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(54) **Tube for a heat exchanger**

(57) The present invention relates to a tube for a heat exchanger comprising a region with dimples according to a specific pattern such that it increases the degree of heat exchange with low pressure drop. The use of a tube for a heat exchanger according to the invention in heat

exchangers for EGR (Exhaust Gas Recirculation) systems is of particular interest. The present invention is also considered of interest for the environment as it increases the efficiency of the heat exchangers for which it is designed.

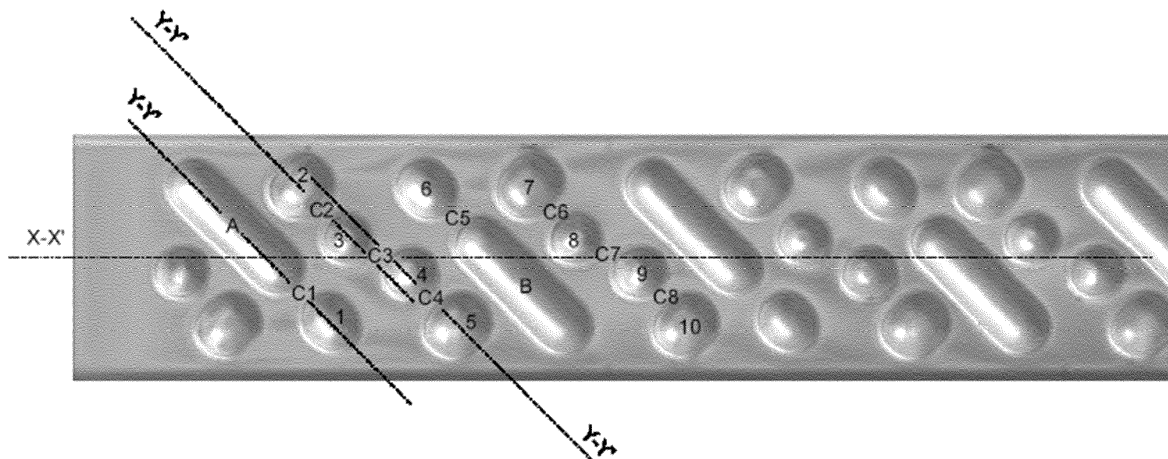


FIG. 1

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Description

Object of the Invention

[0001] The present invention relates to a tube for a heat exchanger comprising a region with dimples according to a specific pattern such that it increases the degree of heat exchange with low pressure drop.

[0002] The use of a tube for a heat exchanger according to the invention in heat exchangers for EGR (Exhaust Gas Recirculation) systems is of particular interest. The present invention is also considered of interest for the environment as it increases the efficiency of the heat exchangers for which it is designed.

Background of the Invention

[0003] Heat exchangers are devices promoting heat transfer between two fluids through an exchange surface which prevents the mixing of both fluids. The amount of transferred heat is proportional to the exchange surface and also proportional to the exchange rate per unit area.

[0004] The heat exchange rate per unit area depends primarily on flow conditions around the exchange surface and on fluid properties. Given that convective heat transfer mechanisms are much more efficient than diffusive heat transfer mechanisms, solutions used in the state of the art seek to enhance convection in the vicinity of the exchange surface.

[0005] One of the means for increasing convection in the vicinity of the exchange surface is the use of fins. The most widely used fins are projections in the form of plates emerging from the surface. Fins have a dual effect on the flow flowing in the vicinity of the exchange surface, the first effect being an increase in the effective surface in contact with the fluid since the exchange surface remains the same except for the area where the fin starts, plus the area on both sides of the fin; and the second effect being an increase in turbulence in the vicinity of the exchange surface.

[0006] Increasing turbulence enhances convection effects since the occurrence of vortices having a small characteristic diameter generates movement structures favoring mass exchange between the vicinity of the exchange surface and regions further away where the main flow is located, the final result being increased convective heat transport between the exchange surface and the fluid.

[0007] This clear advantage has the drawback that although heat exchange increases, pressure drop also increases. When the heat exchange area is formed by tubes through which a first fluid flows and said tubes are immersed in a second fluid with which it exchanges heat and which in turn is housed in a shell, pressure drop occurs both between shell inlet and outlet and between tube inlet and outlet.

[0008] A high pressure drop involves the need for higher propulsion energy. The pressure drop allows estab-

lishing, together with heat exchange rate, the overall degree of efficiency of the heat exchanger. An efficient heat exchanger therefore requires not only a high heat exchange rate but also low pressure drop.

[0009] A high heat exchange rate allows reducing the volume necessary for housing the exchange surface for specific heat requirements, for example.

[0010] A particular case of tubes for a heat exchanger that uses fins are those known in this state of the art as hybrid tubes, fin and tube or fin and plate. Hybrid tubes are tubes formed by means of sheet metal the shape of which is of a planar configuration, i.e., according to the section thereof, it has two parallel planar segments laterally closed by means of respective curved segments.

[0011] The inside of this tube having a planar configuration has a second part formed by a sheet with several bends forming fins where this sheet is trapped between the two planar surfaces.

