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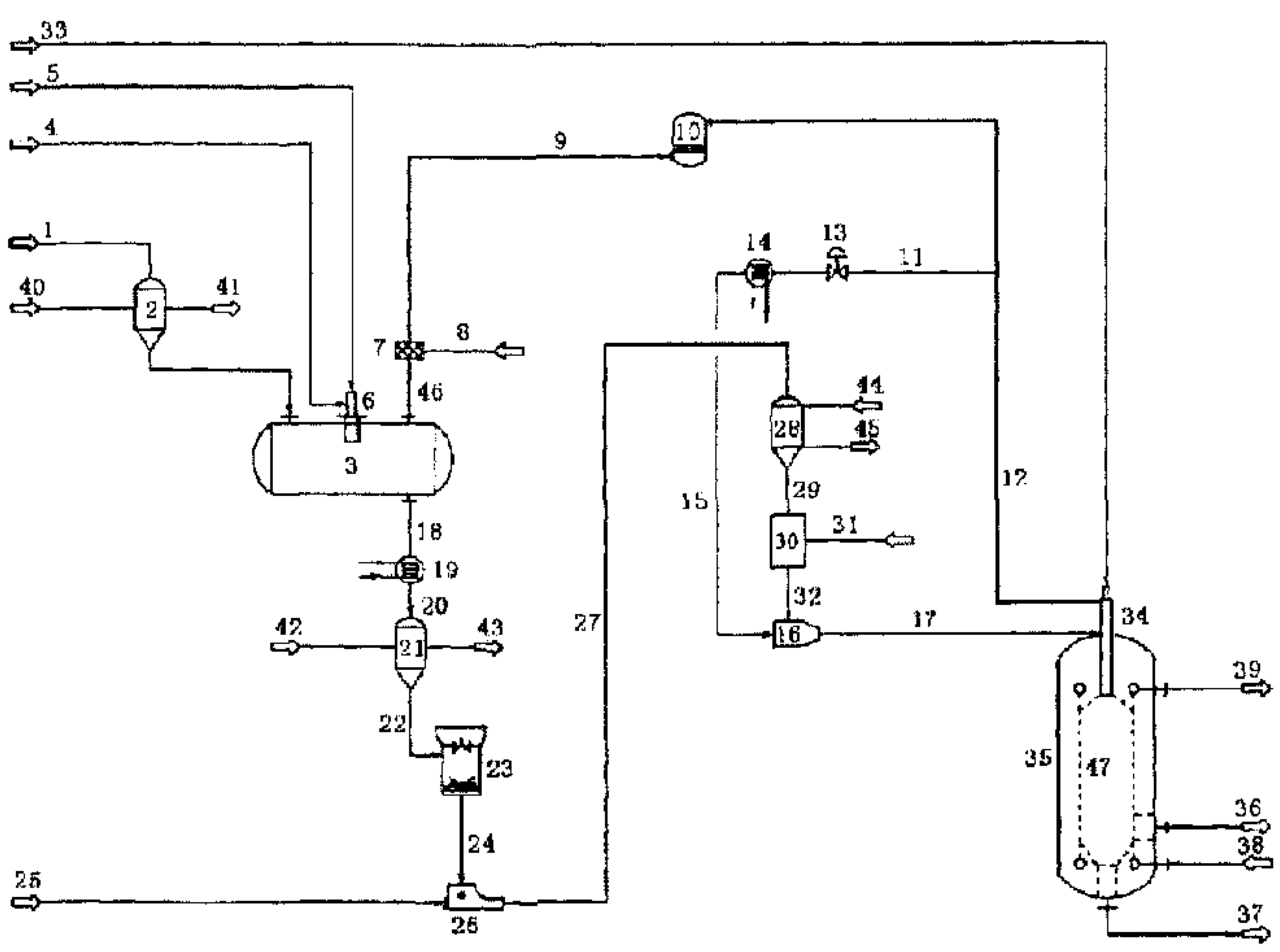
(72) **Inventeurs/Inventors**:
ZHANG, HAIQING, CN;
ZHANG, SHIRONG, CN;
SUN, QIN, CN;
QIU, PENG, CN;
ZHENG, SHENGHUA, CN

