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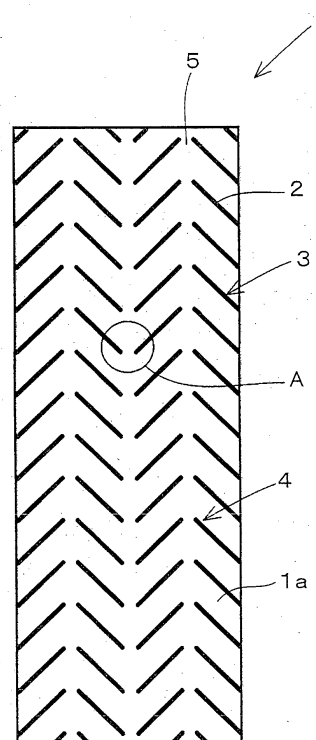
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(54) **BASE PANEL MATERIAL FOR USE AS HEAT EXCHANGE PLATE AND METHOD FOR MANUFACTURING SUCH BASE PANEL MATERIAL**

(57) The object of the invention is to provide: a plate for a heat-exchanging plate that allows a liquid film generated during the operation of a heat exchanger to be efficiently discharged, allows irregularities to be formed such that the thickness of the liquid film is reduced, and allows enhancing heat-transfer performance without collapse of the irregularities; and a method for producing the plate. A plate (1) for a heat-exchanging plate is constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and is obtained through press working, which is implemented as a post-process, of the flat plate. The irregularities include a plurality of projections (2) formed at a predetermined spacing. The plurality of projections (2) include first ridges (2a) disposed at an angle $+\theta$ with respect to the width direction of the plate (1), and second ridges (2b) disposed at an angle $-\theta$ with respect to the width direction of the plate (1). The projections (2) are formed into V-shapes by the first ridges (2a) and the second ridges (2b).

FIG.1



Description

Technical Field

[0001] The present invention relates to a plate for use as heat-exchanging plate and to a method for producing the plate.

Background Art

[0002] Heat-exchanging plates that are built into heat exchangers or the like are required to exhibit high heat transfer properties. In order to enhance heat transfer properties, it suffices to expand the surface area of the plate through formation of micron-order fine irregularities on the surface of the plate. For instance, Patent Literature 1 and Patent Literature 2 disclose the following technologies as methods for transferring micron-order fine irregularities onto the surface of a plate.

[0003] The method for transfer onto a metal plate surface disclosed in Patent Literature 1 involves pressing a transfer portion having irregularities, which has been transferred to the outer peripheral face of transfer rolls, against a metal sheet that is transported by transport rolls. In this method, transferred portions of irregular shape identical to those of the transfer portions of the transfer rolls become formed on the surface of the metal sheet.

[0004] A plate of a heat-exchanging plate disclosed in Patent Literature 2 is a plate for a heat-exchanging plate, the plate being constituted by a titanium-made flat plate having fine irregularities formed on the surface, and being obtained through press working, as a post-process, of the flat plate. In this plate, the irregularities on the surface thereof are set in such a manner that a shape parameter defined as height (μm) of projections $\times$ [width (μm) of recesses / pitch (μm) between adjacent projections / angle (deg) of projections] is 0.94 or smaller.

[0005] In the technology disclosed in Patent Literature 1, the heat-exchanging plate has enhanced heat transfer properties by virtue of the increased surface area achieved through formation of micron-order fine irregularities on the surface of the flat plate. In many instances, however, plates (flat plate) having fine irregularities formed on the surface are rarely used as they are (i.e. with irregularities remaining thereon), as heat-exchanging plates.

[0006] Ordinarily, a plurality of projections having a height ranging from several mm to several cm (for instance, angular projections referred to as "herringbone") is formed by press working on the surface of the heat-exchanging plate. In the technology disclosed in Patent Literature 1, therefore, the fine irregularities formed on the surface of the plate for the heat-exchanging plate are flattened during press working. It is accordingly desirable to enhance the press formability of the plate.

[0007] Therefore, Patent Literature 2 discloses a technology for solving the issue of press formability of the

above plates.

[0008] In the technology disclosed in Patent Literature 2, press formability of the plate is enhanced by defining a shape parameter of the irregularities that are formed on the surface of the heat-exchanging plate. When built into a heat exchanger, the projections formed on the plate promote turbulence and forced convection, to thereby enhance condensation thermal transfer.

[0009] The condensation thermal transfer achieved by the heat-exchanging plate is significantly affected by the discharge of the generated liquid. In the uneven shape (projection shape) of the plate formed using the technology of Patent Literature 2, however, the effect of discharge of the generated liquid may in some instances be weaker than expected (i.e. smaller discharge amount of generated liquid), since the generated liquid spreads out on account of surface tension. Heat transfer properties in a condensation thermal transfer process are thus hard to enhance in the plate formed using the technology of Patent Literature 2.

[0010] Further, the turbulence-promoting effect in the heat-exchanging plate may in some instances be weaker than expected on account of the low height and divided shape (i.e. not a shape of contiguous projections) of the uneven shape that is formed according to the technology of Patent Literature 2. In the uneven shape of Patent Literature 2, moreover, the contact surface area with a medium during condensation of a gas into liquid is small due to the liquid film that forms in the condensation process, and thus the effect of promoting condensation thermal transfer may be weaker than expected.

[0011] That is, the heat-transfer performance of the heat-exchanging plate that is built into the heat exchanger is lowered by the liquid film that is generated when the heat exchanger is operated. In the production of the plate for a heat-exchanging plate, therefore, the design of the plate must ensure that the generated liquid film is discharged with good efficiency and that the film is thin.

Citation List

Patent Literature

[0012]

Patent Literature 1: Japanese Unexamined Patent Publication No. 2006-239744

Patent Literature 2: Japanese Unexamined Patent Publication No. 2013-76551

Summary of Invention

[0013] It is an object of the present invention to provide a plate for a heat-exchanging plate of enhanced heat-transfer performance that allows a liquid film generated during the operation of a heat exchanger to be efficiently drained, allows forming irregularities such that the thickness of the liquid film is reduced, and allows enhancing

heat-transfer performance without collapse of the irregularities; and a method for producing the plate.

[0014] The plate for a heat-exchanging plate of the present invention is a plate being constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and being obtained through press-working, which is a post-process, of the flat plate, wherein the irregularities include a plurality of projections that are formed at a predetermined spacing; and the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to the width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, the projections being formed into V-shapes by the first ridges and the second ridges.

[0015] The method for producing a plate for a heat-exchanging plate of the present invention is a method for producing a plate being constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and being obtained through press-working, which is a post-process, of the flat plate, the method including: forming the irregularities on the surface such that the irregularities include a plurality of projections formed at a predetermined spacing; and forming, when forming the irregularities, the plurality of projections in such a manner that the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to the width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, and the projections are formed into V-shapes by the first ridges and the second ridges.