[0012] Such tube is very efficient as regards exchange rate but has specific problems due to the thermal expansion effect of the inner sheet, for example, which can cause fatigue in areas where this expansion generates stresses. This is the case of the tube embedment area, for example, where expansion of the inner part is limited by the embedment.

[0013] An alternative to such tubes is a tube also having a planar configuration containing dimples on at least one of its faces. Dimples are not as efficient as fins since they cannot be compacted as much nor can they increase the exchange area to the same extent, but they have the advantage of not having the expansion problems indicated above and of increasing tube rigidity.

[0014] The conventional way of manufacturing such tubes is based on a drawn metal sheet that is subsequently bent according to a longitudinal direction until the tube is closed. The tube is closed by means of a longitudinally extending weld bead joining the edges facing one another, for example.

[0015] The presence of dimples increases turbulence and therefore the heat transfer rate. Planar tubes formed by dimples having various dimple patterns to increase the heat exchange rate are known.

[0016] Patterns that are modified downstream to take into account flow variations due to the influence of dimples located upstream are also known. Nevertheless, such patterns make manufacturing the tube difficult since the same mold cannot be used in stamping along the entire length of the tube or actuators modifying the depth of the dimples as the sheet stamping operation for obtaining the tube progresses are required in machines.

[0017] Although these patterns increase the heat transfer rate, they also increase pressure drop.

[0018] The present invention relates to a tube incorporating dimples for increasing the heat transfer rate which allows overcoming the drawbacks identified above using a dimple pattern combining a high heat exchange rate and a low pressure drop.

Description of the Invention

[0019] The tube for a heat exchanger according to the present invention is a tube having a flattened configuration comprising a first essentially planar face and a second essentially planar face parallel to and spaced from the first face. The flattened configuration of the tube must therefore be interpreted by the presence of the first planar face and the second planar face arranged parallel to one another and both faces being connected by side walls. Although the side walls can have any configuration, the most common embodiments use a configuration in a semicircular segment according to the section of the tube.

[0020] At least one face has a plurality of dimples configured according to a pattern that is repeated along the longitudinal direction X-X' of the tube. The longitudinal direction of the tube is the direction along which the directrix of the tube extends.

[0021] The pattern is configured by means of a plurality of groups of dimple alignments covering the width of the planar face. The dimples usually have a fillet radius in the root so that stamping does not generate excessive residual stresses or deformation does not weaken the sheet. This fillet radius causes a certain spacing between other dimples or the walls of the tube so the indication that the dimples cover the width of the planar face must be interpreted to mean that there can be a transition area or a passage channel between the dimples located on the sides of the planar face and the walls of the tube.

[0022] The plurality of groups of alignments complies with:

being aligned according to one and the same direction Y-Y' arranged obliquely between 40° and 50° degrees with respect to the longitudinal direction X-X', and where at least the tube comprises:

- *a first group which is formed by two dimples, a first elongated dimple extending according to the oblique direction Y-Y' aligned with a first point dimple such that a first flow channel is established between the elongated dimple and the point dimple,*
- *a second group which is formed by four point dimples, a second point dimple, a third point dimple, a fourth point dimple and a fifth point dimple, essentially aligned according to the oblique direction Y-Y', such that a second flow channel is established between the second point dimple and the third point dimple, a third flow channel is established between the third point dimple and the fourth point dimple, a fourth flow channel is established between the fourth point dimple and the fifth point dimple,*
- *a third group which is formed by two dimples, a sixth point dimple aligned with a second elongated dimple, extending according to the ob-*

lique direction Y-Y', such that a fifth flow channel is established between the sixth point dimple and the second elongated dimple,

- *a fourth group which is formed by four point dimples, a seventh dimple, an eighth dimple, a ninth dimple and a tenth dimple, essentially aligned according to the oblique direction Y-Y', such that a sixth flow channel is established between the seventh point dimple and the eighth point dimple, a seventh flow channel is established between the eighth point dimple and the ninth point dimple, an eighth flow channel is established between the ninth point dimple and the tenth point dimple,*

wherein the position of the first flow channel is such that the flow going through same in the operating mode is mainly transported towards the third flow channel and the fourth flow channel.

[0023] The pattern contains elongated dimples and point dimples. The elongated dimples have a preferred direction. When a group of dimples is indicated as being aligned in a specific direction, it must be interpreted as the elongated dimples extending with the orientation of the alignment, and furthermore the axis along which they extend also passes through the locations of the point dimples except for possible minor deviations.

[0024] The pattern formed by each group which is formed by the plurality of dimples has an oblique orientation Y-Y' towards one and the same side. This orientation leads to the existence of speed components that are also oblique but does not reorient the entire flow in this direction. The strategic position of passage sites with continuity between consecutively arranged groups of dimples generates preferred passage channels oriented either in the longitudinal direction or even in the oblique direction but with an opposite inclination with respect to the oblique direction Y-Y' according to the symmetry defined by the longitudinal axis X-X'.

