ABSTRACT OF THE DISCLOSURE

The invention is directed to a heat exchanger including a plurality of individual extruded heat exchange elements, means joining the elements together along the generally longitudinally extending sides thereof for defining a first duct means substantially surrounding a longitudinally extending second duct means so that a first fluid may be passed through the first duct means in a heat exchange relationship with a second fluid passed through the second duct means and with at least a substantial proportion of the heat transferred between the first and second fluids passing through wall portions of the heat exchange elements.

This invention relates to heat exchangers, and is especially applicable to heat exchangers which are internally fired and of large size, whether vertical or horizontal, although the invention can be used for any size and many methods of heating or cooling. Again, this invention has particular, but not exclusive, relevance to heat exchangers for high temperature work, i.e. with the heat exchanger arranged such that both or all fluids pass through the heat exchanger (the fluid(s) being heated and the fluid(s) being cooled) are at a temperature substantially above 100°C, e.g., above 150°C, some time during their passage through the heat exchanger. Thus, for example, a heat transfer liquid such as a diphenyl/diphenyl oxide eutectic can be heated to temperatures considerably higher than 150°C and heat transfer liquid temperatures of 400°—450°C, can be expected with special liquids. Gases could be heated to as high as a 1000°C or even 1500°C if the heat exchanger is suitably constructed.

According to a first aspect of this invention, there is provided an extruded heat exchange element so formed that a plurality of such elements can be joined together along their generally longitudinally-extending sides to provide a first duct or group of ducts substantially surrounding a longitudinally-extending second duct or group of ducts, the first duct or group of ducts being for passing a first fluid through the heat exchanger in heat exchange relationship with a second fluid passed through the second duct or group of ducts.

According to a second aspect of this invention, there is provided a heat exchanger built from a plurality (e.g. at least three or four) of extruded heat exchange elements, the elements, initially separate, being joined together along their generally longitudinally-extending sides to provide a first duct or group of ducts substantially surrounding a longitudinally-extending second duct (e.g. a centrally-disposed duct) or group of ducts, the first duct or group of ducts being for passing a first fluid through the heat exchanger in heat exchange relationship with a second fluid passed through the second duct or group of ducts, with at least a substantial proportion of the heat transferred between the first and second fluids passing through the walls of said elements.

Thus the overall dimensions of the ducts or group of ducts can be altered by altering the number of heat exchange elements used, and this enables different sizes of heat exchanger to be built using the same basic elements. The individual elements can be arranged to be connected together in many different ways, for instance by bolting along flanges provided on the elements, or by clamping the elements with external rings or by any other form of clamp, or by welding; if desired, the individual elements need not be directly in contact with one another, but can be joined together by way of intermediate material, for instance sealing material and members for holding the sealing material in position. Thus exact mating of the longitudinal sides of the elements is not essential.

The cross-section of the elements can be as desired; if, as is preferred, the elements are of hollow section closed on all longitudinally-extending sides, the elements can be for instance square or rectangular or trapezoid-shaped with the longitudinally-extending end sides converging (in transverse cross-section) such that they make the same angle with the longitudinally-extending parallel sides with a view to joining the elements together along their respective end sides, or each element can be in the shape of an arc defined between two concentric circles and two radii with a view to joining the elements along their respective sides defined by the radii. An advantage of using hollow section elements closed on all sides is that the elements need not have any welded seams and can have good resistance to pressure, say up to 200 lbs./sq. in. (about 14 kg./cm.²). Nonetheless, the elements need not be closed on all sides, as for instance two opposite sides may be left open with the remaining two sides supported by a frame or one side could be left open with the element having a semi-circular cross-section.

Using suitably designed elements, it is possible to form a heat exchanger without any external bracing. Local overheating is not a serious problem when heating water, for any small bubbles of steam so formed are quickly re-absorbed by the water when they reach a cooler mass of water. However, with heat-sensitive fluids such as some phenol-based heat-transfer liquids, local overheating can lead to irreversible changes such as coagulation, and must be avoided. Thus, especially if the first fluid is sensitive to local overheating and is being heated by a hotter second fluid, the walls of the elements separating said first duct or group of ducts from the second duct or group of ducts may have their surfaces facing said first duct or group of ducts substantially extended by projections, such as fins or protuberances, and if the projections are suitably designed, they can be extruded with the elements. In general, any heat-transfer surface of the heat exchanger can be provided with such projections.

As extrusion can be a relatively cheap way of fabricating an element, the exchanger can be of any suitable size, with the sizes of individual elements chosen as appropriate. Thus a small heat exchanger of 2 ft. 6 ins. (about 75 cms.) diameter could be built up of elements 4 ft. (about 120 cms.) long of ¾ inch (about 0.6 cm.) wall thickness, whilst a 10 ft. (about 3 metres) diameter heat exchanger could be built up of elements 18 to 20 ft. (about 5.4 to 6
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metres) long of 1/4 inch to 1/2 inch (about 0.6 cm. to 3.8 cms.) wall thickness, depending on the pressures to be resisted. With such a heat exchanger, it may eventually be possible to produce capacities greater than 10 million B.t.u. per hour, and possibly even up to 100 million B.t.u. per hour.

The elements are preferably joined together in an annular configuration, the term "annular" not referring solely to shapes defined between concentric circles but also to shapes defined between polygons, the polygons not necessarily being geometrically similar or concentric, and between non-concentric circles; however, for convenience, the exchanger will normally have a concentric form, in transverse cross-section.

Further elements (preferably also extruded) may be built up around the first duct or group of ducts, to provide a third duct or group of ducts in order to reduce the height of a vertical exchanger or the length of a horizontal exchanger, or even to put a third fluid in heat exchange relationship with one of the other two fluids; a multi-pass exchanger is particularly appropriate for heating gas, as there is little radiant transfer, the heat being mostly transferred by conduction and convection.

