



(11)

EP 4 105 589 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.12.2022 Bulletin 2022/51

(51) International Patent Classification (IPC):
F28F 7/00 ^(2006.01) **F28F 21/00** ^(2006.01)

(21) Application number: **21179189.2**

(52) Cooperative Patent Classification (CPC):
F28F 7/02; F28F 9/0219; F28F 21/02;
F28F 2275/00

(22) Date of filing: **14.06.2021**

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **HEAT EXCHANGE BLOCK, METHOD FOR MANUFACTURING SAME, HEAT EXCHANGER EQUIPPED WITH SUCH A BLOCK AND METHOD FOR IMPLEMENTING SAME**

(57) This heat exchange block (1) comprises a body (10), longitudinal channels (20) intended to the flow of a process fluid, and transverse channels (60), intended to the flow of a service fluid.

According to the invention at least one front face (2), in particular upstream front face delimits a central chamber (3) defining a central surface (S3), a peripheral seat (4) defining a peripheral reference surface (S4) and a transition portion (5),

the distance (h4) between peripheral surface (S4) and closest transverse channel (60') being substantially superior to distance (h3) between central surface (S3) and closest transverse channel (60').

The thermal stress generated on the block of the invention is far lower than in prior art, so that lifetime of both block and heat exchanger is much longer than in prior art.

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Description

Technical field of the invention

[0001] The invention relates to the technical field of block heat exchangers. It relates more particularly to a heat exchange block, which is provided with an improved geometry with regards to both thermal and mechanical issues. The invention also relates to an exchanger which is equipped with such a heat exchange block.

Prior art

[0002] Numerous types of heat exchangers are known, of which mention shall be made inter alia of plate, tube or fin exchangers. The invention relates more particularly to a block type heat exchanger. The latter typically comprises first an inlet and an outlet for a so-called process fluid, both provided along main axis of the exchanger. Moreover the casing of this exchanger is equipped with transverse inlet and outlet, both for a so-called service fluid. Process fluid is for example an acid while service fluid is a heat transfer fluid, such as water.

[0003] The casing accommodates at least one heat exchange block, typically a plurality of these blocks which are stacked on top on one another. Each block is made of a thermally conductive material. The present invention more specifically relates to process fluids which are corrosive to metals. In this respect, said material is typically graphite optionally associated with additives, for example of the polymer type. This block may be parallelepipedic or cylindrical, bearing in mind that the invention more specifically aims cylindrical shaped blocks.

[0004] Two series of channels, intended for the circulation of respectively process fluid and service fluid, are hollowed in said block. First channels are longitudinal and open onto the front faces of the body, while the second channels are transverse and open onto the opposite transverse faces of the body.

[0005] Block heat exchangers of the above known type are described for example in EP-A-0 196 548 and WO-A-2006/081965.

[0006] Block heat exchangers of the prior art, such as above disclosed, are however not satisfactory, in particular with regard to mechanical issues. Indeed, some material failures have been observed, which reduce the lifetime of the exchanger. These failures occur in particular at the outer periphery of the front face of the block, which is upstream with reference to the flow of hot process fluid.

[0007] That being said, one aim of the present invention is providing a heat exchange block which makes it possible to remedy the drawbacks, inherent to above-mentioned prior art.

[0008] A further aim of the present invention is providing such a block which ensures both satisfactory mechanical and thermal performances to the heat exchanger equipped therewith.

[0009] A further aim of the present invention is provid-

ing such a heat exchanger, which has a relatively simple structure and which can be manufactured without any particular risk of mechanical rupture, particularly with respect to the channels hollowed in the blocks belonging to this exchanger.

Objects of the invention

[0010] One object of the present invention is a heat exchange block comprising

- a body (10), said body being in particular made of graphite, said body having in particular a cylindrical shape
- first so-called longitudinal channels (20), formed in this body along a longitudinal direction (L1) of the block, which open onto two opposite front faces (2, 6) of the body, said longitudinal channels being intended to the flow of a first so-called process fluid,
- second so-called transverse channels (60), formed in this body along a transverse direction, which open onto two opposite transverse faces (7,8) of the body, said transverse channels being intended to the flow of a second so-called service fluid, characterized in that at least one front face (2), in particular so-called upstream front face which is intended to receive hot process fluid, is provided with a recess (22) so that said front face delimits:
 - a central chamber (3) defining a so-called central reference surface (S3)
 - a peripheral seat (4) adapted to receive sealing means, said seat protruding upstream with respect to said central chamber along the longitudinal direction, said seat defining a so-called peripheral reference surface (S4)
 - a transition portion (5) which extends between said peripheral seat and said central chamber
 - the so-called peripheral distance (h4) between peripheral surface (S4) and a wall (61) of the closest transverse channel (60') being substantially superior to the so-called central distance (h3) between central surface (S3) and said wall (61) of closest transverse channel (60'), said distances (h3) and (h4) being considered along longitudinal direction of the block.

[0011] According to advantageous features of the heat exchange block according to the invention:

- ratio (h4/h3) between said peripheral distance and said central distance is superior to 1.2, preferably to 2.
- said ratio (h4/h3) between said peripheral distance and said central distance is inferior to 50, preferably to 15.
- said peripheral distance (h4) is superior to d_{60}' , preferably to $2 \cdot d_{60}'$, wherein d_{60}' is the diameter of said

closest transverse channel (60').

- said peripheral distance (h4) is inferior to $10 \cdot d_{60'}$, preferably to $5 \cdot d_{60'}$.
- said central distance (h3) is superior to t_{26} , preferably to $2 \cdot t_{26}$, wherein t_{26} is the smallest material thickness between said longitudinal channels (20) and said transverse channels (60).
- said central distance (h3) is inferior to $0.8 \cdot h_4$, preferably to $0.4 \cdot h_4$.
- so-called transition angle (α_5) between reference surface (S5) of transition portion and reference surface (S3) of chamber is between 30° and 90° .
- only said upstream front face (2) is provided with said recess (22), whereas opposite downstream front face (6) is substantially flush.