[0025] Alternating one oblique direction and another increases local turbulence, in turn allowing significant flow through the channels thus identified. The state of the art teaches that the existence of a large number of dimples increases turbulence but reduces the effective section of the tube since they are projections that penetrate the tube, increasing resistance to passage.

[0026] The special configuration according to the present invention maintains a large number of dimples having the effect of a high degree of turbulence, but it does not significantly reduce the effective section since the formation of channels as established according to the particular dimple pattern according to the invention maintains a flow with low pressure drop since the flow finds preferred passage channels.

[0027] The formation of preferred passage channels depends not only on the relative position of the space between dimples downstream of a specific channel but also on the influence of other surrounding dimples. The

final behavior of a specific dimple design cannot be predicted due to this strong link between neighboring dimples both laterally and in both the downstream and upstream flow direction, and much less so when the use of a pattern which is periodically reproducible along the length of the tube is of interest such as the case where there are changes from one pattern to the next in the downstream flow.

[0028] The only way to determine if a pattern complies with efficiency objectives, i.e., high heat transfer with few losses, is by flow simulation in a tube incorporating the proposed pattern. This simulation can be carried out by means of numerical models (CFD (Computational Fluid Dynamics) simulations), for example. The simulations allow carrying out numerical experiments assessing heat transfer and flow behavior where, in contrast, comparison with other known patterns never allows extrapolating the results.

[0029] The pattern object of the present invention has been proven to efficiently solve the described drawbacks. The combination of a distribution of groups of dimples in one direction combined with the channels formed between consecutively arranged sets has been proven to have an perturbing influence on the surrounding flow extending a smaller distance than those known in the state of the art according to the direction perpendicular to the plane on which the dimples are arranged. This allows the symmetrical arrangement on both opposite faces of the tube to continue to maintain the increase in heat transfer by pattern shown by the use of a pattern on a single face; i.e., the flow modified by the pattern on one face does not negatively interfere with the flow modified by the dimple pattern of the opposite face, something that does occur with other patterns when they are located facing one another.

[0030] The configuration of the pattern proposed by the invention causes vortices to be generated downstream of the dimples which are then homogenized as a result of the fluid flow established through specific preferred channels that are generated with the spaces between dimples. Particularly, an S-shaped or similarly shaped path with vortices is formed, successfully increasing heat transfer such that it makes up for the pressure drop resulting from the dimples.

Description of the Drawings

[0031] The foregoing and other features and advantages of the invention will be more clearly understood based on the following detailed description of a preferred embodiment provided only by way of illustrative and non-limiting example in reference to the attached drawings.

Figure 1 shows a plan view of a tube incorporating along its length X-X' an alignment of patterns according to one embodiment of the invention.

Figure 2 shows a Nusselt number variation map for determining the increase in heat transfer on the sur-

face incorporating the plurality of patterns according to the embodiment shown in Figure 1 in comparison with the heat transfer if this were to occur only by conduction.

Figure 3 shows a tube where both flattened faces have a pattern such as that of the example shown in Figure 1, i.e., repeated along the length of the tube. This figure shows the two patterns being superimposed on one another, the pattern of the visible face being shown by means of continuous lines and the pattern of the opposite non-visible face being shown by means of dotted lines.

Detailed Description of the Invention

[0032] According to the first inventive aspect, the present invention relates to a tube for a heat exchanger showing high convective heat transfer without significant pressure drop. The configuration of the tube is planar, i.e., formed by two laterally connected parallel planar surfaces where there is a plurality of dimples according to a specific pattern located on one or both planar faces.

[0033] Figure 1 shows a tube according to an embodiment having a flattened configuration. In this embodiment, the pattern shows a plurality of dimples (A, B, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10) configured according to a pattern that is repeated along the longitudinal direction X-X' of the tube. Direction X-X' is the longitudinal direction of the tube.

[0034] The group of dimples can be repeated along the length of the tube as many times as necessary.

[0035] The pattern is configured by means of a plurality of groups of dimple alignments covering the width of the planar face, with the understanding that there is a fillet radius between the side dimples and the edge. The plurality of groups of alignments are aligned according to one and the same direction Y-Y' arranged obliquely between 40° and 50° degrees with respect to the longitudinal direction X-X'. In this embodiment shown in Figure 1, the angle of the oblique axis Y-Y' is 45 degrees.

[0036] Particularly, the pattern is formed by at least four groups.

[0037] The first group is formed by two dimples (A, 1), a first elongated dimple (A) extending according to the oblique direction Y-Y' aligned with a first point dimple (1) such that a first flow channel (C1) is established between the elongated dimple (A) and the point dimple (1).

[0038] The flow channel is a gap between the dimples, i.e., the first elongated dimple (A) and the first point dimple (1). A flow channel will be understood hereinafter as such gaps between dimples.

[0039] The flow can go through the position of a dimple since said dimple does not reach the opposite wall of the tube. Nevertheless, it imposes oblique speed components. The passage channels are not subjected to this imposition that laterally diverts part of the flow and allows recovering either a longitudinal trajectory or even also an oblique trajectory but with an inclination opposite that of

the Y-Y' axis with respect to the X-X' axis.