The fluid need not flow in the same direction in adjacent ducts, as transfer pipes can be used to extend the flow path through the exchanger by providing a zig-zag flow through a group of ducts, the ducts being in series or parallel or series/parallel. Thus with series connection, a small quantity of the first fluid can be greatly increased in temperature by being passed through the heat exchanger under a high head; with parallel connection, a large quantity of the first fluid can have its temperature raised a small amount by being passed through the heat exchanger under a low head. The different ways of connecting the transfer pipes gives great flexibility in the characteristics of the heat exchanger.

Tubes may be provided extending down the elements for passing the second fluid, or even a third fluid, through the middle of the first fluid.

The invention will be further described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is an axial section through a double-pass heat exchanger in accordance with the invention, parts of the heat exchanger being omitted for clarity;

FIGURE 2 is a cross-section along the line II—II of FIGURE 1; and

FIGURE 3 is a scrap cross-section through another heat exchanger in accordance with the invention, on a larger scale.

The heat exchanger shown is fired by a burner producing hot gaseous products of combustion; such burners are well known in the art, and only the discharge orifice 1 is indicated in FIGURE 1. In FIGURE 1, the path of the fluid being heated is indicated by single-headed arrows whilst the path of the hot products of combustion is indicated by double-headed arrows.

The heat exchanger of FIGURES 1 and 2 is built up of two annuli of extruded elements 2, 3 joined together along their longitudinally-extending sides. It will be noted that the elements 2 are of trapezoid section, and their longitudinally-extending sides are parallel, whereas the elements 3 are of rectangular section, leaving wedge-shaped gaps between their longitudinally-extending sides; these wedge-shaped gaps can be filled with sealing material or refractory material as desired.

One disadvantage of the trapezoid section elements 2 is that they only abut each other fully in one size of cross-section, i.e., in the twelve-sided cross-section shown. For this reason, it may be more convenient to use rectangular-section elements throughout.

The outer annulus of elements 3 may, if desired, be enclosed by a refractory cover (not shown), but is shown enclosed by an insulating cover 4 (say of fibre glass) and a casing 4a.

Longitudinal fins 5 are extruded with the elements 2 and project into the interior of the elements 2 from their radially inner walls. Fins 6 are mounted on the end plate 7 to prevent any local overheating at this location. In general, fins may be provided on all the heat-exchange surfaces in order to improve efficiency.

Circular-section tubes 8 extend down the interior of the elements 2 and 3 of both inner and outer annuli, from the end plate 7, passing through the intermediate plate 9 and extending up to the other end plate 10.

A refractory cover 11 is provided adjacent the end plate 7.

As indicated by the arrows, the hot products of combustion issue from the discharge orifice 1, pass down the centrally-disposed duct in the middle of the inner annulus of elements 2, and then return along the two rings of tubes 8 to issue from a stack 12. The fluid being heated firstly passes in counter-current to the hot products of combustion down the outer annulus of elements 3, and then back along the inner annulus of elements 2.

The heat exchanger of FIGURES 1 and 2, is a double-pass heat exchanger; in another possible embodiment of the invention, the heat exchanger may be formed as a single-pass heat exchanger, and having read the above description, it would be apparent how to construct a single-pass heat exchanger in accordance with the teachings of the present invention.

Though a multi-pass heat exchanger is desirable when heating using gas, which has a low radiant output, a single-pass is possible when the heat exchanger is oil-fired, giving a high radiant output. Furthermore, it may be possible to have only a single annulus of extruded heat exchange elements in an oil-fired heat exchanger.

FIGURE 3 illustrates a modification of the heat exchanger of FIGURES 1 and 2. The annulus 2 of FIGURE 2 is replaced by an annulus 13 of heat exchange elements 14; the number of elements 14 depends on, for instance desired capacity and flow rates, but may be for example from 20 to 200 or 300; the outside diameter of the tube of the elements 14 may be for example from one inch to four inches or more. The annulus 3 of FIGURE 2 is omitted, a containing wall 15 being mounted around the annulus 13. Otherwise, parts in FIGURE 3 corresponding to parts in FIGURES 1 and 2 are indicated with the same reference numerals.

Each element 14 is extruded as a tube 16 having internal fins 17 and external longitudinal flanges 18. If desired, the flanges 18 may be welded on after extruding the tube 16 and fins 17. Adjacent elements are welded together at 19, along their flanges 18, to build up the annulus 13. If desired, the gas tubes 8 within the elements 14 may connect the fins 17, for support, but this is not essential.

Thus though the invention has been particularly described above, it is only to be limited according to the spirit and scope of the appended claims.

We claim:

1. An internally-fired heat exchanger comprising a casing, a burner for providing hot combustion gases; a longitudinally extending central duct in communication with said burner; and a plurality of individual extruded heat exchange elements of hollow cross-section closed on all longitudinally extending sides and joined together to form at least one annular group of ducts within said casing for fluid to be heated; said fluid being passed in heat exchange relationship with said hot combustion gases with a substantial proportion of the heat transferred between said fluid and gases passing through the walls of said heat exchange elements separating the ducts of said group from said longitudinally extending central duct, said walls having integrally extruded projections protruding into the
ducts of said group to increase the heat transfer surface area.

2. A heat exchanger as claimed in claim 1 wherein said projections are longitudinally extending fins, and the cross-sectional shape of the ducts of said group is trapezoidal.

3. A heat exchanger as claimed in claim 1 further comprising tubes extending through the approximate middle of at least one said elements for passing said hot combustion gases in heat exchange relationship.

4. A heat exchanger as claimed in claim 1 wherein said hot combustion gases provide radiant heat in said longitudinally extending central duct, the surfaces of said walls defining said central duct being plain.