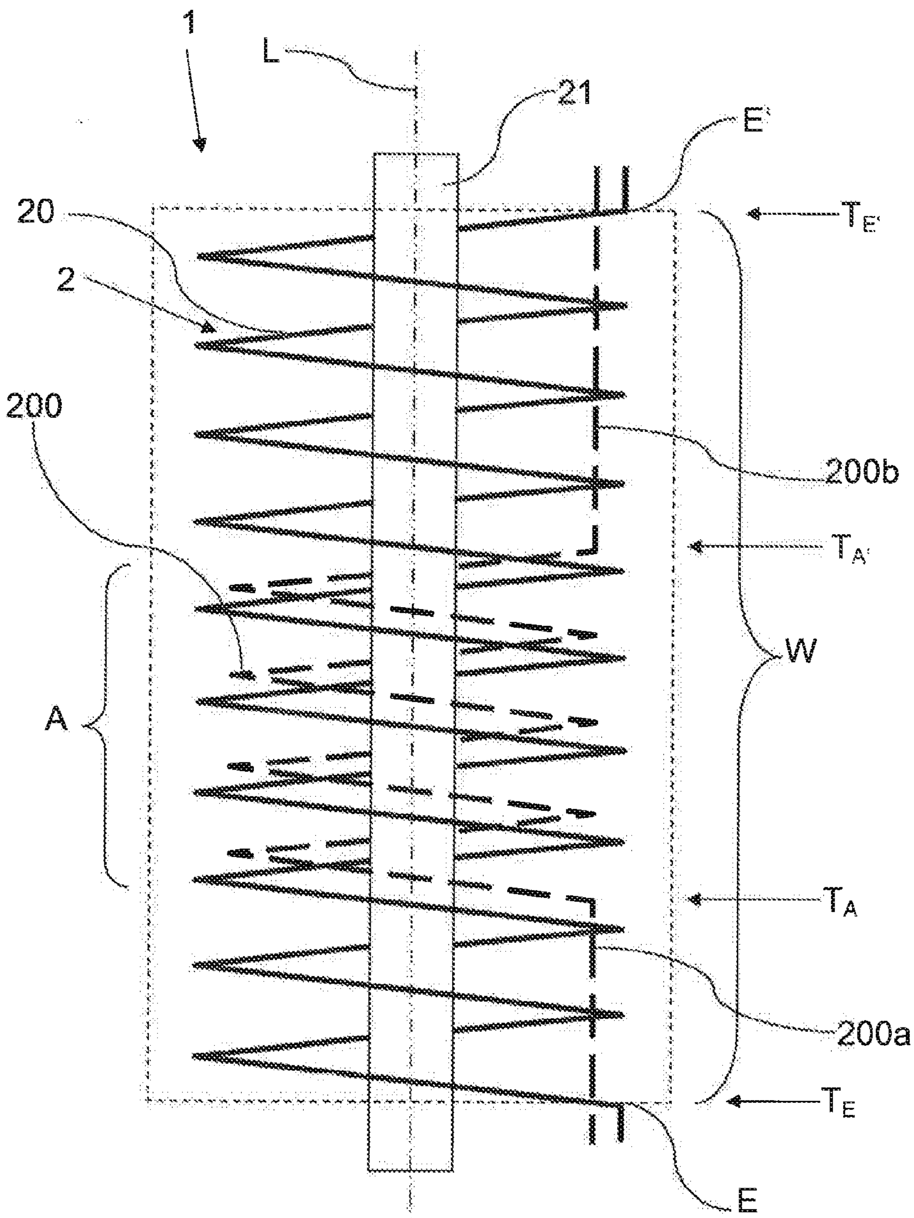


Fig. 2



SUPPLY AND EXTRACTION OF TUBE FLOWS AT INTERMEDIATE TEMPERATURE IN HELICALLY COILED HEAT EXCHANGERS

[0001] The invention relates to a heat exchanger.