(73) **Propriétaire/Owner**:
WUHAN KAIDI ENGINEERING TECHNOLOGY RESEARCH INSTITUTE CO., LTD., CN

(74) **Agent**: H&M PATENT AND TRADEMARK AGENTS

(54) **Titre** : PROCEDE DE GAZEIFICATION A HAUTE TEMPERATURE AVEC DE LA BIOMASSE ET SYSTEME CORRESPONDANT
(54) **Title**: HIGH TEMPERATURE GASIFYING PROCESS WITH BIOMASS AND SYSTEM THEREOF



(57) **Abrégé/Abstract**:
High temperature gasifying process with biomass includes feeding, carbonization, powder making of charcoal, transportation of powdery charcoal and gasifying in gasifier, in which the high temperature charcoal discharged from the carbonization furnace is condensed to 60-200°C through condenser, then is reduced to normal pressure by feeding apparatus for reducing pressure. The charcoal is turned into powder through powder making machine, and then the powdery charcoal is sent to feeding apparatus for increasing pressure, the powdery charcoal with increased pressure is ejected to gasifier by ejector. In the process, the pyrolysis gas produced from carbonization furnace is used as carrier gas, and the ratio of solid to gas in the transportation pipe for powdery charcoal is controlled to 0.03-0.45 m^3/m^3 by adjusting the amount of pyrolysis gas for transportation.

ABSTRACT

High temperature gasifying process with biomass includes feeding, carbonization, powder making of charcoal, transportation of powdery charcoal and gasifying in gasifier, in which the high temperature charcoal discharged from the carbonization furnace is condensed to 60-200°C through condenser, then is reduced to normal pressure by feeding apparatus for reducing pressure. The charcoal is turned into powder through powder making machine, and then the powdery charcoal is sent to feeding apparatus for increasing pressure, the powdery charcoal with increased pressure is ejected to gasifier by ejector. In the process, the pyrolysis gas produced from carbonization furnace is used as carrier gas, and the ratio of solid to gas in the transportation pipe for powdery charcoal is controlled to 0.03-0.45 m^3/m^3 by adjusting the amount of pyrolysis gas for transportation.

HIGH TEMPERATURE GASIFYING PROCESS WITH BIOMASS AND SYSTEM THEREOF

FIELD OF THE INVENTION

[0001] The invention relates to the production of synthesis gas, and more particularly to a method and a system for producing synthesis gas from biomass by high temperature gasification. The method belongs to the technical field of producing synthesis gas or combustible gas by using biomass. The synthesis gas is a mixture gas which contains CO, H_2 and a variety of carbohydrates that contain carbon, hydrogen and oxygen. The synthesis gas produced by the method according to the present invention can be used for gas turbine power generation systems, fuel cells, synthetic oil, metallurgical and other systems.

BACKGROUND OF THE INVENTION

[0002] As dwindling of traditional fossil fuels (coal, oil, and natural gas) reserves and the environmental pollution problems caused by the use of fossil fuels directly threaten human survival and development, attaching importance to development of renewable and environmental friendly energy has become a consensus of governments of all countries. Biomass, an organic matter generated by plants through photosynthesis, has wide sources and large available quantity. It can be transformed into clean gas or liquid fuel for power generation and producing industrial raw materials and chemical products. As energy it is clean and renewable with zero emission of carbon dioxide and with the potential to fully replace fossil fuels as a new energy resource which has become a priority for all countries.

[0003] There are many methods for transforming biomass into clean gas or liquid fuel, among which biomass gasification technology can adapt to a variety of species and has good expansibility. The gasification of biomass is a thermochemical process, i.e., biomass reacts with a gasification agent (such as air, oxygen, vapor, carbon dioxide, etc.) under high temperature to produce a mixed gas consisting of carbohydrate containing carbon, hydrogen, and oxygen. The mixed gas is named synthesis gas. The components of the synthesis gas are decided by the species of used biomass, the type of the gasification agent, the reaction conditions, and the structure of a gasifier used therein. The objectives of gasification is, on the one hand, to minimize the consumption of materials and the gasification agent, as well as the tar content in the synthesis gas, and on the other hand, to maximize the gasification efficiency and the efficiency of carbon conversion, as well as the active ingredient (CO and H_2) content in the synthesis gas. The objectives are decided by the type of the used gasifier, the type of the gasification agent, the particle size of the biomass, the gasification pressure and temperature, and moisture and ash of the biomass, etc.

