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(54) SYNTHESIS GAS PRODUCTION BY PARTIAL COMBUSTION

(54)

(72) [illegible] (Country):	**JOHANNES G. GOETZEE** (Not Available) **PIETER L. KLAASSEN** (Not Available)
(73) [illegible] (Country):	**Shell Oil Company** (United States)
(71) [illegible] (Country):	
(74) [illegible]	
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ABSTRACT

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This invention relates to improvements in process and apparatus for the preparation of gas mixtures containing hydrogen and carbon monoxide by partial combustion of liquid or gaseous hydrocarbon materials with an oxygen-containing gas. The expression oxygen-containing gas is used herein to include air, oxygen-enriched air and substantially pure oxygen.

In a known process for the manufacture of synthesis gas through partial combustion of a first and second fluid with the addition of steam, one of the fluids (which may be either a carbonaceous fuel or an oxygen-containing gas) is fed tangentially into a first zone (sometimes described as a whirl chamber) which has a boundary of a surface of revolution with a velocity sufficient to form an annular, rotating column which advances forwardly toward an open throat in one end of the whirl zone. There is a gradual reduction in the cross section of the whirl zone and accordingly a like reduction in the cross section of the annular rotating column to the dimension of the throat. The other fluid (which may be either a carbonaceous fuel or an oxygen-containing gas but differing from the first fluid) is injected outwardly into the encompassing rotating annular column of the first fluid. There occurs a rapid expansion of the outwardly moving, rotating column from the restricted throat into a sharply enlarged combustion zone which has a boundary wall of substantially a surface of revolution. Normally steam is supplied to the combustion chamber through the throat in the rotating annular column, having been admitted with the first fluid in the formation of the rotating column. If the hydrocarbon used is liquid the annular rotating column will generally be the oxygen-containing gas, with the liquid hydrocarbon being injected outwardly into that column. However, if the hydrocarbon is gaseous, it may be employed to form the outer, rotating annular column and the oxygen-containing gas (here oxygen or a very rich oxygen stream) will be centrally introduced.

A device for the foregoing partial combustion may comprise a whirl chamber connected through a centrally located throat to a refractory-lined combustion chamber, with both chambers being substantially formed of cylinders of revolution around a common axis. The throat will have a reduced diameter with respect to the diameters of the chambers. There is a nozzle centrally located in the whirl chamber and arranged to spray one of the fluids in the form of a hollow cone through the throat into the combustion chamber. The whirl chamber is provided at its periphery with a tangential opening for the admittance of the other fluid. Normally there will also be provision for admitting the necessary steam to the whirl chamber through a tangential opening.

Since the process of the foregoing type employs high temperatures of over 1000°C and often between 1200°C and 1500°C, particularly at points near the throat, the wall of the combustion chamber is made of a refractory material having a great heat resistance. Nevertheless it occasionally happens that disturbances do occur in the combustion zone, for example, due to the irregular supply of one or more of the reactants or because of an inadequate mixing thereof, and the refractory wall is damaged in the vicinity of the throat as the result of the aggressive action of the free oxygen at an elevated temperature.

It is an object of the present invention to provide an improved process and suitable apparatus for the production of gaseous mixtures predominating in hydrogen and carbon monoxide, with provisions guarding against oxidative damage of the refractory lining of the combustion zone.

This and other objects of the present invention will become more apparent during the following description of the invention when taken in conjunction with the accompanying drawing wherein:

Fig. 1 is a cross-sectional view of a preferred device, illustrating both the whirl and combustion chambers for the production of a synthesis gas; and

Fig. 2 is a fragmentary, enlarged view of the throat section connecting the two chambers.

Now, in accordance with the improved process of the present invention at least part of the steam necessary for the partial combustion is introduced in a unique manner so as to achieve protection of the throat and of at least that portion of the combustion zone wall adjacent the throat against oxidative damage. In the improved process steam is employed as a coolant for the wall of the throat, with the steam coolant there being passed in direct heat exchange with the outside wall of the throat. Thereafter the steam is admitted to the interior of the combustion zone in the throat area and passed in a protective layer along at least that portion of the wall of the combustion zone adjacent the throat, thereby forming a blanket of steam which serves to protect the combustion zone wall against the deteriorating effect of the combustion reaction.

In the improved apparatus of the invention the wall of the throat is provided with an internal annular steam passageway with outlet provisions therefrom permitting the flowing of a steam blanket along the interior wall of the combustion zone away from the throat. A conduit is provided for supplying steam to the throat passageway. In a preferred embodiment there are several openings equally spaced apart connecting the annular passageway to the combustion zone. In an alternative an annular slot of more restricted cross section than the passageway itself may be utilized for admitting the steam to the combustion zone.