Brief Description of Drawings

[0016]

[Fig. 1] Fig. 1 is a diagram illustrating schematically an uneven shape formed on a plate for a heat-exchanging plate according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a plan-view diagram (enlarged-view diagram of A in Fig. 1) illustrating the shape of projections formed on the plate according to the embodiment of the present invention.

[Fig. 3] Fig. 3 is a cross-sectional diagram of Fig. 2 along line III-III.

[Fig. 4] Fig. 4 is a diagram for explaining the dimensions of the uneven shape of the plate according to the embodiment of the present invention.

[Fig. 5] Fig. 5 is a cross-sectional diagram for explaining the dimensions of the shape of the projections formed on the plate according to the embodiment of the present invention, being an enlarged cross-sectional diagram of portion B in Fig. 4.

[Fig. 6] Fig. 6 is a diagram illustrating data of experiments performed in order to derive a shape parameter.

[Fig. 7] Fig. 7 is a diagram illustrating results of a condensation heat-transfer performance test.

[Fig. 8] Fig. 8 is a diagram illustrating a relationship between a shape parameter of projections formed on a plate and an improvement rate of condensation thermal transfer properties.

Description of Embodiments

[0017] A plate for a heat-exchanging plate according to an embodiment of the present invention and a method for producing the plate will be explained next in detail with reference to accompanying drawings.

[0018] A plate 1 for a heat-exchanging plate according to the embodiment of the present invention is constituted by a metallic flat plate (for instance, titanium material) having fine irregularities formed on the surface. The plate 1 is subjected to press working, as a post-process, to yield thereafter a heat-exchanging plate (PHE plate). The heat-exchanging plate, which exhibits high heat-transfer performance in a condensation thermal transfer process, is built into a heat exchanger or the like. In addition to the irregularities, specifically, a plurality of projections having for instance a jagged shape generally referred to as herringbone becomes formed on the surface of the heat-exchanging plate through press working of the plate 1.

[0019] Fig. 1 is a diagram illustrating schematically the uneven shape formed on the plate 1 before yielding the heat-exchanging plate according to the embodiment of the present invention. In Fig. 1, the up-and-down direction on the paper is taken as the longitudinal direction or length-wise direction of the plate 1, and the left-right direction on the paper as the width direction of the plate 1.

[0020] Fig. 2 is a plan-view diagram (enlarged-view diagram of portion A of Fig. 1) illustrating the shape of projections 2 formed on the plate 1. Fig. 3 is a cross-sectional diagram along line III-III in Fig. 2.

[0021] As illustrated in Fig. 1, irregularities are formed on the surface 1a of the plate before yielding the heat-exchanging plate according to the embodiment of the present invention. The irregularities have a plurality of projections 2 that are formed at a predetermined spacing. The spaces between the plurality of projections 2 constitute recesses 3. The projections 2 include first ridges 2a and second ridges 2b. The first ridges 2a are disposed at an angle $+\theta$ with respect to the width direction of the plate 1. That is, the first ridges 2a extend in a rectilinear fashion in a direction at $+\theta$ with respect to the width direction of the plate 1. The second ridges 2b are disposed at an angle $-\theta$ with respect to the width direction of the plate 1. That is, the second ridges 2b extend in a rectilinear fashion in a direction at $-\theta$ with respect to the width direction of the plate 1. The projections 2 are formed into V-shapes by the first ridges 2a and the second ridges 2b.

[0022] In further detail, the first ridges 2a and the second ridges 2b are disposed alternately in the width direction of the plate 1. The ridges are formed in such a manner that an extension line from one end of each of the first ridges 2a and an extension line from one end of the sec-

ond ridges 2b intersect each other. The ridges are formed in such a manner that an extension line from the other end of the first ridges 2a and an extension line from the other end of the second ridges 2b intersect each other.

[0023] Specifically, the first ridges 2a and the second ridges 2b adjacent thereto in the projections 2 are formed to a V-shape in a plan view, and respective tops 4 are formed at portions at which the ends of the first ridges 2a and the ends of the second ridges 2b intersect each other. In the present embodiment, however, the first ridges 2a and the second ridges 2b are spaced apart from each other, since as described below a groove portion 5 is formed in the tops 4. The groove portion 5 may be omitted. In this case, the first ridges 2a and the second ridges 2b connect with each other, whereby the projections 2 are formed to shapes of a repeating plurality of V-shapes.

[0024] The plurality of first ridges 2a is disposed at equal spacings in the longitudinal direction of the plate 1, and the plurality of second ridges 2b is disposed likewise at equal spacings in the longitudinal direction of the plate 1.

[0025] The term V-shape in the present embodiment denotes a shape such as that of the cutting edges of saw teeth, in a plan view, i.e. a shape in which ridges oriented in different directions are disposed alternately in a continuous succession. In the plate 1, specifically, the first ridges 2a extending in a straight line are disposed obliquely with respect to the width direction by the angle $+\theta$, while the second ridges 2b extending in a straight line are disposed obliquely with respect to the width direction by the angle $-\theta$. That is, the leftward and downward first ridges 2a, and the rightward and downward second ridges 2b adjacent to the first ridges 2a are disposed alternately in the width direction of the plate 1. The first ridges 2a are connected to other first ridges 2a via the second ridges 2b, and the second ridges 2b are connected to other second ridges 2b via the first ridges 2a.

[0026] The V-shaped projections 2 are formed in plurality that are juxtaposed, in a plan view, at a predetermined spacing in the longitudinal direction of the plate 1.

[0027] As illustrated in Fig. 3, the V-shaped projections 2 are made up of a plurality of side walls erected in the thickness direction of the plate 1, and top walls (top edges) that join the respective side walls. The projections 2 in the present embodiment have been explained as having a substantially rectangular shape in a cross-sectional view, but the projections 2 formed on the surface 1a of the plate 1 may have for instance a substantially trapezoidal shape or substantially angular shape, other than a substantially rectangular shape. That is, the projections 2 may adopt any cross-sectional shape so long as the below-described dimensions of the projections 2 are satisfied.

[0028] Groove portions 5 are additionally formed in the plate 1 that is used in the heat-exchanging plate according to the embodiment of the present invention. Each groove portion 5 is formed so as to extend along the

longitudinal direction of the plate 1, at the tops 4 at which there intersect the first ridges 2a and the second ridges 2b that make up the projections 2.

[0029] As illustrated in Fig. 2, the groove portion 5 (longitudinal groove portion) formed in the plate is formed so as to run rectilinearly through the plurality of tops 4 which are disposed in the length-wise direction on the plate 1. Specifically, the groove portion 5 is formed cutting off the tops 4 of the first ridges 2a and the second ridges 2b in the projections 2. As a result, any two given recesses 3 positioned flanking a respective projection 2 communicate with each other via the groove portion 5. The longitudinal groove portion 5 is set to be wider than the recesses 3 (transversal groove portion) formed between the V-shaped projections 2 and projections 2 adjacent thereto. In Fig. 1 and Fig. 2, the width of the longitudinal groove portions 5 has been depicted as smaller than the width of the recesses 3, for convenience.