[0012] One further object of the present invention is a manufacturing method of a heat exchanger block as defined above, said method comprising:

- providing a preform, in particular a standard heat exchanger block, said preform comprising
 - * a body,
 - * first so-called longitudinal channels, formed in this body along a longitudinal direction of the preform, which open onto two opposite front faces of the preform, said front faces being both substantially flush,
 - * second so-called transverse channels, formed in this body along a transverse direction, which open onto two opposite transverse faces of the preform,
- removing material of the preform, in particular by machining or any analogous process, so as to form said chamber (3) and said transition portion (5).

[0013] One further object of the present invention is a heat exchanger comprising

- an enclosure having a lower cover (310), an upper cover (320) and a peripheral casing (330),
- at least one heat exchange block (1; 101; 201) arranged between the lower cover and the upper cover, each block comprising
 - a body,
 - first so-called longitudinal channels, formed in this body along a longitudinal direction of the block, which open onto two opposite front faces of the body, said longitudinal channels being intended to the flow of a first so-called process fluid,
 - second so-called transverse channels, formed in this body along a transverse direction, which open onto two opposite transverse faces of the body, said transverse channels being intended

to the flow of a second so-called service fluid,

the exchanger further comprising

- first inlet means (322) of a first fluid into the first channels
- second inlet means (336) of the second fluid into the second channels
- first outlet means (312) of the first fluid from the first channels
- second outlet means (337) of the second fluid from the second channels

said exchanger being characterized in that at least one heat exchange block (1) is a heat exchange block as defined above.

[0014] According to one advantageous feature of the invention, said heat exchanger comprises one single heat exchange block (1) as defined above, the latter being a so called upstream block located closest to first inlet means (322), said recess (22) being located on the so called upstream front face (2) turned towards said first inlet means.

[0015] According to one other advantageous feature of the heat exchanger according to the invention, said upper cover (320) comprises a peripheral collar (326) surrounding a central space (324), said cover resting upon said peripheral seat (4) of said single heat exchange block as defined above, said central space being in communication with said recess (22).

[0016] One further object of the present invention is a method for the implementation of a heat exchanger as defined above, wherein the first and second fluids are circulated in the first and second channels, so as to enable the heat exchange thereof, first fluid being admitted in the first inlet means at a temperature superior to 80°C , whereas second fluid is admitted in the second inlet means at a temperature between -20°C and 250°C .

Description of the figures

[0017] The invention will be described hereinafter, with reference to the appended drawings, given by way of nonlimiting example, wherein:

Figure 1 is a longitudinal sectional view, illustrating a heat exchanger which is equipped with a block according to the invention;

Figure 2 is a perspective view with cutaways, illustrating a block according to the invention;

Figure 3 is a longitudinal sectional view, similar to figure 1, illustrating in more detail the upstream extremity of the block of figure 2, as well as of the exchanger of figure 1;

Figure 4 is a longitudinal sectional view, analogous to figure 3, illustrating the upstream extremity of a block according to prior art, as well as of a heat exchanger equipped with such a block;

Figure 5 is a longitudinal sectional view, showing at

still a greater scale the upstream extremity of the block of figure 3.

Figure 6 is a graph, showing the evolution of both thermal and mechanical stresses of the block of the invention, according to the value of a representative ratio of this block.

Detailed description of the invention

[0018] The following reference numbers will be used throughout the present description

I heat exchanger according to the invention
 1 upstream block according to the invention
 10 body of block 1
 12 baffles on 10
 L1 longitudinal direction of the block
 2 upstream front face of block 1
 C P center and periphery of 2
 20 longitudinal channels
 22 recess in front face 2
 3 central chamber of front face 2
 h3 distance between S3 and 61
 4 peripheral seat of front face 2
 h4 distance between S4 and 61
 41 shoulder
 5 transition portion between chamber 3 and seat 4
 S3, S4 and S5 reference surfaces of 3, 4 and 5
 a5 angle between S3 and S5
 6 downstream front face of block 1
 7 upstream face of transverse channels
 8 downstream face of transverse channels
 60 transverse channels
 t26 thickness of material between 20 and 60
 d60 diameter of channel 60
 60' upstream transverse channels
 d60' diameter of channel 60'
 61 wall of 60'
 101 201 blocks part of exchanger I, which are according to prior art
 102 202 upstream faces of blocks 101 201
 106 206 downstream faces of blocks 101 201
 310 lower cover of exchanger I
 312 opening in 310
 320 upper cover of exchanger I
 322 opening in 320
 324 space in 320
 326 collar
 328 springs
 330 casing of exchanger I
 335 peripheral chamber
 336 337 inlet and outlet pipes
 II exchanger according to prior art
 401 upstream block
 402 front face of 401
 h402 distance between 402 and 460'
 C' P' center and periphery of 402
 460 transverse channels

h460 distance between two channels 460
 460' upstream transverse channel
 720 cover
 R rest zone of 720

[0019] Figure 1 illustrates a heat exchanger, referenced I as a whole. This exchanger firstly comprises a plurality of heat exchange blocks 1, 101 and 201. As will be described below in further detail, block 1 is according to the invention whereas blocks 101 and 201 are conform to prior art. In the example, three blocks stacked on top of one another have been represented, it being understood that a different number of blocks may be envisaged. Preferably, whatever the number of blocks, only one single block according to the invention is provided.