The steam should be supplied to the combustion zone at an equal or substantially equal pressure to the other reactants. Since the steam supply source pressure is likely to be greater than the other pressures, it is possible with the correct selection of resistances in the annular cooling passageway of the throat and in the openings or ports connecting the passageway to the combustion zone to effect a loss of sufficient pressure resulting

in the supplying of the steam to the reaction chamber at a pressure substantially equal to that of the remaining reactants. With this precaution there is reduced risk of the cooling passageway being blown clear should there be a disturbance in the operating conditions. The ports or openings connecting the cooling passageway of the throat to the combustion zone should be oriented or directed so that the steam after passage through the ports or openings issues into the combustion chamber as a jacket or blanket flowing over the reaction chamber wall in the immediate vicinity of the throat. The cooling of the throat itself assists in lowering the temperature of the combustion chamber wall adjacent immediately thereto.

Any gaseous or liquid hydrocarbon materials can be used in the process of the invention; for example, natural gas, refinery gas, liquid products obtained by distillation of crude mineral oils, such as gasoline, naphtha, kerosene and gas oil, residual fuel oils or asphalt.

If liquid hydrocarbons are used they are atomized by means of a centrally placed pressure atomizer or the like on injection through the throat. Gaseous hydrocarbons may be injected with the aid of a similarly disposed gas nozzle in such a way that there is intense mixing with the other reactants supplied through the throat or in an alternative the gaseous hydrocarbon may be tangentially admitted to the whirl chamber, in which event pure oxygen or an enriched oxygen stream may be supplied to the combustion chamber through the centrally placed nozzle. The process and apparatus of the present invention constitutes an improvement over that disclosed in United States patent 2,806,517.

With reference to the drawing, the apparatus illustrated includes a combustion chamber 1 enclosed in a refractory wall section 2, which chamber is connected axially through a throat 3 in one end thereof to an axially alligned whirl chamber 5. Both chambers have circular cross sections and in the instance of the whirl chamber there is an enlarged cylindrical portion 7

joining a truncated cone section 9, the small base of which opens into a second cylindrical section 11. As illustrated the second cylindrical section 11 is of somewhat smaller diameter than the larger principal cylindrical section 11. There is a gradual tapering of the walls of the truncated cone section which connects the two cylindrical sections of the whirl chamber. The smaller, second cylindrical section 11 in turn is connected through a second, truncated cone section 12 to the aforementioned throat 3. The gradual reductions in the cross section of the whirl chamber or zone results in a corresponding reduction in the annular rotating column of gas formed therein. It will be seen that the first fluid, normally air, or an oxygen enriched air is admitted through a line 14 and a tangential opening 16 to the interior of the whirl zone. This tangential introduction promotes the formation of an annular, rotating column of air which in its passage through the whirl zone is progressively contracted to a more limited cross section and eventually introduced through the restricted throat into the sharply enlarged combustion zone 1. The second fluid, usually a liquid hydrocarbon, moves through the axially-placed conduit 18 to the nozzle disposed at the end thereof from which it is sprayed in the form of a hollow cone through the throat into the combustion chamber, in conjunction with the whirling air mass passing through the throat. The lower section 19 of the wall of the whirl chamber, that is the part joining the combustion chamber, is provided with an internal annular channel 21 which is connected through an internal conduit 23 to the steam supply line 25. As illustrated, a portion of the steam needed for the synthesis gas production may be supplied through the air inlet line 14 via the bypass line 27 and valve 28. The annular channel 21 leads into the combustion chamber 1 through a series of openings or ports 30 which are equally spaced apart and arranged in a ring around the throat 3. These openings are directed so that in operation steam after passage through the annular channel where it serves to cool the throat wall,

enters the reaction chamber and forms a jacket or screen which flows outwardly over the wall of the combustion chamber immediately joining the throat and protects that part of the refractory wall which is most likely to be exposed to the aggressive action of free oxygen. Instead of a series of discrete openings 30 it is possible to provide a single annular slit leading from the channel 21 into the combustion chamber 1.

In the preferred embodiment of the partial combustion device as illustrated in the drawing, the sides of the annular channel 21 lie parallel to the sloping wall of the lower truncated cone section 12. The ports 30 connecting the annular channel 30 to the combustion chamber extends substantially perpendicular to the sides of the annular chamber and open along the interior face of the combustion zone. This orientation of the ports assures formation of the steam blanket flowing along the refractory wall.

