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(54) **HEAT EXCHANGER TURBULIZERS WITH INTERRUPTED CONVOLUTIONS**

WÄRMETAUSCHERWIRBELERZEUGER MIT UNTERBROCHENEN WELLUNGEN

DISPOSITIFS PRODUCTEURS DE TURBULENCES COMPORTANT DES ONDULATIONS
DISCONTINUES, UTILES DANS UN ECHANGEUR THERMIQUE

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Description

[0001] The present invention relates to heat exchangers and to turbulizers for heat exchangers.

[0002] In heat exchangers made from multiple, stacked, tubes or plate pairs defining flow passages therein, it is common to use turbulizers located in the tubes or between the plates inside the plate pairs to enhance heat transfer, especially where a liquid, such as oil, passes through these flow passages. These turbulizers are commonly in the form of expanded metal inserts and they have undulations or convolutions formed therein to create turbulence in the flow and in this way increase heat transfer in the heat exchanger.

[0003] While conventional turbulizers do increase heat transfer, a difficulty with these turbulizers is that they also increase flow resistance or pressure drop inside the heat exchanger. In fact, the flow resistance increases even more than the heat transfer gain produced by the turbulizer, because only a part of the increased turbulence caused by the turbulizer is effective in promoting heat transfer. The balance is wasted in inefficient eddies or vortices.

[0004] An attempt to alleviate the increased pressure drop mentioned above has been described in EP-A-203458, which discloses turbulizers for heat exchangers having the features of the preamble of enclosed claim 1: a difficulty with the turbulizers described in this patent is that the non-convoluted areas of the turbulizers are too large with respect to the row of convolutions, so the heat transfer efficiency is too low.

[0005] The object of the present invention is to improve the balance between the heat exchange efficiency and flow resistance with respect to the known turbulizer.

[0006] According to the present invention, there is provided a turbulizer for a heat exchanger, the turbulizer including a planar member having a plurality of longitudinal parallel rows of convolutions formed therein characterized by said convolutions being interrupted to form longitudinal neutral channels only between some of the adjacent longitudinal rows of convolutions.

[0007] In this way, the convolutions are periodically interrupted in the turbulizer to form non-convoluted neutral channels located between groups of adjacent longitudinal rows of convolutions. Surprisingly, this substantially reduces the pressure drop caused by the turbulizer without appreciably reducing heat transfer.

[0008] According to another aspect of the invention, there is provided a heat exchanger comprising a plurality of spaced-apart tube members defining flow passages there between; said tube members defining spaced-apart inlet and outlet openings; and a turbulizer as previously defined and located in at least one of the flow passages between the respective inlet and outlet openings.

[0009] Preferred embodiments of the invention will now be described, by way of example, with reference to

the accompanying drawings, in which:

Figure 1 is an exploded perspective view of a preferred embodiment of a plate type heat exchanger according to the present invention;

Figure 2 is an enlarged perspective view of a portion of a turbulizer usable in the heat exchanger of Figure 1 according to the prior art;

Figure 3 is an elevational view of a portion of the turbulizer of Figure 2 taken in the direction of arrow 3 in Figure 2;

Figure 4 is a plan view of the turbulizer of Figures 2 and 3;

Figure 5 is a perspective view of a turbulizer according to the present invention;

Figure 6 is an elevational view of a portion of the turbulizer of Figure 5 taken in the direction of arrow 6 in Figure 5;

Figure 7 is a plan view of the turbulizer shown in Figures 5 and 6;

Figure 8 is a perspective view of another embodiment of a turbulizer according to the present invention;

Figure 9 is an elevational view of a portion of the turbulizer of Figure 8;

Figure 10 is a plan view of the turbulizer shown in Figures 8 and 9.

