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(54) A plate heat exchanger

Plattenwärmetauscher

Echangeur de chaleur à plaques

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- **PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) -& JP 11 173771 A (DAIKIN IND LTD), 2 July 1999 (1999-07-02)**
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Description

[0001] The present invention relates to a plate heat exchanger comprising at least two separate flow paths for primary and secondary fluids to exchange heat, the said two flow paths being substantially defined by heat exchanger plates interconnected by soldering provided with a herring bone pattern of ridges and depressions and offering different pressure drops at equal mass flows of the two fluids.

[0002] Many heat exchangers of the above type are used for heating tap water by means of hot water also used for heating dwelling houses. The inlet temperature of the heating water may be e.g. 75° C, and the outlet temperature thereof may be about 60° C. The inlet temperature of the tap water may be about 10° C and the outlet temperature thereof may be 55° C. This indicates that the mass flow of the heating water must be 2.5 times the mass flow of the tap water. Therefore, it is economical to make the cross section of the flow path for the heating water wider than that of the tap water, e.g. by making the tops of the herring bone pattern flat - and thus wider - while the bottoms are unaltered.

[0003] Although making the heat exchanger "asymmetric" is an improvement it is still an object to further increase the efficiency of the exchanger - i.e. to increase the heat transmission between the heat exchanging fluids without increasing the weight of the plate heat exchanger.

[0004] The Japanese Patent Application No. 11173771 A published July 2nd, 1999 discloses a plate heat exchanger having different pressure drops in the flow paths in case of equal mass flows.

[0005] This is done by increasing the pitch - i. e. the distance between the contacts of adjacent ridges in the herringbone pattern. This known device is adapted to exchange heat between water and a cooling fluid the water flowing through the flow path having the smaller pressure drop. By making small depressions in parts of plates forming the water channels it is obtained that freezing of water will not cause damage to the plate heat exchanger. However, the areas of contact between plates will thus be relatively great and lost for the heat exchange between the fluids. The small depressions in the channels guiding the water flow will cause corresponding very narrow flow channels in the flow path for the cooling fluid. The areas of contact between adjacent plates are not rigidly interconnected in order to increase the elasticity of the plate heat exchanger, but the mechanical strength of the exchanger will be rather poor making the exchanger unsuitable for high pressure fluids.

[0006] The Japanese Patent Application No. 11281283 A also discloses a heat exchanger in which the pressure drops of two heat exchanging fluids are different in case of equal mass flows. According to the embodiment in Figure 5 of said disclosure the flow paths forming a herring bone pattern comprise channels having greater cross sectional flow area provided with two small secondary depressions in the channels of greater cross section. This involves that the flow path having a total relatively high pressure drop will consist of parts causing very different pressure drops. This is an uneconomical way of using the material in the exchanger for exchanging heat. Also - as the pitch will increase with increasing numbers of the secondary depressions - the mechanical strength of the exchanger will decrease due to the smaller numbers of contact points at which the plates could be rigidly connected.

[0007] The object of the present invention is to design an "asymmetric" plate heat exchanger in which the material of the plates is used in a more economic way and thus in which the efficiency is improved while maintaining a high mechanical strength of the exchanger

[0008] According to the present invention a plate heat exchanger comprising at least two separate paths for primary and secondary fluids to exchange heat, the said two flow paths being substantially defined by heat exchanger plates provided with a herring bone pattern of ridges and depressions, the herring bone pattern of two plates being mirror images of each other, wherein each other plate should be turned 180 degrees in its plane relative the adjacent plates, and offering different pressure drops at equal mass flows of the two fluids, wherein the depressions in at least some pairs of plates defining the flow path having the lower pressure drop at least partly are alternatively of two different press depths ($\mathbf{D_1}$, $\mathbf{D_2}$) measured from the plan defined by the tops of the ridges of the herring bone pattern of the heat exchanger plate, the smaller ($\mathbf{D_2}$) being located between two tops of the herring bone pattern and being at least 40% of the greater ($\mathbf{D_1}$), is characterised in that the heat exchanger plates are interconnected by soldering and that the tops of the ridges engaging the tops of a neighbouring plate to define a flow channel having high pressure drop substantially contact each other along points defined by crossing lines.