The quantity of steam which is supplied to the combustion chamber 1 through the opening or openings 30 should at most be equal to the quantity required to enable the partial combustion reaction to proceed favorably. If it is equal to this quantity, no steam need be supplied through the whirl chamber 2. If for satisfactory cooling of the wall of the throat 3, more steam is required than the maximum which it is desired to introduce in the combustion chamber 1, the annular channel 21 is provided with an extra outlet 32 for the superfluous steam not going into the combustion chamber 1.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. In a method of preparing gas mixtures containing predominantly hydrogen and carbon monoxide by partial combustion of a first and second fluid with the addition of steam, one of the fluids being a carbonaceous fuel and the other an oxygen-containing gas, wherein the first fluid is fed tangentially into a first zone having a boundary of a surface of revolution with a velocity sufficient to form an annular rotating column of said first fluid advancing forwardly toward an open throat in one end of said zone and wherein there is a gradual reduction in the cross section of said zone and accordingly of the annular rotating column to the dimension of said throat and wherein there is an injection of the second fluid outwardly into the rotating annular column of the first fluid and wherein there occurs a rapid expansion of the outwardly moving, rotating column from the restricted throat into a sharply enlarged combustion zone having a boundary wall of substantially a surface of revolution, the improvement comprising employing at least part of the steam needed for the reaction as a coolant for the wall of the throat, with the steam coolant being passed in direct heat exchange with the outside wall of said throat, and thereafter introducing the steam coolant to the interior of the combustion chamber at the throat and there flowing the steam in a protective layer along at least that portion of the wall of said combustion zone adjacent to the throat, thereby forming a blanket of steam to protect the combustion zone wall against the deteriorating effect of the combustion reaction.

2. A device for the partial combustion of a first and second fluid with the addition of steam, one of the fluids being a carbonaceous fuel and the other an oxygen-containing gas comprixing in combination a whirl chamber, a refractory-lined combustion chamber, said chambers being substantially formed of cylinders of revolution around a common axis and connected together by a centrally located throat of a reduced diameter with respect to the diameters of both chambers, a nozzle centrally located in the whirl chamber and arranged to spray the first fluid in the form of a hollow cone through said throat into the combustion chamber, said whirl chamber being provided at its periphery with a tangential opening for the second fluid, an annular steam passageway disposed in the wall of the throat with provisions for directing the steam flowing through said annular passageway along the interior wall of the combustion zone, and a conduit for supplying steam to said throat passageway.

3. A device in accordance with claim 2 wherein the provision for directing the steam flowing along the interior wall of the combustion zone comprises a plurality of ports equally spaced apart and arranged in a ring within the wall of the throat and connecting said annular passageway with the interior of the combustion zone.

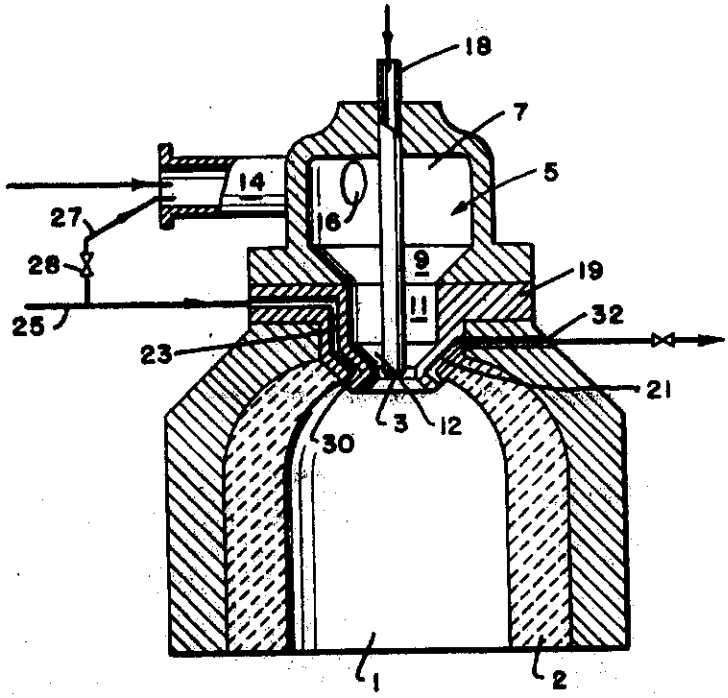

FIG. 1

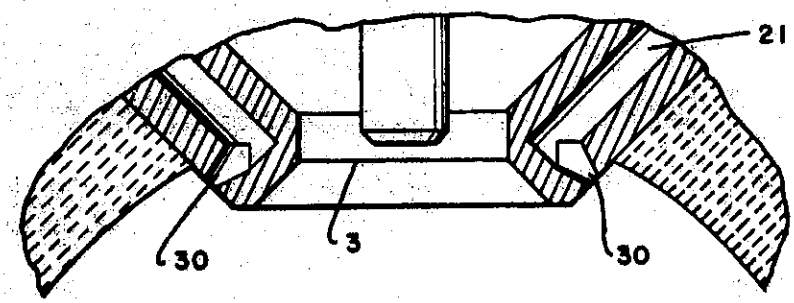

FIG.2

INVENTORS

Johannes G. Goetze
Pieter L. Haasken

PATENT AGENTS

Smart & Biggar