[0010] Referring to Figure 1, a preferred embodiment of a heat exchanger according to the present invention is generally indicated by reference numeral 10. Heat exchanger 10 is formed of a plurality of spaced-apart tube members or plate pairs 12, each having an upper plate 14, a lower plate 16 and a turbulizer 18 located therebetween. Plates 14, 16 are arranged back-to-back and have joined peripheral edges 20. Plates 14, 16 also have raised central portions 22 which define a flow passage therebetween in which turbulizers 18 are located. Raised central portions 22 also define spaced-apart inlet and outlet openings 24, 26 for the flow of fluid, such as oil, through the plate pairs. When the heat exchanger is assembled, all of the inlet openings 24 are aligned and in communication forming an inlet header, and all of the outlet openings 26 are aligned and in communication forming an outlet header. Expanded metal fins 28 are located between the plate pairs for allowing another fluid, such as air to flow transversely through the plate pairs. The plates 14, 16 that are in contact with fins 28 are spaced apart by raised end bosses 29 to make room

for fins 28 between plate central portions 22.

[0011] The plates 14, 16 and the fins 28 can be any shape and configuration desired and are not, *per se*, considered to be part of the present invention. In fact, plates 14, 16 can be formed with outwardly disposed dimples which mate in adjacent plate pairs in which case, fins 28 would not be used.

[0012] Referring next to Figures 2, 3 and 4, a turbulizer 30 is shown which could be used as the turbulizer 18 in Figure 1, according to a prior art solution and which is not encompassed by the enclosed claims. Figures 5, 8 show preferred embodiments of turbulizers according to the present invention. Any one of these could be used as the turbulizer 18 in the heat exchanger 10 shown in Figure 1. The turbulizers shown in Figures 2, 5, 8 are just illustrations of sections or portions of the turbulizers. It will be appreciated that these turbulizers can be made in any length or width desired depending upon the manufacturing method. The turbulizers usually are stamped or roll-formed out of aluminum about 0.01 inches (0.25 mm) thick. However, other materials and heavier or thinner materials can be used for the turbulizers as well.

[0013] Turbulizer 30 is a planar member having a plurality of convolutions 32, 34 formed therein. Convolutions 32, 34 are arranged in parallel rows. Where turbulizer 30 is elongate in shape, convolutions 32, 34 are arranged in parallel, longitudinal rows 36, and also in parallel transverse rows 38.

[0014] Convolutions 32, 34 are interrupted periodically to form non-convoluted pressure recovery zones 40 located between or downstream of the convolutions 32, 34 in each row of convolutions 36. In other words, the convolutions 32, 34 in each row are spaced-apart by pressure recovery zones 40, rather than being located contiguous to one another.

[0015] Turbulizer 30 has a central plane containing pressure recovery zones 40 as indicated by arrow 41 in Figure 3, and convolutions 32, 34 extend alternately above (convolutions 32) and below (convolutions 34) the central plane 41. Convolutions 32, 34 are in the form of bridges, and turbulizer 30 has a high pressure drop orientation in the direction of the bridges, or in the longitudinal direction, and a low pressure drop orientation in the direction passing under the bridges or the transverse direction. In the embodiment shown in Figure 2, the convolutions 32, 34 are interrupted in the high pressure drop direction by pressure recovery zones 40 located between or downstream of the convolutions. As seen best in Figure 4, the pressure recovery zones 40 are located in transverse rows or neutral channels 41 themselves.

[0016] When turbulizer 30 is used as the turbulizer 18 in heat exchanger 10 of Figure 1, fluid flows in the high pressure drop orientation or direction parallel to longitudinal rows 36 from inlet openings 24 to outlet openings 26. The fluid flows around and under or through convolutions 32, 34. This causes turbulence and reduces boundary layer growth increasing the heat transfer co-

efficient. However, pressure recovery zones 40 allow for a pressure recovery to reduce flow resistance or pressure drop in the fluid passing from inlet openings 24 to outlet openings 26.

[0017] In turbulizer 30, convolutions 32, 34 are aligned in the low pressure drop or transverse direction. Also, pressure recovery zones 40 are aligned in the low pressure drop or transverse direction to form neutral channels 41. Pressure recovery zones 40 thus form continuous neutral channels 41 in the low pressure drop direction. These neutral channels 41 also provide areas that can be used to eject the turbulizer from the dies used to produce the turbulizer.

