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(71) Applicant: **GDL**
72540 Mareil En Champagne (FR)

(72) Inventor: **Foyer, Jean**
72540 Mareil En Champagne (FR)

(74) Representative: **Bandpay & Greuter**
30, rue Notre-Dame des Victoires
75002 Paris (FR)

(54) **METHOD FOR PRODUCING SYNTHETIC GAS FROM HEMP**

(57) The present invention relates to a method for producing synthetic gas from hemp, the hemp being harvested at or after full bloom and the method comprising subjecting at least part of the harvested hemp to a pyro-gasification step.

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Description

Technical field

[0001] The present invention relates to a method for producing synthetic gas from hemp.

Technical background

[0002] Many current approaches to energy are unsustainable and non-renewable. Today, the world's energy supply is largely based on fossil fuels. These sources of energy will not last forever and have proven to be contributors to our environmental problems and the world cannot indefinitely continue to base its life on the consumption of finite energy resources.

[0003] Renewable energy and the use of biomass in energy production promotes sustainable development and decreases the use of fossil fuels. Among renewable energy sources, biomass has the lowest risk and capital required to be used in energy generation because of its abundance, renewability, and significant environmental benefits since it is considered as CO_2-neutral fuel which also contributes to the reduction of SO_x and NO_x emissions. Biomass such as wood chips can be used in the production of heat and electricity, and as a biofuel component and novel product for the chemical industry.

[0004] Nowadays hemp has become very important as a crop for biomass production, which can be used for example in energy production. More particularly, hemp is considered as promising energy crop mainly owing to its rapid growth rate and high biomass and energy yields. Hemp biomass may be used for energy purposes in different ways: by burning (co-fired with coal to reduce emissions and offset a fraction of coal use; burned to produce electricity; pelletized to heat structures; made or cut into logs for heating; gasification), as oils (vegetable, seed and plant oil used "as-is" in diesel engines; biodiesel - vegetable oil converted by chemical reaction; converted into high-quality nontoxic lubricants), by conversion of cellulose to alcohol.

[0005] Among other applications, biomass has also been used to produce synthetic gas.

[0006] However, the presence of minerals and other components in the biomass, lead to different by-products in the final product (synthetic gas for example) such as tar, biochar and hydrogen sulfide, which could thus lead to products with low purity and low yield.

[0007] Among different types of biomass, hemp crops have also been used to produce synthetic gas.

[0008] The article "Crop yield and quality parameters of four annual fibre crops (hemp, kenaf, maize and sorghum) in the North of Italy" of S. Amaducci et al. (Industrial Crops and Products, 11 (2000) 179-186) relates to the study of different parameters and features for four fiber crops depending on the harvest time.

[0009] Document "National industrial hemp strategy" (Prepared for: Manitoba Agriculture, Food and Rural Initiative Agriculture and Agri-Food Canada, March 2008, The AGRICOLA Group) provides different types of information regarding the hemp crop such as industrial uses of the hemp crop, hemp cultivation, production of the hemp crop and others.

[0010] Document WO 2020/198477 relates to methods for processing cannabis and hemp so as to improve the recovery of high-value cannabis components and methods for utilizing residual biomass components after the cannabis plant has been fully processed.

[0011] Document WO 2013/056269 relates to different uses of cannabis sativa plant such as creation of bio-fuel, paper, food, consumer textiles, building materials, personal hygiene products and others.

[0012] The article "Industrial Hemp-A promising source for biomass production" of Z. Jankauskiene et al. (Renewable Energy and Energy Efficiency: proceedings of the international scientific conference, May 28-30, 2012, Jelgava, Latvia, Latvia University of Agriculture. - Jelgava 2012, p. 13-18) relates to different hemp cultivars that can be used as a source of biomass.

[0013] There is still a need for a method that makes it possible to efficiently produce highly pure synthetic gas with a high yield.

Summary of the invention

[0014] It is an object of the invention to provide a method for producing synthetic gas from hemp material, the hemp material being obtained from hemp harvested at or after full bloom, and the method comprising subjecting at least part of the hemp material to a pyro-gasification step.

[0015] In some variations, the hemp is harvested at a sunshine duration of at least 700 hours, preferably at least 750 hours and more preferably at least 800 hours.