[0020] These different blocks 1, 101 and 201 are made of any suitable material, in particular adapted to a corrosive environment, such as for example graphite. Each block has a body, which is referenced 10 for what concerns block 1. Said body has a typical cylindrical shape, with a circular cross-section. In a way known as such baffles 12, which are illustrated in particular on figure 2 as well as on figure 5, are provided at the outer periphery of this body 10.

[0021] L1 refers to the main or longitudinal axis of each block, which is parallel with the main axis of the exchanger. In a manner known *per se*, each block is hollowed with different channels, so as to permit the flow of two fluids intended to be placed in mutual heat exchange.

[0022] A first series of channels 20, parallel with the axis L1 and referred to as longitudinal channels, open onto the opposite front faces 2 and 6 of each block. With reference to the flow direction of the fluid along longitudinal channels, each front face 2 is called upstream and each opposite front face 6 is called downstream.

[0023] Moreover, a second series of transverse channels 60, extending obliquely, particularly perpendicular to the axis L1, open onto the opposite transverse faces 7 and 8 of each block. In operation two fluids, circulating respectively in the first and second series of channels, are placed in heat exchange. These channels 20 and 60 are distant from one another, that is to say they do not open into one another.

[0024] Apart from blocks 1 to 201, heat exchanger I also comprises a lower cover 310, an upper cover 320, as well as a peripheral casing 330. Upper cover 320 is hollowed with an opening 322 intended for the inlet of a first so-called process fluid into the longitudinal channels of all three blocks. This inlet is connected with a source of this fluid, which is situated upstream and is not illustrated. Said opening leads to a space 324, provided in the lower face of the cover.

[0025] Moreover, the lower cover 310 is hollowed with an opening 312 intended for the outlet of the first fluid outside the longitudinal channels. This outlet is connected with an appropriate downstream equipment, such as a piping. The latter, which is known as such, is not illustrated on the figures.

[0026] Casing 330 defines, with the opposite walls of the blocks, a peripheral chamber 335 intended for the circulation of a second so-called service fluid, intended to be placed in heat exchange with the process fluid in the blocks 1 to 201. For this purpose, the casing is equipped with respective inlet 336 and outlet 337 pipes of this second fluid, connected with another appropriate downstream equipment, such as a further piping. The latter, which is also known as such, is not illustrated on the figures.

[0027] Above-mentioned space 324 delimits a peripheral collar 326 which rests upon the upstream block 1, in use. So as to avoid any contact between the two fluids, it is critical to ensure a tight seal between the conducting walls of the block 1 and the collar 326. To this end, the interface between said block and said collar is equipped with sealing means, which are known as such and are not illustrated in detail. Moreover upper cover 320 is provided with pressing means, adapted to exert a controlled compressive force on the block, as well as on said sealing means. In the illustrated example, these pressing means are formed by springs 328, in a way known as such

[0028] Advantageously downstream front face 6 of upstream block 1, as well as both front faces 102, 106, 202 and 206 of other blocks 101, 201 are manufactured according to prior art. The general structure of said classic faces is known *per se* and will not be explained here. It is sufficient to explain that these front faces 6, 102, 106, 202 and 206 are substantially flush. The word « flush » means that said front face is globally formed at the same altitude, with reference to main longitudinal axis of the block. In this respect each front face may be either completely flush or hollowed with at least one groove, the depth thereof is low, which is suitable for forming the seat of a sealing member, for example of the O-ring type.

[0029] Upstream front face 2 of upstream block 1 is on the contrary manufactured according to the invention. Indeed it is not flush but is however provided with a central recess 22, the depth thereof is substantial, thus delimiting:

- a central chamber 3, which leads to space 324 provided in the cover;
- a peripheral seat 4, radially surrounding said chamber; and
- a transition portion 5, which extends between said peripheral seat and said central chamber.

[0030] In the present embodiment, said central chamber 3 is flush and defines a so-called central reference surface S3. As an alternative, this chamber may not be flush, for example may have a corrugated shape. In this event, said reference surface is defined by the average altitude of said chamber.

[0031] Said seat 4 protrudes upstream with respect to said central chamber 3 along the longitudinal direction L1. It defines a so-called peripheral reference surface S4 which is flush in the present embodiment. In some vari-

ants this seat is not flush, but is provided for example with grooves adapted to receive some seals. Surface S4 is then defined by the average altitude of the seat, the same way as above mentioned surface S3. In use, collar 326 of upper cover 320 rests upon seat 4, while exerting compressing action on this seat due to the springs 328.

[0032] It is to be noted that, in the present example, a shoulder 41 is provided at the radial inner end of seat 4. This shoulder, the function of which is typically to maintain an annular seal, exerts no mechanical action.

[0033] Transition portion 5 is rectilinear in the present example, when viewed in cross-section on figure 5. By way of an alternatives, this portion may have other shapes with the provision for example of steps. Portion 5 is associated with a transition surface S which is defined the same way as surfaces S3 and S4.

[0034] Let us define some essential representative dimensions of upstream front face 2 of block 1:

- so-called peripheral distance h4 between peripheral surface S4 and the wall 61 of the closest transverse channel 60', along longitudinal direction of the block.
- so-called central distance h3 between central surface S3 and said wall 61 of closest transverse channel, along longitudinal direction of the block.

[0035] According to an essential feature of the invention, which will be detailed below, said distance h4 is far superior to said distance h3. In this respect, it shall be underlined that the applicant has identified explanations with respect to the drawbacks of prior art, as well as the importance of said essential feature.

[0036] Let us refer now to figure 4, illustrating an exchanger II according to prior art. On this figure 4 mechanical elements which are analogous to those of exchanger I are given the same references, added by number 400.

[0037] Let us firstly note R the so-called rest zone where the upper cover 720 rests upon the upstream graphite block 401. In this zone a minimum clamping force has to be applied, which induces a noticeable compressive stress on the area of the graphite column, where the cover 720 is bearing. The compressive load on the rest zone R leads to tensile stresses close to the maximum allowable tensile stress. This problem is compounded by the presence of the upstream transverse channels 460' passing under the surface supporting the cover.

