

[54] **COKING PREVENTION SYSTEM**

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[56] **References Cited**

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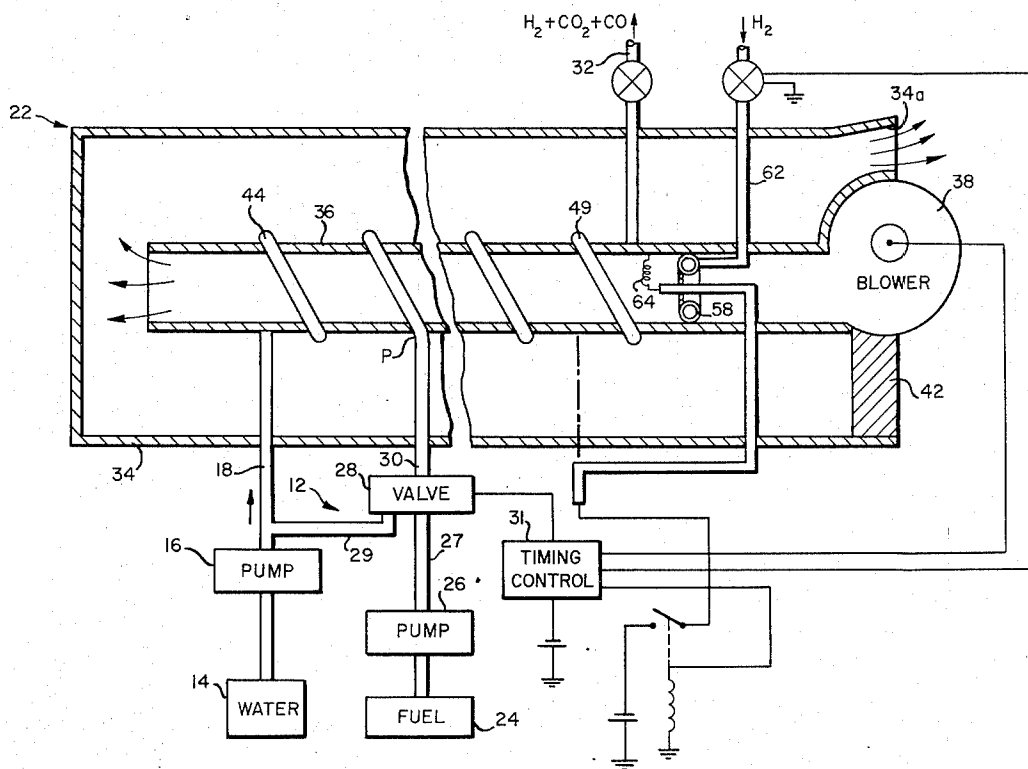
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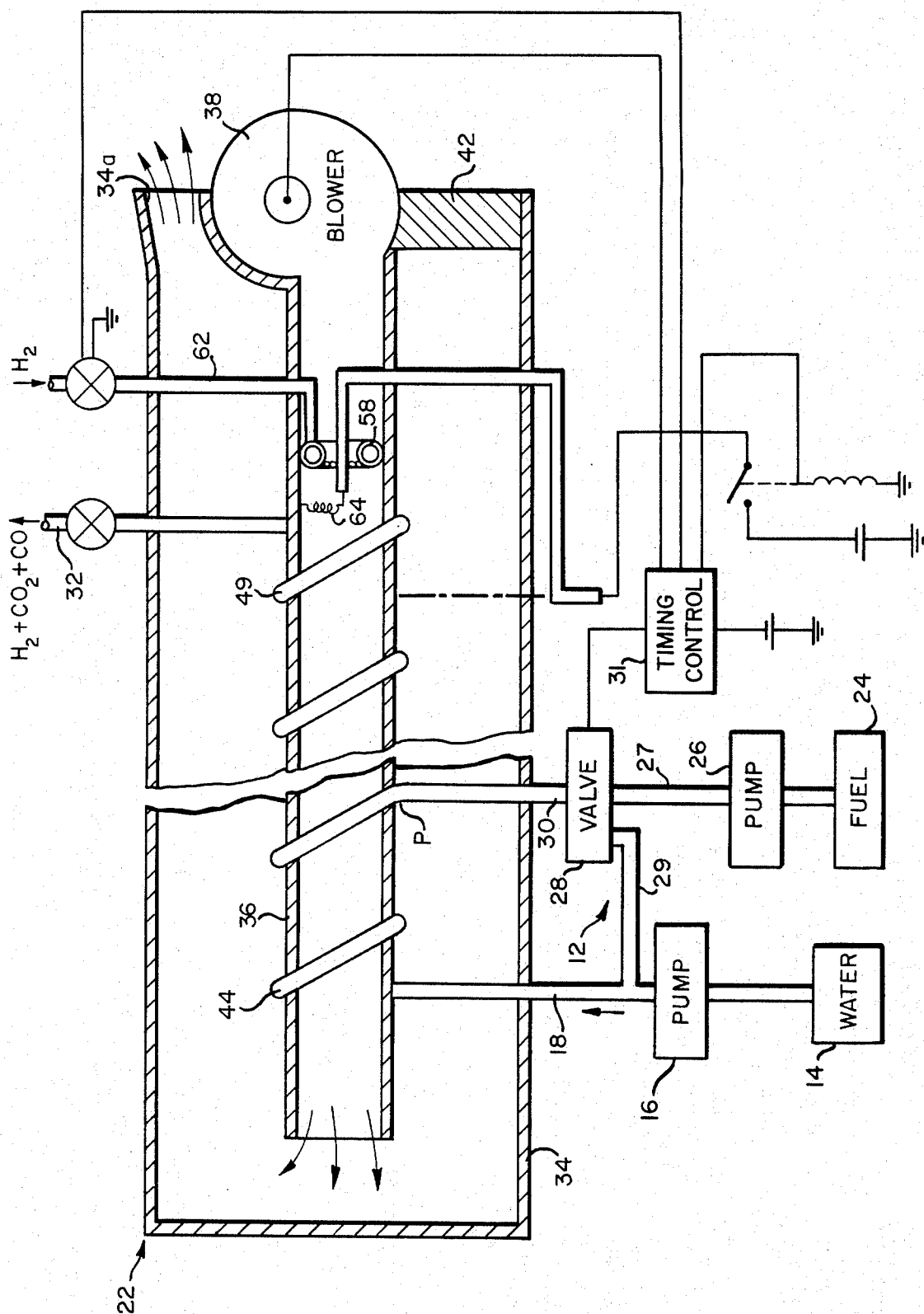
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[57] **ABSTRACT**

