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(54) **METHOD AND PLANT FOR THE THERMAL TREATMENT OF ORGANIC MATTER IN ORDER TO PRODUCE CHARCHOAL OR CHAR**

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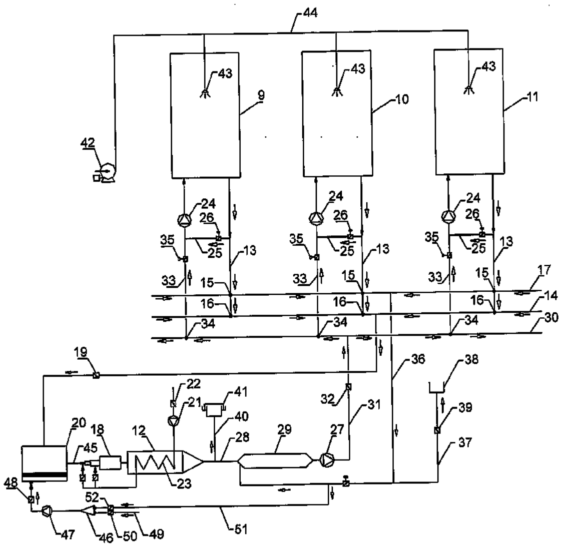
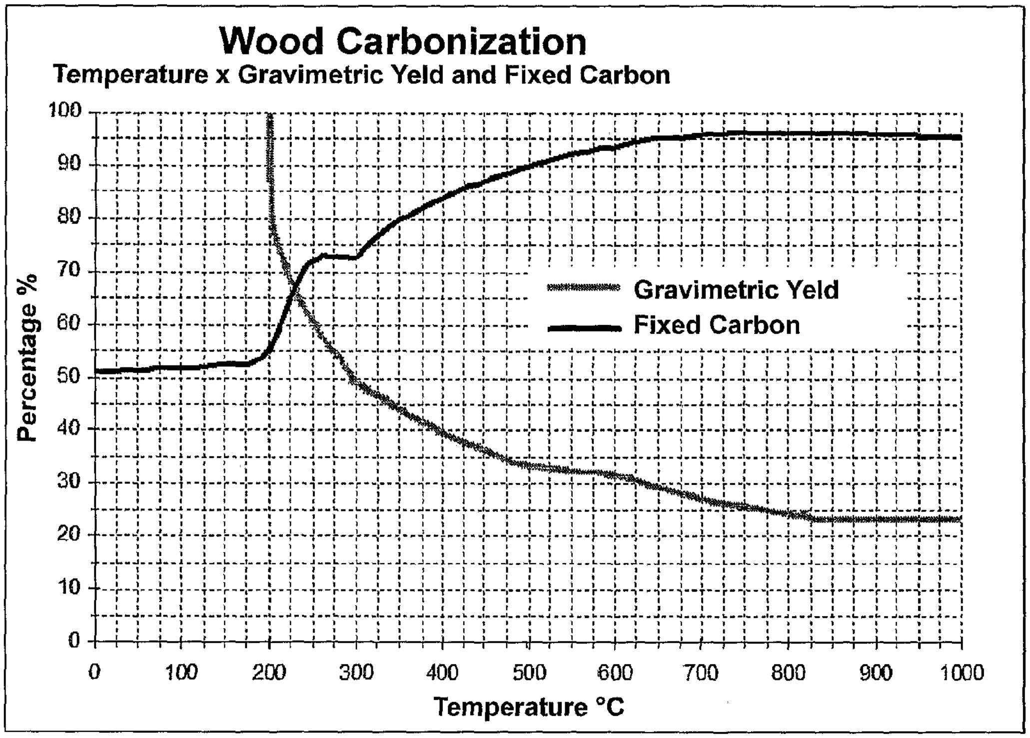
(57) **ABSTRACT**

The organic matter carbonization process is based on thermal treatment at high temperatures, under a controlled atmosphere, if possible in the absence of oxygen. The organic matter carbonization theory was expounded in this text, with emphasis on the thermodynamic aspects. It is shown in this exposition the important misfit between the endothermic and the exothermic carbonization stages, which hinders the use of the energy emitted during the exothermic stage by the brick kilns. Following there is a summary of the carbonization technique actual stage. The present invention relates to a method and plant for the thermal treatment of organic matter comprising independent reactors for the drying and pyrolysis of organic matter, and an independent reactor for the charcoal cooling. In this method the volatile products—non condensable gases and condensable pyrolytic vapors—are burned in an independent combustion chamber in order to supply the energy demanded by the process. In this way wood is not burned, and polluting substances are not emitted to the atmosphere. The method proposed by the present invention allows a precise control of the process in order to obtain the specified charcoal fixed carbon content; and a higher gravimetric yield, which gives an increase of the forest wood, either native or cultivated. In the independent pyrolysis and drying reactors proposed by the present invention, exiting flue gases from an external combustion chamber are driven to the drying reactor where the wood onto roll on buckets are heated and dried. Fuel gases emitted by the carbonizing wood are burned in the combustion chamber as an energy source. Inside the combustion chamber is placed a heat exchanger with the aim to reheat the pyrolytic gases. After reheated, these gases return to the carbonizing reactor in order to supply energy for the endothermic carbonizing step. The aim of this technique is to avoid the mixing of the fuel gases with the flue gases generated inside the combustion chamber, and to precisely control the carbonizing temperature. The present invention allows the production of intermediate products between wet wood and charcoal by halting the carbonization process at the desired stage in order to obtain anhydrous wood, char or, or high volatile content charcoal. The basic concepts of the process are: 1—Utilization of the emitted gases by the carbonizing wood as an energy source. 2—The stages of wood drying, wood pyrolysis and charcoal cooling are performed in independent reactors, inside which only one of these stages occurs. 3—Energy supply during the carbonizing endothermic stage of the pyrolysis by the gases emitted during this stage after reheated in a heat exchanger. Basically the present invention comprises the following equipments: 1—Reaction chambers inside which the process stages are performed. 2—An external combustion chamber. 3—A heat exchanger inside said combustion chamber. 4—A set of pipes. 5—A set of fans. 6—A loading system comprising roll on buckets.




Wood Carbonization
Temperature x Gravimetric Yeld and Fixed Carbon
Percentage %
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90
80
70
60
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Temperature °C
Gravimetric Yeld
Fixed Carbon