[0040] The second group is formed by four point dimples, a second point dimple (2), a third point dimple (3), a fourth point dimple (4) and a fifth point dimple (5), essentially aligned according to the oblique direction Y-Y', such that a second flow channel (C2) is established between the second point dimple (2) and the third point dimple (3), a third flow channel (C3) is established between the third point dimple (3) and the fourth point dimple (4), a fourth flow channel (C4) is established between the fourth point dimple (4) and the fifth point dimple (5).

[0041] As indicated above, the second channel (C2), the third channel (C3) and the fourth channel (C4) do not have to be fed completely by the channels arranged upstream, but they can also receive flow from the main flow of the tube. Such a complex response of the flow to a specific pattern hence arises. In this particular case, the way to align the different flow channels formed between dimples determining different effects on the flow as will be identified below when describing all the elements forming the pattern is of special interest.

[0042] The third group is formed by two dimples (6, B), a sixth point dimple (6) aligned with a second elongated dimple (B), extending according to the oblique direction Y-Y', such that a fifth flow channel (C5) is established between the sixth point dimple (6) and the second elongated dimple (B).

[0043] The fourth group is formed by four point dimples, a seventh dimple (7), an eighth dimple (8), a ninth dimple (9) and a tenth dimple (10), essentially aligned according to the oblique direction Y-Y', such that a sixth flow channel (C6) is established between the seventh point dimple (7) and the eighth point dimple (8), a seventh flow channel (C7) is established between the eighth point dimple (8) and the ninth point dimple (9), an eighth flow channel (C8) is established between the ninth point dimple (9) and the tenth point dimple (10).

[0044] Having identified the third group and the fourth group, it is important to highlight the similarity of these groups with the first and second groups. Nevertheless, this similarity is not by means of a ratio of symmetry since they maintain the inclination in the same direction, nor is it by means of ratio of repetition since the elongated dimple (B) in the third group is located downstream instead of upstream or at the start of the alignment as occurs in the first group.

[0045] In other words, as a result the alignment of all the groups follows the same inclination but the particular alignments of the channels existing between dimples according to the flow direction do not. Although a channel is formed by the passage between two dimples, the channel is considered oriented where the orientation is the direction perpendicular to the line connecting the centroids of both point dimples. Generally, the orientation of the channel will be the direction perpendicular to the line connecting both dimples where said connection is between the regions closest to one another.

[0046] In the pattern shown in Figure 1, it is observed

that the position of the first flow channel (C1) is such that the flow going through same in the operating mode is mainly transported towards the third flow channel (C3) and the fourth flow channel (C4). This branching has an effect on the way in which half the pattern arranged downstream formed by the third and fourth groups is fed.

[0047] It has been pointed out that the four groups have an oblique orientation and the channels formed between dimples establish speed components with transverse components giving rise to oblique flows but with an inclination opposite the Y-Y' direction. In this embodiment, it is observed that in the second group formed by four point dimples essentially aligned according to the oblique direction Y-Y', the first pair of dimples formed by the second point dimple (2) and third point dimple (3) is aligned according to the oblique direction Y-Y', the second pair of dimples formed by the fourth point dimple (4) and the fifth point dimple (5) is aligned according to the oblique direction Y-Y'; and the alignment of the first pair and the alignment of the second pair are misaligned a specific distance despite being parallel.

[0048] This misalignment is shown in Figure 1 by means of two close parallel lines Y-Y'. The technical effect is a change in orientation of the third channel (C3) causing a higher degree of inclination in the direction opposite the inclination of the axis Y-Y' so that a higher flow rate is directed towards the fifth channel (C5) which is located close to the side opposite the side which tends to divert the inclination of the axis Y-Y' imposed on all the groups of dimples. This fifth channel (C5) mainly feeds the passage through the remaining channels located downstream resulting in greater flow uniformity through all the dimples such that the largest possible exchange area is used.

[0049] This same technical effect is achieved with the configuration of the fourth group of point dimples, which are essentially aligned according to the oblique direction Y-Y'. The first pair of dimples formed by the seventh dimple (7) and the eighth dimple (8) is aligned according to the oblique direction Y-Y', the second pair of dimples formed by the ninth dimple (9) and the tenth dimple (10) is aligned according to the oblique direction Y-Y'; and the alignment of the first pair and the alignment of the second pair are misaligned despite being parallel.

[0050] This configuration makes homogenizing the flow easier when the pattern is periodically repeated downstream.

[0051] Generating preferred paths according to an oblique direction with an inclination opposite that established by the axis Y-Y' is enhanced by the condition that the first flow channel (C1), the third flow channel (C3) and the fifth flow channel (C5) are essentially aligned. This preferred path provides a flow reaching even the side opposite the side on which the inclination of the axis Y-Y' offers the bias thereof.

[0052] This configuration with the alignment of three channels, the first flow channel (C1), the third flow channel (C3) and the fifth flow channel (C5), also contributes

to flow homogenization when the pattern is periodically repeated downstream.