[0002] A heat exchanger generally has a pressure-bearing casing, which surrounds a casing chamber for accommodating a first fluid and which extends along a longitudinal axis The heat exchanger may include a core tube, which runs in the casing and which extends along the longitudinal axis wherein for most heat exchanger designs, the core tube extends vertically. The heat exchanger also has a tube bundle which is arranged in the casing chamber and which has multiple tubes to accommodate a second fluid (or multiple fluids). The tubes of the tube bundle are helically coiled around the longitudinal axis or the core tube) in a coil region, extending from a lower coil end to an upper coil end.

[0003] The heat exchangers of this type known from the prior art, include tubes and tube flows that are coiled over the entire bundle length, i.e. along the entire coil region. This results in tube flows for all of the tubes in the bundle that have approximately the same temperature at the beginning of the bundle and also at the end of the bundle.

[0004] Therefore, if it is desired that one or more tube flows have a temperature at the inlet or outlet which lies between the bundle inlet temperature and the bundle outlet temperature, then the bundle must be divided into at least two bundles. The separation of the bundles is realized at planes where the desired temperature prevails. When a tube bundle is divided or separated in this way, two separate, relatively short bundles are created. The portion of the second fluid which has not yet reached its predefined final temperature is conducted from one bundle to the other separate bundle, for example by a connecting tube line. The portion of the second fluid which has reached its defined final temperature at the separation point is extracted from the heat exchanger at the separation point. Alternatively, the individual bundles may be installed in separate heat exchangers.

[0005] The present invention provides a new design for a heat exchanger where it is desired to produce fluids at more than one temperature. The present invention provides a relatively simple design.

[0006] The heat exchanger of the invention has at least one tube which is coiled around the longitudinal axis (or the core tube when in place) in only a section of the coil region. Below this section, the at least one tube runs as a straight tube to the lower coil end. Alternatively, above this section, the at least one tube runs as a straight tube to the upper coil end. In another alternative, the at least one tube runs as a straight tube both above and below the coiled section to the respective lower coil end and upper coil end.

[0007] The tubes of the tube bundle of the helically coiled heat exchanger of the invention may be coiled around the core tube so that the core tube bears the load of the tubes of the tube bundle. The tubes of the tube bundle may be coiled in multiple layers around the core tube, with spacers provided between the individual layers.

[0008] The tube bundle may also have multiple tube groups, wherein the tubes of a tube group have a common inlet and outlet, such that the tubes of a tube group can be supplied with a fluid flow which is distributed among the individual tubes of the tube group.

[0009] By having the at least one tube, helically coiled for only a section of the longitudinal axis (or core tube) as noted above, the heat exchange occurs substantially only in that section. Below and above the section, where the tube runs as a straight tube there is very little heat exchange as compared to the coiled portion. The coiled and straight tube sections may be formed integrally or may be connected in some other way.

[0010] According to the invention, the tube bundles of the heat exchanger do not have to be divided. Rather, the at least one tube is coiled only in the stated section where the desired temperature prevails. Before and after the coiled section, the at least one tube extends as a straight tube to the respective coil end and does not significantly participate in the exchange of heat The heat exchange that occurs in the straight tube portions is negligible as compared to the coiled portion.

[0011] A straight profile of a tube or tube section is generally defined to mean a linear profile of the tube or tube section. However, the invention also includes tubes or tube sections that have some curvature but wherein that tube section participates to a significantly lesser extent in the exchange of heat as compared to the coiled section. For example, a profile for the tube section according to the invention is realized if the respective tube section extends along or parallel to the longitudinal axis or is coiled around the core tube extending around the longitudinal axis of the heat exchanger by less than 180°.

[0012] According to the invention, the coiled section of the tube is selected and positioned along the longitudinal axis (or core tube), such that during operation of the heat exchanger, the desired intermediate temperature prevails in the coiled section. This desired temperature is lower than the temperature prevailing at the lower coil end and higher than a temperature prevailing at the upper coil end.

[0013] The heat exchanger of the invention may include multiple tubes which are coiled only around a section of the longitudinal axis or the core tube, and then extend as straight tubes below the coiled portion to the lower coil end, or above the coiled portion to the upper coil end, or both below and above the coiled portion. The multiple tubes may be coiled in multiple layers around the core tube.