[0009] The invention will be described in more detail with reference to the accompanying drawings in which:

Fig. 1 is a plan view of plate in one known type of a plate heat exchanger.

Fig.2 schematically shows the crossing patterns of two plates according to Fig. 1 placed on each other - after one of them has been turned in its plan.

Fig. 3 is a section along the line **A-A** in Fig. 1.

Fig. 4 is a section along the line **B-B** in Fig. 2 in a stack of four plates according to Fig. 1.

Fig. 5 is a section corresponding to Fig. 4, but through a known "asymmetric" plate heat exchanger.

Fig. 6 is a section corresponding to those of Figs. 4 and 5, but through a plate heat exchanger according to the Japanese Patent Application No. 11173771 A.

Fig. 7 is a section corresponding to Fig. 6, but through a plate heat exchanger according to the Japanese Patent application No. 11281283 A.

Fig. 8 shows a section corresponding to those shown in Figs. 4-7 through two neighboring plates of a heat exchanger according to the present invention - the plates being drawn apart.

Fig. 9 is a section through four plates in heat exchanger according to the present invention.

[0010] Figure 1 is a plan view of a plate 1 of a known and widely used plate heat exchanger provided with a herring bone pattern of ridges 2 and depressions 3. In the exchanger a stack of plates of this type is formed after turning each other plate in the stack in its plane. Figure 2 illustrates how the ridges and depressions then will cross each other.

[0011] Fig. 3 - which is a section along the line **A-A** in Fig. 1 - illustrates the pitch **P** and the press depth **D** both values being of importance for characterising the plate heat exchanger.

[0012] Fig. 4 is a section along the line **B-B** of Fig. 2 through four plates in a heat exchanger according to the Figures 1-3. The two flows of heat exchanging fluids limited by the plates are shown by different hatching. It will be understood that the two flow paths are offering equal pressure drops at equal mass flows.

[0013] By increasing the pitch **P** and making the tops 2 of the ridges flat the flow path of one of the fluids will obtain a greater cross section than the flow path of the other fluid.

[0014] However, as shown in Fig. 5 the contact areas between the heat exchanger plates will be much larger. These areas cannot be used for heat exchange between the two flows of fluids.

[0015] Fig. 6 shows a prior art plate heat exchanger according to the Japanese Patent Application No. 11173771 which shows a plate heat exchanger of the "asymmetric" type in which the pairs of plates limiting the flow path having the greater cross sectional area are provided with depressions of less depths $\mathbf{D_2}$ than the press depths $\mathbf{D_1}$ of tops of the ridges of the herring bone pattern. This has been done in order to make the plate heat exchanger more resistant against damage caused by ice formations. The plan contact areas between the plates and not used for heat exchange are still existing in this embodiment.

[0016] Another proposal for manufacturing an "asymmetric" plate heat exchanger has been described in the Japanese Patent Application No. 11281283 A. Here the contact areas between the plates of the exchanger has been established by replacing the plan contact areas by areas containing small depressions. This has been shown in Fig. 7 and it will be understood that the flow path having the greater pressure drop will consist of channels of large cross section and at least the double number of much smaller cross sections. This design is detrimental to the heat transfer in the narrow channels because of the much lower flow rate than in the flow channels having wider cross sections.

[0017] Fig. 8 shows a section corresponding to the sections shown in Figs. 4-7 through two heat exchanger plates according to the present invention. A primary press depth press depth - i. e. the distance between the plan defined by the tops of the ridges and the lowest plan defined by bottoms of ridges - has been indicated as $\mathbf{D_1}$. A secondary press depth defined as the distance between the plan of the tops of the ridges of the herring bone pattern and a plan of the bottom of minor depressions has been designated by $\mathbf{D_2}$. The pitch of the herringbone pattern has been indicated by **P**.