Figure 1

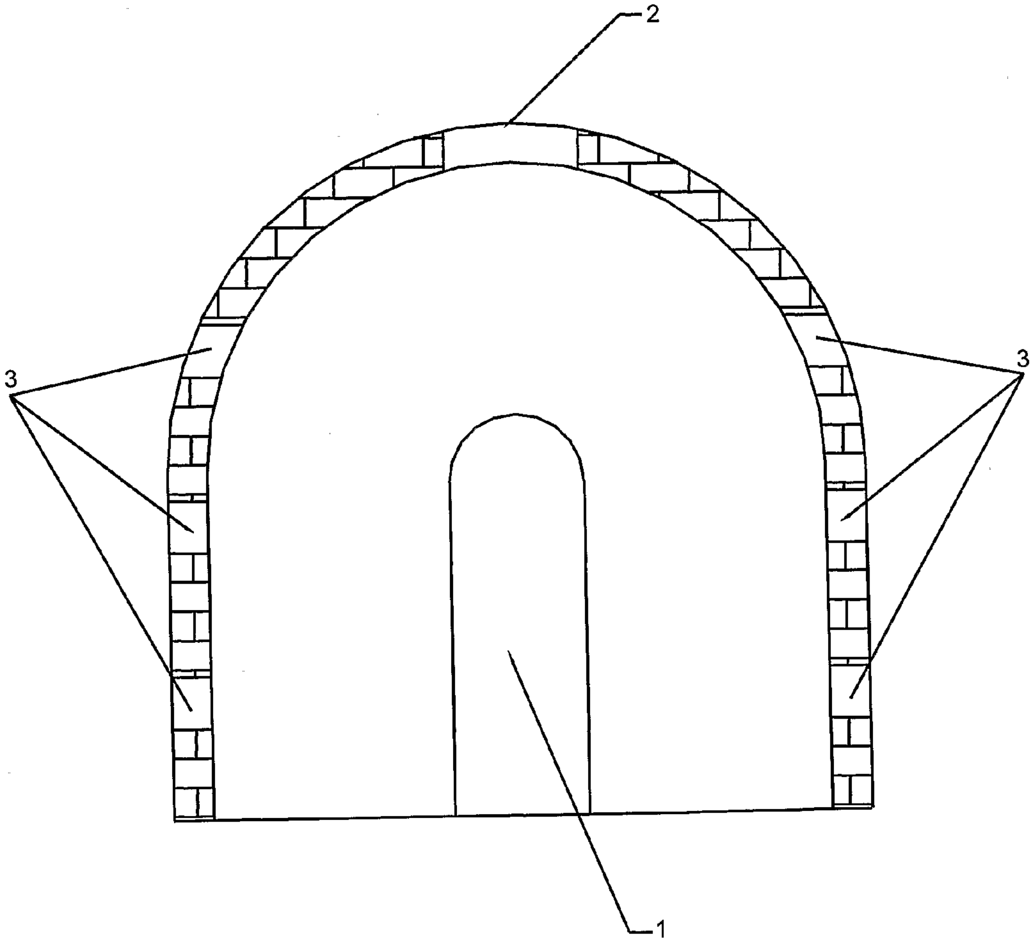

Figure 2

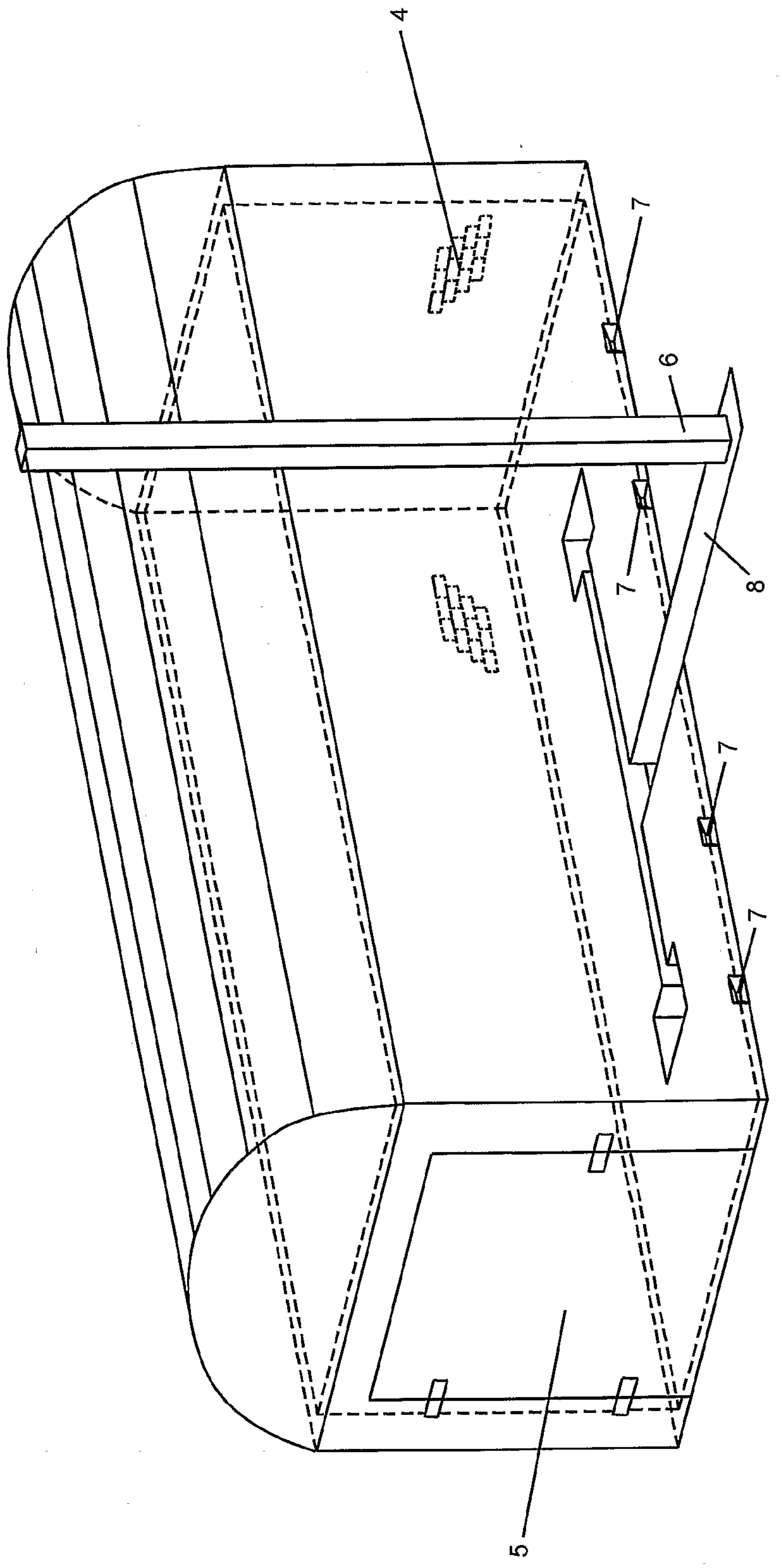

Figure 3

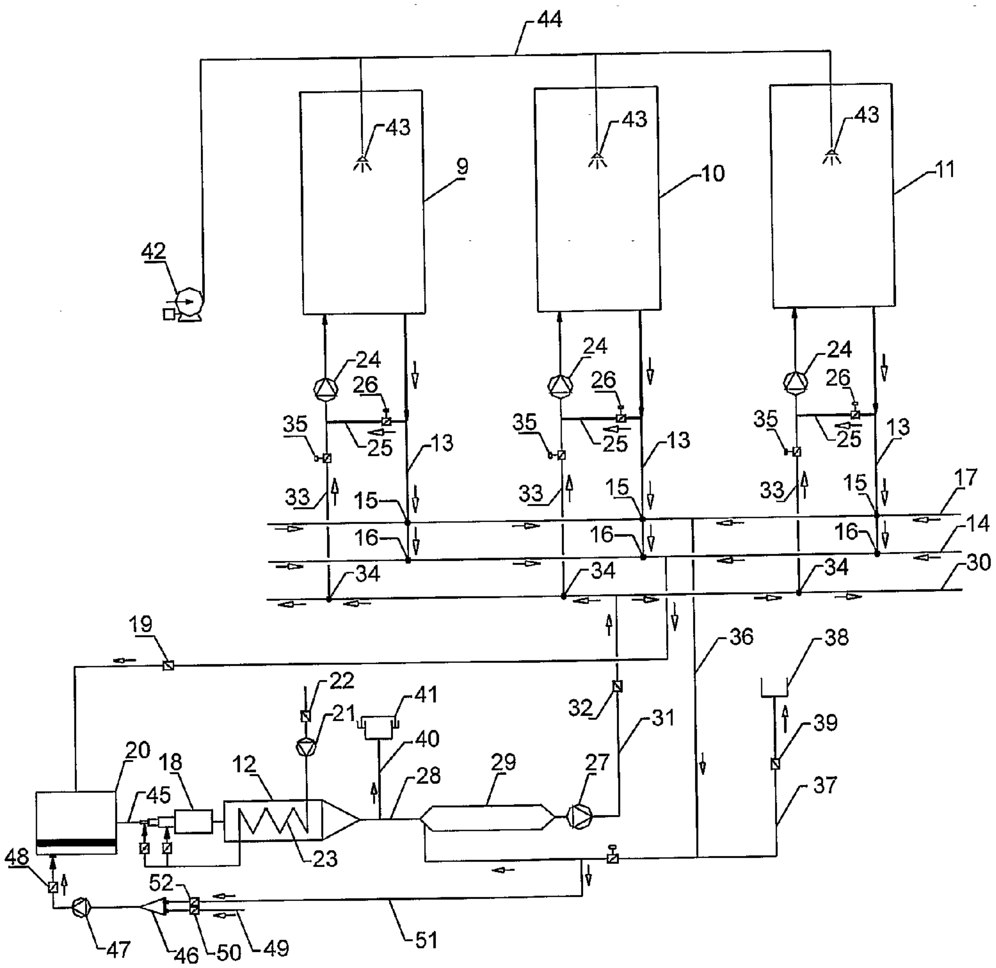
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Figure 4

