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(12) **Patent:**

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(54) PROCESS FOR THE PRODUCTION OF SYNTHESIS GAS WITH SIMULTANEOUS GENERATION OF ENERGY

(54) PROCEDE POUR LA PRODUCTION DE GAZ DE SYNTHESE AVEC GENERATION SIMULTANEE D'ENERGIE

(72) (Country):	**LAJOS VON SZESZICH** (Not Available)
(73) (Country):	**DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORMALS ROESSLER**
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The present invention relates to a process for the production of synthesis gas with simultaneous generation of energy.

It is known practice to burn hydrocarbon, preferably methane, in a gas engine with oxygen in quantities not sufficient for the complete oxidation of the hydrocarbon. In this process a valuable synthesic gas, consisting predominantly of hydrogen and carbon monoxide, is obtained with simultaneous generation of energy.

In the practice of this process the aim is to operate with the smallest possible quantities of oxygen in order to avoid complete combustion of major portions of the hydrocarbon and to obtain the largest possible quantities of the valuable synthesis gas. It is possible in the practice to attain a mixture ratio of for example 1 part by volume of methane to 0.76 to 0.70 parts by volume of oxygen. Below this quantity of oxygen there is formation of soot, and an even and reliable functioning of the engine is not longer possible.

Even at a ratio of methane to oxygen of 1 : 0.76 it is difficult to make the engine run evenly. In fact, if low ignition pressures occur, the reaction of the gas mixture will no longer be complete, soot forms, and the energy generated is considerably reduced.

It has now been found that these difficulties can be overcome if care is taken that the maximum indicated ignition pressure attains or exceeds 35 kg/sqcm at each piston stroke. At such an ignition pressure no soot is formed in the gas mixture and the engine functions perfectly. This observation is surprising. In fact, if enough oxygen is used

in the mixture with the hydrocarbon for the latter to burn completely, the ignition pressure is of no great importance in the operation of the engine. There is no danger in operating at ignition pressures of for example 20 kg/sqcm. When operating with a deficiency of oxygen, however, it has been found that an engine functions irregularly at this ignition pressure.

To attain the required ignition pressure, various measures familiar to the expert can be taken. A primer must be used which has a high ignition energy and does not fail. A high ignition pressure can be achieved also by correct adjustment of the pre-ignition conditions which may be such that knocking in the engine is just avoided. Also there may be used a ratio of compression such that engine knocking is no more than avoided.

It has further been found that the functioning of a gas engine with a gas mixture containing 1.52 atom of oxygen per atom of carbon, and at indicated ignition pressures of 35 kg/sqcm or more, can be much improved if the ignition temperature in the engine cylinder is adjusted to at least 17° before the upper limit of ignition failure. For a gas mixture containing 1.48 atom of oxygen per atom of carbon a pre-ignition temperature of 22° to 30° has proved the most favorable.

This observation, too, is surprising. In fact, when it is attempted to operate a gas engine with a mixture of gaseous hydrocarbon and oxygen in such quantity as is sufficient for the complete combustion of the hydrocarbon at a pre-ignition temperature of only 15°, it will be found that the resulting ignition pressures are so high that the

safety of operation is jeopardized. Moreover, engine knocking will then occur. The more surprising was it that the same measure led to full success when working with a deficiency of oxygen.

It may be advantageous in the process to mix the gases to be reacted intimately outside the engine and to supply them to the engine through an intermediate tank.

Also there may be added to the gas mixture, if desired, inert gases such as nitrogen and/or gases participating in the reaction, such as carbon dioxide or water vapor.

Example

A crude methane, containing 97% methane, 1% hydrogen, and 2% nitrogen, is partially burned in a gas engine with oxygen containing 98% oxygen and 2% nitrogen, for the purpose of producing a synthesis gas with simultaneous generation of power. The volumetric ratio of oxygen (100%) to methane (100%) is 0.70. If the compression ratio is adjusted to 1:7.55 and the pre-ignition temperature to 19° before the upper dead point or limit of ignition failure the indicated ignition pressure is 28-33 kg/sqcm. The synthesis gas produced under these conditions contains 3-4% of unburned methane and 1-1.5% unreacted oxygen. The machine runs irregularly, occasionally idle strokes occur, and the recorded indicator diagrams show that in many cases the ignition of the gas mixture occurs too late and that evidently there is a secondary combustion after the opening of the outlet valve. If the compression ratio is increased to 1:8.8 and the pre-ignition temperature is left at 19° before the upper dead point, indicated ignition pressure of 37-41 kg/sqcm will be obtained. The machine runs perfectly evenly,

and accordingly the indicator diagrams are regular, the synthesis gas contains 1.5-1.8% of unreacted methane and 0.4-0.6% unreacted oxygen. If under the same conditions the pre-ignition temperature is adjusted to 13° before the upper dead point, the indicated pressures are 34-37 kg/sqcm the machine runs irregularly with occasional idle strokes, and in the synthesis gas more residual methane and more unreacted oxygen appear.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a process for the production of carbon monoxide and hydrogen containing synthesis gas in a cyclically operating internal combustion engine by the combustion of a gas mixture containing a hydrocarbon fuel and an amount of oxygen insufficient for the complete combustion of the hydrocarbon, the steps which comprise intimately mixing the components of said gas mixture outside of the engine to provide an intimately mixed gas mixture in which the ratio of hydrocarbon and oxygen is such to provide at least 1 atom of carbon in the hydrocarbon for every 1.52 atoms of oxygen, supplying said intimately mixed gas mixture to the engine through an intermediate storage tank, and providing ignition pressures in said internal combustion engine which are at least 35 kg/cm^2.

2. The process of claim 1 in addition adjusting the spark advance of the engine to at least 17^{o} ahead of upper dead center.

3. The process of claim 1 in which said hydrocarbon is methane.

4. The process of claim 1 in which said gas mixture is prepared outside of the engine by intimate mixture of the components and said intimately mixed gas mixture is supplied to the engine through an intermedate storage tank.

5. The process of claim 1 in which said gas mixture additionally contains an inert gas.

6. The process of claim 1 in which said gas mixture additionally contains carbon dioxide.

7. The process of claim 1 in which said gas mixture additionally contains steam.

8. In a process for the production of carbon monoxide and hydrogen containing synthesis gas in a cyclically operating internal combustion engine by the combustion of a gas mixture containing a hydrocarbon fuel and an amount of oxygen insufficient for the complete combustion of the hydrocarbon, the steps which comprise intimately mixing the components of said gas mixture outside of the engine to provide an intimately mixed gas mixture in which the ratio of hydrocarbon and oxygen is such to provide at least 1 atom of carbon in the hydrocarbon for every 1.48 atoms of oxygen, supplying said intimately mixed gas mixture to the engine through an intermediate storage tank, providing ignition pressures in said internal combustion engine which are at least 35 kg/cm^2 and adjusting the spark advance of the engine to 22 to 30° ahead of upper dead center.