[0004] The gasification furnace used in the gasification process can be divided into three classes: fixed bed, fluidized bed and entrained flow bed. The fixed bed has a simple gasification structure, convenience operation, flexible operation mode, a higher rate of carbon conversion, a wide range of running load which can be between 20% and 110%, and the solid fuel stays in the bed for a long period of time. However, the temperature is nonuniform and it has less efficiency of heat exchange, low heating value of the synthesis gas at the outlet, and the synthesis gas contains a large amount of tar. The fluidized bed is convenient for material addition and ash release, and the temperature is uniform and easy for adjustment. However, it is sensitive to the characteristics of raw materials. If the adhesion, thermal stability, moisture content, or ash melting point of raw materials changes, the operation will become abnormal. Furthermore, in order to ensure normal fluidization of the gasification furnace, it needs to keep lower temperature, and the synthesis gas has a large amount of tar. Since a large amount of tar is produced in the fixed bed and the fluidized bed, a tar cracking unit and purification equipment must be installed, which results in a complicated process. The entrained flow bed has a high and uniform operating temperature, good amplification characteristics, and particularly suitable for large-scale industrialization. Tar is cracked completely. However, the entrained flow bed has a strict requirement on particle size of raw materials. Based on current grinding technology, there is no way to grind biomass having much cellulose to a size suitable for the entrained flow bed. So the entrained flow bed cannot be used for gasification of biomass. Nowadays, tar cracking and pretreatment of biomass prior to gasification are tough problems for the development of biomass gasification.

[0005] Chinese Patent Application No. 200510043836.0 discloses a method and a device for gasifying low tar biomass. The method includes pyrolysis and gasification independently, and biomass is transformed into synthesis gas containing low content of tar. In the method, pyrolysis gas and charcoal experience incomplete combustion in the gasifier at around 1000°C, and tar is cracked under high temperature. Although the tar content is decreased greatly, a lot of charcoal is consumed, resulting in a low content of CO produced in the subsequent reduction reaction and a high content of CO_2 in the synthesis gas. Secondly, due to a low temperature in the combustion reaction, the temperature at the subsequent reduction becomes lower, and the average temperature in the reduction zone is less than 700°C, and thereby the yield of effective synthesis gas (CO and H_2) is decreased significantly (about 30%). Thirdly, the ash and unreacted carbon residue from the reduction reaction is directly discharged, resulting in a low carbon conversion rate. Finally, the gasifier used in the method is in the form of a fixed bed, since the reduction reaction absorbs heat, the temperature difference between the top and the bottom (the top is about 1000°C and the bottom is about 500°C) of the bed is huge, which is an inherent disadvantage of fixed bed.

[0006] U. S. Pat. No. 6,863,878B2 discloses a method and a device of producing synthesis gas with carbon-containing materials. The method includes carbonization (or pyrolysis) and gasification independently. In the method, the carbonization temperature is controlled less than 450°F as so to reduce the tar content resulted from pyrolysis. However, during carbonization stage, solid products are not ground prior to transporting to the reaction coils of the gasifier, which will affect the speed and degree of gasification reaction. Secondly, since the gasification reaction happens in the reaction coil, a large amount of transport gas is needed, but the transport gas will take away a lot of heat during transporting, and thereby the gasification efficiency is low, the temperature is nonuniform, and the subsequent waste heat recovery system is massive. Thirdly, it is not economic that newly-produced synthesis gas is used to provide heat for gasification and carbonization. Fourthly, combustion products (mainly CO_2 and H_2O) are directly discharged and not fully utilized, resulting in low gasification efficiency. Finally, the ash and unreacted carbon residue in the synthesis gas are also discharged directly, resulting in low carbon conversion rate.