[0038] To ensure mechanical performance heat exchangers according to prior art are provided with a substantial thickness of material, which forms a flush front face 402. In other words, as shown on said figure 4, distance h402 separating said front face 2 and the upstream transverse channels 460' is far higher than the distance h460 between two adjacent series of transverse channels. This makes it possible to reduce the stress supported by the graphite material in the area of the first layer of horizontal channels.

[0039] Even though this design is theoretically advantageous as far as mechanical matter are concerned, it

however creates an undesired thermal-stress issue. The latter, which is illustrated on figure 4, is especially severe when the process fluid is introduced in the heat exchanger at a high temperature.

[0040] In the center C' of front face 402 the graphite surface is firstly in contact with the hot incoming process fluid. Moreover it is far away from the first cooling channel, due to the high value of h_{402} . In periphery P' of this front face, the graphite surface is also in contact with the hot incoming process fluid. However, contrary to center C' , this periphery P' is also quite close from the service fluid, the temperature of which is far inferior to that of process fluid.

[0041] As a consequence temperature $T_{C'}$ in the center is far superior to temperature $T_{P'}$ in the periphery. As a result the volume of graphite in the vicinity of the center expands more than the volume of graphite in the vicinity of the periphery, which induces the development of a thermal stress across the heat exchanger. This stress is likely to cause some material failure, especially in the periphery area P' .

[0042] The latter is indeed submitted to a combination of a mechanical stress due to clamping force, as well as of a thermal stress due to thermal gradient through the graphite block. This failure phenomenon is likely to occur especially in transient modes, when the heat exchanger starts receiving some hot process fluid, after being idle for a time long enough to have an even and low temperature. As a summary the applicant has identified that, even though upstream end of prior art exchange blocks are provided with a substantial thickness of material, it paradoxically leads to mechanical fragility.

[0043] As mentioned above one essential feature of the invention is to significantly increase ratio h_4/h_3 . In this respect figure 6 illustrates the variations of both mechanical and thermal stresses, with respect to ratio h_4/h_3 . On the graph of figure 6, x-axis corresponds to said ratio. Moreover chain-dotted lines illustrate the variation of a parameter M which is representative of mechanical stress of the block, dotted lines illustrate the variation of parameter T which is representative of thermal stress of the block, whereas solid lines illustrate the global stress G , i.e. the sum of M and T stress values. Both for M and T , the lower the value, the better is the behaviour.

[0044] As shown by this figure 6, thermal stress decreases as ratio h_4/h_3 increases. Moreover mechanical stress increases as said ratio h_4/h_3 increases. However, in a surprising manner, the decrease of thermal stress is far more significant than the increase of mechanical stress. As a result, the value of the global stress G tends to decrease due to the increase of ratio h_4/h_3 .

[0045] In theory this increase of ratio h_4/h_3 can be achieved, either by increasing the value of h_4 and/or by reducing the value of h_3 . In practice it is preferred to keep h_4 at a value, which is similar to that of prior art blocks. In this respect, h_4 is advantageously set so that the stress applied by the clamping force, through the upper cover, is compatible with the material mechanical properties.

Due to the specific geometry of the front face 2 of the block, the clamping force is mostly carried by the annular seat 4, as well as subsidiary by the transition portion 5.

[0046] On the other hand, h_3 is significantly reduced so as to reach values that are far inferior to prior art. In other words the central portion of the front face is rendered much thinner than the periphery of the block. Moreover, in a surprising way, this reduction of h_3 is not prejudicial to the global mechanical behavior. This makes it possible to lower by far thermal stress, with respect to prior blocks with flush front face such as illustrated on figure 4. Therefore h_3 can be advantageously set at a very low value, without any regards for mechanical stresses imposed by the clamping force. This low value favors an efficient thermal exchange between the top surface of chamber 3 and the underlying layer of horizontal channels 60', as they are close from each other.

[0047] When compared to the prior art, there is an improved thermal exchange between the column top surface in contact with the hot process fluid and the first layer of channels in contact with the cold service fluid. As a consequence the center portion C of the front face 2, as illustrated on figure 3, has in use a lower temperature than the center portion C' of prior art, illustrated on figure 4. The thermal gradient $T_P - T_C$, according to the invention, is therefore significantly reduced with respect to prior art gradient $T_{P'} - T_{C'}$.

[0048] As a consequence, the thermal stress generated by this thermal gradient is far lower than in prior art, so that lifetime of both block 1 and heat exchanger according to the invention is much longer than in prior art. This reduction of blocks breakages leads to a decrease of the global volume of impregnated graphite to be manufactured. In addition, less wastes of such impregnated graphite are to be handled.

[0049] As a summary, the invention takes the side to remove graphite material in a targeted zone. This makes it possible to improve thermal performances, due to this local thinning, while preserving high mechanical performances. Therefore, in a surprising way, removing material is not prejudicial to global mechanical behaviour.

[0050] Turning back to graph of figure 6, those skilled in the art will be in a position to choose an appropriate value of ratio h_4/h_3 , so as to obtain a significant decrease of global stress G and, therefore, to substantially improve the global behaviour of the block and of the whole exchanger. In this respect ratio h_4/h_3 is advantageously superior to 1.2, preferably superior to 2. Moreover those skilled in the art will choose this ratio, so as to preserve the global mechanical strength of the block as well as of the exchanger. In this respect said ratio h_4/h_3 is advantageously inferior to 50, preferably inferior to 15.

