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THERMOSELECT (TO)

Synthesis Clean Gas

Patent claims

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1. Method for total material emission-free utilisation
of the synthesis clean gas obtained during high-
temperature recycling of waste of all types,
characterised in that
- 10 the synthesis clean gas so obtained is acted on by
water vapour in a catalytic process in order to convert
the carbon monoxide contained in the synthesis gas at
least partially into carbon dioxide and hydrogen, to
lead the remaining residual gases back into the high-
15 temperature reactor, and then, in a known separation
process, such as in a "pressure swing adsorption
plant", to separate the main product obtained,
consisting of hydrogen, carbon monoxide and carbon
dioxide, into the components hydrogen and/or carbon
20 monoxide and/or carbon dioxide and use it thus.

2. Method according to claim 1,
characterised in that the synthesis clean gas thus
obtained is subjected continuously to partial
25 conversion until hydrogen and carbon monoxide reach the
necessary volume ration of 2 to 1 for the synthesis of
methanol; thereafter carbon dioxide is separated by



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generally known methods such that, from the remaining hydrogen-carbon monoxide mixture, methanol can be obtained in a synthesis ($2H_2 + CO \rightarrow CH_3OH$).

- 5 3. Method according to claim 1,
characterised in that the synthesis clean gas so
obtained is completely converted into carbon dioxide
and hydrogen, and the substances so obtained are used
separately.

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4. Method according to claim 3,
characterised in that the hydrogen is used, together
with the nitrogen resulting from the air separation in
the generation of oxygen during high temperature
15 gasification, for the synthesis of ammonia.

5. Method according to claim 3,
characterised in that the hydrogen is used by
preference as a fuel to run the fleet of lorries
20 charging the thermal treatment installation.

6. Method according to claim 3,
characterised in that the hydrogen is used in fuel
cells to generate electric power.

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Specification

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All the known thermal processes for disposing of waste are characterised in that emissions in gaseous form are produced and in that residual materials remain to be dumped.

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In DE 41 30 416 C1, a thermal process for waste utilisation is described which, in comparison with all the known processes used in industrial production, has substantial ecological, economic and technical advantages. The resultant granulated mineral material is absolutely inert; the iron metal alloy can be used metallurgically. In claim 11 of this method it is proposed that purified synthesis gas should be used thermally or as energy; in so doing, harmful substances, caused by the combustion process, are

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inevitably produced which can damage the atmosphere at
least partially. The heavy metals contained in the
synthesis gas and compounds of chlorine and fluorine
are separated, and, amongst other things, a heavy metal
5 sulphide or hydroxide sludge is produced which has to
be dumped.

Although with this method only minimal concentrations
of harmful substances can occur which lie far below all
10 regulations and standards, and the residual amounts to
be dumped lie at below 1% measured against the input,
this method, too, is neither emission-free nor free of
residue.

15 The object underlying the present invention is to
develop a method in which the synthesis gas is
completely used as a substance and no emissions are
produced.

20 The object is achieved according to the invention by
the features quoted in the characterising part of claim
1.

Advantageous further developments and embodiments of
25 the achievement of this object arise from the secondary
claims.

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According to the invention, it is thus proposed that synthesis clean gas, preferably stemming from the process such as is described in DE 41 30 416 C1, be converted at least partially into CO₂ and hydrogen. It should be particularly emphasised that the remaining residual gases can be led back into the high-temperature reactor, and the process takes place without emissions. The converted components are then put to some use.

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A preferred form of embodiment provides for the synthesis clean gas, consisting essentially of hydrogen, carbon monoxide and carbon dioxide, to be acted on by water vapour in a catalytic process, in order to convert the carbon monoxide contained in the synthesis gas completely into hydrogen and carbon dioxide ($\text{CO} + \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{CO}_2$). The two gas components, hydrogen and carbon dioxide, can be separated by generally known methods (such as a pressure swing adsorption plant, for example) and used commercially.

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Carbon dioxide can be condensed, cooled and used as dry ice.

