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METHOD FOR COOLING FLUE GAS

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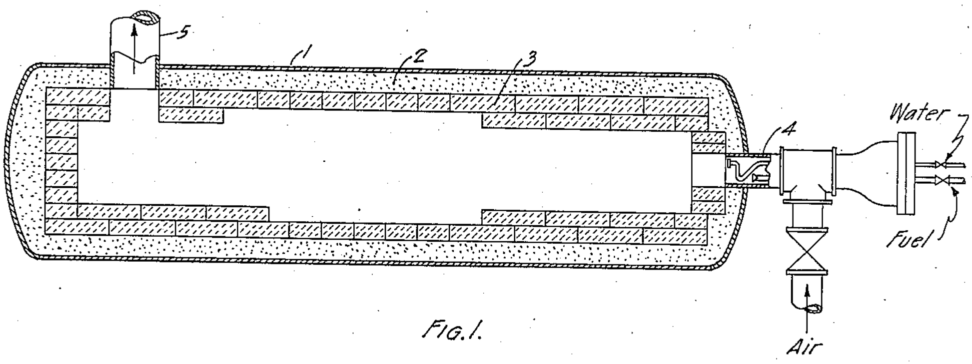

FIG. 1.

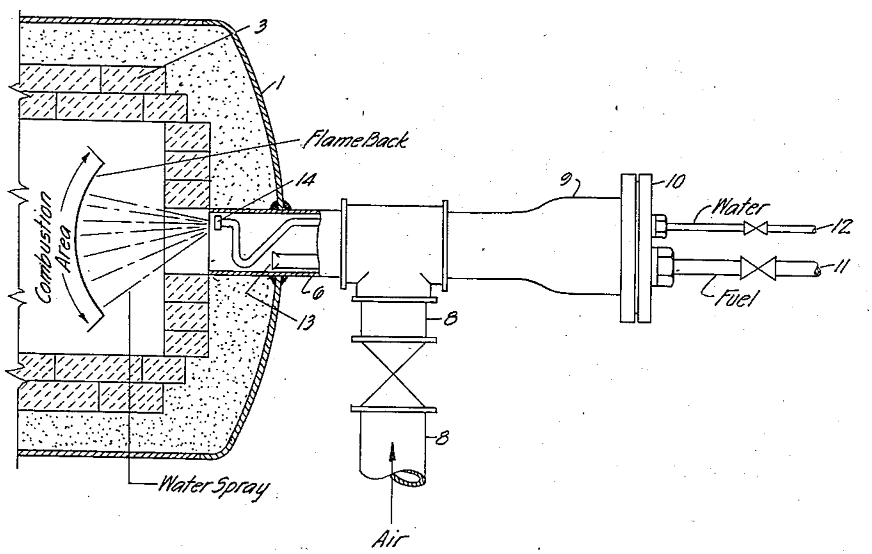

FIG. 2

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METHOD FOR COOLING FLUE GAS

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4 Claims. (Cl. 252—372)

This invention relates to the production of flue gases under superatmospheric pressures, and more particularly is concerned with a method for preventing undue deterioration of the furnace by the action of extremely high temperatures obtained in the vicinity of the combustion zone.

Production of flue gases by burning suitable fuels such as hydrocarbon gases, or liquids, or powdered coal under considerable superatmospheric pressure may be required in a number of industrial processes. For instance, it may be desired to use large quantities of a gas substantially free from oxygen at high temperatures and pressures. To this end a fuel may be burned at normal pressures in a furnace, and after cooling the products of combustion sufficiently to enable their being handled by compressors, they are compressed and then reheated in suitable coils. On the other hand, the same result may be had by the much more simple method of combining compressed air and fuel and burning the resulting mixture under a superatmospheric pressure. In this manner, difficulties due to the condensation of water upon compressing relatively cool flue gases, are avoided, liquid water not only tending to interfere with the proper operation of the compressors, but also frequently causing serious corrosion therein.

Again, it may be desired to crack hydrocarbons under considerable superatmospheric pressures by directly contacting them with hot combustion gases. In this case the indirect heating method of the flue gases is impractical because the temperatures to which they must be heated are so high that they would tend to react with the materials of good heating conductivities used in the construction of heating coils, and moreover these materials would lose a good deal of their tensile strength, thus being unable to withstand high pressures.

When, however, the combustion is carried out under pressure, the pressure-resisting material need not be exposed to high temperatures since it may be lined on the inside with heat-resisting, insulating material such as fire brick, magnesite brick, silica brick, etc.

It is well recognized that for structural reasons as well as to minimize the cost, it is desirable to build pressure vessels as small as possible. This means that usually the combustion space in a pressure furnace is limited to a minimum necessary for complete combustion. Moreover, as the result of the combustion under pressure, unusually high local temperatures are reached which, within the small area available, give rise to the evolution of a very large amount of radiant heat. Under these conditions, the burner and the fireproof brick lining in the vicinity of the place of actual combustion are bound to be damaged due to exposure to excessive temperatures, with the result that the maintenance cost of such furnaces is very high.