[0051] In an advantageous way, with reference in particular to figure 5:

- h_4 is superior to $d_{60'}$, preferably to $2 \cdot d_{60'}$, wherein $d_{60'}$ is the diameter of channels 60'. In this respect, h_4 is superior for example to 8 mm.

- h4 is inferior to $10 \cdot d_{60'}$, preferably to $5 \cdot d_{60'}$. In this respect, h4 is inferior for example to 100 mm, in particular to 50 mm.
- h3 is superior to t26, preferably to $2 \cdot t_{26}$, wherein t26 is the material thickness between channels 20 and 60. On this figure 5, the walls of one channel 20 are schematically shown in dotted lines. In this respect, h3 is superior for example to 1 mm.
- h3 is inferior to $0.8 \cdot h_4$, preferably to $0.4 \cdot h_4$. In this respect, h3 is inferior for example to 20 mm.

[0052] Turning back to figure 5, let us note a5 the angle between reference surface S5 of portion 5 and surface S3. Typically said angle a5 is between 30 and 90°. In the illustrated example, said portion is rectilinear. However, said portion 5 may be differently shaped, in particular stepped. In this case, reference surface is a line passing through bottom point and top point of said portion 5.

[0053] Block 1 may be manufactured starting from a standard block according to prior art, opposite front faces of which are substantially flush. In this respect, recess 22 is provided in one single of these front faces. This stage may be carried out typically by a machining process. Once said recess has been provided, this leads to the formation of both central chamber 3 and transition portion 5. Typically no material is removed in the periphery of said standard block, at the level of seat 4. Such a manufacturing method is advantageous, since it makes it possible to revamp a classic heat exchange block.

[0054] In view of the use of the above heat exchanger I, process fluid and service fluid are admitted in a way known as such, via inlets 322 and 336. By way of example, admission temperature of process fluid is advantageously superior to 80°C. In this range of temperatures, the specific geometry of the invention is especially advantageous, with regard to prior art designs. Moreover admission temperature of service fluid is typically between -20 and 250°C. Once these two fluids have been admitted in the exchanger, they are placed in heat exchange in a usual way. Cooled process fluid is discharged via the outlet opening 312, whereas warmed up service fluid is discharged via the outlet tube 337.

[0055] The invention is not limited to the example, which has been described above with reference to the appended figures 1 to 3, as well as 5 and 6.

[0056] Indeed, in this example, the block 1 is provided with one single chamber 3 on its upstream front face. As a variant, which is however less preferred, opposite front faces may be both provided with a respective chamber.

[0057] In addition this example refers to an exchanger equipped with one single block according to the invention, which is provided upstream. As a variant such an exchanger may be equipped with more than one block, in particular with two adjacent blocks positioned upstream. As another variant, the exchanger may be equipped with an upstream so-called neutral block. In a way known as such, this neutral block does not ensure any exchange function, but an auxiliary function such as

the fluid distribution. In this respect at least one block according to the invention is positioned upstream, adjacent said neutral block.

[0058] Finally, in the present example, the exchanger extends vertically with a top inlet of process fluid, as well as a bottom outlet of said process fluid. Alternatively said process fluid may flow from the bottom to the top. As another variant, the exchanger may extend horizontally or in an oblique manner.

Claims

1. Heat exchange block (1) comprising

- a body (10), said body being in particular made of graphite, said body having in particular a cylindrical shape
- first so-called longitudinal channels (20), formed in this body along a longitudinal direction (L1) of the block, which open onto two opposite front faces (2, 6) of the body, said longitudinal channels being intended to the flow of a first so-called process fluid,
- second so-called transverse channels (60), formed in this body along a transverse direction, which open onto two opposite transverse faces (7, 8) of the body, said transverse channels being intended to the flow of a second so-called service fluid, **characterized in that** at least one front face (2), in particular so-called upstream front face which is intended to receive hot process fluid, is provided with a recess (22) so that said front face delimits:
 - a central chamber (3) defining a so-called central reference surface (S3)
 - a peripheral seat (4) adapted to receive sealing means, said seat protruding upstream with respect to said central chamber along the longitudinal direction, said seat defining a so-called peripheral reference surface (S4)
 - a transition portion (5) which extends between said peripheral seat and said central chamber,

the so-called peripheral distance (h4) between peripheral surface (S4) and a wall (61) of the closest transverse channel (60') being substantially superior to the so-called central distance (h3) between central surface (S3) and said wall (61) of closest transverse channel (60'), said distances (h3) and (h4) being considered along longitudinal direction of the block.

2. Heat exchange block according to claim 1, **characterized in that** ratio (h4/h3) between said peripheral distance and said central distance is superior to 1.2, preferably to 2.

3. Heat exchange block according to one of the pre-

ceding claims **characterized in that** said ratio (h_4/h_3) between said peripheral distance and said central distance is inferior to 50, preferably to 15.

4. Heat exchange block according to one of the preceding claims **characterized in that** said peripheral distance (h_4) is superior to d_{60} , preferably to $2 \cdot d_{60}$, wherein d_{60} is the diameter of said closest transverse channel (60). 10
5. Heat exchange block according to one of the preceding claims, **characterized in that** said peripheral distance (h_4) is inferior to $10 \cdot d_{60}$, preferably to $5 \cdot d_{60}$. 15
6. Heat exchange block according to one of the preceding claims **characterized in that** said central distance (h_3) is superior to t_{26} , preferably to $2 \cdot t_{26}$, wherein t_{26} is the smallest material thickness between said longitudinal channels (20) and said transverse channels (60). 20
7. Heat exchange block according to one of the preceding claims, **characterized in that** said central distance (h_3) is inferior to $0.8 \cdot h_4$, preferably to $0.4 \cdot h_4$. 25
8. Heat exchange block according to one of the preceding claims, **characterized in that** so-called transition angle (α_5) between reference surface (S_5) of transition portion and reference surface (S_3) of chamber is between 30° and 90° . 30
9. Heat exchange block according to any preceding claim, **characterized in that** only said upstream front face (2) is provided with said recess (22), whereas opposite downstream front face (6) is substantially flush. 35
10. A manufacturing method of a heat exchanger block according to any preceding claim, said method comprising: 40
 - providing a preform, in particular a standard heat exchanger block, said preform comprising 45
 - * a body,
 - * first so-called longitudinal channels, formed in this body along a longitudinal direction of the preform, which open onto two opposite front faces of the preform, said front faces being both substantially flush,
 - * second so-called transverse channels, formed in this body along a transverse direction, which open onto two opposite transverse faces of the preform, 50
 - removing material of the preform, in particular 55

by machining or any analogous process, so as to form said chamber (3) and said transition portion (5).