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Hydrogen can be used as energy and/or as a substance. If hydrogen is used as a general or motor fuel, this is an absolutely emission-free energy carrier, since only



water is produced when hydrogen is used as energy ($2H_2$
+ $O_2 \rightarrow 2H_2O$).

If hydrogen instead of fossil fuels, the damage to the
5 environment which inevitably results from the use of
fossil fuels is dispensed with. Since the raw
materials, from which fossil fuels are obtained, are
limited, these resources can be used more sensibly.

10 Moreover, hydrogen can be used in fuel cells as energy
to produce electric power. Compared with conventional
power stations, fuel cells not only have a
substantially higher degree of efficiency, they also
generate electric power without any harmful substances
15 being produced in the process.

Hydrogen can be used as a substance in hydrogenation
and synthesis processes, for example. In organic
hydrogenation, organic molecules existing under
20 pressure and at defined temperatures are enriched with
hydrogen.

In inorganic hydrogenation, metal oxides are reduced
with hydrogen to metals
25 (e.g. $WO_3 + 3H_2 \rightarrow W + 3H_2O$).



"Ammonia" can be produced in a synthesis from hydrogen and nitrogen. It should be particularly stressed that the oxygen needed for waste gasification is obtained with an air separation plant; nitrogen also results from this which can be used commercially for the synthesis of ammonia. It is particularly advantageous that the air separation plant is already a component part of the process.

10 If hydrogen is to be used for the manufacture of methanol, it makes sense to convert the carbon dioxide present in the synthesis gas into hydrogen and carbon by applying water vapour to it, to the extent that hydrogen and carbon monoxide are present in the
15 synthesis gas in a ratio of 2:1 (partial conversion).

Next, carbon dioxide is separated by generally known methods, hydrogen and carbon monoxide are submitted to
20 a synthesis, and methanol results.

Through the use of the hydrogen as a substance, chemical raw materials are obtained which are able to be stored and transported and which can be used in a
25 variety of ways.



Abstract

5 Method for total material emission-free utilisation
of the synthesis clean gas obtained during high-
temperature recycling of waste of all types, in which
method the synthesis clean gas is continuously
converted in a catalytic process into carbon dioxide
10 and hydrogen, at least partially.

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Synthesis Clean Gas

Specification

All the known thermal processes for disposing of waste are characterised in that emissions in gaseous form are produced and in that residual materials remain to be dumped.

In DE 41 30 416 C1, a thermal process for waste utilisation is described which, in comparison with all the known processes used in industrial production, has substantial ecological, economic and technical advantages. The resultant granulated mineral material is absolutely inert; the iron metal alloy can be used metallurgically. In claim 11 of this method it is proposed that purified synthesis gas should be used thermally or as energy; in so doing, harmful substances, caused by the combustion process, are

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inevitably produced which can damage the atmosphere at least partially. The heavy metals contained in the synthesis gas and compounds of chlorine and fluorine are separated, and, amongst other things, a heavy metal sulphide or hydroxide sludge is produced which has to be dumped.

Although with this method only minimal concentrations of harmful substances can occur which lie far below all regulations and standards, and the residual amounts to be dumped lie at below 1% measured against the input, this method, too, is neither emission-free nor free of residue.

The object underlying the present invention is to develop a method in which the synthesis gas is completely used as a substance and no emissions are produced.

The object is achieved according to the invention by the features quoted in the characterising part of claim 1.

Advantageous further developments and embodiments of the achievement of this object arise from the secondary claims.

According to the invention, it is thus proposed that synthesis clean gas, preferably stemming from the process such as is described in DE 41 30 416 C1, be converted at least partially into CO₂ and hydrogen. It should be particularly emphasised that the remaining residual gases can be led back into the high-temperature reactor, and the process takes place without emissions. The converted components are then put to some use.

A preferred form of embodiment provides for the synthesis clean gas, consisting essentially of hydrogen, carbon monoxide and carbon dioxide, to be acted on by water vapour in a catalytic process, in order to convert the carbon monoxide contained in the synthesis gas completely into hydrogen and carbon dioxide ($\text{CO} + \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{CO}_2$). The two gas components, hydrogen and carbon dioxide, can be separated by generally known methods (such as a pressure swing adsorption plant, for example) and used commercially.

