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(71) Applicants:
- **Valeo Autosystemy SP. Z.O.O.**
  32-050 Skawina (PL)
- **Valeo Systemes Thermiques**
  78320 Le Mesnil Saint Denis (FR)

(72) Inventors:
- **Szostek, Dawid**
  31-352 Kraków (PL)
- **Kurowski, Boleslaw**
  34-120 Andrychów (PL)
- **Zurek, Jacek**
  31-975 Kraków (PL)
- **Bednarczyk, Maciej**
  32-050 Skawina (PL)
- **Farlay, Benjamin**
  78720 Carnay La Ville (FR)

(74) Representative: **Kowal, Elzbieta et al**
Polservice
Kancelaria Rzecznikow
Patentowych sp. z o.o.
Bluszczanska 73
00-712 Warszawa (PL)

(54) **TURBULATOR FIN FOR A TUBE-FIN ASSEMBLY ADAPTED FOR A HEAT EXCHANGER AND A FIN FORMING ROLL ADAPTED TO FORM SAID TURBULATOR FIN**

(57) Turbulator fin for a tube-fin assembly adapted for a heat exchanger, the turbulator fin comprising a corrugated sheet with a plurality of adjacent folds between a first transverse side of the sheet and a second transverse side of the sheet, each fold having a fixed fold height (h) delimited by adjacent fold lines and each fold having a fold length (L) in longitudinal direction of the sheet, characterized in that, the end fold forming the edge of the sheet of at least one transverse side of the sheet has a reduced fold height (hr) compared to the fixed fold height (h).

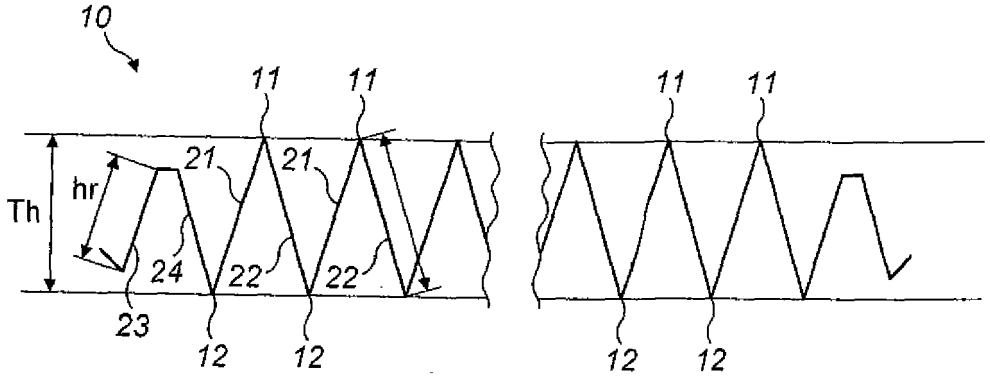

FIG. 1

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Description

Technical Field

[0001] The present disclosure relates to a turbulator fin for a tube-fin assembly adapted to be used in a heat exchanger. More particularly, the present disclosure relates to a turbulator fin and tube-fin assembly for a Charge Air Cooler (CAC) for use in the automotive industry.

[0002] The disclosure also relates to a fin forming roll for forming a turbulator fin for the tube-fin assembly according to the disclosure.

Background of the Invention

[0003] In turbocharged engine applications, the air used for the engine combustion is compressed in order to increase its density. The thermodynamic effect of this compression is an increase in the temperature of the compressed air. If the compressed air is not cooled to a sufficient level, the engine combustion may not be efficient, or the combustion engine may not operate at all.

[0004] Therefore, prior to entering the combustion chamber, the compressed air is cooled by means of a Charge Air Cooler (CAC).

[0005] In the prior art Charge Air Coolers are disclosed which comprise heat exchangers comprising tubes for guiding air through the heat exchangers, wherein the tubes are internally provided with turbulator fins.

[0006] A turbulator fin normally comprises a folded metal sheet and serves for improving the heat exchange inside the heat exchanger. Each of the folds is provided with louvers to avoid laminar flow along the surface of the turbulator fin.