- 5 11. Heat exchanger comprising
 - an enclosure having a lower cover (310), an upper cover (320) and a peripheral casing (330),
 - at least one heat exchange block (1; 101; 201) arranged between the lower cover and the upper cover, each block comprising
 - a body,
 - first so-called longitudinal channels, formed in this body along a longitudinal direction of the block, which open onto two opposite front faces of the body, said longitudinal channels being intended to the flow of a first so-called process fluid,
 - second so-called transverse channels, formed in this body along a transverse direction, which open onto two opposite transverse faces of the body, said transverse channels being intended to the flow of a second so-called service fluid, 10
- the exchanger further comprising
 - first inlet means (322) of a first fluid into the first channels
 - second inlet means (336) of the second fluid into the second channels
 - first outlet means (312) of the first fluid from the first channels
 - second outlet means (337) of the second fluid from the second channels 15

said exchanger being **characterized in that** at least one heat exchange block (1) is a heat exchange block according to any of claims 1 to 9.

12. Heat exchanger according to preceding claim, comprising one single heat exchange block (1) according to any of claims 1 to 9, the latter being a so called upstream block located closest to first inlet means (322), said recess (22) being located on the so called upstream front face (2) turned towards said first inlet means. 20
13. Heat exchanger according to preceding claim, **characterized in that** it said upper cover (320) comprises a peripheral collar (326) surrounding a central space (324), said cover resting upon said peripheral seat (4) of said single heat exchange block according to any of claims 1 to 9, said central space being in communication with said recess (22). 25
14. A method for the implementation of a heat exchanger according to one of claims 11 to 13, wherein the first 30

and second fluids are circulated in the first and second channels, so as to enable the heat exchange thereof, first fluid being admitted in the first inlet means at a temperature superior to 80°C, whereas second fluid is admitted in the second inlet means at a temperature between -20°C and 250°C.