[0018] The width of the convoluted longitudinal rows 36 is preferably as narrow as is practical for tool design and maintenance purposes. For automotive cooling purposes, a preferred minimum width would be about 0.02 inches (0.5 mm). The maximum width should not exceed ten times the minimum. Typically, the maximum width would be about 0.2 inches (5 mm). The longitudinal length of pressure recovery zones 40 ranges from about 5% of the longitudinal or centerline to centerline spacing between convolutions 32, 34 to about 75% of the spacing between any two consecutive convolutions 32, 34. A preferable range would be between 0.02 inches (0.5 mm) to about 0.5 inches (1.25 cm), or about 40% to 50% of the centerline to centerline distance between longitudinally consecutive convolutions 32, 34.

[0019] The height of convolutions 32, 34 above or below the central plane 41 containing pressure recovery zones 40 depends upon the thickness of the material used for turbulizer 30. This height should not be less than the material thickness and typically ranges from this minimum to about 10 times the material thickness where aluminum is used for turbulizer 30. A good range is from 0.01 inches (0.25 mm) to 0.5 inches (1.25 cm).

[0020] The longitudinal length of convolutions 32, 34 is normally about 2 times the height of the convolutions. The height normally ranges from about 2 times the material thickness to about 20 times the material thickness. A good range is from 0.02 inches (0.5 mm) to about 1.0 inch (2.5 cm).

[0021] Referring next to Figures 5, 6 and 7, a turbulizer 55 is shown that is most similar to turbulizer 30 of Figure 2, except the convolutions 32, 34 are also interrupted in the low pressure drop direction to form further pressure recovery zones 56 located between some of the rows of convolutions 36. Actually, pressure recovery zones 56 extend longitudinally the full length of turbulizer 55 to form longitudinal neutral channels 58 in the high pressure drop or longitudinal direction of turbulizer 55. For manufacturing purposes, the width of neutral channels 58 preferably is about the same as the width of the rows of convolutions 36. In turbulizer 55, the convolutions 32, 34 are aligned in the low pressure drop or transverse direction, but they could be staggered as well. Where convolutions 32, 34 are aligned in the low pressure drop or transverse direction, it will be appreciated

that pressure recovery zones 40 are aligned to give transverse neutral channels 59 in the low pressure drop direction, and pressure recovery zones 56 are aligned to give longitudinal neutral channels 58 in the high pressure drop direction. Where convolutions 32, 34 are staggered, only longitudinal neutral channels 58 would be formed. In all other respects, turbulizer 55 is similar to turbulizers 30, 45 and 50.

[0022] Referring next to Figures 8, 9 and 10, a turbulizer 60 is shown where the convolutions 32, 34 are interrupted only in the low pressure drop or transverse direction and only between some of the rows of convolutions 36. These interruptions make pressure recovery zones 61 in the form of longitudinal neutral channels 62. In all other respects, turbulizer 60 is similar to turbulizers 30 and 55. In Figures 8 to 10, turbulizer 60 is shown cut to length in the middle of convolutions 32, 34. This has been done for the purposes of illustration. In practice, the turbulizers would normally be cut to length between the convolutions, as is the case in Figures 1 to 7.

[0023] Having described preferred embodiments of the invention, it will be appreciated that various modifications can be made to the structures described above. For example, instead of using plate pairs 12 as tube members defining the flow passages containing turbulizers 18, continuous flat or oblong tubes could be used instead. In this case, turbulizers 18 would be inserted lengthwise into one end of the tubes. In turbulizers 18, the convolutions 32, 34 have been shown to be rounded with various curvatures. These convolutions can be any configuration, such as semi-circular, sinusoidal, trapezoidal or even V-shaped, if desired. In heat exchanger 10 shown in Figure 1, turbulizer 18 is shown to be orientated such that the flow is in the high pressure drop or longitudinal direction. However, the turbulizer could be rotated 90 degrees so that the flow from inlet 24 to outlet 26 is in the low pressure drop direction if desired. It will also be appreciated that the various features of turbulizers 30, 55 and 60 could be mixed and matched, or a combination of these features could be employed in the same turbulizer. Also, any given heat exchanger could have any one or a combination of the turbulizers described above. Other modifications to the structure described above will be apparent to those skilled in the art.

