

PATENT SPECIFICATION

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(54) TURBULATOR FOR USE IN A FLUID CONDUIT

(71) I, RONALD HARRY SMICK, a citizen of the United States of America, of 745 Chapel Street, Ottawa, County of La-Salle, State of Illinois 61350, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a turbulator for a fluid flowing through a conduit and more particularly concerns an improved turbulator capable of mixing and directing a heating fluid, such as flue gas, substantially completely and uniformly against the internal walls of a heat exchanger conduit such as a fire tube or the like.

Since at least about the turn of the century, various baffles or diverters have been proposed for installation in boiler fire tubes and the like for diverting the hot flue gases against the side walls of boiler fire tubes. One approach, as shown in U.S. Patent Nos. 1,056,373 (Fig. 1), 2,091,274, 2,691,991 and 2,852,042 has been to insert in the fire tube an essentially flat, longitudinally extending strip of metal having a plurality of tabs, tongues or ears struck from the web of the strip and bent to project at alternating angles so as to divert a portion of the flue gas back and forth across the width of the fire tube.

Another approach has been to twist the strip into a spiral and also to provide it with various deflecting ears or lobes to create a swirling turbulent flow within the flue tube. (See U.S. Patent Nos. 1,056,373 Fig. 2, 1,272,113, 1,961,744 and 2,865,405). Yet another approach has been to provide an essentially flat strip of metal with a series of undulating bends with (see U.S. Patent Nos. 2,161,887 and 2,591,398 Figs. 1—3) or without (see U.S. Patent Nos. 1,948,064, 2,660,198 and 2,591,398 Fig. 4) projecting ears.

In the main, however, these former devices have tended to stratify the hot gases

on opposite sides of the flat strips, to centrifuge the cooler more dense gases out along the edges of the spiral strips or, due to the tab size or width of the undulating strips, to cause too great a flow restriction in the flue tube.

With regard to the latter problem, perhaps the most commercially successful turbulator to date has been one patterned after the embodiment shown in Figure 4 of Brock Patent No. 2,591,398 but with the strip width reduced by half or more and the tilt angle (see Co. 3, 11. 38—42) changed to about 45°. Such turbulators, or zig-zag baffles are shown as applied in space heater applications in U.S. Patent Nos. 3,185,143 and 3,359,964. While such "Brock" turbulators have been effective in improving the heat transfer of flue gases and other heating fluids to the walls of fire tubes and the like, they tend to direct the hot fluid against only one-half of the circumference of the tube (e.g. "downwardly" as indicated at Co. 3, 1. 42).

According to the present invention there is provided a turbulator for insertion in a heat exchanger conduit having substantially straight, longitudinal internal walls, said turbulator being made of an elongate strip of metal formed into a series of deflection panels successively joined together end to end in zig-zag fashion by substantially triangular bridging portions each having a pair of legs forming an apex positioned laterally of the longitudinal axis of said turbulator and joined to a base substantially parallel to said axis characterised by said deflection panels along the length of said strip alternately angling back and forth and simultaneously tilting up and down relative to said axis for mixing and directing heat exchanger fluid flowing within the conduit substantially completely and uniformly against the internal walls of the conduit.

In an embodiment of the invention there is provided a turbulator for insertion in a heat exchanger conduit having substantially parallel internal walls. The turbulator is made of an elongated strip of metal formed

into a series of alternating deflection panels successively joined together by substantially triangular bridging portions disposed laterally of the axis of the turbulator and is characterised by deflection panels along the length of the strip alternately angling back and forth and simultaneously tilting up and down relative to the axis for mixing and directing heat exchanger fluid flowing within the conduit substantially completely and uniformly against the internal walls of the conduit. In a preferred embodiment the deflection panels are arranged in three successive groups along the direction of flow of the heat exchanger fluid with the first group having a tilt angle of about 30°, the second group having a tilt angle of about 45° and the third group having a tilt angle of about 60° relative to the axis. Preferably, with width of the strip times the width of the conduit is equal to about 30% of the cross sectional area of the conduit and each of the panels due to its tilt presents an effective area of about 20% of the cross sectional area of the conduit.

The invention will now be described by way of example only with particular reference to the accompanying drawings wherein:

Figure 1 is a fragmentary horizontal sectional view of an exemplary fire tube with the improved turbulator of the present invention illustrated therein in plan view;

Figs. 2 and 3, respectively, are vertical side and end sectional views taken substantially along lines 2—2 and 3—3 in Fig. 1;

Fig. 4 is an enlarged fragmentary plan view of one portion of the turbulator shown in Fig. 1 and of central segment of the turbulator shown in Fig. 6;

Fig. 5 is a fragmentary sectional view of a fire tube with the improved turbulator of the present invention disposed vertically therein and illustrated in side elevation;

Fig. 6 is a fragmentary sectional view, similar to Fig. 1, with a modified form of the turbulator of the present invention illustrated therein in three segments each having a different tilt angle relative to the horizontal; and,

Figs. 7 and 8, respectively, are enlarged fragmentary plan views, similar to Fig. 4 of the left and right-hand segments of the modified turbulator shown in Fig. 6.