[0016] In some variations, the hemp material comprises or is hemp stalk.

[0017] In some variations, the hemp material has a cellulose content of at least 40 % dry matter by weight relative to the weight of the hemp.

[0018] In some variations, the hemp material has a content in lignin equal to or lower than 15 % dry matter by weight relative to the weight of the hemp.

[0019] In some variations, the pyro-gasification step is carried out at a temperature equal to or higher than 850°C, preferably equal to or higher than 900°C, and preferably equal to or higher than 1000°C, more preferably equal to or higher than 1100°C, and even more preferably equal to or higher than 1200°C.

[0020] In some variations, the pyro-gasification step is carried out in the presence of a carrier gas, preferably selected from nitrogen and/or carbon dioxide.

[0021] In some variations, the hemp material is subjected to from one to three grinding steps, and more preferably three grinding steps, prior to the pyro-gasification step.

[0022] In some variations, the hemp material undergoing the pyro-gasification step is in the form of particles having a size from 100 to 400 μm, and preferably from 150 to 250 μm.

[0023] In some variations, the method further comprises subjecting the synthetic gas to a filtration step after the pyro-gasification step.

[0024] In some variations, the synthetic gas comprises carbon monoxide in a content from 10 to 60 %, and preferably from 20 to 40 % by volume relative to the volume of the synthetic gas.

[0025] In some variations, the synthetic gas comprises hydrogen in a content from 30 to 80 %, and preferably from 35 to 60 % by volume relative to the volume of the synthetic gas.

[0026] In some variations, the synthetic gas comprises methane in a content from 0.5 to 20 %, and preferably from 2 to 10 % by volume relative to the volume of the synthetic gas.

[0027] In some variations, the synthetic gas comprises hydrogen sulfide in a content equal to or lower than 180 mg/m^3, preferably in a content equal to or lower than 100 mg/m^3, more preferably is substantially devoid of hydrogen sulfide.

[0028] The present invention addresses the need mentioned above. In particular the invention provides a method that makes it possible to efficiently produce highly pure synthetic gas with a high yield.

[0029] This is achieved by the method according to the present invention. More particularly, this is achieved by a method wherein the hemp is harvested at or after full bloom. In fact, it has been found that when the hemp is harvested at or after full bloom, the performance of the pyro-gasification process is optimized. In particular, the higher calorific value of the synthetic gas is high, and the amount of ash in the hemp is low, which implies that a lesser content of impurities is generated in the synthetic gas.

Detailed description

[0030] The invention will now be described in more detail without limitation in the following description.

[0031] The method according to the invention makes it possible to produce synthetic gas from hemp having a high yield and high purity.

[0032] By *"synthetic gas"* or *"syngas"* is meant a fuel gas mixture comprising, and preferably consisting essentially of hydrogen, carbon monoxide, carbon dioxide and methane.

[0033] The term *"industrial hemp"* or *"hemp"* refers to varieties of *Cannabis sativa.* Preferably, said hemp is characterized by low levels of tetrahydrocannabinol (THC), grown for specific industrial, health, and food outcomes.

[0034] The hemp used in the method according to the present invention is harvested at or after full bloom. *"Full bloom"* should be distinguished from bloom and end of bloom:

- Bloom: this is the point in time when the stigma appears.
- Full bloom: this is the point in time when the last female flowers open on the apex.
- End of bloom: this is the point in time when the last female flowers are fertilized. At this point, the plant ceases to grow.

[0035] The end of bloom generally occurs approximately one week after full bloom. In some embodiments, the hemp used in the method according to the invention is harvested at or after the end of bloom.

[0036] This determination is made on individual plants. Each of the above stages is considered as reached by the crop when 85% of the plants in the crop are at or past this stage. Male flowers and male plants if present are not taken into account.

[0037] The date of full bloom depends on a number of factors, among which the date of seeding of the crop, the crop variety, the photoperiod, and the weather conditions to which the crop is subjected, and in particular temperature and sunshine duration.

[0038] The *"sunshine duration"* is defined as the sum of the periods for which the direct solar irradiance on the crops exceeds 120 W.m^{-2}. The starting point for measuring the sunshine duration is seeding. The sunshine duration is measured according to the standard ISO 9488 : 1999.