[0007] Chinese Patent Application No. 200610124638.1 discloses a method of producing synthesis gas from biomass by combined cycle high temperature gasification. The method includes carbonization and high temperature gasification. However, in the method, heating by the gasifier or cycled synthesis gas has hidden danger, the heating rate of pyrolysis is very slow, material consumption is high, and thereby the total gasification efficiency is low. Secondly, the charcoal powder transportation system (two-stage ejecting) is complicated, for high temperature gasification system, the synthesis gas for charcoal powder transportation is something like inert gas, so more oxygen and effective synthesis gas are consumed, and the gasification efficiency will be decreased by about between 5 and 10%. Furthermore, high pressure of charcoal from the carbonization furnace is directly transported into a high pressure milling machine after cooling without decompression, which is very difficult to achieve in industry.

[0008] From the above mentioned methods, conventional gasification, whether from biomass or from solid carbon-containing materials, cannot produce synthesis gas with high efficiency and low cost. Although the technology of independent pyrolysis and gasification can adapt to a variety of biomass and reduce the content of tar in synthesis gas, shortcomings such as nonuniform temperature, large investment in equipment for waste heat recovery, high material consumption, low gasification efficiency, and low carbon conversion rate limit the application of biomass gasification in industry. Particularly, there is no effective method for gasifying biomass applied to an entrained flow bed.

SUMMARY OF THE INVENTION

[0009] In view of the above-described problems, it is one objective of the invention to provide a method and system for producing synthesis gas from biomass by high temperature gasification that has high efficiency and low cost.

[0010] To achieve the above objectives, in accordance with one embodiment of the invention, There is provided a method for producing synthesis gas from biomass by high temperature gasification that has high efficiency and low cost, the method comprising feeding raw material, carbonizing, pulverizing the charcoal, and transporting charcoal powder to the gasification furnace for gasification, characterized in that prior to pulverizing, the charcoal is reduced to a normal pressure by a decompression feeding system of charcoal, pulverized into powders, and transported to a supercharging feeding system of charcoal powder by normal pressure transport gas; and the pressurized charcoal powder is transported to gasifier.

[0011] In a class of this embodiment, the high-temperature charcoal at the outlet of carbonization furnace is cooled to 60～200□ by cooler, and transported into the decompression feeding system to be depressurized.

[0012] In a class of this embodiment, the charcoal power with pressurized is ejected to gasifier by ejector, pyrolysis gas produced from carbonization furnace is used as carrier gas, and the ratio of solid to gas in the transportation pipe for charcoal power is controlled at between 0.03 and $0.45 m^3/m^3$ by adjusting the amount of pyrolysis gas for transportation.

[0013] In a class of this embodiment, further comprises fluidizing after said charcoal power pressurized, and said charcoal power is fluidized by said external combustible gas.

[0014] In a class of this embodiment, carbonizing goes on through direct combustion of external combustible gas and oxygen in carbonization furnace, a temperature of a burner nozzle of the carbonization furnace is controlled by adjusting the ratio of the amount of combustible gas to oxygen; a temperature of carbonization furnace is controlled by adjusting the amount of oxygen, and yields pyrolysis gas and charcoal from carbonization furnace.

[0015] In a class of this embodiment, the temperature of carbonization furnace is controlled at between 400□ and 600□ by adjusting the amount of oxygen; the temperature of a burner nozzle of the carbonization furnace is controlled at between 1200□and 1800□ by adjusting the input amount of the external combustible gas at between more than 1 and less than 5 times that required for a complete combustion with the external oxygen.

[0016] In a class of this embodiment, an outlet of the pyrolysis gas is disposed on the top of the carbonization furnace and connected to the gasifier, a filter is disposed at the outlet of the pyrolysis gas, and a purge gas of the filter is the external combustible gas.

[0017] In accordance with another embodiment of the invention, there is provided a system for producing synthesis gas from biomass by high temperature gasification that has high efficiency and low cost, the system comprising a supercharging feeding system of biomass; a carbonization furnace having at least a burner nozzle; a pulverizing system; a gasifier; a pneumatic conveying system; and a plurality of connecting pipes thereof; characterized in that from a charcoal outlet of the carbonization furnace to the gasifier, a charcoal cooler, a decompression feeding system of charcoal, a pulverizer, a supercharging feeding system of charcoal powder and an ejector of charcoal powder are disposed sequentially.