There is shown in Figures 1, 2 and 3 an exemplary fire tube 10 in which the improved turbulator 12 of the present invention is disposed. While the illustrated fire tube 10 is circular in cross section it will be understood that it could be square, rectangular or, indeed, any other closed geometric shape. Moreover, although the term fire tube is used herein, it is intended to broadly refer to any heat exchanger tube

in which one heat exchanger fluid flows through the inside of the tube and another fluid flows over the outside of the tube. Likewise, when the term flue gas is used it should be understood broadly to encompass other heat exchanger mediums that could be either liquid, gas or a mixture thereof such as steam.

In the present invention, the improved turbulator 12 is formed from an elongated strip of metal into a series of alternating deflection panels 14 and 16 successively joined together by substantially triangular bridging portions 18. As shown in Figs. 1—3, the turbulator 12 may have a partial panel 20 at one end and, preferably, has a projecting handle 22 at the other end. It will also be seen in Fig. 1 that the turbulator 12 is sized so that the deflection panels 14, 16 extend substantially completely across the width or diameter of the fire tube 10 and that the bridging portions 18 are disposed laterally of the longitudinal axis of the turbulator 12.

Pursuant to the present invention, the deflection panels 14, 16 alternately angle back and forth and simultaneously tilt up and down, respectively, relative to the longitudinal axis of the turbulator 12. Thus, as seen in Figs. 1 and 2, and assuming the direction of flow of flue gases in the fire tube 10 is from left to right, deflection panels 14 direct the flue gases up and toward one side of the fire tube 10 and deflection panels 16 direct the flue gases down and to the other side of the fire tube. This alternate angling and tilting of the deflection panels 14, 16 not only thoroughly mixes the flue gases but, more importantly, directs the flue gases substantially completely and uniformly against the internal walls of the fire tube 10. As those skilled in the art will appreciate this greatly improves the heat exchanger efficiency of the turbulator 12-fire tube 10 combination over those prior designs which direct the flue gases only over about one-half of the fire tube surface. Greater efficiency, of course, also means a reduction in fuel costs.

Another advantage of the improved turbulator of the present invention is that since the alternate angling and tilting of the deflection baffles 14, 16 directs the flue gases around 360° of the internal surface of the fire tube 10, the turbulator may be installed in the fire tube without particular regard to its rotational orientation about its axis. This not only simplifies the initial installation but also eliminates expensive service calls which have arisen in the past when the prior unidirectional turbulators have been misoriented.

As noted above, the improved turbulator 12 preferably includes a handle portion 22 which extends out of the end of the fire tube

10. When it is desired to remove the
turbulator 12 from the fire tube it is only
necessary to pull the handle 22 to the right
as seen in Fig. 1 and Fig. 2. The last
deflection panel 14a adjacent the handle 22
is also dimensioned somewhat longer than
the other panels 14, 16. Thus, as shown in
Fig. 1 the last panel 14a engages and is
biased against the edge of the fire tube 10
when the turbulator 12 is fully inserted. This
effectively holds the turbulator 12 in place
in the fire tube and prevents rattling which
might otherwise occur.

In the embodiment shown in Figs. 1—3,
all of the panels 14, 16 tilt at approximately
45° to the longitudinal axis of the turbulator
12, it being understood that the panels 14 tilt
up and forwardly whereas the panels 16 tilt
down and forwardly with respect to the axis.
For clarity, an enlarged view of one of the
panels 16, two of the triangular bridging
portions 18 and parts of two of the panels 14
is shown in Fig. 4. It will also be noted that
each of the triangular bridging portions 18 is
also tilted about 45° so that its base section
23 is closer to the turbulator axis than is its
apex 24. As those skilled in the art will
appreciate, it is the formation of these
essentially triangular bridging portions 18
and the merger of the panels 14 and 16 into
legs 26 thereof which effects the alternate
tilting of the panels 14, 16 while they also
angle back and forth across the fire tube, in
this case at an angle of about 45° to the axis
of the turbulator.

It is important that the turbulator 12 not
occupy too great a portion of the cross
section of the fire tube 10 or it will create an
excessive flow restriction. I have found that
an efficient turbulator 12 results when the
width of the strip of metal times the width or
diameter of the fire tube is equal to about
30% of the cross sectional area of the fire
tube. It will be appreciated, of course, that
due to the tilt of the panels 14, 16 their
effective frontal area is less. With a strip of
the foregoing width and a panel tilt of about
45° the effective area of each panel is about
20% of the cross sectional area of the fire
tube (see Figure 3).

The length of the turbulator 12 may be
substantially the same length as the fire tube
10 or it may shorter. It will also be
understood that where there is a vertical
array of horizontal fire tubes 10, longer
turbulators can be installed in the top tubes
and shorter turbulators in the lower tubes to
balance the heat load. This arrangement has
been commonly employed with the prior
"brock" type turbulators (see e.g. Figure 1
of U.S.A. Patent Specification No.
3,185,143) and is not *per se* part of the
present invention.