[0039] In some embodiments, the hemp used in the method according to the invention is harvested at a sunshine duration of at least 700 hours, preferably at least 750 hours, more preferably at least 800 hours. In some variations, it

may be harvested at a sunshine duration from 700 to 1300 hours. For example, the sunshine duration may be from 700 to 750 hours, or from 750 to 800 hours, or from 800 to 850 hours, or from 850 to 900 hours, or from 900 to 950 hours, or from 950 to 1000 hours, or from 1000 to 1050 hours, or from 1050 to 1100 hours, or from 1100 to 1150 hours, or from 1150 to 1200 hours, or from 1250 to 1300 hours.

[0040] Preferably, the hemp is harvested when the moisture content of the hemp is 15% by weight or lower. It is conventional in hemp culture to ret the hemp on the field, after cutting, in order to facilitate the obtention of high quality fibers. However, retting is not necessary for the present method, and is thus preferably not carried out.

[0041] More generally, in the present method, the hemp may be collected sooner than in conventional hemp culture. This is advantageous in terms of soil management.

[0042] According to some embodiments, the entire harvested hemp is used to produce synthetic gas. In other words, the stalk, the flowers and the leaves are used to produce synthetic gas.

[0043] According to other preferred embodiments, the flowers and leaves are separated from the stalk prior to carrying out the method according to the invention. Thus, in this case, only the stalk is used to produce the synthetic gas. This is advantageous, as the majority of the cellulose in the hemp is found in the stalk. Besides, hemp flowers and leaves may be used for other industrial purposes. The term *"hemp material"* designates herein the part of the hemp used for carrying out the method.

[0044] The hemp material used in the method for producing synthetic gas may have a content in cellulose of at least 40 % dry matter by weight relative to the weight of the hemp.

[0045] For example, this cellulose content may be from 40 to 45 %; or from 45 to 50 %; or from 50 to 55 %; or from 55 to 60 %; or from 60 to 65 %; or from 65 to 70 %; or from 70 to 75 %; or from 75 to 80 %; or higher than 80 % by weight relative to the weight of the hemp material. The cellulose content may be measured by using the standard NF V18-122.

[0046] The hemp material used in the method for producing synthetic gas may have a content in lignin equal to or lower than 15 % dry matter by weight relative to the weight of the hemp.

[0047] The hemp material may have a content in hemi-cellulose equal to or lower than 20 % by weight relative to the weight of the hemp.

[0048] The cellulose content in the hemp material is desirably as high as possible. After a certain point, the transformation of a significant part of the cellulose in jemp into hemicellulose then lignin occurs. Lignin is responsible for the production of by-products such as different aromatic compounds and tar. Thus, harvesting the hemp before allows to maximize the cellulose content and thus minimize the lignin content, which makes it possible to provide high-yield synthetic gas and to reduce or even avoid the formation of by-products such as tar, soot and biochar. Harvesting the hemp at the above specific moment also allows to obtain high-yield synthetic gas with reduced amounts (or even devoid) of sulfur compounds such as hydrogen sulfide.

[0049] According to some embodiments, the hemp material may have a content in minerals (ashes) from 1 to 15 %, and preferably from 1.5 to 10 % by weight relative to the weight of the hemp material. This content is measured by calcining the hemp material and by measuring the resulting weight (as all carbon components have been transformed to gas). Examples of minerals may include calcium, potassium, iron, silicon and heavy metals (in trace amounts) such as lead.

[0050] After the harvest, the hemp material may be dried in order to achieve at least 80 % of dry matter, and preferably at least 85 % of dry matter. Drying may be carried out by leaving the hemp material under sunlight for a suitable duration. This step makes it possible to avoid fermentation and self-combustion of the hemp.

[0051] According to some embodiments, after the harvest and optionally the drying, the hemp material may be pressed and stored for further use.

[0052] Alternatively or additionally, one or more grinding steps may be carried out in order to reduce the size of the hemp material. Preferably, the method according to the invention may comprise from one to three grinding steps, and more preferably three grinding steps. The purpose of such steps is to reduce the size of the hemp material, preferably in order to form hemp particles prior to subjecting said hemp particles to pyro-gasification.

[0053] For example, a first step of grinding may be carried out in order to reduce the size, notably the length, of the hemp material from a few dozen centimeters to a few millimeters.