In fuel reformation systems of the type wherein fuel and water are pumped through separate delivery lines to a heated conduit in a reaction chamber to be thermally cracked to generate hydrogen and other gases, the relatively hot fuel delivery tube tends to become clogged with coke deposits. In the present system, a slug of water is injected periodically into the fuel delivery tube and this water vaporizes generating a high pressure which is sufficient to scrub the delivery tube of the gasoline and coke deposits present there from the previous cycle, thus maintaining a clean fuel delivery tube.

4 Claims, 1 Drawing Figure





COKING PREVENTION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to apparatus for thermally decomposing a hydrocarbon to generate hydrogen and carbon dioxide gases. It relates more particularly to apparatus of this type which steam reforms the hydrogen during the process.

Steam reformation apparatus of the type with which we are concerned here has wide application in connection with the generation of hydrogen, carbon monoxide and carbon dioxide gases. These gases have a variety of industrial uses. For example, hydrogen gas can be used as a fuel source for internal combustion engines, fuel cells, heaters and the like. A fuel reformation system designed especially for that is described in copending application Ser. No. 140,858, filed May 6, 1971, entitled HYDROGEN GENERATING SYSTEM. An improved system of the same sort is disclosed in copending application Ser. No. 202,938, filed Nov. 29, 1971, entitled FUEL REFORMATION SYSTEM.