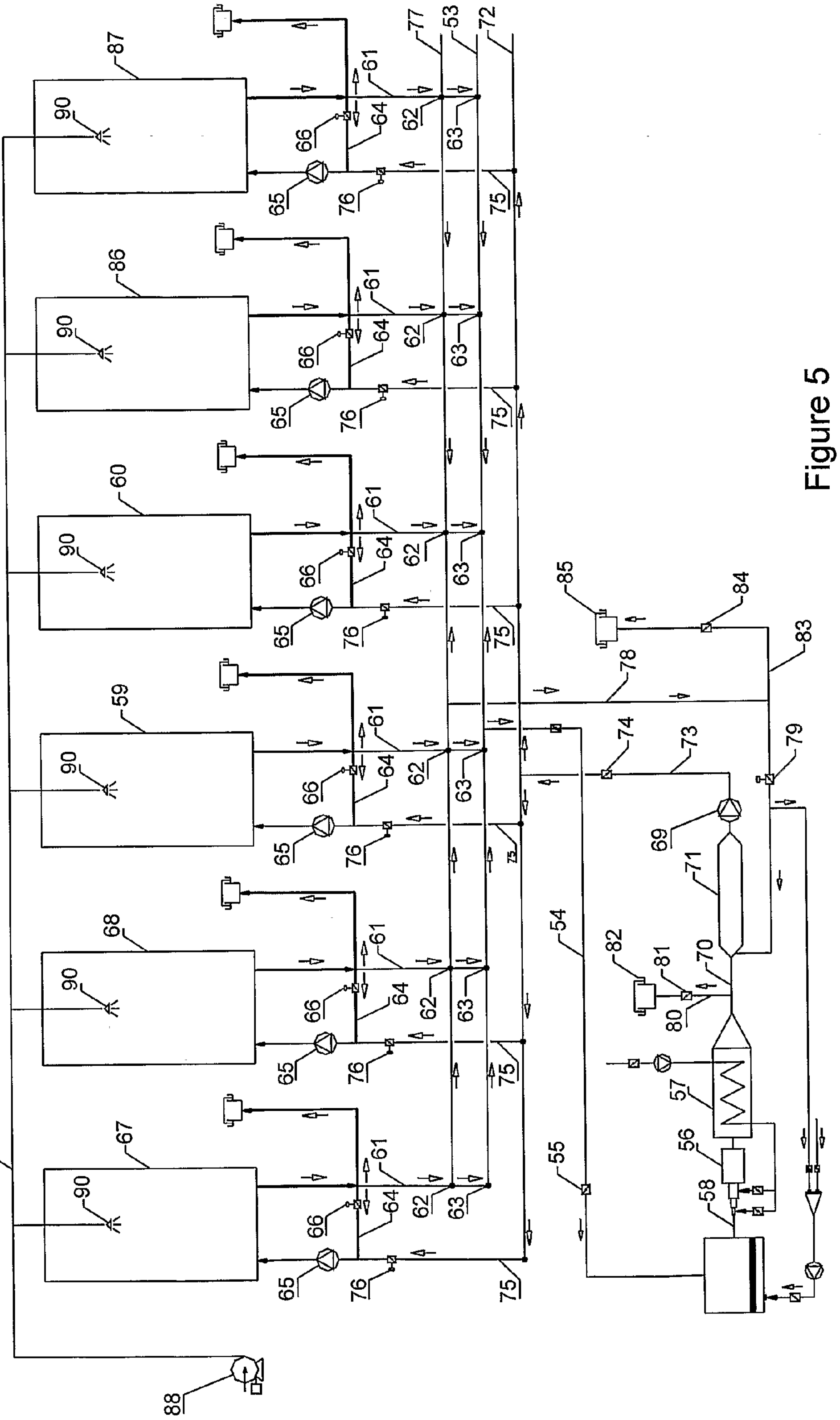
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Figure 5

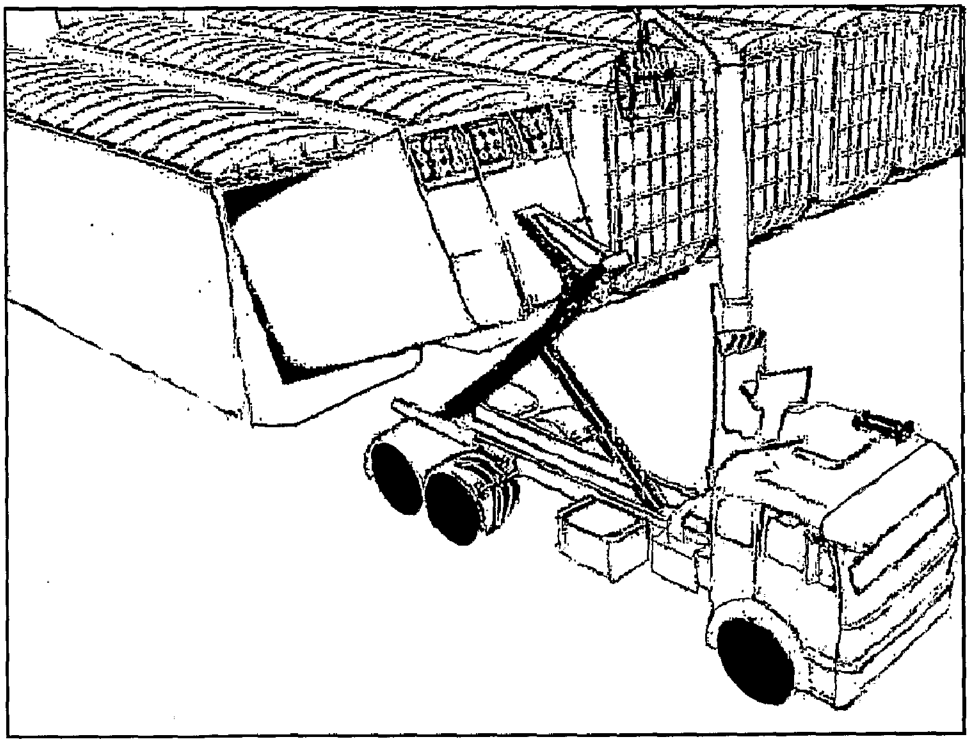

Figure 6

METHOD AND PLANT FOR THE THERMAL TREATMENT OF ORGANIC MATTER IN ORDER TO PRODUCE CHARCHOAL OR CHAR

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method and plant for the thermal treatment of organic materials applied to the carbonization of ditto organic materials in order to produce charcoal or char.

[0002] Any type of organic matter can be used as raw material: log wood in any size, coconut peel, babassu coconut, rice straw, saw mill wastes, sugar cane, sugar cane straw and vegetal wastes in general. In order to simplify wood will be the reference, but the text can be applied to any type of biomass.

[0003] Brazil is the world greatest charcoal producer with an average annual production of 8.5 millions of metric tons. This production is only a small fraction of the actual potential to produce charcoal from cultivated biomass and agricultural crop wastes. The principal aim of this invention in to bring logistic, environmental, technical, economic and global energy efficiency when compared to most of the existing biomass carbonization processes.

Theory of the Biomass Carbonization

[0004] The term "biomass" was created in 1975 in order to describe the natural materials suitable to be used as fuels. The term encompasses all organic matter of vegetal or animal origin, inclusive the resulting materials of its natural or artificial transformation (e.g. charcoal). The origin of any type of biomass is the photosynthesis.

[0005] Solar energy stored in the biomass turns it in a renewable energy source. Growth of biomass is due to the conversion of atmospheric carbon dioxide through photosynthesis in organic compounds. Bioenergy is the energy stored in the plants and animals or in its residues. Combustion is the simplest way to recover this energy. The use of cultivated biomass as an energy source is beneficial to the environment. When burning fossil fuel oxygen is consumed and CO_2 is emitted to the atmosphere. The basic fossil fuel combustion reaction is:

$$C_{(s)}+O_{2(g)}+3.76N_{2(g)}\rightarrow CO_{2(g)}+3.76N_{2(g)}$$

[0006] The CO_2 concentration increase in the atmosphere, intensified in the last 200 years, is one of the reasons for the so called "greenhouse effect", which is supposed to be the main responsible for the planet heating. Besides, the corresponding decrease of the oxygen concentration in the atmosphere according reaction (**1**) is followed by a decrease in the ozone concentration, due to the thermodynamic equilibrium oxygen-ozone. The reduction of the ozone concentration increases the ultra violet radiation on the earth, and consequently the risk of skin cancer. If nothing is done to reduce the consumption of fossil fuels, the future generations will inherit a hostile planet. When burning a biomass fuel, CO_2 is emitted to the atmosphere in the same way as a fossil fuel. But during the growth of the cultivated biomass, CO_2 is absorbed from the atmosphere and oxygen is emitted through the photosynthesis process. The final balance is no reduction of the oxygen concentration in the atmosphere, which is extremely beneficial to the environment.

[0007] In natural life cycle soon after the biomass death an exothermic decomposition of its elementary molecules starts. Biomass conversion with energy liberation recreates the natural decomposition process, but in a much faster way, and this energy is a renewable energy. When burning biomass carbon is recycled, no CO_2 being emitted to the atmosphere, such as happens when burning fossil fuels. Biomass is the only source of renewable energy. Being a renewable source, it should to have in mind that fossil fuels are exhaustible.

[0008] Organic matter is the primary origin of fossil fuels. Organic matter piled up on the sedimentary rocks during the Cambrian geologic period, was transformed in the absence of oxygen in fossil fuels: coal, oil and natural gas. By its turn, this organic matter came from solar energy through the photosynthesis process. This accumulated chemical energy during 600 millions years has been increasingly wasted by humankind.