[0018] The herring bone patterns of the two plates 4 and 5 shown in Fig. 8 are mirror images of each other and thus two tools are used for the pressing of the plates. Also each other of the plates should be turned 180 degrees in its plan relative the adjacent plates in the stack in order to obtain the crossing herring bone patterns. Figure 9 is a section through four plates 4, 5, 6 and 7 of the types shown in Fig. 8 and corresponding to the sections C-C shown in Figs. 4-7. The three channels formed for the flows exchanging heat are shown by two different hatchings. It will be understood from Fig. 9 that the resistance for the flow limited by the plates 5 and 6 is higher than the resistance for the flow limited by the plates 4 and 5 or 6 and 7. However, the contact areas between the plates are kept at a minimum, but the number of contacts at which the plates are interconnected by soldering is substantial and will give mechanical strength to the heat exchanger. It is essential to maintain a substantial mass flow of fluid through the cross sections designed by 8 in Fig. 9. The mass flow through the area 8 is nearly proportional to its cross sectional area and this is in turn mainly dependant on the magnitude of the press depth $\mathbf{D_2}$. A small press depth $\mathbf{D_2}$ - e.g. as shown in Fig. 7 - will make the areas 8 small and may almost block passage of fluid. A small secondary press depth will the have nearly the same effect as the large contact areas between the ridges of the herring bone pattern shown in Fig. 5.

Claims

1. A plate heat exchanger comprising at least two separate flow paths for primary and secondary fluids to exchange heat, the said two flow paths being substantially defined by heat exchanger plates (4-7) provided with a herring bone pattern of ridges and depressions (2, 3), the herring bone pattern of two plates (4, 5) being mirror images of each other, wherein each other plate should be turned 180 degrees in its plane relative the adjacent plates, and offering different pressure drops at equal mass flows of the two fluids, wherein the depressions in at least some pairs of plates defining the flow path having

the lower pressure drop at least partly are alternatively of two different press depths (D_1, D_2) measured from the plane defined by the tops of the ridges of the herring bone pattern of the heat exchanger plate, the smaller (D_2) being located between two tops of the herring bone pattern and being at least 40% of the greater (D_1), **characterized in that** the heat exchanger plates (4-7) are interconnected by soldering and **in that** the tops of the ridges engaging the tops of a neighbouring plate to define a flow channel having high pressure drop substantially contact each other along points defined by crossing lines.

Patentansprüche

1. Plattenwärmetauscher, umfassend wenigstens zwei separate Strömungswege für primäre und sekundäre Fluide zum Wärmetausch, wobei die beiden Strömungswege im Wesentlichen durch Wärmetauscherplatten (4-7) definiert sind, die mit fischgrätenartig angeordneten Erhöhungen und Vertiefungen (2, 3) versehen sind, wobei die Fischgrätenstrukturen von zwei Platten (4, 5) Spiegelbilder voneinander sind und jede andere Platte um 180° in ihrer Ebene bezüglich den benachbarten Platten zu drehen ist, und unterschiedliche Druckabfälle bei gleichen Masseflüssen der beiden Fluide bereitstellen, wobei die Vertiefungen in wenigstens einigen Plattenpaaren, die den Strömungsweg mit dem geringeren Druckabfall definieren, wenigstens teilweise alternativ aus zwei unterschiedlichen Presstiefen (D_1, D_2) bestehen, gemessen von der Ebene, die durch die Oberseiten der Erhöhungen der Fischgrätenstruktur der Wärmetauscherplatten definiert wird, wobei sich die kleineren (D_2) zwischen zwei Oberseiten der Fischgrätenstruktur befinden und wenigstens 40 % der größeren (D_1) betragen, **dadurch gekennzeichnet, dass** die Wärmetauscherplatten (4-7) miteinander verlötet sind, und dadurch, dass die Oberseiten der Erhöhungen, welche die Oberseiten einer benachbarten Platte dergestalt in Eingriff nehmen, dass ein Strömungskanal definiert wird, der einen hohen Druckabfall aufweist, einander im Wesentlichen entlang Punkten berühren, die durch Kreuzungslinien definiert sind.