Basically, the steam reformation process involves heating a hydrocarbon, e.g., gasoline, and water in a reaction chamber where the fuel-water mixture is heated under pressure to a high temperature, e.g., 1,500° C. The water is converted to high energy steam which mixes with the hydrocarbons in the fuel so that the mixture thermally decomposes to hydrogen and carbon dioxide and/or carbon monoxide gases.

After these systems operate for a period of time, it has been found that free carbon deposits tend to build up in the fuel delivery tube to the reaction chamber. This is because the fuel delivery tube becomes quite hot in use due to the heat conducted to it from the reaction chamber. In many cases, the temperature can exceed the thermal cracking temperature of gasoline, resulting in the buildup of coke deposits in the tube. These deposits affect the flow of fuel to the reaction chamber and, in extreme cases, can completely clog the tube and disable the system.

The buildup of these deposits is particularly bothersome in those systems wherein the fuel is injected periodically into the reaction chamber since the temperature buildup at the delivery tube is even greater because the tube is not being cooled by continuously flowing incoming fuel. Such a system is shown, for example, in the latter pending application mentioned above.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a system for minimizing the buildup of free carbon (herein called coking) in the fuel delivery tube of steam reformation apparatus of the above type.

Another object of the invention is to provide a steam reformation system which is automatically purged of carbon deposits in its fuel delivery tube.

Yet another object of the invention is to provide a system for increasing the efficiency of the fuel reformation systems of the variety described herein.

Other objects will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the several steps and the relation of one or more such steps with respect to each of the others and the apparatus embodying the features of construction, combination of elements and arrangement of parts which are adapted

to effect such steps, all as exemplified in the following detailed disclosure, and the scope of the invention will be indicated in the claims.

Stated briefly, a slug of water is injected periodically into the fuel delivery tube leading to the reaction chamber at a relatively cool region thereof. The slug of water travels to the hot zone of the delivery tube close to the hot reaction chamber and vaporizes. In so doing, it generates a great pressure due to its expansion which is sufficient to purge the delivery tube of any gasoline or coke deposits remaining in the delivery tube and also cools the delivery tube to some extent, minimizing the buildup of coke deposits during the interval between successive water injections.

As a result, the injection of fuel into the system can be controlled more closely with a resulting increase in the overall efficiency of the system. Also, the fact that coke deposits in the fuel delivery tube are kept to a minimum means that the down-time of the system is correspondingly reduced.

BRIEF DESCRIPTION OF THE DRAWING

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing in which the FIGURE is a diagrammatic view of a hydrocarbon steam reformation system incorporating the subject anti-coking apparatus in its fuel delivery tube.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing FIGURE, the system for reforming a liquid hydrocarbon fuel is shown generally at 10. The anti-coking device which forms a part of system 10 is indicated generally at 12 and its operation will be described in detail later.

The system illustrated specifically herein operates much like an embodiment disclosed in the latter pending application mentioned above. More particularly, water from a supply 14 is pumped under high pressure by a pump 16 through a water inlet conduit 18 to a thermal reaction chamber shown generally at 22. At the same time, hydrocarbon fuel from a supply 24 is pumped by a pump 26 through a conduit 27 to one inlet of an electrically operated dual valve 28. The other valve inlet is connected by a pipe 29 to conduit 18 and the single valve outlet is coupled by a delivery tube 30 to chamber 22 at a point downstream from the water inlet to that chamber. Valve 28 is controlled by a timing control 31 in a manner to be described later.

The fuel-water mixture in chamber 22 is thermally decomposed so that the fluid leaving the chamber through its outlet conduit 32 is comprised essentially of hydrogen gas, carbon dioxide and/or carbon monoxide gases plus water vapor. These resultant products can then be separated and used for various purposes.