[0007] The tubes of a Charge Air Cooler have a rectangular cross section. The turbulator fin has dimensions that fill the inside of the tube as much as possible.

[0008] Tubes for Charge Air Coolers are produced by means of electric welding or folding. The result of such production processes is that the resulting tube height in the corners of the tube is reduced when compared to the remaining part of the tubes.

[0009] In practice, it is difficult to fill the interior of the tubes near the corners with the turbulator fins. The areas of the tube which are not properly filled by means of the turbulator fin will create air bypasses which reduce the heat exchange efficiency of known Charge Air Coolers.

[0010] In view of the present emission standards which apply to the automotive industry, with even more stringent legislation underway, the current trend is to move towards combustion engines with higher inlet pressures and temperatures to improve fuel efficiency. In order to allow this, the compressed air needs to be cooled to even lower temperatures prior to entering the combustion chamber to ensure operation of the combustion engines.

[0011] Therefore, there appears to be a need for efficient and effective heat exchangers which are adapted to be used as Charge Air Coolers and allow cost and space efficient heat exchange.

Summary of the Invention

[0012] In one aspect, the present disclosure is directed to a turbulator fin for a tube-fin assembly adapted for a heat exchanger, the turbulator fin comprising a corrugated sheet with a plurality of adjacent folds between a first transverse side of the sheet and a second transverse side of the sheet, each fold having a fixed fold height (h) delimited by adjacent fold lines and each fold having a fold length (L) in the longitudinal direction of the sheet, characterized in that, the end fold forming the edge of the sheet of at least one transverse side of the sheet has a reduced fold height (hr) compared to the fixed fold height (h).

[0013] According to an embodiment of the invention, the fold height of the end fold on both transverse sides of the sheet is reduced with respect to the fixed fold height (h).

[0014] According to an embodiment of the invention the fold height of the folds towards at least one transverse side of the sheet decreases.

[0015] According to an embodiment of the invention the assembly of two adjacent folds essentially has the form of a V, wherein the assembly of the at least one end fold with reduced fold height (hr) and its adjacent fold essentially has the form of a truncated V.

[0016] In a further aspect, the disclosure relates to an assembly of a tube for a heat exchanger and a turbulator fin, wherein the assembly comprises a turbulator fin according to the present disclosure.

[0017] In yet another aspect, the disclosure relates to a heat exchanger comprising the assembly according to the disclosure.

[0018] In yet another aspect, the disclosure relates to a fin forming roll for forming a turbulator fin for a tube-fin assembly according to the present disclosure, wherein the roll comprises a plurality of folding dents, the folding dents essentially being triangular shaped, the fin forming roll being adapted to cooperate with a second fin forming roll to form a fin forming mill, characterized in that, the fin forming roll comprises at least a first and an adjacent second folding dent having a truncated top end.

Brief Description of the Drawings

[0019]

Figure 1 shows a forward end of a turbulator fin according to the present disclosure.

Figure 2 shows the assembly of a tube for a heat exchanger and the turbulator fin, according to the disclosure, inserted inside said tube.

Figure 3 shows an alternative embodiment for a tube for a heat exchanger, with the turbulator fin according

to the present disclosure inserted inside said tube.

Figure 4 shows a folded sheet during the production of a turbulator fin according to the disclosure, and

Figure 5 shows a cross-section of a fin forming roll adapted to produce the turbulator fin according to the present disclosure.

Detailed Description of the Drawings

[0020] In the context of the present disclosure it should be noted that reference is made to a heat exchanger used as a Charge Air Cooler (CAC). The terms Charge Air Cooler, intercooler or aftercooler are commonly used interchangeably. The term intercooler refers to the fact that heat exchange is performed in between two stages of compression, i.e. between compression in the compressor and compression in the cylinder of the engine. The term aftercooler refers to the charge air being cooled after being compressed in the compressor.