Revendications

1. Echangeur de chaleur à plaques comprenant au moins deux trajets d'écoulement séparés pour que des fluides principal et secondaire échangent de la chaleur, lesdits deux trajets d'écoulement étant sensiblement définis par des plaques d'échangeur de chaleur (4 à 7) pourvues d'un motif en chevrons d'arêtes et de renfoncements (2, 3), les motifs en chevrons de deux plaques (4, 5) étant des images symétriques l'une de l'autre, dans lequel chaque autre plaque devrait être tournée de 180 degrés dans son plan par rapport aux plaques adjacentes, et présentant différentes chutes de pression à des débits massiques identiques des deux fluides, dans lequel les renfoncements dans au moins certaines paires de plaques définissant le trajet d'écoulement ayant la plus faible chute de pression au moins partiellement ont alternativement deux profondeurs d'enfoncement différentes (D_1, D_2) mesurées par rapport au plan défini par les sommets des arêtes du motif en chevrons de la plaque d'échangeur de chaleur, la plus petite (D_2) étant située entre deux sommets du motif en chevrons et étant égale à au moins 40 % de la plus grande (D_1), **caractérisé en ce que** les plaques d'échangeur de chaleur (4 à 7) sont interconnectées par soudage et **en ce que** les sommets des arêtes en prise avec les sommets d'une plaque voisine pour définir un canal d'écoulement ayant une chute de pression élevée sont sensiblement en contact les uns avec les autres le long des points définis par les lignes de croisement.