[0053] The described pattern can also be configured as shown in Figures 1 and 3, such that there is an alignment between the first channel (C1), the fourth channel (C4) and the eighth channel (C8). These three channels form a preferred path for longitudinal guiding of the flow so that it does not tend to keep excessively towards the outside of the pattern, the side wall of the tube. In the alignment of these three channels (C1, C4, C8), the elongated dimple (B) of the third group is interposed between the fourth channel (C4) and the eighth channel (C8). Nevertheless, this interposition does not prevent the effect of the alignment since, as indicated above, the flow reaching a channel is fed not only by the flow from channels arranged upstream but also by the main flow of the tube.

[0054] Given that the preferred path formed by the alignment of channels is configured between dimples, this path is undulated and enhances vorticity generation, having as an immediate consequence an increase in the degree of heat transfer with the surface of the tube.

[0055] Additionally, the pattern according to this same embodiment greatly enhances the creation of preferred paths on the side opposite the side on which the inclination of the axis Y-Y' offers the bias thereof, establishing the alignment of the second channel (C2), the fifth channel (C5) and the sixth channel (C6).

[0056] In this same example, the second point dimple (2), the fifth point dimple (5), the seventh point dimple (7) and the tenth point dimple (10) are widened in the direction transverse to the oblique direction Y-Y'. The technical effect of this widening is the prolongation of the dimples towards the sides of the tube so that the main flow does not seek preferred paths for passage through these sides and is concentrated on the segment with dimples for increasing heat exchange.

[0057] In this same embodiment, the pattern shown in Figure 1 is repeated on the opposite face. It has been proven by means of numerical simulation that pressure drop due to the inclusion of a dimple pattern on one face, when comparing said pressure drop with that obtained in an embodiment in which only one face of the tube has a dimple pattern, is not greater than two-fold even when the projection according to a plane transverse to the tube shows that the dimples have a depth reducing the section on both faces to one third. In other words, the heat transfer:pressure drop ratio is more favorable if there is a dimple pattern on both faces of the tube than if there is a pattern on only one face.

[0058] This means that flow perturbations generated by the dimples on one face do not have a negative influence on the pressure drop in the other face. This influence will be even less with sections in which the depth of the dimples is proportionally less than that indicated.

[0059] Figure 2 depicts the Nusselt number value on the surface of the tube, a high Nusselt number value being observed homogeneously for all the dimples. This in-

dicates that, for the position corresponding to a dimple, there is a large increase in heat transfer on the surface in comparison with the heat transfer that occurs only by conduction, and all this with reduced pressure drop.

[0060] Said Nusselt number value is obtained by means of the following ratio:

$$Nu = \frac{h_{ef} L_{ref}}{k}$$

where L_{ref} is the hydraulic diameter of the tube, k is the conductivity of said tube and h_{ef} is the film coefficient value, or convective heat transfer coefficient according to the ratio:

$$h_{ef} = \frac{q}{T_w - T_{ref}}$$

where q is the thermal power transferred in the convective process, T_w is the wall temperature of the tube and T_{ref} is a reference temperature value which corresponds to the temperature at the hot gas inlet of the tube.

[0061] In the example shown in Figure 2, 6.75 mm has been used as the value of the hydraulic radius L_{ref} .

[0062] In the example shown in Figure 2, 673.15 K has been used as the reference temperature value T_{ref} .

[0063] The figure therefore shows the distribution of Nusselt number values as a function of the heat transfer that occurs with the passage of a hot gas flow through the tube, the direction of which is also shown in the figure.

[0064] A dimple pattern of these characteristics results in a highly efficient tube when it is part of a heat exchanger, according to the transferred thermal power values as demonstrated by the Nusselt number values represented.

[0065] Figure 3 shows a tube where both flattened faces have a pattern such as that of the example shown in Figure 1 which is repeated along the length of the tube. This figure shows the two patterns being superimposed on one another, the pattern of the visible face is shown by means of continuous lines and the pattern of the opposite non-visible face is shown by means of dotted lines. To make identifying the dimples on both faces easier, the reference numbers of the visible face are located on each dimple whereas the numbers of the dimples located on the non-visible face are located outside the area occupied by the depiction of the tube.

[0066] The pattern of the first face and the pattern of the second face are distributed longitudinally such that they extend the same length. In this case, it is not only because the dimples have the same size, but because the distribution shown on both faces takes up the same length.

[0067] The pattern of the first face and the pattern of the second face are positioned such that the end of the first elongated dimple (A) located closest to the central

axis of the tube of the first face and the end of the second elongated dimple (B) located closest to the central axis of the tube of the second face overlap one another according to a projection on a plane parallel to both faces. In this manner, flow perturbations due to the presence of dimples on one face has been shown to not significantly affect the flow modified by the presence of dimples on the opposite face.