[0021] Figure 1 shows a front end of turbulator fin 10 according to the present disclosure. The turbulator fin 10 comprises a plurality of folds wherein each fold is delimited by upper fold lines 11 and lower fold lines 12. A first fold has, together with an adjacent fold, essentially the form of a V or inversed V. From one transverse side of the turbulator fin (the left in Figure 1) to a second transverse side of the turbulator fin (the right in Figure 1), the turbulator fin 10 has a turbulator tube height (Th) which is chosen to coincide with the interior of a cooling tube as shown with reference to Figures 2 and 3.

[0022] Each fold has a fold height (h) which is fixed for all folds of the turbulator fin 10 in order to provide the turbulator fin with the required turbulator tube height (Th).

[0023] According to the disclosure, the folds forming the transverse side of the turbulator fin 10 comprise a different fold height (hr). As shown in Figure 1, folds 23 and 24 forming the transverse side of the sheet at the left hand side of Figure 1 have a different fold height than the remaining folds 21, 22 over the width of the fin adjacent folds which together essentially have the form of a V or an inversed V.

[0024] Figure 2 shows an assembly of a tube 30 having in its interior the turbulator fin 10 according to Figure 1. The corners 32 and 33 of the tube 30 provide the interior at the transverse side of the tube 30 seen at the left hand side of Figure 2 with reduced inside height. Despite the reduced inside height, the turbulator fin 10 can efficiently fill up the interior space of the tube 30 due to the reduced fold height (hr) of the folds 23, 24. The tube 30 according to Figure 2 is, for instance, a tube 30 obtained by means of electric welding.

[0025] In Figure 3, a cooling tube 40 is shown having in its interior the turbulator fin 10 according to Figure 1. The cooling tube 40 is obtained by means of folding, wherein the transverse side of the tube shows a first folding lip 41 and a second folding lip 42 which together form the outside wall of the tube 40. As a result of the folding process, the inside of the cooling tube 40 has a reduced height. Despite the presence of a reduced height, the turbulator fin 10 is capable of efficiently filling up the interior space of the cooling tube 40 because of the reduced height (hr) of folds 23 and 24.

[0026] In Figure 4, a step in the production of a first and a second turbulator fin 10 according to the present disclosure is shown. The turbulator fin 10 shown on the right hand side of Figure 4 is connected to the turbulator fin 10 shown on the left hand side and can be separated by cutting the two elements apart according to the cutting line 50. Both turbulator fins 10 as shown in Figure 4 are obtained by folding a thin metal sheet by means of a folding mill with a first and a second cooperating forming roll. An example of a roll to be used to obtain the turbulator fin 10 according to the present disclosure is shown in Figure 5.

[0027] Figure 5 shows a first roll 60 and a second roll 70 of a pair of rolls which are together capable of forming a turbulator fin 10. The roll 60 is provided at its circumference with a plurality of forming dents 61. The forming dents are triangular shaped. In order to obtain the turbulator fin 10 according to the invention, at least two adjacent dents 62, 63 have a truncated top. Moreover, the area between the dents 62, 63 may be filled up with element 64 to allow obtaining a folded sheet as shown in Figure 4. The second roll 70 has a corresponding shape with folding dents 71 and one truncated folding dent 72.

[0028] The roll 60 may be provided with a cutting element 65 to provide the cutting according to the cutting line 50 as mentioned with reference to Figure 4. Alternatively, the cutting according to the cutting line 50 may be executed in a further production process after completion of the forming of the metal sheet by means of rolls 60 and 70.

Claims

1. Turbulator fin (10) for a tube-fin assembly adapted for a heat exchanger, the turbulator fin (10) comprising a corrugated sheet with a plurality of adjacent folds (21, 22) between a first transverse side of the sheet and a second transverse side of the sheet, each fold having a fixed fold height (h) delimited by adjacent fold lines (11, 12) and each fold having a fold length (L) in longitudinal direction of the sheet, **characterized in that**, the end fold (23) forming the edge of the sheet of at least one transverse side of the sheet has a reduced fold height (hr) compared to the fixed fold height (h).