[0009] Energy from biomass can be obtained in several ways. When heated through a thermo-chemical process, biomass is decomposed in less complex substances. Any type of biomass can be submitted in a thermo-chemical conversion process. Due to the high productivity, low cost, high density and quality wood is the main biomass submitted to thermo-chemical processes. Pyrolysis is the anaerobic (lack of oxygen or air) thermal decomposition process. When oxygen is enough for the complete biomass chemical reaction, we have combustion or gasification.

[0010] Pyrolysis is the thermal biomass conversion at 300-800° C. temperature range in the total absence of air, or with not enough air for combustion. Biomass pyrolysis is also called carbonization or wood destructive distillation. Carbonization is the process when charcoal is the main product of interest. Heat can be indirectly supplied, or produced by burning part of the biomass (direct heating). High temperature (1,000° C.) produces a maximum of fuel gas (gasification), whereas low temperature pyrolysis (<500° C.) produces a maximum of charcoal.

[0011] When heating organic matter in the absence of oxygen, a chemical decomposition occurs giving a solid product—charcoal—and volatiles products partially condensable at room temperature. This condensation gives several liquid products such as pyrolygenous liquor, acetic acid, methanol, tar, and a significant amount of constituents in smaller proportion. With the exception of water vapor the condensable volatile components are highly polluters. The emission of a heavy smoke containing those condensable components, is very harmful to the health. After condensed those components pollute the soil and the water sources. The emission of those condensable components is a characteristic of the primitive brick carbonizing kilns.

[0012] Carbonizing temperatures when charcoal is the desired main product are in the range 300-500° C. Charcoal is light, has a high low heating value, and burns with no smoke, while wood is much denser, its combustion producing a lot of smoke. Charcoal contains ashes, its content depending on the type of wood, earth contamination, etc. Besides charcoal, a gaseous phase is emitted to the atmosphere, containing condensable and non condensable gases. The non condensable gases can be burned in order to generate thermal energy. Basically the components of the no condensable gases are: CO_2, CO, H_2, CH_4 and C_nH_m. The condensable gases also contain combustible components. When not burned, as already mentioned are strongly polluters and harmful to the health.

[0013] Pyrolysis is the basic biomass thermodynamic conversion process. When heated in the absence of air, a decomposition of the biomass in less complex components occurs. Pyrolysis is a complex process through intermediate radicals, the final result being a solid residue rich in carbon (charcoal), and a volatile fraction composed of gases, organic vapors and tar components. This volatile fraction if not used either as a fuel or for the liquefaction of the condensable components is very polluter. Although being a rather simple technology for the biomass conversion in solid fuel, carbonization is a very complex process.

[0014] Carbonization is performed in the following steps.

I—Drying—Before wood could be carbonized, the water in it must be driven off. It is a strongly endothermic step. The temperature does not go over 110° C. as far as the wood moisture is not driven off.

II—Final moisture water driven off, and dehydration reactions, temperature 110 to 175° C., still an endothermic step.

III—Pre-carbonization, temperature range 175-270° C., still an endothermic step. The wood decomposition starts, with the emission of CO, CO_2, acetic acid and methanol. Wood color changes to dark brown. Char is the product obtained in the final of this step.

IV—Transition step, temperature 270-290° C. Decomposition reactions continue, beginning the exothermic step.

V—Carbonization or pyrolysis—It is a term loosely applied when the chemical structure of wood breaks down under high temperature and in the absence of air. The pyrolysis phase is exothermic and the temperature rises up to 290-380° C. with the emission of hydrocarbon gaseous products, the solid residue becomes charcoal with a high volatile matter content. The emitted gases during pyrolysis have a significant heating value. Gases species are: CO, CO_2, H_2, CH_4, water vapor, hydrocarbon gases, and vapors of tar, methanol, acetic acid and pyrolygneous liquor. In the present text we use carbonization or pyrolysis for this stage.

VI—Final step, with an increase of temperature and fixed carbon, decreasing the volatile matter content. The higher the temperature, the higher charcoal fixed carbon content.

VII—Cooling—Charcoal produced must be cooled, in order not to burn when opening the kiln or retort, which must be tightly sealed.

[0015] Fixed carbon content is a very important metallurgical charcoal property. FIG. **1** shows the relation between carbonization temperature, fixed carbon, and gravimetric yield, which is, the ratio. (kg of charcoal)/(ton of anhydrous wood).

[0016] Basically the carbonization process starts with a strongly endothermic step before the exothermic step. It should be emphasized the difference in phase of the endothermic and the exothermic steps of the carbonization process, which starts with the strongly endothermic wood drying, followed by the exothermic carbonization step, and the emission of combustible gaseous substances. The energy emitted by the wood during the carbonization step is more than enough to supply the energy demand of the drying step. The problem of using the energy emitted by the carbonizing wood during the drying wood step is the difference in phase of those two steps. If the energy emitted during the exothermic step is wasted, part of the wood loaded into the carbonization reactor should be burned in order to supply the energy for the endothermic step, although the energy emitted during the exothermic phase plus the energy content of the combustible gases emitted during this step is more than the energy demanded by the endothermic reactions of the carbonization process.

[0017] Table I is a summary of the theory of the evolution of biomass carbonization.

TABLE I

Theoretical evolution of the wood carbonization.

	Temperature-° C.					
	>100	200-280	280-380	380-n 500	500-700	700-900
Period	Drying	Pre-carbonizing		Carbonizing		
	Water release	Oxygenated gases release	Start of hydrocarbon gases release	Hydrocarbon gases stage	Charcoal dissociation	Hydrogen stage
Fixed carbon	60%	68%	78%	84%	89%	91%
Non condensable						
% CO2	68.0	66.5	35.5	31.5	12.2	0.5
% CO	30.0	30.0	20.5	12.3	24.6	9.7
% H2	0.0	0.2	6.5	7.5	42.7	80.9
% Hydrocarbon	2.0	3.3	37.5	48.7	20.5	8.9
LHV Gas Kj/Nm3	4,600	5,000	16,300	19,800	15,300	13,200
Vapor condensable components	Water vapor	Water vapor Acetic acid	Acetic acid Methylic alcohol Light tars	Heavy tars	Tar Parafin	Little condensation
Gases Quantity	Very small	Small	Important	Important	Small	Large
Gases components		CO2, CO, CH3OH, CH3CHO, CH3CO2H	CO2, CH4, CO, H2O, H2, CH3OH, CH3CHO, CH3CO2H	H2, CO, CO2, Hydrocarbons		
Gravimetric yield - %		44.0	38.0	35.0	31.0	26.0

Ref.—Uhart, 1971; Doat & Pétroff, 1975

Carbonization Technique Actual State

[0018] Charcoal is the first wood product used by mankind. Cave men observed that the residue of burned wood produced a hotter flame with less smoke in the cave. Later on, when by hazard a mixture of this residue was fired together with certain types of stones, a heavy liquid emerged, starting in that way the age of metals.

[0019] The annual charcoal consumption in Brazil is over 8 millions tons. Approximately 60% of the wood for charcoal production in Brazil comes from the high productivity eucalyptus plantations. In Brazil only the kiln method is used for charcoal making. Those kilns do not take advantage of the exothermic energy phase, burning part of the charged wood in the kiln as the energy source for the carbonization process. Besides, brick kilns have no charcoal quality control because the whole operation is based on visual observation of the emitted gaseous products color.

[0020] Several types of charcoal producer furnaces were developed since the beginning of its utilization. The first charcoal production process was probably the pit kiln, used until today in some countries. Wood is slowly burned in a pit covered by earth. According to the heat generation process, carbonizing furnaces can be classified as:

[0021] a)—Internal wood combustion by a controlled air input.

[0022] b)—External combustion.

[0023] c)—Retort with gases recycling.

[0024] Internal wood combustion is the more common type. Carbonization starts by a controlled air input into the furnace in order to burn part of the wood and heat the kiln until the carbonization temperature. Air input continues always in a small controlled amount, until the complete wood transformation in charcoal. Gases and volatiles produced during the carbonization process are emitted to the atmosphere, charcoal being the only product. In this type of furnace up to 20% of the charged wood is burned. This is one of the oldest processes of charcoal manufacture, the more common furnaces being earth mound and pit kilns, portable steel kilns and brick furnaces. In Brazil until today only brick furnaces are used.

[0025] In the external combustion furnaces the hot gases from a combustion chamber are introduced into the furnace in order to supply the necessary heat for the endothermic carbonization steps. It is possible to burn any kind of fuel in the combustion chamber, such as agricultural and forestry wastes, charcoal fines, tar, fuel oil or natural gas. The investment cost in this system is higher, but it allows a better control, producing good quality charcoal with a higher yield.

[0026] The retort method uses retort which works on a continuous basis. Wood is loaded at the top and as it descends through the retort it is first dried by ascending hot gases in the top section, then carbonized by recycling hot gases in the middle section, and finally cooled and withdrawn at the bottom. An ingenious system of recirculation and combustion of the pyrolysis gases ensures that the maximum advantage is taken of their thermal and chemical energy content. The automatic working of the plant leads to a reduction of the personnel required.