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Fig. 1

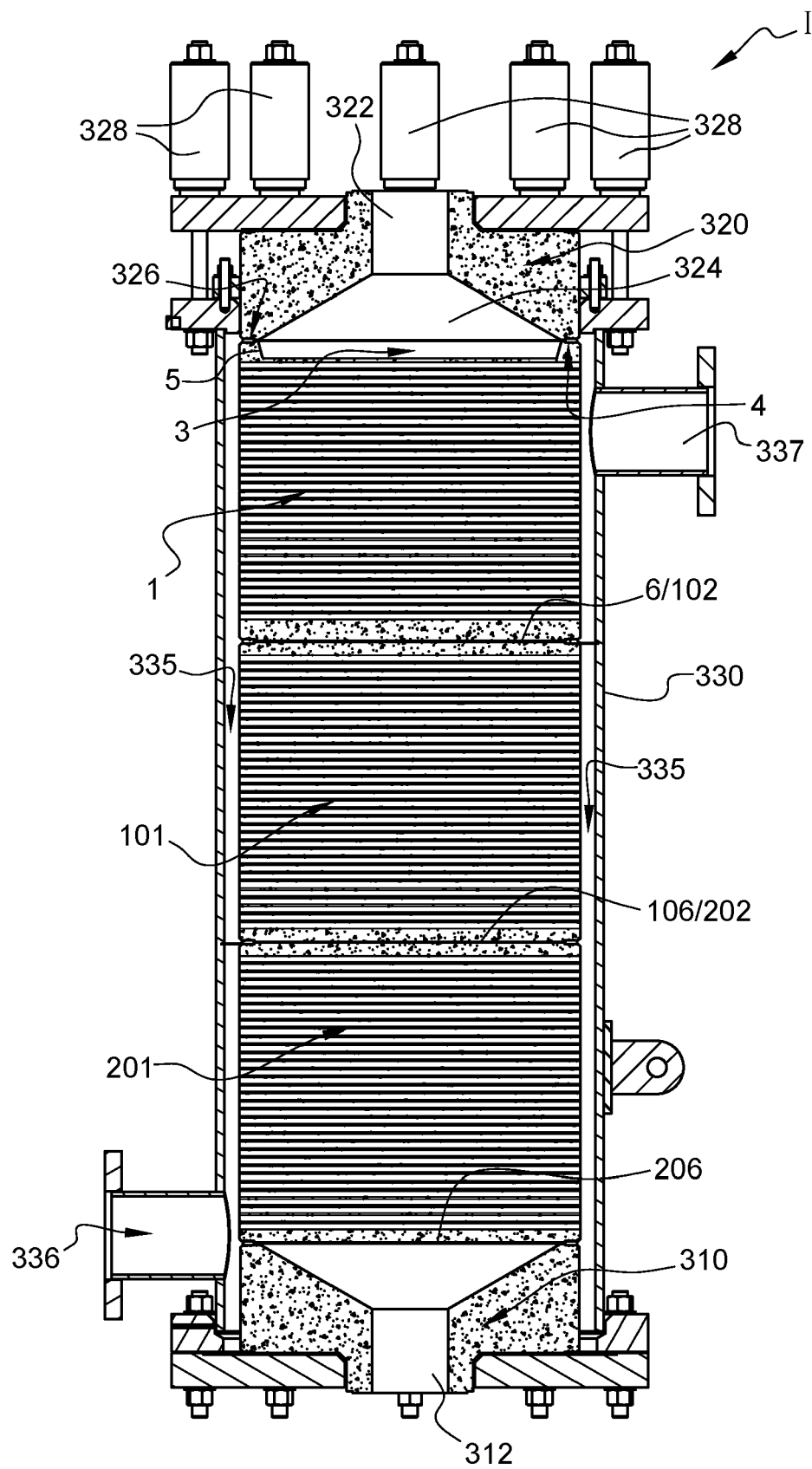


Fig. 2

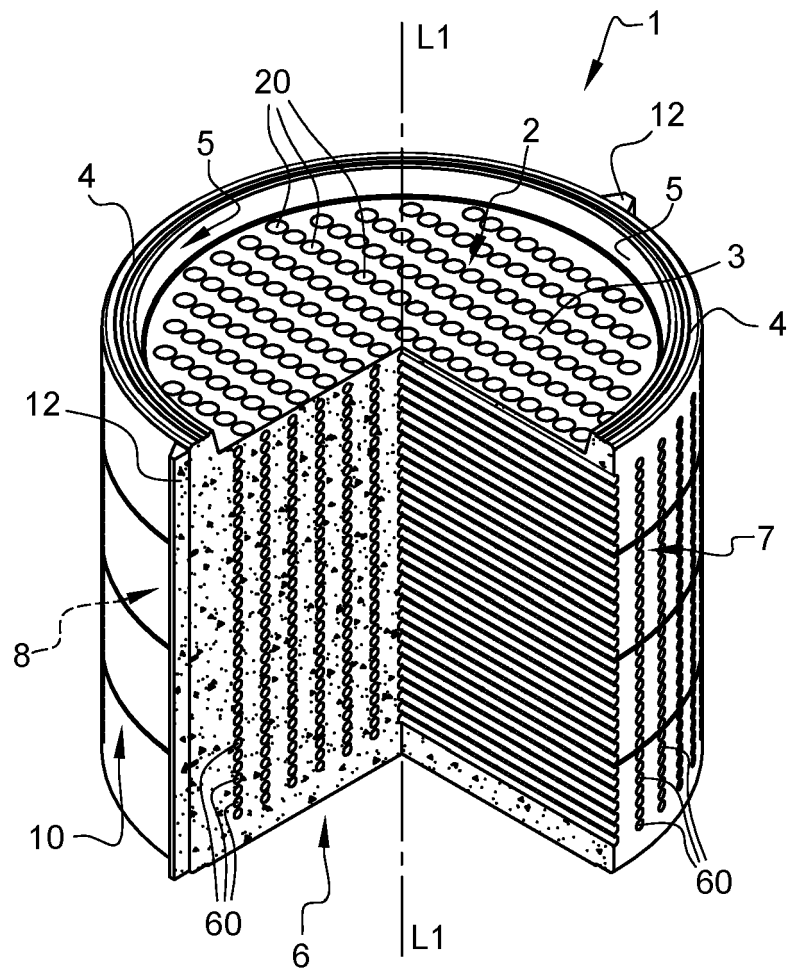


Fig. 6

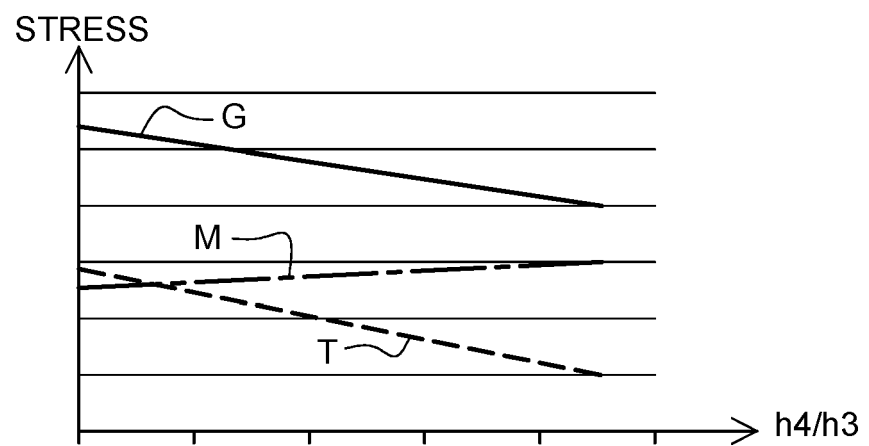


Fig. 3

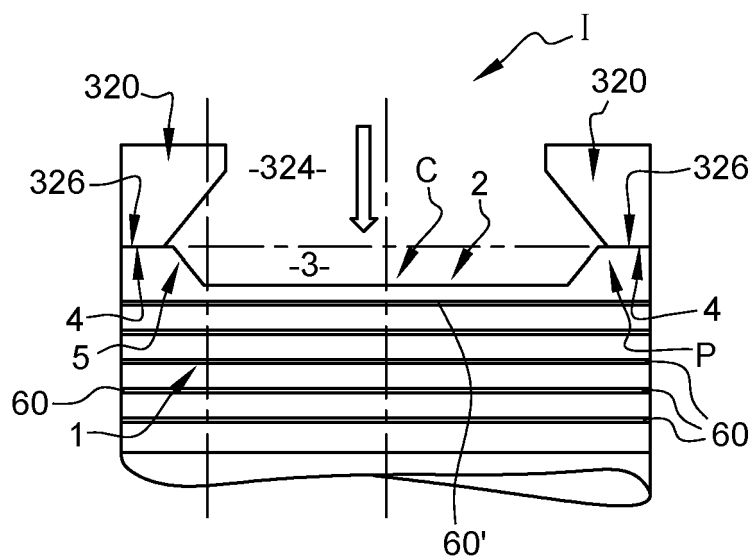


Fig. 4
PRIOR ART

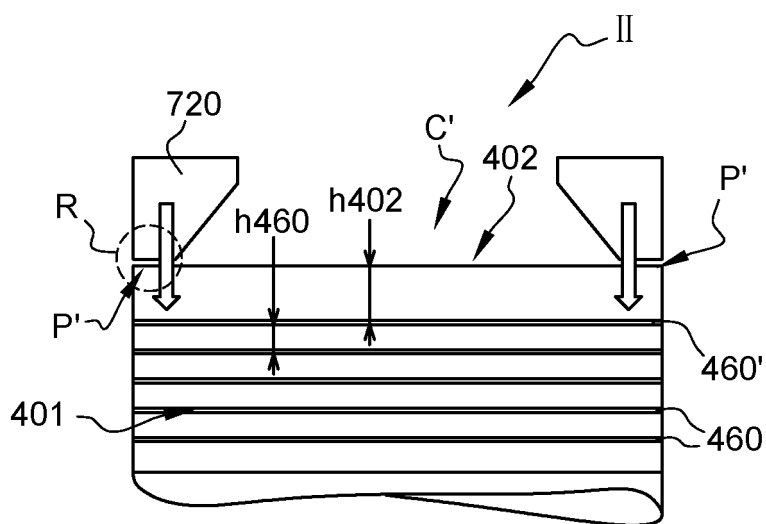