[0030] In summary, the surface shape of the plate 1 for a heat-exchanging plate according to the embodiment of the present invention is a shape such as that of the draining grooves (tread patterns) that are carved in the contact patch of tires used in automobiles or the like. The transversal groove portions (recesses) 3 are formed so as to open in the width direction with respect to the longitudinal groove portions 5 that are formed in the longitudinal direction of the plate 1.

[0031] With the plate 1 having the uneven shape, which is formed on the surface 1a, in a case where the plate 1 is used as a heat-exchanging plate, flow of condensate generated in the heat exchanger can be regulated and the condensate can be discharged quickly in the length-wise direction of the plate 1 (heat-exchanging plate) using the longitudinal groove portions 5, while condensation thermal transfer properties can be enhanced through promotion of turbulence and forced convection.

[0032] The dimensions of the uneven shape on the surface of the plate 1 according to the embodiment of the present invention described above will be explained next in detail on the basis of experimental results.

[0033] Fig. 4 is a diagram for explaining the dimensions of the uneven shape formed on the plate 1. Fig. 5 is a diagram for explaining the dimensions of the shape of the projections 2 formed on the plate 1 (enlarged diagram of portion B in Fig. 4, illustrating a partial cutaway cross-section of portion B). Fig. 6 is a diagram illustrating data of experiments performed in order to derive a shape parameter. Fig. 7 is a diagram illustrating results of a condensation heat-transfer performance test. Fig. 8 is a diagram illustrating a relationship between a shape parameter of the projections 2 formed on the plate 1 and an improvement rate of condensation thermal transfer properties.

[0034] As illustrated in Fig. 4 and Fig. 5, prescribed dimensions are set for the uneven shape of the surface of the plate 1.

[0035] Specifically, a height h of the projections 2 is set to be 0.02 mm or greater and 0.1 mm or less, and a

width W_a of the projections 2 is set to be 0.08 mm or greater and 1 mm or less. The angle θ formed by the projections 2 with respect to the width direction of the plate 1 is set to be 10° or greater and 80° or less. A width W_b of the recesses 3 is set to be 0.1 mm or greater and 1 mm or less.

[0036] A projection pitch P_1 being the pitch between mutually adjacent projections 2 is set to be 0.2 mm or greater and 2 mm or less. That is, the projection pitch P_1 can be regarded as a combination of the width W_a of the projections 2 and the width W_b of the recesses 3 (projection pitch $P_1 = \text{width } W_a \text{ of projections 2} + \text{width } W_b \text{ of recesses 3}$).

[0037] A width W_c of the longitudinal groove portion 5 is set to be 0.5 mm or greater and 500 mm or less. A width pitch P_2 being the pitch between mutually adjacent longitudinal groove portions 5 is set to be 5 mm or greater and 1000 mm or less.

[0038] The irregularities of the surface 1a of the plate 1 are formed in such a manner that a shape parameter defined as "height h (mm) of the projections 2 $\times$ width W_b (mm) of the recesses 3 $\times$ [width W_c (mm) / width pitch P_2 (mm) of the longitudinal groove portions 5]" is 0.0025 mm^2 or greater.

[0039] An explanation follows next on the rationale behind such dimensions of the uneven shape of the plate 1.

[0040] The inventors of the present application focused on a shape parameter of the uneven shape "height h (mm) of the projections 2 $\times$ width W_b (mm) of the recesses 3 $\times$ [width W_c (mm) / width pitch P_2 (mm) of the longitudinal groove portions 5]" in order to optimize the height h of the projections 2, the width W_a of the projections 2, the angle θ of the projections 2, the width W_b of the recesses 3, the projection pitch P_1 of adjacent projections 2, the width W_c of the longitudinal groove portions 5, and the width pitch P_2 of the adjacent longitudinal groove portions 5, when producing the plate 1 for a heat-exchanging plate.

[0041] To optimize the uneven shape, the inventors of the present application produced a plurality of plates 1 having different dimensions of the uneven shape, and examined an improvement rate on condensation heat-transfer performance of each plate 1.

[0042] As illustrated in Fig. 6, there were produced seventeen plates 1 of dissimilar uneven shape dimensions. In the plate 1 denoted by number 0 in Fig. 6, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.04 mm, width W_a of the projections 2: 0.125 mm, width W_b of the recesses 3: 0.6 mm, projection pitch P_1 of adjacent projections 2: 0.725 mm, angle θ of the projections 2: 45° , width W_c of the longitudinal groove portions 5: 4 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 20 mm.

[0043] From the dimensions of the uneven shape, there are the derived a parameter A ($h \times W_b$) of 0.024 mm^2 and a parameter B (W_c/P_2) of 0.2. In turn, a shape parameter " $(A \times B):h \times W_b \times [W_c/P_2]$ " of 0.0048 mm^2 is derived from parameters A and B .

[0044] As illustrated in Fig. 7, the plate 1 (number 0) having the above uneven shape exhibited a heat transfer coefficient U , in a heat exchanger, of $1044 \text{ (W/m}^2\text{K)}$. The plate 1 (number 0) exhibited an improvement of 16% with respect to the heat transfer coefficient U ($900 \text{ (W/m}^2\text{K)}$) of a conventional (smooth-surface) plate (working example).

[0045] In the plate 1 denoted by number 1 in Fig. 6, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.05 mm, width W_a of the projections 2: 0.1 mm, width W_b of the recesses 3: 0.4 mm, projection pitch P_1 of adjacent projections 2: 0.5 mm, angle θ of the projections 2: 45° , width W_c of the longitudinal groove portions 5: 4 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 13.5 mm.

[0046] From the dimensions of the uneven shape, there are the derived a parameter A ($h \times W_b$) of 0.02 mm^2 and a parameter B (W_c/P_2) of 0.2963. A shape parameter " $h \times W_b \times [W_c/P_2]$ " of 0.0059 mm^2 is derived from parameters A and B .

[0047] The plate 1 (number 1) having the above uneven shape exhibited an improvement of 20.6% in condensation heat-transfer performance as compared with a conventional plate (working example).

[0048] In the plate 1 denoted by number 2 in Fig. 6, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.04 mm, width W_a of the projections 2: 0.1 mm, width W_b of the recesses 3: 0.4 mm, projection pitch P_1 of adjacent projections 2: 0.5 mm, angle θ of the projections 2: 45° , width W_c of the longitudinal groove portions 5: 4 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 13.5 mm.