[0027] Retort processes are normally used when the desired main product is the liquefied volatiles emitted by the carbonization wood, charcoal being a by product. Through a sequence of distillation and condensation operations several important chemical products such as acetic acid, methanol, solvents, food aromatizers, etc, are recovered from the carbonizing wood. Due to the much higher investment cost, carbonizing retorts are not economically feasible when the only desired product is charcoal. Besides it is necessary to saw the wood in short logs, not over 30 cm. The investment cost is raised by the saw mill and the wood sawing operation raises the charcoal cost. As above mentioned, in Brazil only the brick kiln method is used. Brazil is the greatest charcoal producer in the world and almost 95% of its production occurs in the South East states of Minas Gerais, Sao Paulo, Goias and Bahia located approximately 3,000 kilometers from the Amazon region. The charcoal main applications are: as thermal reducer in the iron, ferrous alloys, silicon metal, calcium carbide furnaces and as renewable energy source in the lime and cement industry. Approximately one third of the pig iron produced in Brazil is based on the charcoal as a thermal reducer.

[0028] The typical beehive furnace used in Brazil has 10 to 30 cubic meters capacity, FIG. **2**. Log wood is vertically charged into the kiln through gate **1**. Above these shorter horizontal logs are placed to the underside of the dome. After charging, the door openings are bricked up and sealed with a weak cement and mud mortar. Ignition is started through the hole **2** on the top, which is closed when the fire takes hold. The beehive kiln has been improved by erecting a chimney aside walls **3**.

[0029] Carbonization moves downward, with air being drawn in through holes in the dome and vertical wall **3**, the smoke being emitted by the same holes. As the combustion proceeds, all openings are sealed. When the smoke coming from the chimneys turns a light blue, all the openings, including the chimneys, are closed and sealed carefully with mud. The kiln is then brushed all over with several layers of clay slurry to close all leaks and cracks. If this is not done thoroughly, the infiltration of air will maintain a certain amount of combustion and slow the cooling. Air leakage into the kiln would burn the charcoal from the carbonizing wood. The charcoal cooling, which is the final carbonization step is started. Total time for the complete cycle goes from 9 to 13 days. The beehive kiln has been improved by erecting chimneys aside walls **3**.

[0030] A very high volume concrete kiln developed and still used in the United States is known as Missouri kiln. Those kilns are large permanent structures which were developed for charcoal making in the deciduous hardwood forest of the state of Missouri, from which they get their name. They are rectangular in shape with a vaulted roof, FIG. **3**. They vary greatly in size normally up to 12 meters long, 7 meters wide and 4 meters tall. This enables considerable economy of scale, the entry of vehicles for direct loading and unloading, but the kiln is difficult to control.

[0031] The concrete walls were replaced by low density refractory silicon-aluminum bricks. The walls **4** thickness is normally 25 cm, FIG. **3**. Steel doors gates **5** are protected by refractory concrete. The kiln usually has four chimneys **6**, along each side. Air vents **7** are provided along the base of the furnace walls. Wood is charged upon a log basis transversally placed on the soil. The wood pile is lid through a channel **8** under the central part of the furnace. The furnace operation requires considerable skill. The doors in particular are vulnerable to misuse and if the seal is damaged, operation of the furnace becomes very difficult.

[0032] Such as in the beehive type of brick furnaces, the carbonization is controlled by the color of the emitted gases. A light blue color occurs in the end of the carbonization process. By closing the air vents **7**, the charcoal cooling is started. Like the beehive furnaces, the total cycle lasts from 9 to 12 days.

[0033] A deficiency of the Missouri furnace is the non homogenous carbonization. In a certain moment there may be very hot regions where the charcoal burns, together with regions still in the final wood drying step. An evolution of the furnace control is the temperature measurement by infra red pyrometers, which show the differences in temperature. Through the control of the air input by the air vents **8**, a better homogenization of the carbonizing wood pile is obtained.

[0034] In Brazil, Missouri furnaces were installed by some companies, mainly by the integrated steel mills. Most of the Brazilian charcoal producers operate with traditional brick furnaces not equipped with smoke recycling or ways to burning the energetic gases emitted by the carbonizing wood.

[0035] Brick furnaces do not take advantage of the combustible gases emitted by the carbonizing wood. As a result, one of the basic characteristic of these furnaces is the burning of part of the charged wood. In the brick kilns occurs a certain overlapping of the drying and pyrolysis steps. The emission to the atmosphere of harmful gases containing up 45 to 50 kg of methane per ton of charcoal is another characteristic of these kilns. As far as greenhouse effect is concerned, this methane content is equivalent of one ton of CO_2.

[0036] The humidity content of the charged wood in the traditional brick furnaces should be not over 25-30% (w.b.). Soon after being cut down, wood moisture content is an average of 50% (w.b.). It is impossible to carbonize or to use wood as a fuel with this moisture content, being necessary to reduce it to 25-30% (w.b.) level, which is done by appropriately piling it during 100 to 120 days. This labor intensive piling requires the following operations.

[0037] Wood cut in logs at least one meter long.

[0038] Wood piling in an adequate way in order to air dry it.

[0039] Load the log wood in the truck.

[0040] Transfer of the wood from the truck to the furnace when Missouri kilns are used, or to the yard in the case of beehive kilns.

[0041] Wood feed into the beehive furnaces.

[0042] Transfer of the charcoal from the brick kiln to the truck. During the transfer of the lower layers impurities are many times mixed with the charcoal.

[0043] Transfer from the truck to the charcoal bin.

[0044] This labor intensive sequence of operations is responsible for approximately 60% of the charcoal from brick furnaces cost. Besides, when contaminated by impurities the charcoal ash content is raised.

[0045] Gravimetric yield is the relation (kg of charcoal/(ton of anhydrous wood). Due to the burning of part of the charged wood brick furnaces gravimetric yield is low, from 25 to 34%. That is, only 250 to 340 kg of charcoal per ton of anhydrous wood is obtained. The upper level of this range is obtained in the rectangular brick furnaces with internal temperatures measurement.

[0046] It follows that the main disadvantages of carbonizing wood in brick furnaces are:

1—Low gravimetric yield.

2—Emission to the environment of harmful gases.

3—Long cooling time due to the low heat conductivity of the brick walls.

4—Non homogeneous charcoal quality.

5—Lack of carbonization control, which is made by the smoke color and the brick wall temperature.

6—The carbonization routine can be led in more than one way, depending on the operator.

7—Burning part of the charged wood in order to supply energy for the endothermic carbonization step.

8—Low productivity, due to the long cycle time.

9—Waste of the energetic gaseous (condensable and non condensable) emitted during the wood carbonization.

10—Necessity of storing the wood for drying.

SOLUTION OF THE PROBLEMS

[0047] The principal aim of the present invention is to solve the above mentioned problems by providing a method for carbonizing biomass that considerably simplifies, with respect to conventional carbonization methods, the operations for pollutant removal and for energy recovery of the products of biomass pyrolysis.

[0048] Within the scope of this aim, an object of the invention is to provide a method that can be controlled and managed in a very simple manner on the basis of parameters preset according to the type of biomass being treated, with high operating flexibility. Another object of the invention is to provide a plant that can perform such a treatment method in a practically continuous manner.

[0049] Another object of the invention is to provide a structurally simple plant requiring relatively low investments and operating costs.

[0050] Another object of the invention is to provide a plant offering adequate assurances against a danger of environmental pollution.

[0051] This aim, these objects and others which will become apparent hereinafter are achieved by a wood carbonizing system which uses the gaseous constituents emitted by the wood during the pyrolysis step as the supplier of the necessary energy for the process. There follows the description of the devised system, which we named the DPC Process.

[0052] The emitted energy during the exothermic step of the biomass carbonization is sufficient to meet the thermal demand of the process endothermic phases. But brick kilns do not take advantage of this energy because the endothermic stage occurs before the exothermic pyrolysis step. The wood carbonizing process is self sufficient in energy. However, this energy is only available after the drying endothermic stage, being necessary to burn part of the carbonizing wood in brick kilns. The DPC Process basic characteristic is the sharp separation of the drying and pyrolysis stages, which are performed in independent reactors in such a way that the energy content in the emitted gases by the carbonizing wood is used to supply the thermal demand of the endothermic steps. The devised DPC Process resolves the drying and pyrolysis steps difference in time problem.

[0053] The basic concepts of the DPC Process described in this exposition are:

1—Utilization of the emitted gases—condensable and non condensable—as a source of the thermal energy required by the carbonization process.

2—Utilization of the gases emitted during the pyrolysis step as a heat carrier for the endothermic stage of the pyrolysis.