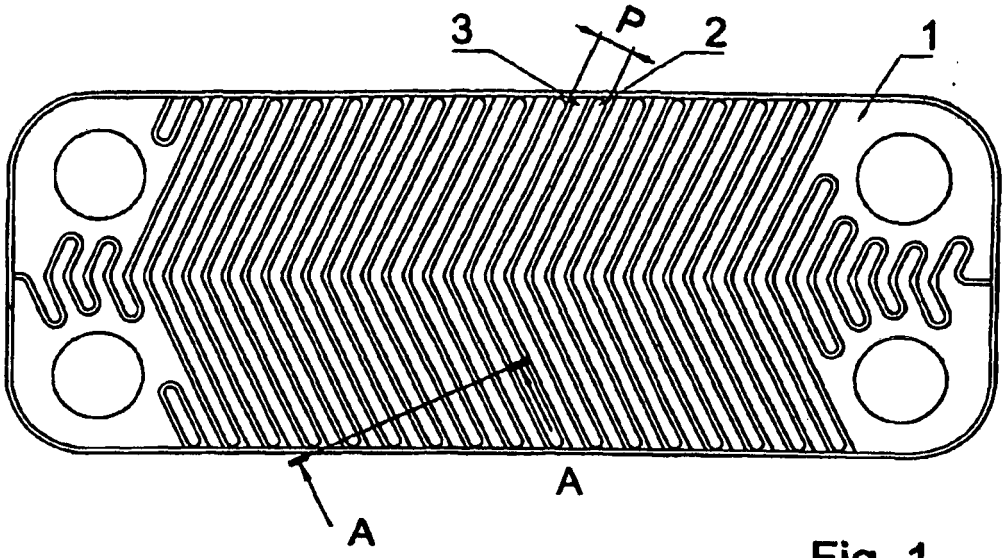

Fig. 1

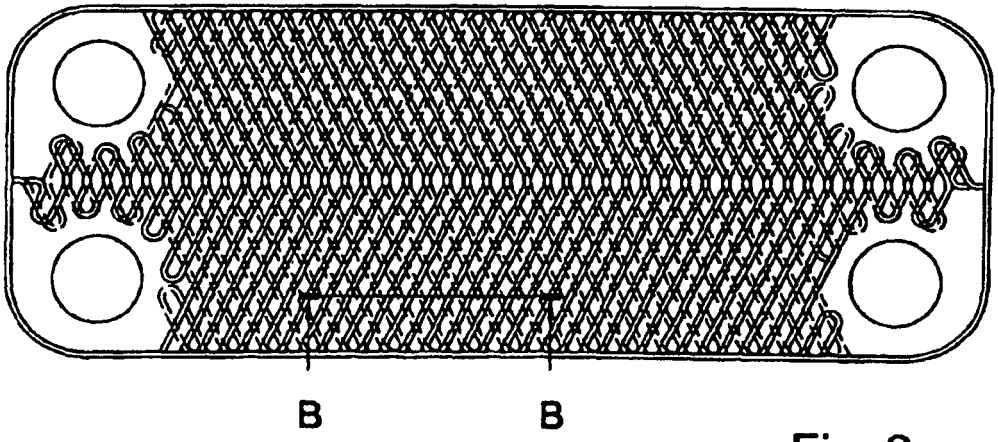

Fig. 2

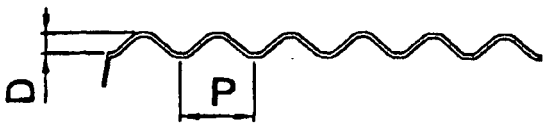

Fig. 3

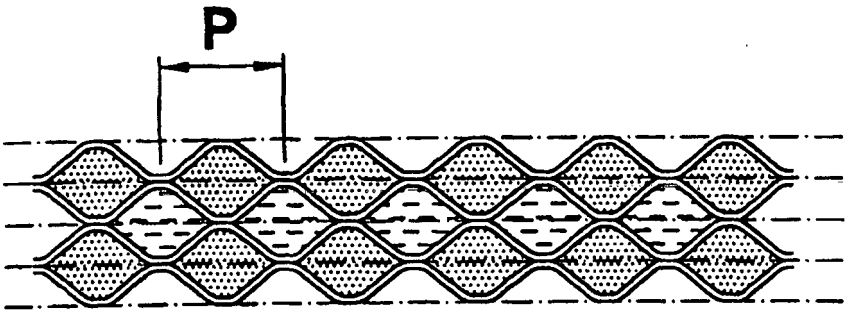

Fig. 4

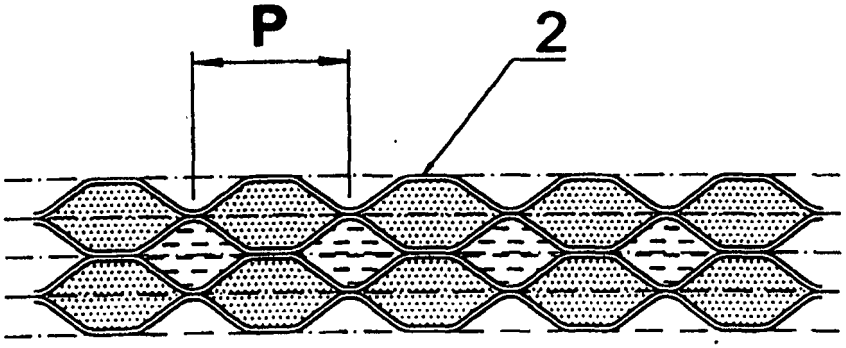

Fig. 5

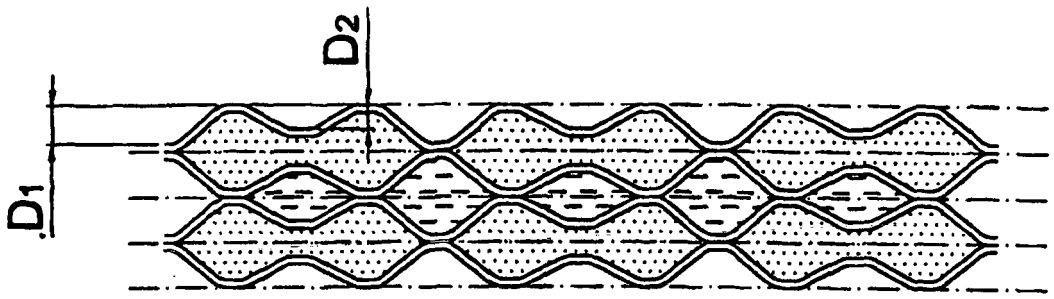