[0049] From the dimensions of the uneven shape, there are the derived a parameter A ($h \times W_b$) of 0.016 mm^2 and a parameter B (W_c/P_2) of 0.2963. The shape parameter " $h \times W_b \times [W_c/P_2]$ " of 0.0047 mm^2 is derived from parameters A and B .

[0050] The plate 1 (number 2) having the above uneven shape exhibited an improvement of 10% in condensation heat-transfer performance as compared with a conventional plate (working example).

[0051] The plates 1 denoted by number 3 to number 13 in Fig. 6 exhibited likewise improvements of 5% or more in condensation heat-transfer performance as compared with a conventional plate, similarly to the plate 1 denoted by number 0 to number 2 (working examples).

[0052] In the plate denoted by number 14 in Fig. 6, by contrast, there is formed an uneven shape the dimensions whereof include height h of the projections 2: 0.03 mm, width W_a of the projections 2: 0.1 mm, width W_b of the recesses 3: 0.3 mm, projection pitch P_1 of adjacent projections 2: 0.4 mm, angle θ of the projections 2: 45° , width W_c of the longitudinal groove portions 5: 2 mm, and width pitch P_2 of adjacent longitudinal groove portions 5: 9 mm.

[0053] From the dimensions of the uneven shape, there are the derived a parameter A ($h \times W_b$) of 0.009 mm^2 and a parameter B (W_c/P_2) of 0.2222. A shape pa-

parameter " $h \times W_b \times [W_c/P_2]$ " of 0.002 mm^2 is derived from parameters A and B.

[0054] The plate (number 14) having the above uneven shape exhibited merely an improvement of only 3.4% in condensation heat-transfer performance as compared with a conventional plate (comparative example).

[0055] As in the case of the plate denoted by number 14, the plates denoted by number 15 and number 16 in Fig. 6 exhibited virtually no improvement in condensation heat-transfer performance as compared with a conventional plate (comparative examples).

[0056] As Fig. 8 reveals, the inventors of the present application found that the shape parameter defined as "height h (mm) of the projections $2 \times$ width W_b (mm) of the recesses $3 \times$ [width W_c (mm) / width pitch P_2 (mm) of the groove portions 5]" for irregularities formed on the surface 1a of the plate must be 0.0025 mm^2 or greater in order to improve the condensation heat-transfer performance of the plate 1 by 5% with respect to conventional instances.

[0057] As described above, the plate 1 for a heat-exchanging plate according to the embodiment of the present invention allows promoting accumulation and discharge of condensate by virtue of the fine uneven shape, being a combination of V-shapes and longitudinal grooves, that are formed on the surface of the plate.

[0058] By prescribing the dimensions of the projections 2, it becomes possible to reduce the thickness of the condensate film and increase thereby the surface area of contact with the medium during condensation of a gas into liquid, and to form the fine uneven shape of the surface without collapsing during press working.

[0059] That is, the plate 1 according to the embodiment of the present invention allows producing a heat-exchanging plate the condensation heat-transfer performance of which is far superior to that of conventional plates.

[0060] A method for producing the plate 1 for a heat-exchanging plate described above will be explained next.

[0061] To produce the plate 1, first, determination is made on the material, plate thickness and external dimensions of the plate 1, the shape of the fine irregularities that are formed on the surface 1a of the plate, as well as the dimensions of the shape, taking into consideration the desired dimensions, plate thickness and so forth of the heat-exchanging plate that is the final product.

[0062] When establishing the shape and shape dimensions of the fine irregularities that are to be formed on the surface 1a of the plate, the shape of the irregularities is prescribed to be a V-shape, and there are prescribed the dimensions of the projections 22, the dimensions of the recesses 3, the pitch P_1 of the projections 22, the dimensions of the longitudinal groove portions 5 and the pitch P_2 of the longitudinal groove portions 5 in the V shape.

[0063] Regarding more specifically the dimensions of the projections 2, the height h is set to lie in the range from 0.02 mm to 0.1 mm , the width W_a is set to lie in the range from 0.08 mm to 1 mm , and the angle θ is set to

lie in the range from 10° to 80° . Regarding the dimensions of the recesses 3, the width W_b is set to lie in the range from 0.1 mm to 1 mm . The pitch P_1 between projections 2 and other projections 2 adjacent thereto is set to lie in the range from 0.2 mm to 2 mm .

[0064] Regarding the dimensions of the groove portions 5, the width W_c is set to lie in the range from 0.5 mm to 500 mm , and the width pitch P_2 between groove portions 5 and other groove portions 5 adjacent thereto is set to be 5 mm or greater and 1000 mm or less.

[0065] The dimensions of the irregularities are set so that the value derived from the shape parameter defined as "height h (mm) of the projections $2 \times$ width W_b (mm) of the recesses $3 \times$ [width W_c (mm) / width pitch P_2 (mm) of the groove portions 5]" is 0.0025 mm^2 or greater.

[0066] On the basis of the above items thus defined, a metallic flat plate (for instance, titanium material) that constitutes the plate 1 is prepared, and the plate 1 is formed to a predetermined size. A lubricating layer formed on the surface 1a of the plate is removed by a laser processing method, and the portion having had the layer removed therefrom is pickled, to form thereby fine irregularities and produce the plate 1 for a heat-exchanging plate.

[0067] By resorting to the production method of the present embodiment to form the irregularities, it becomes possible to form a fine uneven shape (microscopic irregularities) being a combination of V-shapes and longitudinal grooves on the surface, and to produce a plate 1 of very good heat transfer properties (very high heat transfer rate).

[0068] The embodiment disclosed herein is, in all features thereof, exemplary in nature, and is not meant to be limiting in any way.

[0069] The production method of the present embodiment is appropriate for producing a plate 1 for a heat-exchanging plate in which a flat plate made of titanium is utilized, but can also be resorted to in order to produce a plate 1 for a heat-exchanging plate in which a plate made of an aluminum alloy or a high-tensile plate is utilized. That is, a plate of any material may be used in the method for producing a plate 1 for a heat-exchanging plate of the present embodiment, so long as the plate is made of metal.

[0070] In particular, features not explicitly described in the embodiments disclosed herein, for instance operational conditions, working conditions, various parameters, as well as dimensions, weight, volume and so forth of constructions are features that do not depart from the scope of ordinary implementation by a person skilled in the art, and take on values that can be easily conceived of by a normal person skilled in the art.

[0071] An outline of the above embodiment follows next.

[0072] The plate for a heat-exchanging plate of the above embodiment is a plate being constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and being obtained through press-working,

which is a post-process, of the flat plate, wherein the irregularities include a plurality of projections that are formed at a predetermined spacing; and the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to the width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, the projections being formed into V-shapes by the first ridges and the second ridges.

[0073] Preferably, a groove portion may be formed along the longitudinal direction of the plate, at respective tops of the V-shapes.