3—The functions of wood drying, pyrolysis and the charcoal cooling are performed simultaneous and independently into a least three reactors, FIG. **4**. The emitted gases during pyrolysis with a significant heat value are burned in a combustion chamber, generating hot gases which are transported to the reactor performing the wood drying

[0054] Any DPC reactor can perform the functions of drying, pyrolysis and charcoal cooling. The process can be performed in more than three reactors, depending on the desired capacity of the charcoal plant.

[0055] The disposal of the reactors in the DPC Process, object of the present report, is shown in FIG. **4**. The system consists of three independent reactors, **9**, **10** and **11**, and an independent combustion chamber **12**. Let us suppose that in a certain moment the drying step is performed in reactor **10**, and charcoal being cooled in reactor **11**. In reactor **10** condensable and non condensable gases containing combustible components are emitted by the carbonizing wood. These gases exit reactor **10** through pipe **13**. Most of these gases are transported through pipe **13** to the collecting pyrolytic gases pipe **14**, passing through valves **15** and **16**. Valve **15** stays opened allowing the pass of the gases to collector pipe **14**, but hinders the pass of the ditto gases to the diluting gases collector **17**. From the collector pipe **14** pyrolytic gases are transported to the gas burner **18** situated at the combustion chamber **12**, flow controlled by valve **19**, passing before through gasifier **20**. Combustion air driven by fan **21**, flow controlled by valve **22**, mixed with the fuel gases in the burner **18**. Combustion air is preheated by heat exchanger **23** placed inside the combustion chamber **12**. Hot fuel gases generated by the carbonizingwood return to the reactor **10** driven by fan **24** through pipe **25**, flow controlled by valve **26**. The purpose of this return is to control the temperature in the carbonizing reactor. The fixed carbon content and other metallurgical charcoal properties are functions of the carbonizing temperature. Therefore part of the pyrolytic gases flow in a closed circuit, a looping. The fuel gases closed circuit with the aim of a precise control of the biomass carbonizing stage, is a basic characteristic of the DPC Process described in this text. The carbonization end is shown by the decreasing pyrolytic gases flow. The temperature in the carbonizing reactor **10** remains in the range 310-350° C., adequate to the metallurgical charcoal. The carbonization speed is controlled by the return flow of the pyrolytic gases.

[0056] Hot flue gases generated by burning pyrolytic gases in the combustion chamber **12** are driven by fan **27** through pipe **28** to mixer **29**. Diluting gases coming from drying reactor chamber **9** are mixed with hot flue gases coming from combustion chamber **12** inside mixer **29**. This gaseous mixture suctioned by fan **27** is driven to the pipe collecting hot gases **30** by pipe **31**, flow controlled by valve **32**. From pipe **30**, hot flue gases mixed with said diluting gases coming from reactor **9**, are suctioned by fan **24** through pipe **33**, passing by valve **34** totally opened, and by control flow valve **35**. Hot flue gases are then insufflated into the drying reactor **9**. Steam from the drying wood joins the hot flue gases. This gaseous mixture exits the drying reactor at approximately 120° C. through pipe **13**, being driven to the diluting gases pipe **17**, valve **15** remaining totally opened, and valve **16** totally closed. Pipe **17** is a diluting gases distributor. These gases are transported to mixer **29** through pipe **36**. Inside mixer **29** the diluting gases, which we will name recycle gases, are mixed with the hot flue gases coming from the combustion chamber **12**. The excess of the recycle gases is driven through pipe **37** to the chimney **38**, flow controlled by valve **39**, and from said chimney **38** to the atmosphere. The drying reactor **9** inside which wood drying is performed demands the maximum heat input. In order to avoid high temperatures in the drying reactor, hot flue gases exiting combustion chamber **12** are mixed with the diluting gases flowing through pipe **17**. This technique, which we named "recirculation", allows the heat input in the drying reactor **9** at the desired temperature. The drying reactor **9** ideal entering gas temperature is in the range 300-350° C. Performing in this temperature range undesirable steel containers overheating will not occurs. Besides when drying at high temperatures, wood cracks weakening the charcoal. The recirculation technique is another basic characteristic of the DPC Process described in the present text.

[0057] Most of the pyrolytic gases generated during the wood carbonizing step are driven to the burner **18** of the combustion chamber **12**. A small parcel of ditto gases return to the carbonizing reactor **10** in order to control the carbonizing wood temperature, as above explained. As a result of this technique no polluting gases are emitted the atmosphere. Depending on the initial wood moisture, an excess of flue gases from the combustion chamber may occur. Ditto excess is driven by pipe **28**, through valve **40** to the chimney **41**, from which they are emitted to the atmosphere.

[0058] Charcoal cooling is being performed in reactor **11**, which is done in two stages. The cooling starts by turning off fan **24** and closing control flow valves **26** and **35** placed in pipes **25** and **33**. Valve **15** remains closed. Reactor **11** should be tightly sealed, since any air leakage will burn the hot charcoal. Heat radiation to the atmosphere starts the charcoal cooling. During this cooling stage, a small part of the carbon contained in the gaseous atmosphere from the carbonization stage, is absorbed by the charcoal, slightly raising the charcoal fixed carbon. Besides this gaseous atmosphere small pressure hinders atmospheric air entrance. Charcoal cooling continues by the injection of a very fine water spray in reactor **11**. Water is injected under high pressure by pump **42** to atomizer **43** through pipe **44**. Water is divided in very fine drips, which quickly vaporizes cooling the charcoal. When the cooling reactor **11** temperature falls to 95° C., water injection is stopped. Charcoal cooling is concluded by heat radiation to the atmosphere.

[0059] During the entire carbonization process in reactors **9**, **10** and **11**, wood remains motionless, avoiding charcoal fines generation. Wood drying, carbonization and charcoal cooling occur simultaneously until the end. When the process is terminated drying reactor **9** receives hot pyrolytic gases, charcoal cooling starts in reactor **11**, and reactor **11** is unloaded. A new wood container is placed in reactor **11**, starting the wood drying. By adequate maneuvers in valves **15**, **16** and **34** situated in pipes **14**, **17** and **30**, reactors **9**, **10** and **11** functions are changed. Reactor **9** becomes a pyrolysis kiln, charcoal cooling is done in reactor **10**, and reactor **11** becomes a drying reactor. When starting the system, fuel gas to burning in combustion chamber **12** is not available, as none reactor is in the pyrolysis stage. Therefore an external heat source is necessary in order to start and finish the drying of the wood loaded in reactor **9**. Two options are available for the system start: natural gas utilization in burner **18**, or, which is preferable, to set up a wood gas producer. The first cycle will be started by burning wood gas coming from this gas producer. FIG. **4** shows the wood gas producer **20** and pipe **45** which transports the low heating value gas generated in the gas producer **20** to the burner **18**. The gasifying agent comes from mixer **46**, being injected in gas producer **20** by fan **47**, flow controlled by valve **48**. Atmospheric air is driven to mixer **46** through pipe **49**, flow control by valve **50**. Diluting gas is carried to mixer **40** through pipe **51**, flow control by valve **52**. A small proportion of diluting gas is mixed with the gasifying air in order to avoid too high temperatures in the lower part of the gas producer. The gas producer capacity should be adequate to the thermal demand by the drying reactor **9**. Besides, the gas producer will assure the supply of fuel gas in the case of an eventual deficiency of combustible gas emitted by the carbonizing wood.

[0060] It should be remarked that once started the system by burning a fuel gas from an external source, the process is continuous, although wood remains motionless during the whole cycle. There is permanently in operation a drying reactor, a carbonizing reactor and charcoal cooling in the third one. At the end of the cycle the function of each reactor changes, but the process is incessant, continuous. Total wood carbonization time in the DPC Process is approximately 72 hours. Taking into account the possibility of loading the wood in the drying reactor soon after cutting down the wood, charcoal can be made approximately seven days after the wood cutting down, while in brick kilns this time goes over 130 days.

[0061] In the starting of the carbonization stage and at the end of the wood carbonization, emission of combustible gaseous constituents is very small. In order to assure the continuous supply of combustible gas to the combustion chamber **12** it is necessary a minimum of six reactors in operation. So, we will have two or more carbonizing reactors, two or more drying reactors and the correspondent number of cooling reactors. In order to avoid oscillations in the pyrolytic gas volume and in its low heating value, carbonization in second reactor is started when the first reactor is near to maximum gas emission. In that technique of operation when fuel gases generation in the first reactor starts decreasing, the second reactor is going towards the maximum pyrolytic gases emission, which allows the regularity maintenance. The system productivity is increased when a minimum of six reactors is running.

[0062] FIG. **5** shows a system with six reactors.