[0054] At the end of this step, the (number) average length of the hemp material may be from 5 to 60 mm, preferably from 10 to 40 mm, and more preferably from 15 to 30 mm. This step may be carried out in a shredder with a cooled rotor.

[0055] The hemp material may then be dried in order to achieve at least 90 % of dry matter, and preferably at least 95 % of dry matter. Drying may be carried out in a rotative furnace with air flow.

[0056] According to some embodiments, during this drying step, different undesired elements (such as minerals, rock fragments, metallic elements) may be removed.

[0057] According to some embodiments, a second step of grinding may be carried out in order to further reduce the size, notably the length, of the hemp material from the above size range to few millimeters. At the end of this step, the (number) average length of the hemp particles may be from 1 mm to 2 cm, preferably from 1 to 1 cm, and more preferably

from 2 to 7 mm. The grinding can be carried out either with a knife / counter-knife mill or by a hammer mill. These apparatuses may preferably be equipped with a sieve screen which can be of different shape but calibrated to the desired size (for example less than 4 mm, or less than 1 mm, etc.)

[0058] According to some embodiments, the method according to the invention may further comprise a step comprising passing the hemp particles through an inert atmosphere. Such inert atmosphere may be for example a gas chosen from air, nitrogen, and carbon dioxide.

[0059] According to some embodiments, a third grinding step (or micronization step) may be carried out. This makes it possible to obtain an ideal size of the hemp particles prior to transforming hemp into synthetic gas. In fact, an ideal size makes it possible to maximize the reaction kinetics of the generation of synthetic gas. Thus, at the end of this step the size of the hemp particles may be from 100 to 400 μm, and preferably from 150 to 250 μm. For example, this size may be from 100 to 150 μm; or from 150 to 200 μm; or from 200 to 250 μm; or from 250 to 300 μm or from 300 to 350 μm; or from 350 to 400 μm. In this case, by *"size"* is meant the median diameter (Dv50) of the hemp particles according to a volume-based particle distribution.

[0060] The hemp particles are then subjected to a pyro-gasification step.

[0061] By *"pyro-gasification step"* is meant a step which combines pyrolysis at a very high temperature and gasification, i.e. the transformation of the organic material in the hemp material into one or more gases. Such step may be carried out in a chamber, such as an oven.

[0062] The pyro-gasification step may be carried out at a temperature equal to or higher than 850°C, preferably equal to or higher than 900°C, preferably equal to or higher than 1000°C, more preferably equal to or higher than 1100°C, and even more preferably equal to or higher than 1200°C. A particularly preferred range of temperature is from 950 to 1080°C.

[0063] During this step, a carrier gas may be used to transfer the hemp material into the heated chamber. Such carrier gas may be for example nitrogen or carbon dioxide or a mixture comprising nitrogen and carbon dioxide (for example comprising from 10 mol.% nitrogen and 90 mol.% carbon dioxide to 90 mol.% nitrogen and 10 mol.% carbon dioxide). Alternatively, water vapor can also be employed (optionally in combination with nitrogen and/or carbon dioxide).

[0064] The residence time of the hemp particles in the heated chamber may be from 0.5 seconds to 2 hours depending on the type of the pyro-gasification step.

[0065] The desired humidity may be achieved by injecting steam water into the heating chamber. In some variations, the relative humidity may be at least 80 %, preferably of at least 85 %, more preferably of at least 90 %; and even more preferably of at least 95 %.

[0066] According to some preferred embodiments, the pyro-gasification step is a continuous step. In other words, the hemp material is continuously introduced at an inlet of the heated chamber and thus gas is continuously produced at the outlet of the heated chamber. In this case, the chamber may be heated for example at a temperature equal to or higher than 950°C such as from 950 to 1200°C.

[0067] According to some embodiments, during a continuous pyro-gasification step, the residence time of the hemp material in the heated chamber may be from 0.5 to 10 seconds, and preferably from 1 to 5 seconds.

[0068] According to other embodiments, during a continuous pyro-gasification step, the residence time of the hemp material in the heated chamber may be from 30 to 120 minutes, and preferably from 60 to 90 minutes.

[0069] In this case, water may be injected in a continuous manner in a hemp/water weight ratio from 2/1 to 1/2, preferably of approximately 1/1.