[0074] Preferably, the height of the projections may be set to be 0.02 mm or greater and 0.1 mm or less; the width of the projections may be set to be 0.08 mm or greater and 1 mm or less; the value of θ may be set to be 10° or greater and 80° or less; the width of recesses between the projections may be set to be 0.1 mm or greater and 1 mm or less; and the pitch P_1 between adjacent projections may be set to be 0.2 mm or greater and 2 mm or less.

[0075] Preferably, the width of the groove portion may be set to be 0.5 mm or greater and 500 mm or less.

[0076] Preferably, the groove portion may be formed in plurality, and the width pitch P_2 between adjacent groove portions may be set to be 5 mm or greater and 1000 mm or less.

[0077] Preferably, the irregularities of the surface of the plate may be set such that a shape parameter defined as "height (mm) of the projections $\times$ width (mm) of recesses between projections $\times$ [width (mm) / width pitch P_2 (mm) of the groove portions]" is 0.0025 mm^2 or greater.

[0078] The method for producing a plate for a heat-exchanging plate of the present invention is a method for producing a plate being constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and being obtained through press-working, which is a post-process, of the flat plate, the method including: forming the irregularities on the surface such that the irregularities include a plurality of projections formed at a predetermined spacing; and forming, when forming the irregularities, the plurality of projections in such a manner that the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to the width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, and the projections are formed into V-shapes by the first ridges and the second ridges.

[0079] Preferably, groove portions may be formed along the longitudinal direction of the plate, at respective tops of the V-shapes.

[0080] Preferably, the height of the projections may be set to be 0.02 mm or greater and 0.1 mm or less; the width of the projections may be set to be 0.08 mm or greater and 1 mm or less; θ may be set to be 10° or greater and 80° or less; the width of recesses between the projections may be set to be 0.1 mm or greater and 1 mm or less; and the pitch P_1 between adjacent projec-

tions may be set to be 0.2 mm or greater and 2 mm or less.

[0081] Preferably, the width of the groove portion may be set to be 0.5 mm or greater and 500 mm or less.

[0082] When forming the groove portion in plurality, preferably, a width pitch P_2 between adjacent groove portions may be set to be 5 mm or greater and 1000 mm or less.

[0083] Preferably, the irregularities of the surface of the plate may be designed such that a shape parameter defined as height (mm) of the projections $\times$ width (mm) of recesses between projections $\times$ [width (mm) / width pitch P_2 (mm) of the groove portions] is 0.0025 mm^2 or greater.

[0084] The plate for a heat-exchanging plate and the method for producing the plate in the above embodiment allow a liquid film generated during the operation of a heat exchanger to be efficiently discharged, allow forming irregularities such that the thickness of the liquid film is reduced, and allow enhancing heat-transfer performance without collapse of the irregularities.

Claims

1. A plate for a heat-exchanging plate, the plate being constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and being obtained through press-working, which is implemented as a post-process, of the flat plate, wherein the irregularities include a plurality of projections that are formed at a predetermined spacing; and the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to a width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, the projections being formed into V-shapes by the first ridges and the second ridges.
2. The plate for a heat-exchanging plate according to claim 1, wherein a groove portion is formed along a longitudinal direction of the plate, at respective tops of the V-shapes.
3. The plate for a heat-exchanging plate according to claim 1, wherein
 - a height of the projections is set to be 0.02 mm or greater and 0.1 mm or less;
 - a width of the projections is set to be 0.08 mm or greater and 1 mm or less;
 - a value of θ is set to be 10° or greater and 80° or less;
 - a width of recesses between the projections is set to be 0.1 mm or greater and 1 mm or less; and
 - a pitch P_1 between adjacent projections is set to be 0.2 mm or greater and 2 mm or less.
4. The plate for a heat-exchanging plate according to claim 2, wherein a width of the groove portion is set

to be 0.5 mm or greater and 500 mm or less.

5. The plate for a heat-exchanging plate according to claim 2 or 4, wherein the groove portion is formed in plurality, and a width pitch P_2 between adjacent groove portions is set to be 5 mm or greater and 1000 mm or less. 5
6. The plate for a heat-exchanging plate according to claim 5, wherein the irregularities of the surface of the plate are set such that a shape parameter defined as "height (mm) of the projections $\times$ width (mm) of recesses between projections $\times$ [width (mm) / width pitch P_2 (mm) of the groove portions]" is 0.0025 mm² or greater. 10
15
7. A method for producing a plate for a heat-exchanging plate, the plate being constituted by a metallic flat plate having fine irregularities formed on a surface thereof, and being obtained through press-working, which is implemented as a post-process, of the flat plate, the method comprising: 20
 forming the irregularities on the surface such that the irregularities include a plurality of projections formed at a predetermined spacing; and 25
 forming, when forming the irregularities, the plurality of projections such that the plurality of projections includes first ridges disposed at an angle $+\theta$ with respect to a width direction of the plate and second ridges disposed at an angle $-\theta$ with respect to the width direction of the plate, and the projections are formed into V-shapes by the first ridges and the second ridges. 30
35
8. The method for producing a plate for a heat-exchanging plate according to claim 7, the method further comprising: forming a groove portion along the longitudinal direction of the plate, at respective tops of the V-shapes. 40
9. The method for producing a plate for a heat-exchanging plate according to claim 7, wherein a height of the projections is set to be 0.02 mm or greater and 0.1 mm or less, 45
 a width of the projections is set to be 0.08 mm or greater and 1 mm or less;
 the θ is set to be 10° or greater and 80° or less;
 a width of recesses between the projections is set to be 0.1 mm or greater and 1 mm or less; and 50
 a pitch P_1 between adjacent projections is set to be 0.2 mm or greater and 2 mm or less.
10. The method for producing a plate for a heat-exchanging plate according to claim 8, wherein a width of the groove portion is set to be 0.5 mm or greater and 500 mm or less. 55

11. The method for producing a plate for a heat-exchanging plate according to claim 8 or 10, wherein when forming the groove portion in plurality, a width pitch P_2 between adjacent groove portions is set to be 5 mm or greater and 1000 mm or less.

12. The method for producing a plate for a heat-exchanging plate according to claim 11, wherein the irregularities of the surface of the plate are designed such that a shape parameter defined as height (mm) of the projections $\times$ width (mm) of recesses between projections $\times$ [width (mm) / width pitch P_2 (mm) of the groove portions] is 0.0025 mm² or greater.