It is the purpose of our invention to lower the flame temperature in the furnaces which are damaged due to excessively high flame temperatures by injecting into the flame a non-combustible cooling liquid.

Heretofore, when it was desired to lower the temperature of the combustion gases in a furnace the means usually resorted to consisted of cooling a portion of the combustion gases and recirculating the same through the furnace, or by introducing steam in some suitable manner. Such cooling gases were used in the form of blankets to protect certain parts of the furnace or they were simply commingled with the fuel-air mixture undergoing combustion to produce a flue gas mixture having a more moderate average temperature.

We have found that the above means are insufficient adequately to protect the burner and furnace lining in many instances, particularly if combustion is carried out under substantially superatmospheric pressures, and that even by injecting large quantities of steam or cooled flue gases, the maintenance cost of pressure furnaces remains excessive due to a premature destruction of parts thereof. However, we have discovered that we can successfully overcome these difficulties by injecting, instead of steam or flue gases, a finely divided spray of water from a point within or near the mouth of the burner into the fuel-air mixture, into the space back of the flame.

Our invention will be fully understood from the following description of the attached drawing: Figure 1 represents a partial sectional elevation of a pressure furnace with burner. Figure 2 shows the burner of Figure 1 on an enlarged scale.

Referring to Figure 1: A pressure vessel **1** is lined on the inside with a layer **2** of a suitable insulating material such as kieselguhr, rock wool, asbestos, expanded vermiculite, fireproof cement, etc., which layer is faced with a lining **3** of fire brick of the type of magnesite or silica brick. The vessel has a burner arrangement **4** at one end and an exit conduit **5** for hot flue gases at the opposite end.

The burner arrangement as shown in Figure 2 consists of the following essential parts: Tube 6, for introducing a combustible mixture into the furnace proper, protrudes into pressure vessel 1 through insulating layer 2 as far as brick lining 3, being welded to the vessel to hold the desired superatmospheric pressures. An opening in the fire brick lining of approximately the same or slightly larger cross sectional area as that of tube 6 allows the combustible mixture to enter the combustion space of the furnace. Screwed onto tube 6 at the end outside the furnace is T 7 connecting with valved air line 8. Wedge nipple 9 is attached to T 7 to form a straight line continuation of tube 6. The wedge nipple 9 is blanked off by plate 10, through which pass two pipes, one pipe 11 for the fuel such as natural gas, cracked gas, illuminating gas, acetylene, methane, ethane, propane, butane or liquid fuels such as naphtha, kerosene, distillate oil, residual fuel oil, or even powdered coal which may be moved by high pressure air or by mechanical devices such as a conveyor, not shown, within pipe 11, and the other pipe 12 for water or an equivalent cooling liquid. Fuel pipe 11 extends beyond the T 7 into tube 6 to within a short distance of the mouth of this tube. At the end of pipe 11 in tube 6 is a suitable mechanism 13 of conventional design to effect rapid mixing of the fuel with the air, the latter entering through line 8. Water pipe 12 extends farther than gas pipe 11 to a point within tube 6 close to its mouth. Pipe 12 carries a spray device 14 capable of spraying a controlled amount of water in a finely divided state in the direction of travel of the fuel-air mixture.

When the furnace is in operation the fuel-air mixture produced in tube 6 burns in the combustion space of the furnace, the flame back being at some short distance away from the mouth of the burner as indicated in Figure 2. After the inside of the furnace is well heated so as to prevent a possible extinction of the flame, water is sprayed through nozzle 14 into the space back of the flame. While the water droplets travel from the nozzle towards the burning mixture, they are partly vaporized by the radiant heat before reaching the flame itself, thereby effecting cooling of the burner and nearby parts of the brick lining. The remainder of the water is vaporized in the combustion space proper, considerably lowering the temperature in this area, and greatly reducing the radiant heat emanating therefrom. In this manner the brick lining near this area can be adequately protected.

For the successful operation of our invention two things are essential: first, the amount of water must be so controlled that at no time the temperature in the combustion space is lowered below the ignition temperature of the fuel-air mixture, and secondly the water must be finely sprayed to allow its rapid vaporization. If the water droplets are so large as to enable accumulation of water on the floor of the furnace, serious damage may be done to it and possible explosion may result, due to a sudden evaporation of this water.

Due to the necessity of fine division of the spray water and to avoid operating difficulties, we usually prefer to use a separate water line which is independent of the gas and air lines, as shown in the drawing. By controlling the water pressure in line 12 and the setting of nozzle 14, the fineness of the spray can be regulated more easily than if the water were introduced together with air or gas. If desired, however, the burner may be designed so that the water is atomized by forcing it through a suitable nozzle together with gas or air or both.