[0063] In FIG. **5** we can see three master pipes collectors of the different process gases. Pipe **52** is the pyrolytic gases collector, flowing in this pipe only this type of gases. Pipe **53** carries the pyrolytic gases to pipe **54**, flow controlled by valve **55**. Combustible gases generated by the carbonizing wood are driven to burner **56** set at the combustion chamber **57**, reaching burner **56** through pipe **58**. These gases were produced in the wood carbonizing reactors, supposed to be reactors **59** and **60** at the moment chosen for this description. Gases emitted by the carbonizing wood are transported to pipe **53** by pipe **61**, passing before through valves **62** and **63**. These valves are fixed in such a way that valve **62** although closed, allows passage of the pyrolytic gases only towards pipe **53**, crossing valve **57**, which at this moment remains opened. Part of the pyrolytic gases return to reactors **59** and **60** through pipe **64**, suctioned by fan **65**, flow controlled by valve **66**. The purpose of this return is the temperature control in reactors **59** and **60** in order to avoid the carbonization wood superheating during the pyrolysis exothermic stage. This technique has been previously expounded in the case of three reactors, FIG. **4**. Having two carbonizing reactors, the supply of fuel gas to combustion chamber **57** according the process needs is assured.

[0064] At the moment chosen for this description, reactors **67** and **68** are processing the wood drying. Hot flue gases produced in combustion chamber **57** are suctioned by fan **69** through pipe **70**, which transports ditto hot gases to mixer **71**. From mixer **71** hot flue gases are carried to the collecting flue gases **72**, through pipe **73**, flow controlled by valve **74**. From pipe **72**, said gases are driven to the drying reactors chambers **67** and **68** through pipe **75**, flow controlled by valve **76**. During the wood drying in reactors **67** and **68** water vapor coming from the wood dehydration joins the hot flue gases which entered the drying reactors at 300 to 350° C. Said hot flue gases plus water vapor are driven through pipe **61** to the collecting recycle gases pipe **77**. At this moment valve **62** remains opened and valve **63** remains closed. In other words, effluent gases from drying reactor have no way to access pipe **53** going only to pipe **70**. At this moment valve **66** remains opened for the recirculation. Diluting gases are led to pipe **78**, flow control valve **79**, to the entrance of mixer **71**, where said gases mix with the hot flue gases coming from combustion chamber **57**; with the purpose to obtain the correct drying temperature, such as described in the system with three reactors, FIG. **4**. Such as in the system described with three reactors, FIG. **4**, the excess of hot flue gases produced in the combustion chamber **57**, is carried through pipe **80**, valve **81**, to the chimney **82**, and from said chimney **82** to the atmosphere. The excess recycle gases is driven through pipe **83**, flow control valve **84** to the chimney **85**, and from chimney **85** to the atmosphere. Such as in the system described for three reactors, FIG. **4**, no polluting substances are emitted to the atmosphere.

[0065] At this moment reactors **86** and **87** process the charcoal cooling. Such as in the system with three reactors, charcoal cooling is started with reactors **86** and **87** well sealed, through heat radiation to the atmosphere; continuing by water spray injected by pump **88** through pipe **89** to the water atomizer **90**. When cooling reactors temperature falls to 95° C., charcoal cooling is completed by the heat radiation to the atmosphere.

[0066] The DPC Process described in the present text provides a precise control of the wood carbonization process, producing charcoal according to the metallurgical properties specified by the user. The control is made through pyrometers installed at the gases entrance and the gases exit of each reactor. When drying starts the temperature difference between the entering and the exiting gases is large due to the wood heating and humidity water vaporization thermal demand. This temperature difference reduces while drying goes on. The end of the drying period will be shown by these temperatures convergence, the drying reactor becoming available for the wood carbonization stage. The control of the process through pyrometers placed at the entrance and the exit of each reactor allows the DPC system automation. During the wood carbonization stage the charcoal fixed carbon is a crescent function of the temperature, while the gravimetric yield is a decreasing function of the temperature. FIG. **1** shows the relation between carbonizing temperature, charcoal fixed carbon and gravimetric yield. Steel industry is the main charcoal consumer in Brazil for the pig iron blast furnace. Charcoal fixed carbon for the pig iron blast furnace is specified in the range 70-75%. FIG. **1** shows that carbonizing temperature should be in the range 320-350° C. for the fixed carbon content in the range 70-75%.

[0067] In the DPC process, object of the present exposition, no combustion occurs in the carbonizing reactor; so it is not necessary carbonizing temperatures over 350° C. As this temperature is compatible with the performance of common carbon steel, it is possible to place the wood in metallic containers.

[0068] The energy content of the emitted gases by the carbonizing wood is sufficient to drying wood soon after cutting down, according to thermodynamic computations. The cutting down wood humidity is approximately 50% (w.b). One of the advantages of the DPC process is the capacity to drying wood soon after cutting down, avoiding the wood storing at the atmospheric air in order to reduce the humidity to water content in the wood compatible with the carbonization process in brick kilns. That storage has an economical cost. However, if convenient to recover the condensable products, wood can be dried by adequately placing it in the atmospheric air during a minimum of one hundred days. Condensation of the condensable constituents present in the pyrolytic gas followed by separation of the various products by the conventional extraction processes will allow the recover of several wood liquid products present in the condensable gases.

[0069] Alternatively, the energy of the fuel gases emitted by the carbonizing wood can be used for thermal electric generation. It is an economically very attractive alternative if the carbonization plant is located in the proximity of the charcoal blast furnace. Hot flue gases effluents from auxiliary equipments of the pig iron producer plant can be used for the wood drying. In that case, pyrolytic combustible gases or tar produced by the condensation of those gases, can be used for thermal electric generation, which turns the pig iron plant self sufficient in energy.

[0070] As previously explained, in the traditional wood carbonization brick kilns, it is necessary to store the wood in order to dry it. The wood handling for storing, drying and transporting to the brick carbonizing kilns is responsible for approximately 60% of the charcoal cost. It should be added the financial cost due to the drying time, minimum of one hundred days in the Brazilian weather conditions.

[0071] DPC Process described in this exposition gives the opportunity for an excellent solution of the drying logistic problem.

[0072] Soon after cutting down wood in the forest without any kind of piling, is sawed in the length of a roll on truck bucket with no need of several smaller wood cuts. The cut wood is manually or mechanically loaded into the bucket of a roll on truck. The truck raises the bucket onto its body, and carries the bucket full of wood to the carbonizing plant where the bucket is placed into the drying reactor, starting soon after the wood drying. At the end of the carbonizing process the truck takes out the bucket of this reactor, and transports the charcoal to its store bin. It should be noted that between the wood sawing and the charcoal unloading into the bin, no laborer work has been necessary. This technique has been possible due the absence of any kind of combustion in the interior of the carbonizing reactor and due to the temperature control. Besides there is not any kind of charcoal contamination by the impurities present in the kiln floor. FIG. **6** shows the arrangement of the association DPC equipment—roll on bucket. This technique is a significant advantage of the DPC Process described in this report when compared with the conventional brick kilns carbonization.

[0073] Due to the independence of the drying, pyrolysis and cooling reactors it is possible to halt the process at any stage. So, DPC Process can produce anhydrous wood, char or charcoal with a high volatile content. The later is a very convenient fuel, adequate to replace fossil fuels in industrial furnaces or in boilers.

[0074] A biomass energy concentration is done through anhydrous wood, char or high volatile charcoal. Due to the distances in large countries like Brazil, the biomass energy concentration is very relevant for its transportation.

[0075] It is possible to carbonize small size biomass such as coconut shells, bones, babassu palm coconut, elephant grass, straw, sugar cane and a variety of other biomass can be used in the DPC Process. Tests done in a DPC reactor showed the elephant grass carbonization feasibility, which was achieved by the first time in the world.

[0076] The following products can be obtained by the DPC Process.

[0077] Charcoal with a minimum of 78% fixed carbon content to be used as a reducer in the electric furnaces. In comparison with coke the advantages are: no sulfur and higher electric resistivity.

[0078] Charcoal for the steel industry. Advantages when compared with coke: no sulfur, higher reactivity, lower ash content, smaller slag volume.

[0079] Charcoal with 30-50% of volatile matter, the ideal fuel for replacing fossil fuels in the industry or for thermoelectric generation.

[0080] Charcoal from small size biomass, agricultural wastes in general.

[0081] Char.

[0082] Anhydrous wood.

[0083] Table 2 shows the low heating value of these products.

TABLE 2

Main wood products low heating value.

PRODUCT	LOW HEATING VALUE - KJ/KG
WET WOOD	6,275-8,367
AIR DRIED WOOD	11,295-12,550
ANHYDROUS WOOD	18,425-22,000
CHAR	22,590-23,000
HIGH VOLATILE CHARCOAL	25,000-27,600
BLAST FURNACE CHARCOAL	30,000-31,400

[0084] The energetic concentration given by the DPC Process, as shown in table 2 is very relevant for large countries.