FIG.1

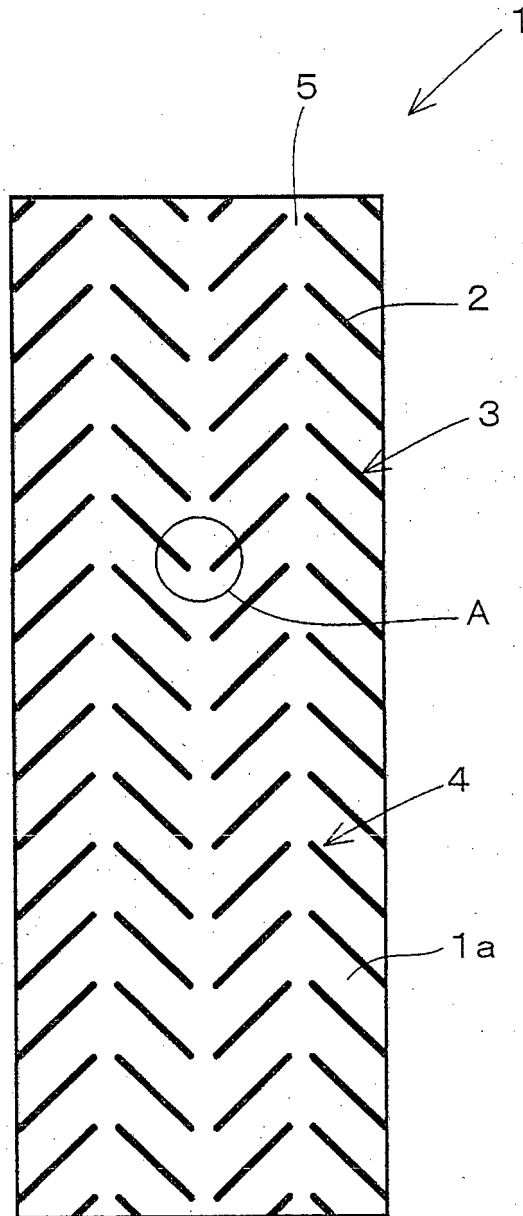


FIG.2

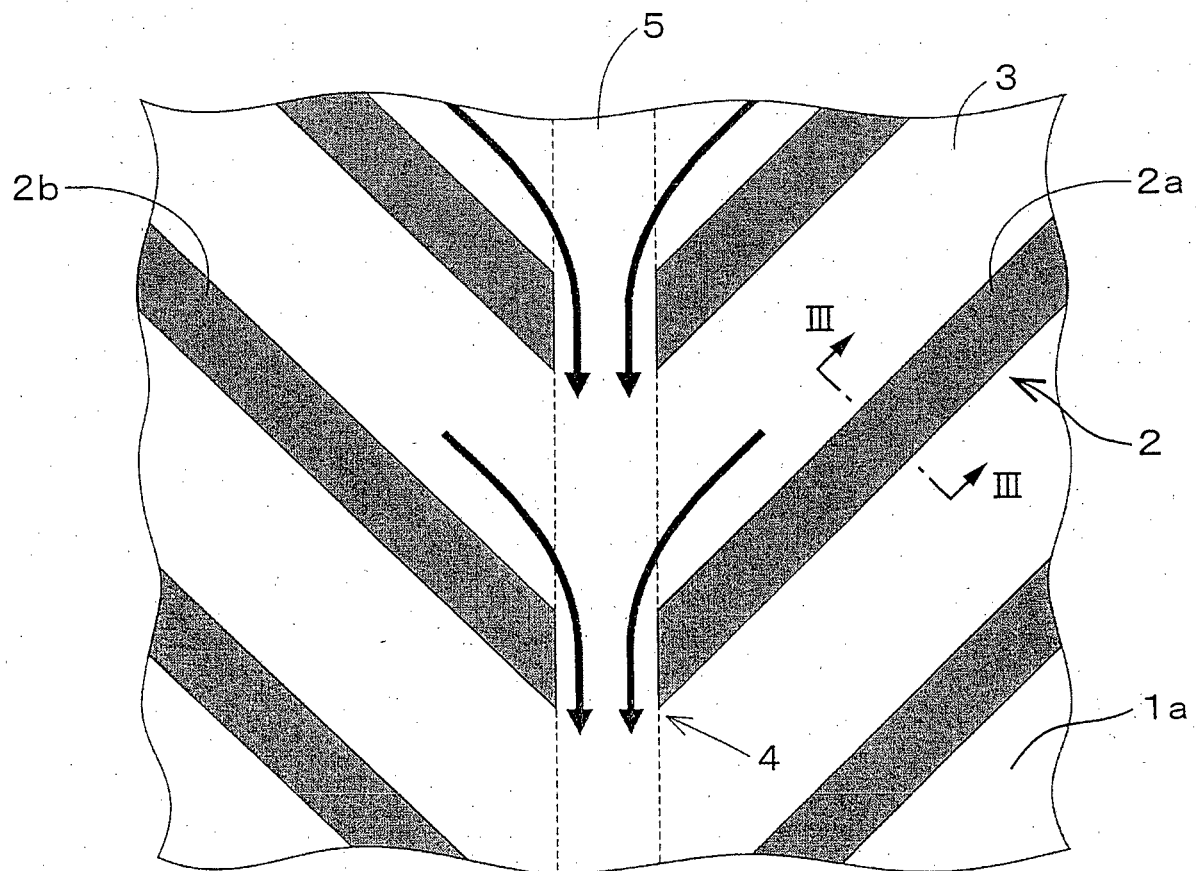


FIG.3

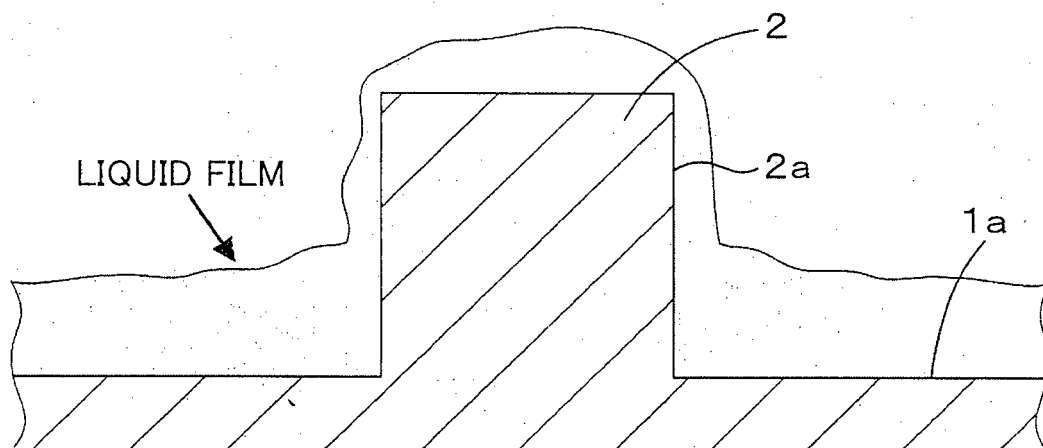


FIG.4

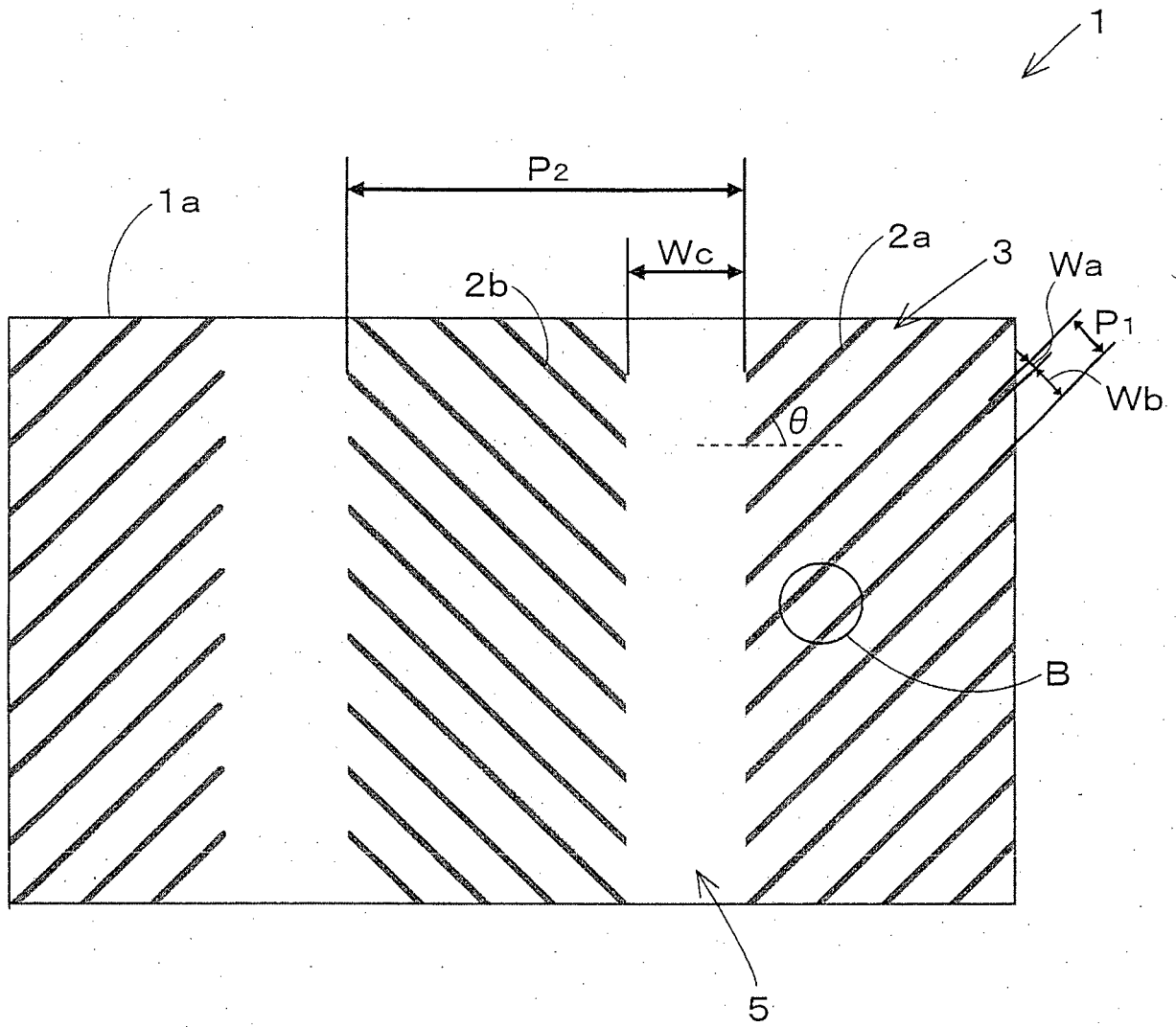


FIG.5

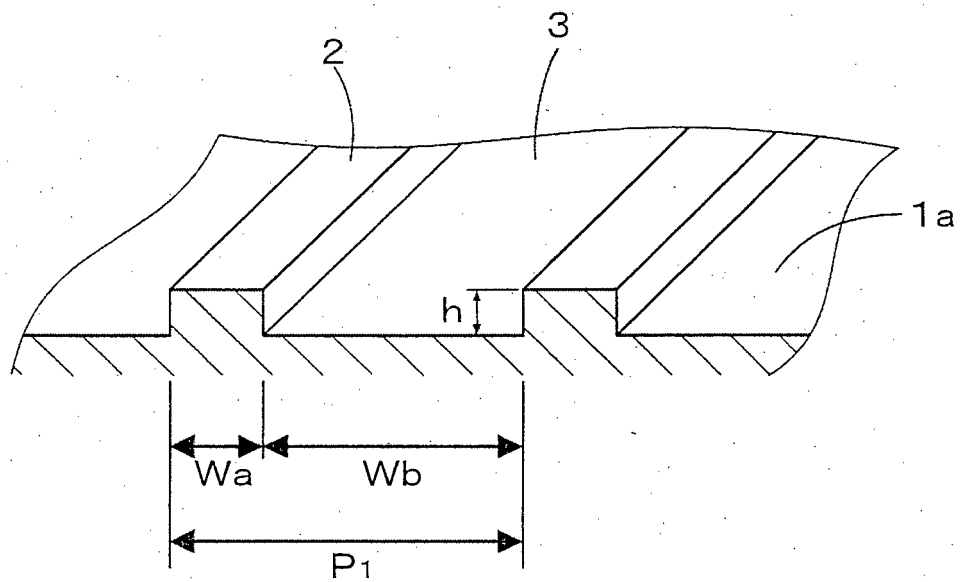


FIG.6

	PROJECTION HEIGHT h	PROJECTION WIDTH W_a	RECESS WIDTH W_b	PROJECTION RECESS PITCH P_1	ANGLE θ	GROOVE WIDTH W_c	GROOVE PITCH P_2	PROJECTION HEIGHT $\times$ RECESS WIDTH $A=h \times W_b$	GROOVE WIDTH/ GROOVE PITCH $B=W_c/P_2$	$A \times B$	IMPROVEMENT RATE OF CONDENSATION HEAT-TRANSFER PERFORMANCE	
	(mm)	mm	mm	mm	°	mm	mm	mm ²			%	
0	0.04	0.125	0.6	0.725	45	4	20	0.024	0.2	0.0048	16	EXAMPLE
1	0.05	0.1	0.4	0.5	45	4	13.5	0.0200	0.2963	0.0059	20.6	EXAMPLE
2	0.04	0.1	0.4	0.5	45	4	13.5	0.0160	0.2963	0.0047	10.0	EXAMPLE
3	0.03	0.1	0.4	0.5	45	4	13.5	0.0120	0.2963	0.0036	9.3	EXAMPLE
4	0.03	0.1	0.4	0.5	40	4	13.5	0.0120	0.2963	0.0036	10.3	EXAMPLE
5	0.03	0.1	0.4	0.5	30	4	13.5	0.0120	0.2963	0.0036	10.1	EXAMPLE