Because the flue gases are directed
around 360° by the turbulator 12, it may also

be employed to advantage in vertically
oriented fire tubes. A portion of such a
vertical fire tube with one of the improved
turbulators 12 is shown in Figure 5. The
turbulator 12 here is otherwise the same as
shown in Figures 1—3.

In accordance with another feature of the
present invention the tilt angle of the
deflection panels may be varied from
relatively shallow at the entrance end of the
turbulator to relatively steep adjacent the
exit end. When the hot gases enter the fire
tube the gas substantially fills the tube and
only moderate mixing and small deflection
is required to insure that the gas heats the
internal surface of the tube. However, as the
gas flows along in the fire tube it loses heat
to the tube and contracts. Progressively
more mixing and deflection is now required
to direct the gas against the tube walls.

Three sections of such a modified
turbulator 30 are shown in Fig. 6. In the
center section, the deflection panels 14 and
16 are disposed with the same 45° tilt angle
as in Figs. 1—4. In the left-hand or entrance
section, the deflection panels 14b, 16b have
a tilt angle of about 30° relative to the
turbulator longitudinal axis and in the
right-hand section, the tilt angle of the
panels 14c, 16c is about 60° relative to the
longitudinal axis. Reference may be made in
Fig. 4 for an enlarged view of the panel 16
and portions of the panels 14 in the center
section of Fig. 6. Figures 7 and 8 are
similarly enlarged fragmentary views of the
left-hand and right-hand sections of the
turbulator shown in Fig. 6 and more clearly
illustrate the difference in tilt angle of the
panels 14b, 16b and 14c, 16c.

The modified turbulator embodiment
shown in Fig. 6 has been found to be
particularly effective in uniformly distribut-
ing the flue gases to the internal walls of the
fire tubes in older, low draft boilers. It will
be appreciated, of course, that while only
one pair of panels 14, 16 is shown in each of
the three sections of Fig. 6, that in practice
there will be a plurality of panels 14b, 16b
having a tilt angle of about 30° to the
turbulator axis, followed by a plurality of
panels 14, 16 having a 45° tilt and then a
section of panels 14c, 16c tilted about 60° to
the turbulator axis.

WHAT I CLAIM IS:—

1. A turbulator for insertion in a heat
exchanger conduit having substantially
straight, longitudinal internal walls, said
turbulator being made of an elongate
strip of metal formed into a series
of deflection panels successively joined
together end to end in zig-zag fashion by
substantially triangular bridging portions
each having a pair of legs forming an apex
positioned laterally of the longitudinal axis

10. When it is desired to remove the
turbulator 12 from the fire tube it is only
necessary to pull the handle 22 to the right
as seen in Fig. 1 and Fig. 2. The last
deflection panel 14a adjacent the handle 22
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the other panels 14, 16. Thus, as shown in
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together end to end in zig-zag fashion by
substantially triangular bridging portions
each having a pair of legs forming an apex
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of said turbulator and joined to a base substantially parallel to said axis characterised by said deflection panels along the length of said strip alternately angling back and forth and simultaneously tilting up and down relative to said axis for mixing and directing heat exchanger fluid flowing within the conduit substantially completely and uniformly against the internal walls of the conduit.

2. A turbulator as claimed in Claim 1 wherein said deflection panels are disposed substantially at right angles to one another and alternately tilt up and down relative to said axis in the range of from about 30° to about 60°.

3. A turbulator as claimed in Claim 2 wherein said tilt angle is substantially 45°.

4. A turbulator as claimed in Claim 2 wherein said tilt angle of said panels changes from about 30° to about 60° from the upstream to the downstream end of said turbulator along the direction of flow of said heat exchanger fluid.

5. A turbulator as claimed in Claim 4 wherein said panels are arranged in three successive groups along the direction of flow of said heat exchanger fluid with the first group having a tilt angle of about 30°, the second group having a tilt angle of about 45° and the third group having a tilt angle of about 60° relative to said axis.

6. A turbulator as claimed in Claim 1 wherein the width of said strip times the

width of said conduit is equal to about 30% of the cross sectional area of said conduit.

7. A turbulator as claimed in Claim 1 wherein each of said panels due to its tilt presents an effective area of about 20% of the cross sectional area of said conduit.

8. A turbulator as claimed in Claim 2 wherein the bases of said triangular bridging portions are disposed substantially parallel to said axis.

9. A turbulator as claimed in Claim 8 wherein said triangular bridging portions are each tilted inwardly with the base thereof closer to said axis than the apex thereof.

10. A turbulator as claimed in Claim 1 including a handle portion arranged to project out of one end of said conduit the deflection panel adjacent the handle being longer than the other panel such as to engage and be biased against the edge of the conduit when the turbulator is fully inserted.

11. A turbulator substantially as hereinbefore described and as shown in Figures 1 to 5 or Figures 6 to 8 of the accompanying drawings.

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