2. Turbulator fin (10) according to claim 1, wherein the fold height (hr) of the end fold (23) on both transverse sides of the sheet is reduced with respect to the fixed fold height (h).

3. Turbulator fin (10), according to claim 1 or 2, wherein the fold height of the folds towards at least one transverse side of the sheet decreases.

4. Turbulator fin (10) according to any of the preceding claims, wherein the assembly of two adjacent folds (21, 22) essentially has the form of a V, wherein the assembly of the at least one end fold (23) with reduced fold height (hr) and its adjacent fold (24) essentially has the form of a truncated V.

5. Assembly of a tube (30, 40) for a heat exchanger and a turbulator fin (10), wherein the assembly comprises a turbulator fin (10) according to any of the preceding claims.

6. Heat exchanger comprising the assembly of claim 5.

7. Fin forming roll (60) for forming a turbulator fin for a tube-fin assembly according to any of claims 1- 4, wherein the roll (60) comprises a plurality of folding dents (61); the folding dents (61) essentially being triangular shaped, the fin forming roll (60) being adapted to cooperate with a second fin forming roll (70) to form a fin forming mill, **characterized in that** the fin forming roll (60) comprises at least a first (62) and an adjacent second folding dent (63) having a truncated top end.

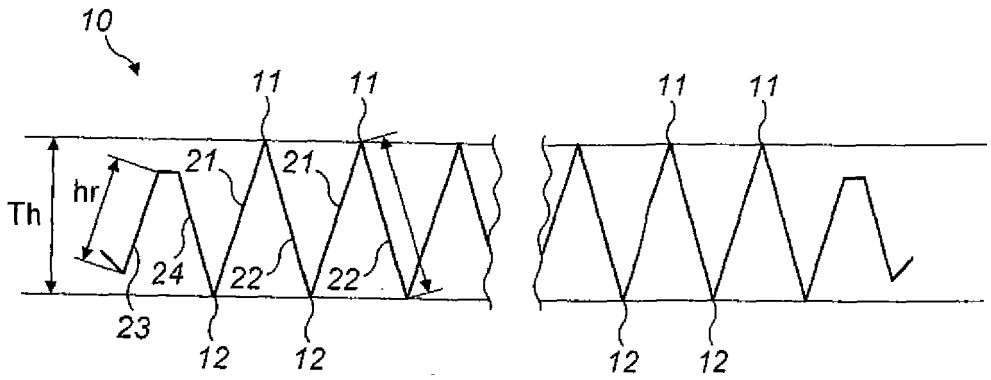

FIG. 1

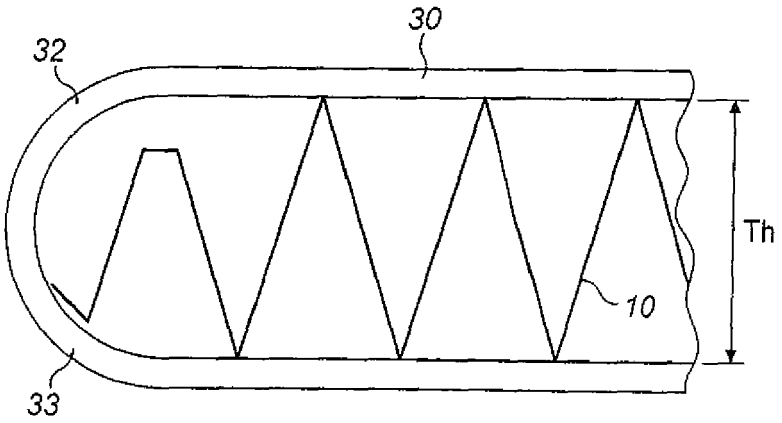

FIG. 2

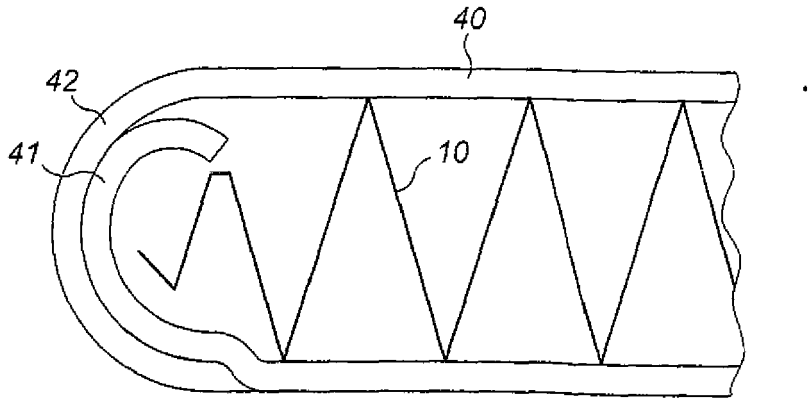

FIG. 3

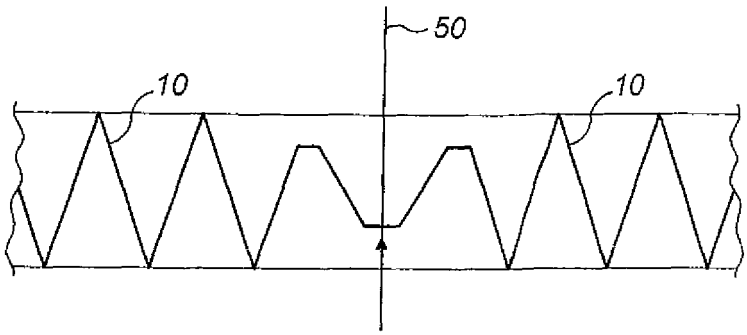

FIG. 4

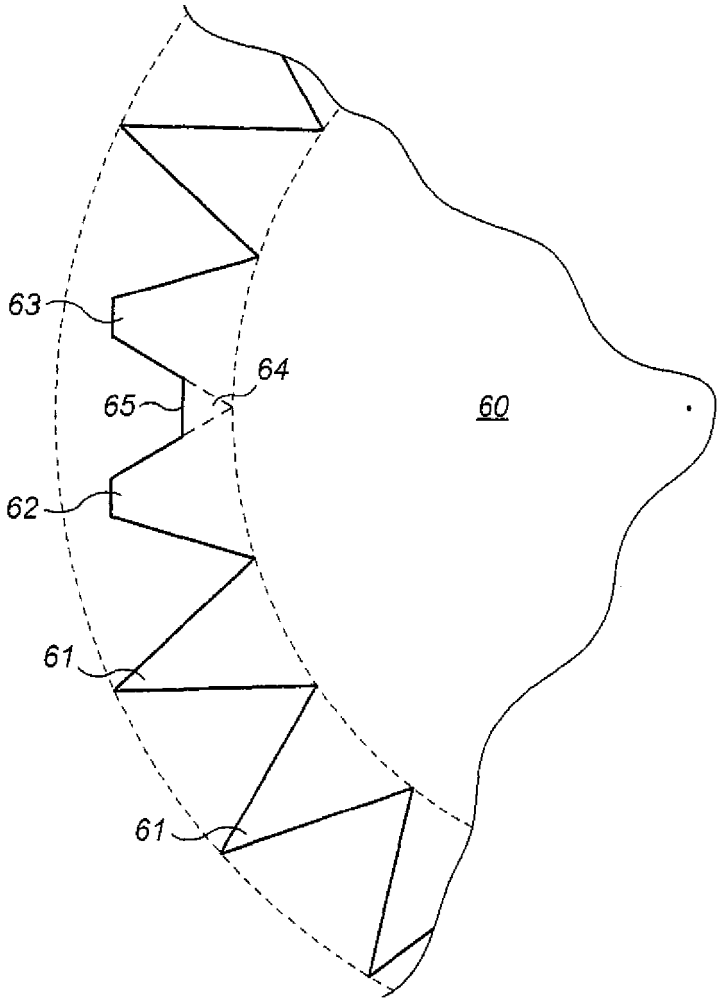

FIG. 5

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Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 May 2016	Louchet, Nicolas

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