[0070] At the end of the pyro-gasification step, the produced synthetic gas may exit the heated chamber at atmospheric pressure and at a temperature from 300 to 800°C, and at a temperature from 300 to 400°C, and more preferably from 350 to 380°C.

[0071] The synthetic gas obtained by the method according to the invention may comprise carbon monoxide in a content from 10 to 60 %, preferably from 20 to 40 % and more preferably from 12 to 24 % by volume relative to the volume of the synthetic gas.

[0072] Furthermore, this gas may comprise hydrogen in a content from 30 to 80 %, and preferably from 33 to 60 % by volume relative to the volume of the synthetic gas.

[0073] In addition, the synthetic gas may comprise methane in a content from 0.5 to 20 %, and preferably from 2 to 10 % by volume relative to the volume of the synthetic gas.

[0074] In addition, the synthetic gas may comprise water in a content from 0.5 to 35 %, and preferably from 5 to 30 % by volume relative to the volume of the synthetic gas.

[0075] In addition, the synthetic gas may comprise carbon dioxide in a content from 0.5 to 20 %, and preferably from 5 to 20 % by volume relative to the volume of the synthetic gas.

[0076] According to some embodiments, the synthetic gas may comprise hydrogen sulfide (H_2S) in a content equal to or lower than 180 mg/m^3. The H_2S content may be 100 mg/m^3 or lower, or 50 mg/m^3 or lower, or 10 mg/m^3 or lower. In some embodiments, the synthetic gas is substantially (or completely) devoid of H_2S. In some embodiments, the amount of H_2S may be at least 1 mg/m^3 or at least 10 mg/m^3.

[0077] The synthetic gas may also have a content in other sulfur compounds in a content equal to or lower than 300

mg/m^3

[0078] According to some embodiments, the synthetic gas may comprise tar in a content equal to or lower than 400 mg/m^3.

[0079] According to some embodiments, the synthetic gas may comprise dust (particles having an average diameter from 0.5 to 10 μm) in a content equal to or lower than 6500 mg/m^3.

[0080] According to some embodiments, the synthetic gas may comprise ammonia (NH_3) in a content equal to or lower than 1030 mg/m^3.

[0081] According to some embodiments, the synthetic gas may comprise hydrogen chloride (HCl) in a content equal to or lower than 8 mg/m^3.

[0082] According to some embodiments, the synthetic gas may comprise hydrogen cyanide (HCN) in a content equal to or lower than 200 mg/m^3.

[0083] According to some embodiments, the synthetic gas may comprise volatile organic compounds (COV) in a content equal to or lower than 45 g/m^3.

[0084] According to some embodiments, the synthetic gas may comprise nitrogen oxides (NOx) in a content equal to or lower than 5 mg/m^3.

[0085] According to some embodiments, the synthetic gas may comprise nitrous oxides (N_2O) in a content equal to or lower than 600 mg/m^3.

[0086] The above concentration ranges of carbon monoxide, hydrogen, methane, water, carbon dioxide and various impurities (H_2S, etc.) relate to the synthetic gas obtained from the pyro-gasification step, before any optional purification (e.g. filtration) step as described below. Besides, these ranges are calculated by deducting the contribution from the carrier gas (which can be for example nitrogen or a combination of nitrogen and carbon dioxide) in the synthetic gas.

[0087] According to some embodiments, the process may create ashes in a content equal to or lower than 5% in weight. These ashes may have a content in carbon (biochar) equal to or lower than 3% in weight.

[0088] The method according to the present invention makes it possible to obtain a high-purity synthetic gas comprising reduced amounts of by-products, or even being devoid of such by-products. This makes it possible to reduce significantly the number of additional purification steps and as a result to reduce the costs related to any purification process.

[0089] The method according to the present invention may further comprise a filtration step after the pyro-gasification step. The filtration may be carried out for example in a cyclone filter, a bag filter or an electrostatic filter.

[0090] The purpose of this step is to remove certain by-products present in the synthetic gas. Such by-products may be sulfur oxides (SO_x) such as sulfur dioxide (SO_2), nitrogen oxides (NO_x) such as nitrogen monoxide (NO) and nitrogen dioxide (NO_2), nitrous oxide (N_2O), hydrogen sulfide (H_2S) soot, biochar, tar (EPA-PAH), ammonia (NH_3), hydrogen cyanide (HCN), hydrogen chloride (HCl), volatile organic compounds (VOC), mercury (Hg), and dust.