6	0.03	0.1	0.5	0.6	45	4	13.5	0.0150	0.2963	0.0044	11.8	EXAMPLE
7	0.03	0.1	0.6	0.7	45	4	13.5	0.0180	0.2963	0.0053	10.1	EXAMPLE
8	0.03	0.1	0.6	0.7	30	4	13.5	0.0180	0.2963	0.0053	7.7	EXAMPLE
9	0.03	0.1	0.4	0.5	45	4	9	0.0120	0.4444	0.0053	6.4	EXAMPLE
10	0.03	0.1	0.6	0.7	30	4	9	0.0180	0.4444	0.0080	7.6	EXAMPLE
11	0.03	0.1	0.4	0.5	45	4	13.5	0.0120	0.2963	0.0036	5.4	EXAMPLE
12	0.03	0.1	0.4	0.5	45	4	9	0.0120	0.4444	0.0053	6.0	EXAMPLE
13	0.03	0.1	0.4	0.5	45	2	9	0.0120	0.2222	0.0027	7.8	EXAMPLE
14	0.03	0.1	0.3	0.4	45	2	9	0.0090	0.2222	0.0020	3.4	COMP. EX.
15	0.03	0.1	0.1	0.2	45	2	9	0.0030	0.2222	0.0007	1.8	COMP. EX.
16	0.03	0.1	0.4	0.5	45	1	9	0.0120	0.1111	0.0013	4.5	COMP. EX.

FIG.7

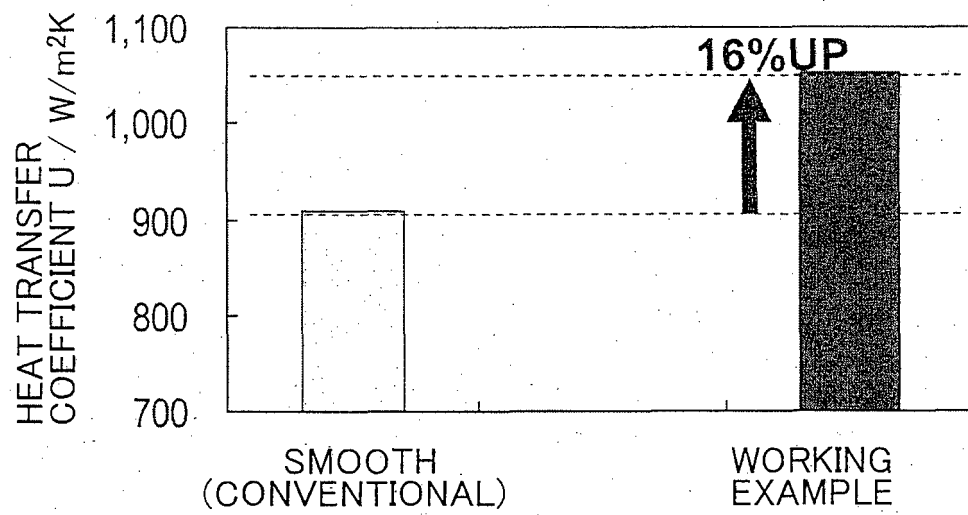
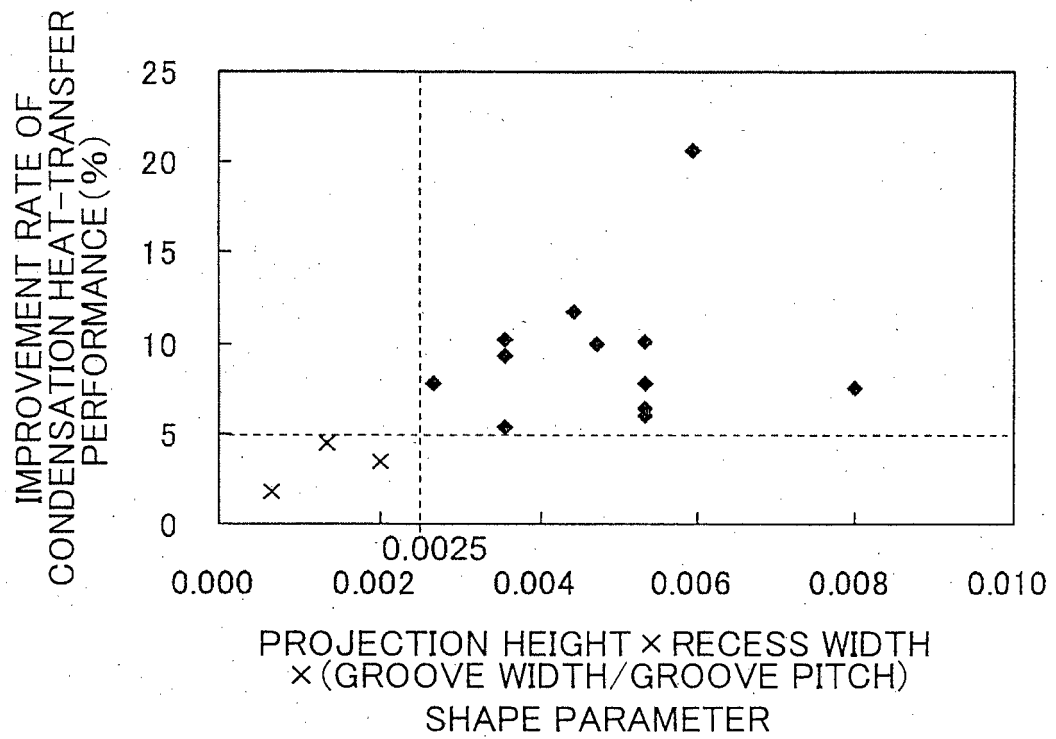


FIG.8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/054563

A. CLASSIFICATION OF SUBJECT MATTER

F28F3/04(2006.01) i, F28D9/00(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F3/04, F28D9/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 58-8996 A (Nippon Mining Co., Ltd.),	1, 7
Y	19 January 1983 (19.01.1983), entire text; all drawings (Family: none)	2, 4-6, 8, 10-12
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 23505/1981 (Laid-open No. 137972/1982) (Diesel Kiki Co., Ltd.), 28 August 1982 (28.08.1982), fig. 2, 4 (Family: none)	2, 4-6, 8, 10-12

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

21 April 2015 (21.04.15)

Date of mailing of the international search report

12 May 2015 (12.05.15)

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/054563

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-76551 A (Kobe Steel, Ltd.), 25 April 2013 (25.04.2013), entire text; all drawings & US 2014/0202677 A1 & WO 2013/039214 A1 & EP 2757341 A1 & CN 103782125 A & KR 10-2014-0049595 A	1-12

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006239744 A [0012]
- JP 2013076551 A [0012]