The pressures in the furnace may vary within wide limits depending upon the purpose for which the flue gases are to be used. Pressures from slightly above atmospheric to above 100 lbs. may be required, pressures up to about 20 lbs. being most common.

The advantages of our method of cooling furnace linings over those employing steam or recirculating flue gases comprise among others greater efficiency which results in a considerable saving of repair costs and cheaper operation. To obtain an effective reduction of temperature in the combustion space with flue gases or steam, a relatively large amount of cooling medium is required. Thus the cost of recirculation or steam generation may form a considerable portion of the cost of producing the flue gases. On the other hand, when using water the required amount of cooling medium is very much smaller and the cost of introducing same is but a small fraction of that of introducing gases for the same purpose.

By our method of cooling, the flue gases remain clean and free from soot and other impurities which are apt to lessen the usefulness of the flue gases, particularly when applied for purposes such as regeneration of catalysts. In this respect our process differs fundamentally from processes in which a mineral oil is injected into a stream of hot flue gases for the purpose of cracking. In the latter type processes, the flue gases become contaminated with carbon black and oxyhydrocarbons such as formaldehyde. Moreover, in such cracking processes, the oil is not injected into the fuel-air mixture undergoing combustion, but into the flue gases after the combustion is substantially complete, because otherwise coke formation is excessive and the yield of desided cracked hydrocarbons accordingly low.

Thus, while liquids of the type of hydrocarbon oils are unsuitable in our process for the purpose of cooling the flame, certain non-combustible liquids other than water or mixtures of a predominant amount of such non-combustible liquids with combustible substances may be used, such as liquid carbondioxide, liquid sulfur dioxide, dilute aqueous solutions of ammonia, alcohols, ketones, aldehydes, carboxylic acids, amines, etc. When using cooling liquids containing combustible substances care should be taken to introduce with the fuel-air mixture an amount of air in excess of that necessary to burn the fuel, to insure substantially complete combustion of the combustible material in the solution to avoid formation of soot or other impurities.

We claim as our invention:

1. A pressure furnace for the production of flue gases under superatmospheric pressure comprising a pressure-resistant shell lined with siliceous material forming a combustion chamber susceptible to excessive damage, such as spalling, under the temperature and pressure conditions developed in the furnace in the absence of injected water, a burner consisting essentially of a mixing device for producing under pressure a fuel-air mixture at one end of the furnace, a conduit forming the mouth of the burner for continuously conveying this mixture into the combustion chamber and maintaining a flame therein, an independent water conduit in said burner extending into said first conduit, the end of the water conduit being neaı the mouth of the

burner and having a spray nozzle for spraying liquid water in a finely divided state into the space back of the flame and throughout the flame in a quantity sufficient to cool the same to prevent spalling while maintaining the flame, and an outlet for combustion gases at another end of the furnace.

2. A pressure furnace for the production of flue gases under superatmospheric pressure comprising a pressure-resistant shell lined with siliceous material forming a combustion chamber susceptible to excessive damage, such as spalling, under the temperature and pressure conditions developed in the furnace in the absence of injected water, a burner consisting essentially of a mixing device for producing under pressure a fuel-air mixture at one end of the furnace, a conduit forming the mouth of the burner for continuously conveying this mixture into the combustion chamber and maintaining a flame therein, an independent water conduit communicating with said burner, the end of the water conduit terminating in the first-named conduit which forms the mouth of the burner and being adapted to introduce water in the form of a spray into the space back of the flame and throughout the flame in a quantity sufficient to cool the same to prevent spalling while maintaining the flame, and an outlet for combustion gases at another end of the furnace.

3. A pressure furnace for the production of flue gases under superatmospheric pressure comprising a pressure-resistant shell lined with siliceous material forming a combustion chamber susceptible to excessive damage, such as spalling, under the temperature and pressure conditions developed in the furnace in the absence of injected water, a burner comprising a mixing device for producing under pressure a fuel-air mixture at one end of the furnace in communication with the combustion chamber, and disposed to maintain a flame therein, independent water conduit means terminating in communication with the combustion chamber in the near vicinity of said burner for introducing water in the form of a spray into the space back of the flame and throughout the flame in a quantity sufficient to cool the same to prevent spalling while maintaining the flame, and an outlet for combustion gases at another end of the furnace.

4. In a method for producing combustion gas under superatmospheric pressure in a combustion chamber lined with siliceous material susceptible to excessive damage, such as spalling, under temperature and pressure conditions developed in the chamber in the absence of injected water, wherein a fuel and an oxygen-containing gas is burned in the combustion chamber to produce a flame and the resultant combustion gases are removed from the combustion chamber, the improvement of injecting water in the form of a spray into the space back of the flame and throughout the flame from the near vicinity of the point at which the fuel and oxygen-containing gas are introduced into the combustion chamber in a quantity sufficient to cool the same to prevent spalling while maintaining the flame.

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