[0014] In addition, multiple tubes of a tube bundle may be coiled in multiple layers around the longitudinal axis or around the core tube.

[0015] The heat exchanger according to the invention may be used for realizing an indirect exchange of heat between a refrigerant flow, as the first fluid, and a hydrocarbon-containing flow, as the second fluid, wherein, the hydrocarbon-containing flow may be natural gas. The heat exchanger according to the invention may be used for all types of fluid flows.

[0016] Further details and advantages of the invention will be discussed with reference to the drawing figures.

[0017] FIG. **1** shows a partial sectional view of a heat exchanger according to the invention.

[0018] FIG. **2** is a schematic illustration of a heat exchanger according to the invention.

[0019] FIG. **1** and FIG. **2** show a heat exchanger **1** wherein a tube bundle **2** with at least one tube **200** is coiled around a core tube **21** of the heat exchanger **1** over only a portion of the length along a longitudinal axis L or along the core tube **21**. The coiled portion exists only in a section A of the overall coil region W. Outside the section A, the tube **200** has tube sections **200***a*, **200***b* which run in substantially straight, linear fashion along the longitudinal axis L or along the core tube **21**. Thus, the coiled part of the tube **200** in the section A is exposed to predefined desired temperatures, and does not significantly participate in heat exchange in the straight sections outside of the section A.

[0020] The tube sections **200***a*, **200***b* may be formed integrally with the coiled portion in section A or may be connected in to the coiled section in some other way.

[0021] The heat exchanger shown in FIG. **1** and FIG. **2** have a core tube **21** onto which the tubes **200** of the tube bundle **20** are coiled, such that the core tube **21** bears the load of the tubes **20**, **200**. The invention is however also applicable to helically coiled heat exchangers without a core tube.

[0022] The heat exchanger **1** is designed for the indirect exchange of heat between a first fluid and a second fluid. The heat exchanger **1** has a casing **10** which surrounds a casing chamber M for accommodating the first fluid. The first fluid can be introduced into the casing chamber M via an inlet connector **101** on the casing **10** and can be extracted from the casing chamber M via an outlet connector **102** on the casing **10**,

[0023] The casing **10** extends along the longitudinal axis L in a vertical direction. The tube bundle **2** is also arranged in the casing chamber M, the tube bundle **2** having a multiplicity of tubes **20** for accommodating the second fluid. The tubes **20**, in a coil region W which extends along the longitudinal axis L from a lower coil end E to an upper coil end E', may be helically coiled in multiple layers **22** around a core tube **21**. The core tube **21** also extends along the longitudinal axis L and is arranged concentrically in the casing chamber M. Multiple tubes **20** of the tube bundle **2** may each form a tube group (three such tube groups are shown in FIG. **1**), wherein the tubes of a tube group may be combined in an associated tube plate **104**. The second fluid can be introduced into the tubes **20** of the respective tube group via inlet connectors **103** on the casing **10** and can be extracted from the tubes **20** of the corresponding tube group via outlet connectors **105**. Heat is therefore exchanged indirectly between the two fluids, wherein the fluids are preferably conducted through the heat exchanger **1** in a countercurrent configuration.

[0024] As shown in FIG. **2**, the tube bundle **2** has at least one tube **200** which is coiled around the core tube **21** (or around the longitudinal axis L) only in a section A of the coil region W. In section A, the desired temperature for the exchange of heat prevails for the flow conducted in the tube **200**. The temperature may be selected by the position of the section A along the longitudinal axis L relative to the coil region W and by the extent of the section A along the longitudinal axis L.

[0025] The tube bundle **2**, and the associated fluid flow, has an input temperature T_E, at the lower coil end E and has an output temperature $T_{E'}$ at the upper coil end E'.

[0026] Below the section A or above the section A or both below and above the section A, the at least one tube **200** has tube sections **200***a* and **200***b* which run in substantially straight or linear fashion to the lower coil end E and the upper coil end E' respectively and then to an associated inlet connector **103** or outlet connector **105** respectively.