[0085] Table 3 shows a comparison of the unit energy cost from biomass, and from fuel oil, according to current prices in Brazil. The third column of table 3 indicates the relation between the biomass energy unit cost and the fuel oil energy unit cost.

TABLE 3

Comparison of the energy unit cost.

PRODUCT	LHV - GJ/T	US$/GJ	US$BIOMASS/US$FUEL OIL
AIR DRIED WOOD	12.0	5.5	0.25
CHAR	22.5	11.1	0.51
HV CHARCOAL	26.0	13.7.	0.64
B.F. CHARCOAL	30.1	14.8	0.69
FUEL OIL	40.1	21.5	1.00

[0086] The advantages of the DPC Process object of the present exposition, associated with the use of roll on buckets are.

1—Higher charcoal yield.

2—No noxious emissions to the atmosphere.

3—It is not necessary to store wood during a long time in order to reduce its humidity.

4—It is not necessary to saw the wood in small lengths.

5—The wood remains motionless in the reactors, which eliminates charcoal fines generation.

6—Lower labor cost.

7—A lower charcoal production cost.

8—An important logistic advantage.

9—Able to produce anhydrous wood, char and charcoal with high volatiles content, very convenient fuels.

10—It is a process suitable for any degree of mechanization or automation.

11—Precise process control.

12—It is a high productivity process, the residence time of the wet wood in the reactor is in the order of 72 hours.

13—The investment cost expressed in US$ per ton of charcoal is lower than the retort processes (continuous carbonization process).

14—It is possible to carbonize small size dimensions biomass.

[0087] There are also significant social advantages given by the DPC Process in the case of Brazil. No childish or slave hand labor is used. A DPC Process wood carbonization plant will only employ qualified professionals, adequately trained, representing a social gain.

[0088] The process is suitable for the carbonization of several high productivity biomass crops, such as sugar cane and elephant grass raising a new window of opportunities for the strong agricultural sector of the Brazilian or any other large country economy. Harvesting sugar cane or elephant grass for energy applications can be an important job generator in remote and poor areas of any country, avoiding the migrant exodus to the big cities.

[0089] The energetic concentration of the biomass given by the DPC Process is very important for any developing country.

[0090] The use of the cultivated biomass by the steel industry can generate a lot of jobs in the field, reducing the migration of rural laborers to the big cities. Each ten hectares of cultivated forest, generates a job in the field.

[0091] The economic advantages of the DPC Process can be resumed as follows. Approximately 60% of the pig iron cost is due to the charcoal. A significant reduction in the charcoal cost given by the DPC Process will decrease the pig iron and steel cost, raising the competitive conditions of the producer companies of these commodities. Besides, pig iron and steel obtained when charcoal is used as a thermal reducer have better quality.

[0092] The gravimetric yield, that is (kg of charcoal)/(ton of anhydrous wood) of the DPC Process is in the range 40-42%, while brick kilns range is 28-34%. In other words, while brick kilns produce 280-340 kg of charcoal per ton of anhydrous wood, the DPC Process obtains 400 to 420 kg of charcoal per ton of anhydrous wood. That means an increase of 30% in the charcoal production per hectare of cultivated forest. As a result, keeping constant the charcoal consumption by the steel or pig iron plant, the forest will last 30% more time.

[0093] Numerous tests, starting in small units later in industrial reactors, have confirmed all advantages of the DPC Process, with emphasis in the higher gravimetric yield, and no pollution at all.

[0094] The remarkable reduction of the charcoal cost and the increase of cultivated forest time duration are sufficient to emphasize the important advantages of the DPC Process, an innovative process integrally developed in Brazil.

What is claimed is:

1- A plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to obtain charcoal, said plant comprising: reactors chambers, inside which roll on buckets are placed, a combustion chamber, said combustion chamber located away from the reactors; inside the combustion chamber a heat exchanger is placed; pipes, and a conjunct of fans for moving the process gaseous substances.

2- A method for the thermal pyrolytic treatment of organic matter, particularly wood in order to obtain charcoal, according to claim **1**, comprising a step for loading the organic matter or wood onto a roll bucket; a step for the insertion of said roll on bucket containing the organic matter or wood inside a drying reactor chamber; a step for heating and drying the organic matter or wood inside said drying reactor chamber; a step for carbonizing said organic matter or wood inside said carbonizing reactor chamber; a step for cooling the charcoal or any intermediate product inside said cooling reactor chamber; and a step for removing away the roll on bucket containing charcoal or any intermediate product from said cooling reactor chamber.

3- A method for the thermal pyrolytic treatment of organic matter, particularly wood in order to obtain charcoal, according to claims **1** and **2**, comprising a conjunct of interconnected reactor chambers, between which the process gaseous fluids flow through pipes.

4- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal according to claims **1**, **2** and **3**; wherein the process stages of drying carbonizing and cooling occur simultaneous and independently inside said reactor chambers in such a way that only one of said steps is being performed in a certain reactor chamber.

5- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal, according to claims **1** and **2**, characterized by the utilization of a combustion chamber placed away from said reactor chambers.

6- A method for the thermal pyrolytic treatment of organic matter particularly wood on order to obtain charcoal, according to claims **1** and **5** wherein a heat exchanger is placed inside ditto combustion chamber.

7- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal, according to claims **1**, **2**, **3**, **4** and **5** wherein a conjunct of fans aspire and blow the process gaseous substances through pipes and into the reactor chambers of the system; ditto gaseous substances at the temperature and the chemical composition according to the step being performed inside the respective reactor chamber.

8- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal, according to claims **1**, **5** and **7** wherein the emitted gaseous substances by the carbonizing wood are burned in said combustion chamber, avoiding in this way any kind of pollution by ditto gaseous substances.

9- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal, according to claims **1**, **3**, **4**, **5**, **7** e **8** wherein fumes exiting form said combustion chamber are transported to the drying reactor, and insuflated into said drying reactors.

10- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal, according to claims **1**, **3**, **4**, **5**, **7** and **9** wherein fumes which incorporated water vapor emitted by the drying wood, are partially recycled and mixed with ditto fumes exiting said combustion chamber in order to adjust the temperature of the gaseous substances blown into said drying reactors chambers.

11- A method for the thermal pyrolytic treatment of organic matter particularly wood in order to obtain charcoal, according claims **1** and **6** wherein during the pyrolysis step inside the carbonizing reactor chamber, part of the gaseous substances emitted by the carbonizing wood are driven to ditto heat exchanger where they are reheated returning thereafter to ditto carbonizing reactor chamber; as a thermal fluid in order to control the carbonizing temperature according to the desired charcoal fixed carbon.

12- Method for the thermal pyrolytic treatment of organic matter particularly wood in order to make charcoal, according to claims **1**, and **5** wherein the energy content of the gaseous substances emitted by the carbonizing wood, can be utilized either to drying high moisture content wood, or to supplying energy of any purpose, such as for example, thermo electric generation.

13- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **4** and **7** wherein means for transporting hot fumes plus diluting gases to the drying reactors comprises an aspirator, said aspirator being connected to the combustion chamber through an extraction duct.

14- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **4**, **5** and **6** wherein means for extracting the gaseous substances emitted by the carbonizing wood inside the carbonizing reactors chambers comprises an aspirator, said aspirator being connected to ditto carbonizing chambers through an extraction duct.

15- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according do claims **1** and **5** wherein the excess hot fumes generated inside said combustion chamber not necessary for the drying stage, is driven to a discharge duct being connected to a stack which discharge said flue gases to the atmosphere, in such a way that no polluting gaseous substances are emitted to the atmosphere.

16- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **4**, **9** and **10** wherein the excess diluting recycled gases not necessary for the drying stage, is driven to a discharge duct being connected to a stack which discharge said diluting gases to the atmosphere in such a way that no polluting gaseous substances are not emitted to the atmosphere.

17- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **2**, **3** and **4** wherein the charcoal or any other solid substance produced, is cooled through heat radiation to the atmosphere, said cooling continuing by a water spray inside said cooling reactor, and completed by heat radiation to the atmosphere.

18- Method for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **2**, and **4** wherein the carbonization process can be halted at any stage in order to produce anhydrous wood, char or charcoal with hi volatile matter content.

19- Method for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according claims **1**, **2** and **4** wherein the process is controlled through temperature measurements of the entering and exiting gaseous substances into and from each reactor chamber.

20- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1** and **2** wherein the organic matter particularly wood to be thermally treated, is loaded onto roll on buckets, inside which after insertion into said reactor chambers the drying, pyrolysis and cooling stages will be simultaneous and independently performed.

21- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **2** and **4** wherein the condensation and by products recovery is performed more efficiently due to the independency of the drying and pyrolysis steps.

22- Plant for the thermal pyrolytic treatment of organic matter, particularly wood in order to make charcoal, according to claims **1**, **2**, **4** and **20** wherein any degree of mechanization or automation can be used.

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