[0018] In a class of this embodiment, the burner nozzle of the carbonization furnace is connected to an external combustible gas pipe and an external oxygen pipe respectively.

[0019] In a class of this embodiment, the ejector of charcoal powder is connected to the pyrolysis gas pipe and charcoal power pipe.

[0020] Advantages of the invention are summarized below:

[0021] 1. The method according to the present invention adopts the technology of raw material depressurized feeding and atmospheric pressure charcoal milling. Compared with the high-pressure milling technology adopted by the combined-cycle high-temperature gasification method for producing synthesis gas from biomass proposed by the Chinese Patent Application No. 200610124638.1, Conventional supercharging pulverization is feasible theoretically, but there are many technical difficulties for practice, such as high pressure sealing and safety. In the invention, the decompression feeding of charcoal and pulverization at normal pressure is safe and easy for practice.

[0022] 2. The carbonization furnace is heated by a direct combustion between external combustible gas and external oxygen. The external combustible gas is natural gas or exhaust gas containing hydrocarbon produced by other systems. The heating technology of carbonization furnace according to this invention has the following three features. Firstly, the combustible gas is supplied by the outside of the system. Secondly, the heat required by the carbonization process is supplied by the direct combustion of the external combustible gas and external oxygen by using the chemical energy of combustible gas. Thirdly, due to direct combustion, the heating effect of the carbonization furnace is very good so that the carbonization process can be achieved quickly. There are three main differences between the method according to the present invention and the method for producing synthesis gas from biomass by combined cycle high temperature gasification (hereinafter referred to as the combined-cycle gasification method) proposed by the Chinese Patent Application No. 200610124638.1. Firstly, the combustible gas (i.e., synthesis gas) providing heat for the carbonization furnace of the combined-cycle gasification method is produced by the system itself. Secondly, the combined-cycle gasification method uses the sensible heat of combustible gas to provide the required heat of biomass carbonization by indirect heat exchange. Thirdly, the heating mode is indirect heat exchange, and the heating efficiency is low, the process is complicated, the heating rate of raw materials is slow, and the carbonization a slow pyrolysis process. Therefore, the heating method of carbonization furnace used in the present invention is essentially different from that used in the combined-cycle gasification method. The method according to the present invention improves the situation of the combined-cycle gasification method, such as low pyrothesis rate, bad heating performance of carbonization furnace and so on. Meanwhile, compared to the traditional gas device, the present invention is also essentially different in the manner and purpose of using combustible gas. In summary, the method according to the present invention breaks the industry's force of habit, adopts the external combustible gas, direct combustion, fast pyrolysis carbonization, and it also has solved a series of technical problems brought by the adopted manner, broke the technical bottleneck hindering the application of biomass for producing synthesis gas, and significantly increased the gasification rate of the system, reduced the oxygen consumption of the effective synthesis gas, as well as improved the energy conversion rate of the entire system.

[0023] In the invention, external combustible gas and external oxygen are used, and by adjusting the proportion thereof, the temperature of the carbonization furnace, the temperature of the burner nozzle of the carbonization furnace, and the heating rate can be controlled effectively. The invention has achieved the following objectives: a) to provide heat for the carbonization of biomass by a direct combustion between the external combustible gas and oxygen; b) if the external combustible gas is excess, the excess part can be used as inert gas to absorb heat so as to reduce the temperature of the burner nozzle of the carbonization furnace; however, if real inert gas having no hydrocarbon is introduced to reduce the temperature of the burner nozzle of the carbonization furnace, a large amount of inert gas will enter the gasification system, which means the working efficiency of the system and the quality of the synthesis gas will decrease significantly; c) since the combustible gas is excess, only part of combustible gas is consumed, the excess gas will be consumed in the gasifier, which improves the efficiency of energy utilization. Therefore, the introduction of external combustible gas can improve the gasification efficiency, reduce the oxygen consumption of the synthesis gas, and enhance the energy conversion rate of the system. Compared with the method for producing synthesis gas by combined cycle gasification mentioned above, in the invention, the gasification efficiency has been increased by more than 1%, and the oxygen consumption (the consumed oxygen (mole) for producing 1 mole of CO and H_2) is reduced to less than 0.3mol/mol.