Reaction chamber 22 is comprised of an elongated, generally cylindrical housing 34 having an exhaust opening 34a at one end. A smaller diameter generally cylindrical tube 36 comprised of a heat-resistant material is positioned coaxially inside housing 34. A blower 38 has its outlet extending through the end wall 42 of housing 34 where it communicates with the end of tube 36 so that a strong blast of air can be blown through the tube, pass down the outside wall of the tube and then exit through the housing exhaust opening 34a.

A conduit 44 communicating with the water delivery conduit 18 extends through the wall of housing 34 near the end thereof remote from blower 38. The conduit 44 then spirals around tube 36 and exits through the housing 34 wall near the blower where it communicates with the outlet conduit 32. Conduit 44 is in intimate heat exchange relation with tube 36 so that when the tube 36 is heated, the heat is transferred efficiently to the contents of conduit 44.

Hydrogen gas is introduced into a manifold 58 in tube 36 through a conduit 62 extending through the housing 34 side wall. Also, a conventional hot wire ignition element 64 is provided inside the tube.

During operation of this system, pump 16 pumps water from supply 14 to conduit 44 continuously and the water is converted to superheated steam. At the same time, pump 26 pumps fluid by way of solenoid valve 28 and delivery tube 30 to conduit 44 at a point therein downstream from where the steam forms.

The valve 28 is controlled so that fuel from supply 24 and water from supply 14 via pipe 29 are injected alternately into the delivery tube 30. During the portion of the cycle when fuel is injected, the fuel flows to conduit 44 where it mixes with the steam in the conduit and is reformed as described above. During this portion of the cycle, some coking may occur in the delivery tube 30. However, during the portion of the cycle when water is pumped through tube 30, the water is converted to steam because the tube 30 is very hot due to its proximity to chamber 22. The steam expands under high pressure and scrubs the tube 30 of residual gasoline and coke and carries these residuals into conduit 44 where they are steam-reformed in the high temperature portion of the system.

Thus, once each cycle, the delivery tube 30 is scrubbed clean so that there tends to be no accumulation of carbon or other deposits which might tend to clog the delivery tube and therefore interfere with the proper operation of the apparatus.

While we have shown the anti-coking unit 12 as part of a steam reformation system wherein fuel is injected periodically into the reaction chamber, it has equal application in systems wherein the fuel flows continuously into the chamber. We chose this embodiment because coking tends to occur at a faster rate with intermittent fuel injection since the delivery tube tends to become

hotter.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described:

I claim:

1. In an apparatus for thermally decomposing a hydrocarbon, which apparatus has a high temperature reaction chamber, a water delivery tube for feeding water to the chamber and a fuel delivery tube for feeding fuel to the chamber, the improvement comprising a system for minimizing the accumulation of free carbon in that portion of the fuel delivery tube adjacent the reaction chamber which includes means for intermittently injecting into the fuel delivery tube a slug of water of sufficient mass in relation to the size of the tube so that the water on entering said portion, vaporizes to high pressure steam which scrubs accumulated carbon from the delivery tube and carries it to the reaction chamber.

2. The apparatus defined in claim 1 and further including means for injecting the fuel intermittently into the fuel delivery tube, and means for controlling the fuel and water injections into the fuel delivery tube so that they are out of phase with each other.

3. The apparatus defined in claim 1 wherein the water injecting means include a source of water, a conduit leading from the source to the fuel delivery tube, a valve in the conduit and means for opening the valve in a periodic manner.

4. The method of minimizing the buildup of carbon deposits in the fuel delivery tube to the reaction chamber of a steam reformation system comprising the steps of injecting a slug of water intermittently into the fuel delivery tube for conversion of the water to high pressure steam within the fuel delivery tube and at the temperature of the delivery tube so that the steam scrubs deposits from the tube and carries them into the reaction chamber.

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