Claims

1. A tube for a heat exchanger having a flattened configuration comprising a first essentially planar face and a second essentially planar face parallel to and spaced from the first face; both faces being connected by side walls where at least one face has a plurality of dimples (A, B, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10) configured according to a pattern that is repeated along the longitudinal direction X-X' of the tube, where this pattern is configured by means of a plurality of groups of dimple alignments covering the width of the planar face, aligned according to one and the same direction Y-Y' arranged obliquely between 40° and 50° degrees with respect to the longitudinal direction X-X', and where it at least comprises:

- a first group which is formed by two dimples (A, 1), a first elongated dimple (A) extending according to the oblique direction Y-Y' aligned with a first point dimple (1) such that a first flow channel (C1) is established between the elongated dimple (A) and the point dimple (1),
- a second group which is formed by four point dimples, a second point dimple (2), a third point dimple (3), a fourth point dimple (4) and a fifth point dimple (5), essentially aligned according to the oblique direction Y-Y', such that a second flow channel (C2) is established between the second point dimple (2) and the third point dimple (3), a third flow channel (C3) is established between the third point dimple (3) and the fourth point dimple (4), a fourth flow channel (C4) is established between the fourth point dimple (4) and the fifth point dimple (5),
- a third group which is formed by two dimples (6, B), a sixth point dimple (6) aligned with a second elongated dimple (B), extending according to the oblique direction Y-Y', such that a fifth flow channel (C5) is established between the sixth point dimple (6) and the second elongated dimple (B),
- a fourth group which is formed by four point dimples, a seventh dimple (7), an eighth dimple (8), a ninth dimple (9) and a tenth dimple (10), essentially aligned according to the oblique direction Y-Y', such that a sixth flow channel (C6)

is established between the seventh point dimple (7) and the eighth point dimple (8), a seventh flow channel (C7) is established between the eighth point dimple (8) and the ninth point dimple (9), an eighth flow channel (C8) is established between the ninth point dimple (9) and the tenth point dimple (10),

where the position of the first flow channel (C1) is such that the flow going through same in the operating mode is mainly transported towards the third flow channel (C3) and the fourth flow channel (C4).

2. The tube according to claim 1, where in the second group formed by four point dimples essentially aligned according to the oblique direction Y-Y', the first pair of dimples formed by the second point dimple (2) and third point dimple (3) is aligned according to the oblique direction Y-Y', the second pair of dimples formed by the fourth point dimple (4) and the fifth point dimple (5) is aligned according to the oblique direction Y-Y'; and the alignment of the first pair and the alignment of the second pair are misaligned a specific distance despite being parallel.
3. The tube according to claim 1 or 2, where in the fourth group formed by four point dimples essentially aligned according to the oblique direction Y-Y', the first pair of dimples formed by the seventh dimple (7) and the eighth dimple (8) is aligned according to the oblique direction Y-Y', the second pair of dimples formed by the ninth dimple (9) and the tenth dimple (10) is aligned according to the oblique direction Y-Y'; and the alignment of the first pair and the alignment of the second pair are misaligned despite being parallel.
4. The tube according to any of the preceding claims, where the first flow channel (C1), the third flow channel (C3) and the fifth flow channel (C5) are essentially aligned.
5. The tube according to any of the preceding claims, where the first flow channel (C1), the fourth flow channel (C4) and the eighth flow channel (C8) are essentially aligned.
6. The tube according to any of the preceding claims, where the second flow channel (C2), the fifth flow channel (C5) and the sixth flow channel (C6) are essentially aligned.
7. The tube according to any of the preceding claims, where the second point dimple (2), the fifth point dimple (5), the seventh point dimple (7) and the tenth point dimple (10) are widened in the direction transverse to the oblique direction Y-Y'.

8. The tube according to any of the preceding claims,
where the tube has one and the same pattern on the
first face and the second face.
9. The tube according to any of the preceding claims, 5
where it comprises on a first flattened face one or
more patterns distributed along the length of the tube
and comprises on a second flattened face, the op-
posite face, one or more patterns distributed along
the length of the tube, and where 10
- the pattern of the first face and the pattern of
the second face are distributed longitudinally
such that they extend with the same length,
 - the pattern of the first face and the pattern of 15
the second face are positioned such that the end
of the first elongated dimple (A) located closest
to the central axis of the tube of the first face and
the end of the second elongated dimple (B) lo-
cated closest to the central axis of the tube of 20
the second face overlap one another according
to a projection on a plane parallel to both faces.
10. A heat exchanger comprising one or more tubes ac-
cording to any of the preceding claims. 25