[0091] Depending on the desired use, the method according to the invention may further comprise one or more steps in order to treat and/or separate the different components of the synthetic gas.

[0092] The synthetic gas may for example be treated with a catalyst in order to transform carbon monoxide to carbon dioxide.

[0093] According to some embodiments, the method comprises a step for separating hydrogen from the rest of the components of the synthetic gas. The separated hydrogen may then be used e.g. as a fuel.

[0094] According to some embodiments, the method comprises a step for separating methane from the rest of the components of the synthetic gas.

[0095] According to some embodiments, the method comprises a step for separating carbon monoxide from the rest of the components of the synthetic gas.

[0096] The method according to the present invention may further comprise a step of separating the carbon dioxide formed after treatment of the synthetic gas with a catalyst (as mentioned above) from the rest of the components of the treated synthetic gas.

Example

[0097] The following example illustrates the invention without limiting it.

[0098] Hemp was seeded at two growing sites A and B. Plant samples were harvested at various dates and subjected to pyro-gasification. In most cases, and unless indicated otherwise, the full plants were used. In one case, only the stalks were used.

[0099] The hemp material was ground to particles having a size ranging from 40 to 400 μm, and a mode (size with highest frequency in a volume-based distribution) of approximately 150 μm. The pyro-gasification was carried out in a tubular oven heated at 1050°C. The hemp material was fed to the oven with nitrogen as a carrier gas. The residence time of the hemp material in the oven was approximately 1 second.

[0100] The cellulose content, lignin content and ash content were determined on the hemp material. The Van Soest method was used for determining the cellulose and lignin content.

[0101] The produced synthetic gas was analyzed for its content in carbon monoxide, carbon dioxide, methane and hydrogen by gas phase chromatography. No H_2S was detected in the produced synthetic gas (the limit of detection being 0.1 ppm). The higher calorific value (HCV) of the synthetic gas was also determined using a calorimeter.

[0102] The results are presented in the tables below. For both tested crops, the full bloom took place at approximately 800 hours of sunshine duration. The lines of the tables shaded in gray thus correspond to samples harvested before full bloom.

Characterization of the hemp material:

[0103]

Sample #	Date of harvest	Sunshine duration (h)	Cellulose content (g/kg)	Lignin content (g/kg)	Ash content (wt.%)
A1	09/06/2021	475.6	212.1	31.1	11%
B1	08/06/2021	355.8	196.7	32.7	13%
A2	15/06/2021	550.6	329.7	55.9	10%
B2	15/06/2021	553	309.8	53.2	7%
A3	22/06/2021	580.5	349.1	53.2	7%
B3	22/06/2021	582.1	362.7	54.7	7%
A4	29/06/2021	606.6	362.8	52.8	7%
B4	29/06/2021	609.7	411	62.7	7%
A5	06/07/2021	637	338.7	50.9	8%
B5	06/07/2021	642.6	227.9	55.1	8%
A6	13/07/2021	663.7	409.2	66.6	10%
B6	13/07/2021	670.4	438.8	67.8	7%
A7	20/07/2021	740.8	436.2	65.4	8%
B7	20/07/2021	747.5	444.3	88.6	7%
A8	27/07/2021	783.7	463.2	66.5	10%
B8	29/07/2021	808.5	460.1	69.4	6%
A9	03/08/2021	825	523.3	68.7	8%
B9	05/08/2021	834.6	505.3	65.9	4%
A10	10/08/2021	851	472.3	79.6	6%
B10	12/08/2021	879.9	377.6	64.1	5%
B10 (stalk only)	12/08/2021	879.9	377.6	64.1	5%
A11	18/08/2021	918.4	530.7	75.9	8%
A12	25/08/2021	963.5	541.8	84.8	4%

Characterization of the synthetic gas:

[0104]

