A reforming furnace having tubes made in sections of successively higher alloys as the fluid being treated is subjected to increasingly severe heating.

The present invention relates to liquid heating furnaces, and more particularly to the tubes through which the liquid to be heated flows and the manner in which the tubes are fabricated.

In modern tube heating furnaces, and particularly those used in the petrochemical industry for the making of ethylene and the like, the metal used for the tubes is of material importance. The tubes must have chemical and physical characteristics that are capable of withstanding the maximum temperatures and pressures that are encountered. Usually the maximum stress imposed on a tube is at its exit end where the tube and liquid being heated are hottest. The entire tube, however, has to be capable of withstanding this maximum severity condition even though it may occur in only the last third or fourth of the tube.

The cost of the tubes used in a furnace with severe heating requirements is a large portion of the cost of a furnace. This is both because of the length of the tubes, that may be up to sixty feet long, and because they must be of high alloy steel to withstand the service. Anything that can be done to reduce the cost of the tubes is of importance in the construction of such equipment.

It is an object of the invention to provide a means of lowering the cost of the tubes used in a fluid heating furnace. It is another object of the invention to provide a tube that is made of different materials along its length, which materials vary with the temperature to which that portion of the tube is to be heated or the severity of the service.

The various features of novelty which characterize our invention are pointed out with particularity in the claims annexed to and forming a part of this specification for a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which we have illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a section through one type of furnace in which a tube of the invention can be used; and

FIG. 2 is a view through a different type of furnace.

The furnace disclosed in FIG. 1 is of the type that is disclosed more in detail in Fleischer Patent 3,062,197. A furnace of this type includes a structure 1 forming a furnace chamber having parallel side walls 2 and 3 and having an exhaust or burner 4 at the upper end in one of the sides. The furnace is heated by horizontally extending parallel rows of burners 5 with the rows located one above the other in the side walls. The burners are directed toward a row of tubes, one of which is shown at 6, that extend vertically through the furnace chamber.

Each horizontal row of burners 5 will be fired at a rate to raise the temperature of the portion of the tube in front of it to the desired value. The fluid to be heated which for example, if the product is to be hydrogen, can be a combination of methane and steam, will be directed vertically through the tube from either end thereof. The tube, for reasons to be described below, is made of a plurality of sections 7, 8 and 9 welded together at joints 10.

The furnace shown in FIG. 2 is constructed similar to that of FIG. 1 except that it is a dual furnace having two chambers one of which is indicated at 11 and the other at 12. These chambers are provided with exhaust passages 13 and 14 respectively that lead to a convection heating chamber 15 at the base of a stack. As is frequently the case, the exhaust gases flowing to the stack flow past a group of tubes 16 in chamber 15, known as a convection section, in which the tubes are heated by convection from the exhaust gases. The material flowing through the tubes of convection section 16 is directed to tubes 17 which are located in the chambers formed in furnace sections 11 and 12.

The arrangement can be such that the material flowing through convection section 16 can go to a manifold which in turn supplies the various tubes 17 or it can go through a plurality of connecting pipes 18 directly into each of the tubes 17. The manner in which the piping is fabricated will depend entirely upon the operation which is to be performed by the furnace. In any event the fluid to be treated is preheated in the convection section and is directed to tubes 17 in the two sections 11 and 12 of the furnace which are generally known as the radiant sections. In this section the fluid is raised from its preheat temperature to the final treatment temperature. As shown herein, the tube 18 is welded to the upper end of tube 17 and this latter tube is made up of two sections 19 and 21 that are joined together by a weld 20.

The materials of which the tubes are fabricated will depend upon the severity of the service and the temperature to which the tube and the material flowing through them is heated. The cost of the tubes will vary with their composition. It is almost axiomatic, however, the more severe the service and the higher the temperature and pressure required, the more expensive the tubes.

If, for example, the material to be heated is introduced into the tube at about 700° F. and discharged at 1600° F. the tube will have a temperature gradient of from about 1000° F. to 1850° F. A tube composition which is satisfactory for 1000° F. service is completely unsatisfactory for 1800° F. service. Prior to this time the entire tube has been made of a material capable of operating satisfactorily at the highest temperature encountered.

According to this invention the tubes are made in sections, and welded together, with each section of an analysis capable of withstanding the temperatures encountered along that portion of its length. Examples of materials that will withstand various temperatures are:

- Carbon steel for temperatures below 900° F.
- Alloy steel with 1.25% Cr and 0.5% Mo for use from about 900° F. to about 1150° F.
- Alloy steel with 18% Cr and 8% Ni for use to about 1600° F.
- Alloy steel with 25% Cr and 20% Ni for use from about 1600° F. to 1800° F.
- Alloy steel with 15%–20% Cr and 35% Ni for use to about 1800° F.
- Alloy steel with 80% Ni and 15% Cr for temperatures to above 2000° F.

It will be noticed that the higher the temperature, the higher the alloy used. There are other alloys that are available for use within the temperature ranges mentioned and new alloys are being developed from time to time that can be made into tubes for various service conditions. If their properties are suitable they may also be used.
3. The temperature of a tube and the temperature of the material in it can be determined at any point along its length by conventional methods. When this has been done, the proper alloy for any particular location can be determined. Ordinarily it will not be advisable to have the tube made of more than three sections for a tube forty feet in length.

The furnace or heater of FIG. 1 shows a tube fabricated of three sections each of which will be from ten to fifteen feet in length for a forty foot tube. The direction of flow of the fluid being heated will determine whether the more expensive alloy is the top or bottom section. The tube 17 in FIG. 2 is shown as being of two sections. In a heater of this type the fluid is heated in convection section 16 to about 900° F, so that the convection coil and connecting portion 18 will be made of carbon steel tubes. For the higher temperatures in chamber 11 alloys suitable for the temperatures encountered will be used.

Thus it will be seen that the amount of expensive alloy used in a tube can be materially reduced by matching the alloy to the temperature encountered.

While in accordance with the provisions of the Statutes we have illustrated and described the best form of embodiment of our invention now known to us, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention set forth in the appended claims, and that in some cases certain features of our invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a tube heating furnace for the pyrolysis of hydrocarbons, the combination of structure forming a furnace chamber having opposed walls, a plurality of vertically spaced burners located in said walls, a tube extending vertically through said chamber between said walls and in front of said burners to be heated thereby, said tube being adapted to transport fluid to be raised in temperature as it flows from a first end to a second end, said tube being made in a plurality of end to end sections with each section in the direction of fluid flow being made of a different metal capable of withstanding successively higher temperatures and more severe service than the metal in the preceding section.

2. The combination of claim 1 in which said tube sections are made of different alloys and are welded together.

3. The combination of claim 1 in which one of said walls is provided with an exhaust opening through which products of combustion escape, means forming a convection chamber in communication with said exhaust opening, a convection coil in said convection chamber, and means connecting said coil with said first end of said tube.

4. The combination of claim 3 in which said convection coil is made of a metal capable of withstanding a lower temperature than the metals used in said tube sections.

References Cited

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