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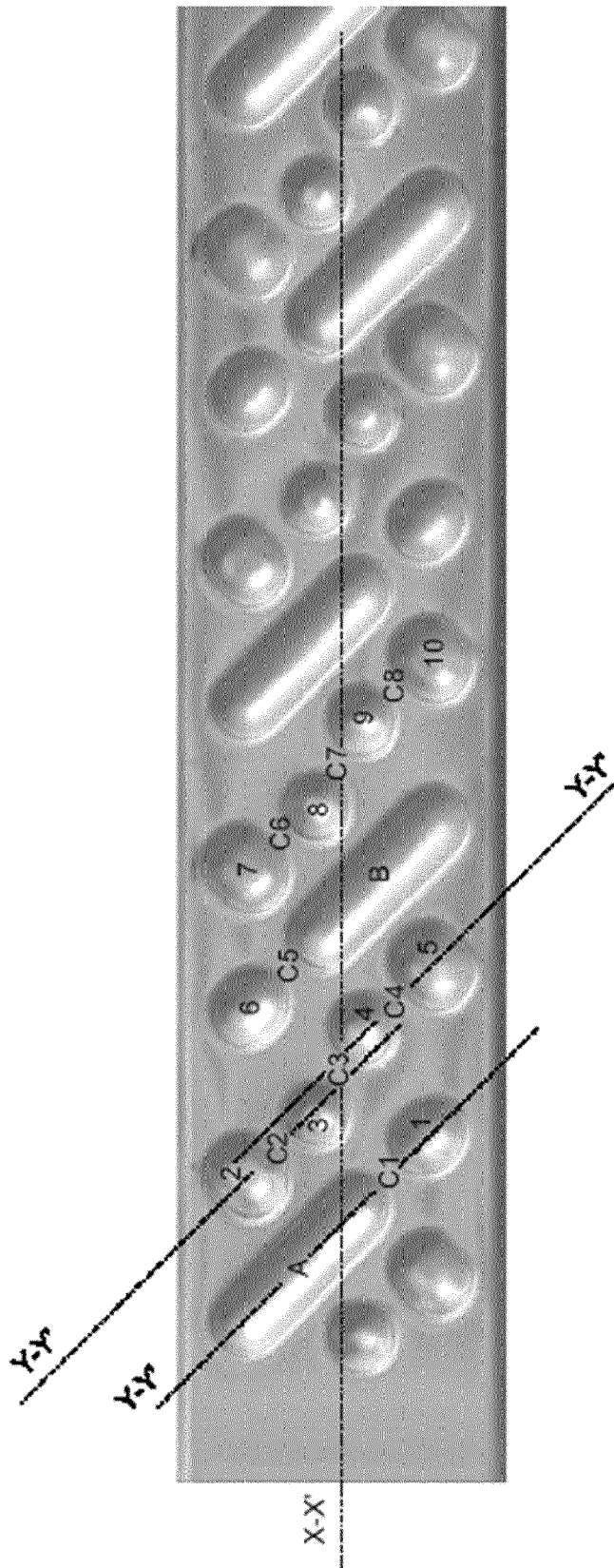
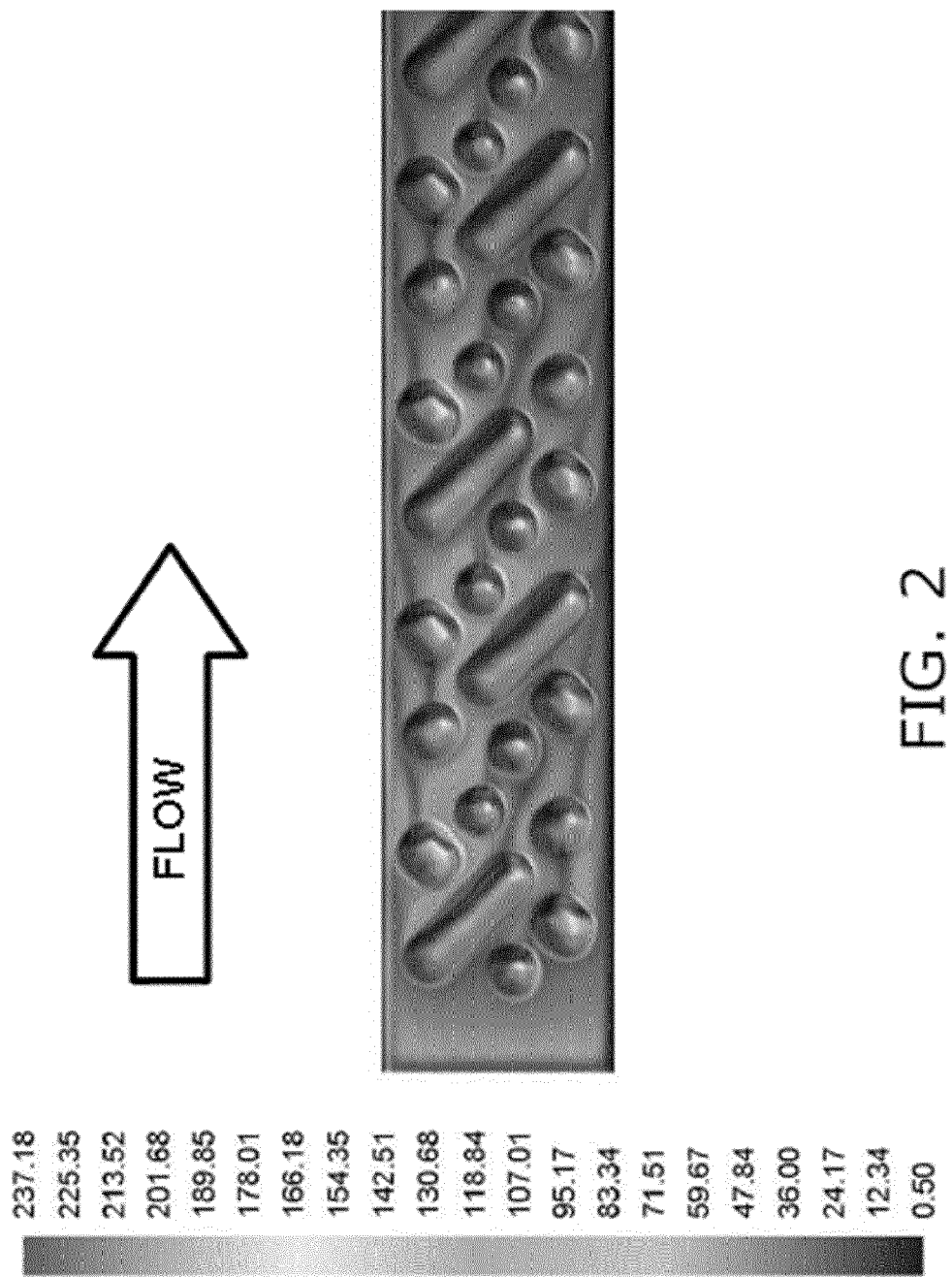
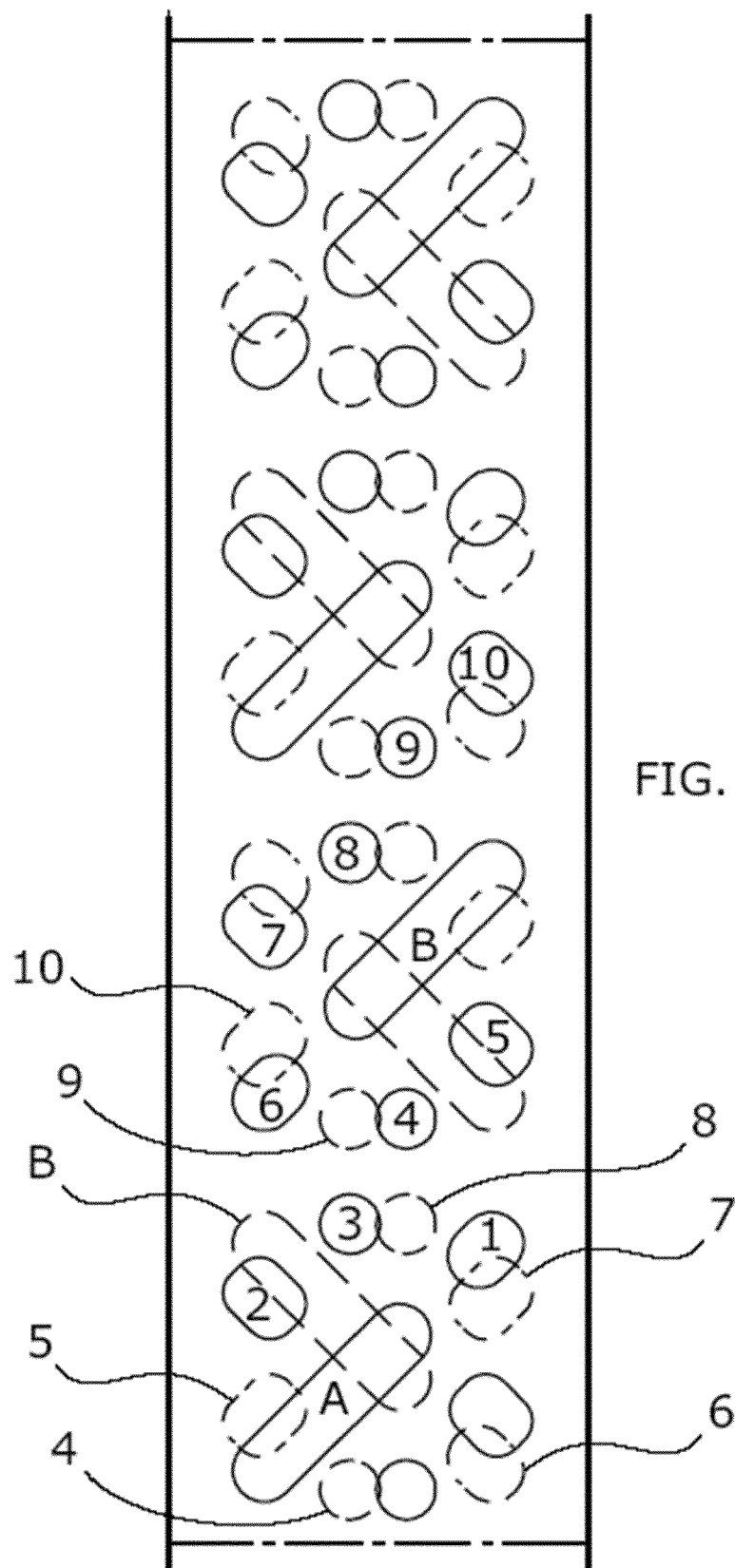


FIG. 1







EUROPEAN SEARCH REPORT

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			F28F F28D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 March 2015	Examiner Martínez Rico, Celia
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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