Sample #	HCV (J/g)	CO (vol.%)	CO_2 (vol.%)	CH_4 (vol.%)	H_2 (vol.%)
A1	14187	9	1.13	1.44	7.06
B1	15217	7.43	1.09	1.31	6.3
A2	16638	8.93	0.98	1.46	7.93
B2	15374	8.67	1.62	1.49	5.61
A3	16674	8.97	1.41	1.51	7.41
B3	15120	7.05	0.5	1.15	6.56
A4	17146	9.61	0.77	1.61	8.56
B4	16661	8.58	1.11	1.68	7.83
A5	17150	9.78	1.41	1.85	8.19
B5	17709	9.49	1.05	1.77	9.05
A6	16541	9.3	1.22	2.02	7.94
B6	16899	8.98	1.74	1.66	6.62
A7	17629	9.83	1.2	1.58	8
B7	17265	7.87	0.86	1.57	6.52
A8	16726	7.75	0.8	1.55	6.6
B8	17266	9.16	1.36	1.67	7.01
A9	16550	9.23	1.14	2.01	7.68
B9	17849	9.64	1.09	2	7.75
A10	17448	8.91	1.11	1.74	7.41
B10	17358	7.92	1.29	1.51	6.24

B10 (stalk only)	17302	10.02	1.03	1.84	8.81
A11	17581	9.49	1.26	2.05	7.7
A12	17455	9.71	1.39	2.22	7.88

[0105] It can readily be seen that the synthetic gas produced from hemp harvested at or after full bloom has a reliably high calorific value. Besides, the ash content in the hemp material is reliably low, ensuring a relatively low level of impurities in the synthetic gas.

[0106] It should be noted that the contribution of the carrier gas N_2 has not been deducted from the composition of the synthetic gas in the above table.

Claims

1. A method for producing synthetic gas from hemp material, the hemp material being obtained from hemp harvested at or after full bloom, and the method comprising subjecting at least part of the hemp material to a pyro-gasification step.

2. The method according to claim 1, wherein the hemp is harvested at a sunshine duration of at least 700 hours,

preferably at least 750 hours and more preferably at least 800 hours.

3. The method according to claim 1 or 2, wherein the hemp material comprises or is hemp stalk.

4. The method according to claim 3, wherein the hemp material has a cellulose content of at least 40 % dry matter by weight relative to the weight of the hemp.

5. The method according to claim 3 or 4, wherein the hemp material has a content in lignin equal to or lower than 15 % dry matter by weight relative to the weight of the hemp.

6. The method according to any one of claims 1 to 5, wherein the pyro-gasification step is carried out at a temperature equal to or higher than 850°C, preferably equal to or higher than 900°C, and preferably equal to or higher than 1000°C, more preferably equal to or higher than 1100°C, and even more preferably equal to or higher than 1200°C.

7. The method according to any one of claims 1 to 6, wherein the pyro-gasification step is carried out in the presence of a carrier gas, preferably selected from nitrogen and/or carbon dioxide.

8. The method according to any one of claims 1 to 7, wherein the hemp material is subjected to from one to three grinding steps, and more preferably three grinding steps, prior to the pyro-gasification step.

9. The method according to any one of claims 1 to 8, wherein the hemp material undergoing the pyro-gasification step is in the form of particles having a size from 100 to 400 μm, and preferably from 150 to 250 μm.

10. The method according to any one of claims 1 to 9, further comprising subjecting the synthetic gas to a filtration step after the pyro-gasification step.

11. The method according to any one of claims 1 to 10, wherein the synthetic gas comprises carbon monoxide in a content from 10 to 60 %, and preferably from 20 to 40 % by volume relative to the volume of the synthetic gas.

12. The method according to any one of claims 1 to 11, wherein the synthetic gas comprises hydrogen in a content from 30 to 80 %, and preferably from 35 to 60 % by volume relative to the volume of the synthetic gas.

13. The method according to any one of claims 1 to 12, wherein the synthetic gas comprises methane in a content from 0.5 to 20 %, and preferably from 2 to 10 % by volume relative to the volume of the synthetic gas.

14. The method according to any one of claims 1 to 13, wherein the synthetic gas comprises hydrogen sulfide in a content equal to or lower than 180 mg/m^3, preferably in a content equal to or lower than 100 mg/m^3, more preferably is substantially devoid of hydrogen sulfide.

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EUROPEAN SEARCH REPORT

Application Number
EP 22 30 5828

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	11 November 2022	Zuurdeeg, Boudewijn

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