Carbon dioxide can be condensed, cooled and used as dry ice.

Hydrogen can be used as energy and/or as a substance. If hydrogen is used as a general or motor fuel, this is an absolutely emission-free energy carrier, since only

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water is produced when hydrogen is used as energy ($2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$).

If hydrogen instead of fossil fuels, the damage to the environment which inevitably results from the use of fossil fuels is dispensed with. Since the raw materials, from which fossil fuels are obtained, are limited, these resources can be used more sensibly.

Moreover, hydrogen can be used in fuel cells as energy to produce electric power. Compared with conventional power stations, fuel cells not only have a substantially higher degree of efficiency, they also generate electric power without any harmful substances being produced in the process.

Hydrogen can be used as a substance in hydrogenation and synthesis processes, for example. In organic hydrogenation, organic molecules existing under pressure and at defined temperatures are enriched with hydrogen.

In inorganic hydrogenation, metal oxides are reduced with hydrogen to metals

(e.g. $\text{WO}_3 + 3\text{H}_2 \rightarrow \text{W} + 3\text{H}_2\text{O}$).

"Ammonia" can be produced in a synthesis from hydrogen and nitrogen. It should be particularly stressed that the oxygen needed for waste gasification is obtained with an air separation plant; nitrogen also results from this which can be used commercially for the synthesis of ammonia. It is particularly advantageous that the air separation plant is already a component part of the process.

If hydrogen is to be used for the manufacture of methanol, it makes sense to convert the carbon dioxide present in the synthesis gas into hydrogen and carbon by applying water vapour to it, to the extent that hydrogen and carbon monoxide are present in the synthesis gas in a ratio of 2:1 (partial conversion).

Next, carbon dioxide is separated by generally known methods, hydrogen and carbon monoxide are submitted to a synthesis, and methanol results.

Through the use of the hydrogen as a substance, chemical raw materials are obtained which are able to be stored and transported and which can be used in a variety of ways.

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Synthesis Clean Gas

Patent claims

1. Method for total material emission-free utilisation of the synthesis clean gas obtained during high-temperature recycling of waste of all types, characterised in that

the synthesis clean gas so obtained is acted on by water vapour in a catalytic process in order to convert the carbon monoxide contained in the synthesis gas at least partially into carbon dioxide and hydrogen, to lead the remaining residual gases back into the high-temperature reactor, and then, in a known separation process, such as in a "pressure swing adsorption plant", to separate the main product obtained, consisting of hydrogen, carbon monoxide and carbon dioxide, into the components hydrogen and/or carbon monoxide and/or carbon dioxide and use it thus.

2. Method according to claim 1, characterised in that the synthesis clean gas thus obtained is subjected continuously to partial conversion until hydrogen and carbon monoxide reach the necessary volume ration of 2 to 1 for the synthesis of methanol; thereafter carbon dioxide is separated by



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generally known methods such that, from the remaining hydrogen-carbon monoxide mixture, methanol can be obtained in a synthesis ($2H_2 + CO \rightarrow CH_3OH$).

3. Method according to claim 1, characterised in that the synthesis clean gas so obtained is completely converted into carbon dioxide and hydrogen, and the substances so obtained are used separately.

4. Method according to claim 3, characterised in that the hydrogen is used, together with the nitrogen resulting from the air separation in the generation of oxygen during high temperature gasification, for the synthesis of ammonia.

5. Method according to claim 3, characterised in that the hydrogen is used by preference as a fuel to run the fleet of lorries charging the thermal treatment installation.

6. Method according to claim 3, characterised in that the hydrogen is used in fuel cells to generate electric power.



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Abstract**Synthesis Clean Gas**

Method for total material emission-free utilisation of the synthesis clean gas obtained during high-temperature recycling of waste of all types, in which method the synthesis clean gas is continuously converted in a catalytic process into carbon dioxide and hydrogen, at least partially.

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