Claims

1. A turbulizer for a heat exchanger, the turbulizer including a planar member having a plurality of longitudinal parallel rows (36) of convolutions (32, 34) formed therein **characterized by** said convolutions (32, 34) being interrupted to form longitudinal neutral channels (58; 62) only between some of the adjacent longitudinal rows (36) of convolutions.
2. A turbulizer as claimed in claim 1, **characterized in**

that the convolutions (32, 34) are in the form of bridges, the bridges being orientated longitudinally to define a high pressure drop orientation in the direction of the bridges and a low pressure drop orientation transversely in the direction passing under the bridges.

3. A turbulizer as claimed in claim 2, **characterized in that** wherein the rows (36) of convolutions are further interrupted in the longitudinal direction to form pressure recovery zones (40) located longitudinally between the convolutions (32, 34).
4. A turbulizer as claimed in claim 3, **characterized in that** the convolutions (32, 34) are aligned in the transverse direction, the pressure recovery zones (40) also being aligned transversely to form neutral channels (59) in the transverse direction.
5. A turbulizer as claimed in claim 2, **characterized in that** the convolutions (32, 34) are staggered in the transverse direction.
6. A turbulizer as claimed in claim 2, **characterized in that** the convolutions (32, 34) are aligned in the transverse direction.
7. A turbulizer as claimed in claim 3, **characterized by** having a central plane containing the pressure recovery zones, the convolutions (32, 34) in each row (36) of convolutions extending alternately above and below the central plane.
8. A turbulizer as claimed in claim 5, **characterized by** having a central plane containing the pressure recovery zones, the convolutions (32, 34) in each row (26) of convolutions extending alternately above and below the central plane.
9. A turbulizer as claimed in claim 1, **characterized in that** said groups include three rows (36) of convolutions, there being a single longitudinal neutral channel (58; 62) between each group.

10. A heat exchanger (10) comprising a plurality of spaced-apart tube members defining flow passages there between; said tube members defining spaced-apart inlet and outlet openings (24, 26); and a turbulizer (55; 60) as claimed in any one of the foregoing claims; said turbulizer (55; 60) being located in at least one of the flow passages between the respective inlet and outlet openings (24, 26).

Patentansprüche

1. Wirbelerzeuger für einen Wärmetauscher, wobei der Wirbelerzeuger ein ebenes Element aufweist,

das eine Vielzahl von länglichen parallelen Reihen (36) von Wellungen (32, 34) besitzt, die darin ausgebildet sind,

dadurch gekennzeichnet,

dass die Wellungen (32, 34) unterbrochen sind, um nur zwischen einigen der benachbarten länglichen Reihen (36) von Wellungen längliche neutrale Kanäle (58; 62) zu bilden.

2. Wirbelerzeuger nach Anspruch 1, **dadurch gekennzeichnet,** **dass** die Wellungen (32, 34) als Brücken ausgebildet sind, die in Längsrichtung orientiert sind, um eine Hochdruckabfallorientierung in Richtung der Brücken und eine Niederdruckabfallorientierung quer in der Richtung, die unter den Brücken verläuft, zu bilden.
3. Wirbelerzeuger nach Anspruch 2, **dadurch gekennzeichnet,** **dass** die Reihen (36) von Wellungen außerdem in Längsrichtung unterbrochen sind, um Druckrückgewinnzonen (40) zu bilden, die zwischen den Wellungen (32, 34) lokalisiert sind.
4. Wirbelerzeuger nach Anspruch 3, **dadurch gekennzeichnet,** **dass** die Wellungen (32, 34) in der Querrichtung fluchten und die Druckrückgewinnzonen (40) ebenfalls quer fluchten, um in der Querrichtung neutrale Kanäle (59) zu bilden.
5. Wirbelerzeuger nach Anspruch 2, **dadurch gekennzeichnet,** **dass** die Wellungen (32, 34) in Querrichtung versetzt angeordnet sind.
6. Wirbelerzeuger nach Anspruch 2, **dadurch gekennzeichnet,** **dass** die Wellungen (32, 34) in Querrichtung fluchtend angeordnet sind.
7. Wirbelerzeuger nach Anspruch 3, **dadurch gekennzeichnet,** **dass** er eine zentrale Ebene besitzt, die die Druckrückgewinnzonen enthält, wobei die Wellungen (32, 34) in jeder Reihe (36) von Wellungen sich abwechselnd über und unter die zentrale Ebene erstrecken.
8. Wirbelerzeuger nach Anspruch 5, **dadurch gekennzeichnet,** **dass** er eine zentrale Ebene besitzt, die die Druckrückgewinnzonen enthält, wobei die Wellungen (32, 34) in jeder Reihe (36) von Wellungen sich abwechselnd über und unter die zentrale Ebene erstrecken.
9. Wirbelerzeuger nach Anspruch 1, **dadurch gekennzeichnet,**