[0027] The desired temperature T_A prevails at the lower transition from the tube section **200***a* to the section A and the desired temperature $T_{A'}$ prevails at the upper transition from the section A to the tube section **200***b*. Since the tube sections **200***a* and **200***b* do not significantly participate in the exchange of heat, a temperature similar to the temperature T_A prevails at the end of the tube section **200***a* or the coil end E, and a temperature similar to temperature $T_{A'}$ prevails at the end of the tube section **200***b* or the coil end E'.

[0028] The casing **10** and the core tube **21** may be of cylindrical form at least in sections, such that the longitudinal axis L forms a cylinder axis of the casing **10** and of the core tube **21** which runs concentrically therein. In the casing chamber M a barrel **3** may be arranged which surrounds the tube bundle **2** or at least one tube **200**, such that, between the tube bundle **2** and the barrel **3**, there is formed an intermediate chamber **4** which surrounds the tube bundle **2** or tube **200**. The barrel **3** serves to prevent the first fluid in the casing chamber M from bypassing the tube bundle **2** and tube **200**. The first fluid is thus guided in the casing chamber M especially in the region of the casing chamber M which is surrounded by the barrel **3**.

[0029] The individual tube layers **22** may (in particular in the case of horizontal mounting of the tube bundle **2**) be supported on one another or on the core tube **21** using spacer elements **6** that extend along the longitudinal axis L. Multiple spacer elements **6** may be arranged one above the other in a radial direction R of the tube bundle **2**.

LIST OF REFERENCE DESIGNATIONS

[0030]

1	Heat Exchanger
2	Tube bundle
3	Barrel
4	Intermediate chamber
6	Spacer elements
10	Casing
20	Tubes
21	Core tube
22	Tube layers
101	Inlet connector
102	Outlet connector
103	Inlet connector
104	Tube plate
105	Outlet connector
200	Tube
200a	Tube section
200b	Tube section
A	Section
E	Lower coil end
E'	Upper coil end
R	Radial direction
L	Longitudinal axis
M	Casing chamber
W	Coil region
T_A, $T_{A'}$, T_E, $T_{E'}$	Temperatures

1. A heat exchanger for the indirect exchange of heat between a first fluid and a second fluid, the heat exchanger comprising:

a casing extending along a longitudinal axis and surrounding a casing chamber, the casing chamber for accommodating the first fluid;

a tube bundle arranged in the casing chamber, the tube bundle having multiple tubes for accommodating the second fluid;

wherein in a coil region extending along the longitudinal axis, the tubes of the tube bundle are helically coiled around the longitudinal axis from a lower coil end to an upper coil end;

wherein at least one tube of the tube bundle is coiled around the longitudinal axis in only a section of the coil region; and

wherein the at least one tube extends as a straight tube below the section of the coil region along the longitudinal axis to the lower coil end; or

wherein the at least one tube extends as a straight tube above the section of the coil region along the longitudinal axis to the upper coil end; or

wherein the at least one tube extends as a straight tube below the section of the coil region along the longitudinal axis to the lower coil end and as a straight tube above the section of the coil region along the longitudinal axis to the upper coil end.

2. The heat exchanger according to claim **1**, wherein the heat exchanger has a core tube that extends along the longitudinal axis within the casing; and

wherein the tubes of the tube bundle are helically coiled around the core tube in the coil region.

3. The heat exchanger according to claim **1**, wherein the section of the coil region is positioned along the longitudinal axis such that, during operation of the heat exchanger a temperature prevails in the section of the coil region that is lower than a temperature prevailing at the lower coil end and that is higher than a temperature prevailing at the upper coil end.

4. The heat exchanger according to claim **1**, wherein the at least one tube of the tube bundle comprises multiple tubes.

5. The heat exchanger according to claim **4**, wherein the multiple tubes are coiled in multiple layers around the longitudinal axis.

6. The heat exchanger according to claim **1**, wherein multiple tube bundles are arranged in the casing chamber.

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