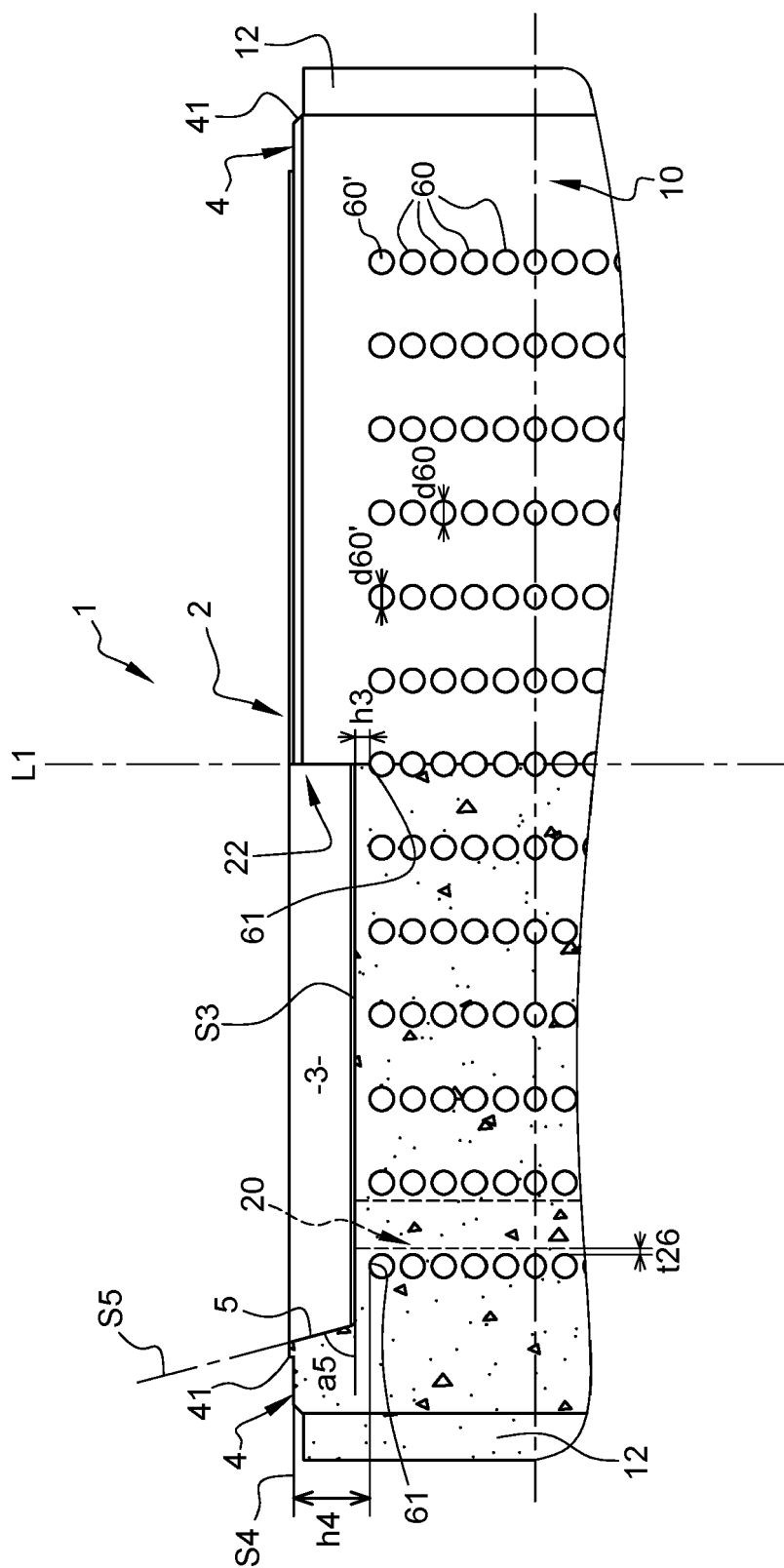


Fig. 5





EUROPEAN SEARCH REPORT

Application Number
EP 21 17 9189

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Place of search Munich		Date of completion of the search 15 November 2021	Examiner Bain, David
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