Fig. 6

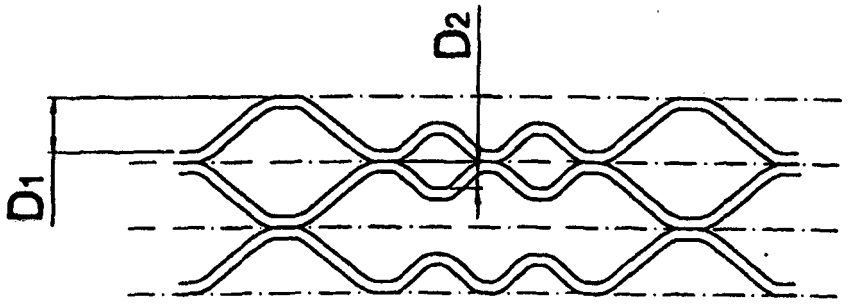

Fig. 7

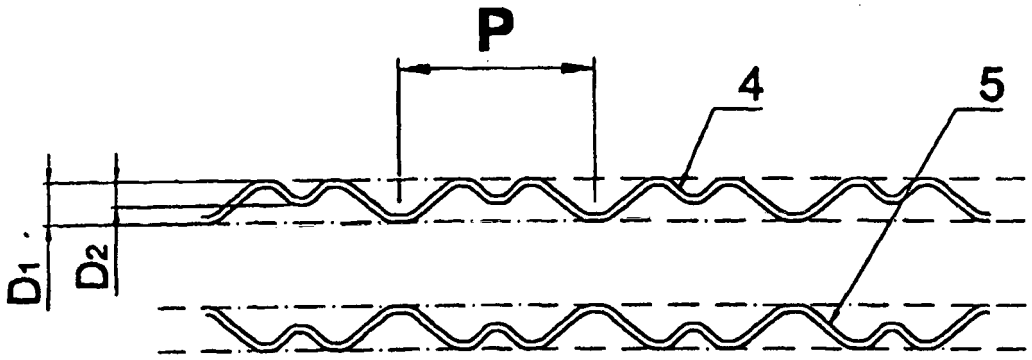

Fig. 8

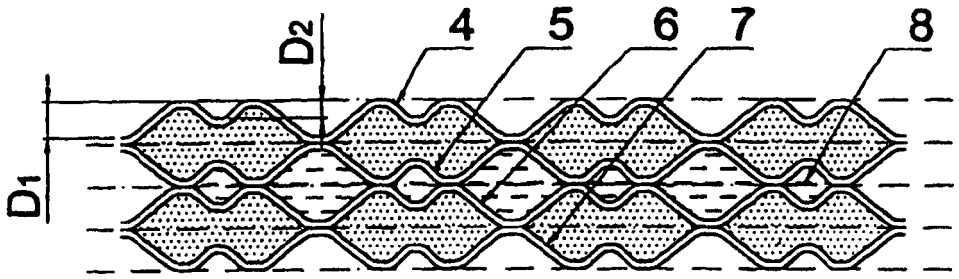

Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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