dass die Gruppen drei Reihen (36) von Wellungen enthalten, wobei zwischen jeder Gruppe ein einziger länglicher neutraler Kanal (58; 62) vorhanden ist.

10. Wärmetauscher (10) mit einer Vielzahl von voneinander beabstandeten Rohrelementen, die dazwischen Strömungsdurchlässe bestimmen, wobei die Rohrelemente voneinander beabstandete Einlass- und Auslassöffnungen (24, 26) bestimmen, und mit einem Wirbelerzeuger (55; 60) nach einem der vorhergehenden Ansprüche, wobei der Wirbelerzeuger (55; 60) in mindestens einem der Strömungsdurchlässe zwischen den entsprechenden Einlass- und Auslassöffnungen (24, 26) lokalisiert ist.

Revendications

1. Turbulateur pour échangeur de chaleur, le turbulateur comprenant un élément plat ayant une pluralité de rangées longitudinales parallèles (36) d'ondulations (32, 34) formées dans celui-ci, **caractérisé en ce que** lesdites ondulations (32, 34) sont interrompues pour former des canaux neutres (58; 62) seulement entre certaines des rangées longitudinales adjacentes (36) d'ondulations.
2. Turbulateur selon la revendication 1, **caractérisé en ce que** les ondulations (32, 34) se présentent sous la forme de ponts, les ponts étant orientés longitudinalement pour définir une orientation de forte chute de pression dans la direction des ponts et une orientation de faible chute de pression transversalement dans la direction passant sous les ponts.
3. Turbulateur selon la revendication 2, **caractérisé en ce que** les rangées (36) d'ondulations sont en outre interrompues dans la direction longitudinale pour former des zones de rétablissement de pression (40) situées longitudinalement entre les ondulations (32, 34).
4. Turbulateur selon la revendication 3, **caractérisé en ce que** les ondulations (32, 34) sont alignées dans la direction transversale, les zones de rétablissement de pression (40) étant également alignées transversalement pour former des canaux neutres (59) dans la direction transversale.
5. Turbulateur selon la revendication 3, **caractérisé en ce que** les ondulations sont en quinconce dans la direction transversale.
6. Turbulateur selon la revendication 2, **caractérisé en ce que** les ondulations sont alignées dans la direction transversale.

7. Turbulateur selon la revendication 3, **caractérisé en ce qu'il** comprend un plan central contenant les zones de rétablissement de pression, les ondulations (32, 34) de chaque rangée (36) d'ondulations s'étendant en alternance au-dessus et au-dessous du plan central. 5
8. Turbulateur selon la revendication 5, **caractérisé en ce qu'il** comprend un plan central contenant les zones de rétablissement de pression, les ondulations (32, 34) de chaque rangée (26) d'ondulations s'étendant en alternance au-dessus et au-dessous du plan central. 10
9. Turbulateur selon la revendication 1, **caractérisé en ce que** lesdits groupes comportent trois rangées (36) d'ondulations, un seul canal longitudinal neutre (58; 62) s'étendant entre deux groupes. 15
10. Echangeur de chaleur (10) comprenant plusieurs éléments tubulaires espacés les uns des autres, formant entre eux des passages d'écoulement, lesdits éléments tubulaires définissant des ouvertures d'entrée et de sortie (24, 26) espacées les unes des autres, et un turbulateur (55; 60) selon l'une quelconque des revendications précédentes, ledit turbulateur (55; 60) étant situé dans au moins un des passages d'écoulement entre les ouvertures d'entrée et de sortie respectives (24, 26). 20 25 30

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