[0024] 3. The method according to the present invention uses pyrolysis gas to deliver charcoal powder. In conventional dry coal gasification, inert gas (CO_2 or N_2) is used as transport gas. The introduction of inert gas results in low gasification efficiency and high oxygen consumption. In the invention, the charcoal powder is transported by pyrolysis gas, compared with Shell, the oxygen consumption is decreased by between 10% and 20%; compared with combined-cycle gasification method, the gasification efficiency is increased by between 5% and 10%.

[0025] 4. The method according to the present invention adopts combustible gas to fluidize the charcoal powder. That the combustible gas fluidizes charcoal powder can avoid the blocking during transporting charcoal powder, avoid introduction of inert gas which will result in low quality of synthesis gas and low gasification efficiency, and also avoid the condensation of the pyrolysis gas resulted from the entrance of pyrolysis gas into the supercharging feeding system of charcoal powder. In addition, through the introduction of high-quality gas, it avoids the inert gas getting into the gasification furnace as in the case of the traditional dry coal gasification, which uses inert gas to fluidize the charcoal powder, and it effectively improves the quality of synthesis gas and gasification efficiency.

[0026] 5. The method according to the present invention uses combustible gas as the equipment purging gas during its normal operation. That the external combustible gas is used as purge gas of the filter can avoid the introduction of inert gas and improve the quality of the synthesis gas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. **1** is a schematic diagram of a system and process for producing synthesis gas from biomass by high temperature gasification according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0028] The preferred examples, the process and the system layout structure according to the present invention, are described with reference to FIG. **1**.

[0029] As shown in FIG. 1, a system for producing synthesis gas from biomass by high temperature gasification comprises: **1**. an inlet of biomass; **2**. a supercharging feeding system of biomass; **3**. a carbonization furnace; **4**. a combustible gas pipe connected to a burner nozzle of the carbonization furnace; **5**. an oxygen pipe connected to the burner nozzle of the carbonization furnace; **6**. a burner nozzle of the carbonization furnace; 7. a filter; **8**. a combustible gas (functioning as purge gas) pipe connected to the filter; **9**. a pyrolysis gas pipe connected to an outlet of the filter; **10**. a buffer tank; **11**. a pyrolysis gas pipe for transporting charcoal powder; **12**. a pyrolysis gas pipe connected to a burner nozzle of a gasifier; **13**. a control valve; **14**. a heater; **15**. a transport pipe of heated pyrolysis gas; 16. an ejector of charcoal powder; **17**. a transport pipe of a mixture of charcoal powder and pyrolysis gas; **18**. an outlet pipe of charcoal; **19**. a charcoal cooler; **20**. a transport pipe of cooled charcoal; **21**. a decompression feeding system of charcoal; **22**. a normal pressure charcoal pipe; **23**. a pulverizer; **24**. a charcoal powder pipe; **25**. a normal pressure transport gas pipe; **26**. a normal pressure pneumatic conveying system; **27**. a transport pipe of a mixture of normal pressure transport gas and charcoal powder; **28**. a supercharging feeding system of charcoal powder; **29**.a high pressure charcoal powder pipe; **30**. a fluidizing device; **31**. a fluidizing gas pipe; **32**. a transport pipe of fluidized charcoal powder; **33**. an oxygen pipe connected to a burner nozzle of a gasifier; **34**. a burner nozzle of a gasifier; **35**. a gasifier; **36**. a synthesis gas outlet; 37. an ash pipe; **38**. a transport pipe of deoxygenated and desalted water; **39**. a saturated vapor pipe; **40**. a gas-charging pipe of the supercharging feeding system of biomass; **41**. a gas-discharging pipe of the supercharging feeding system of biomass; **42**. a gas-charging pipe of the decompression feeding system of charcoal; **43**. a gas-discharging pipe of the decompression feeding system of charcoal; **44**. a gas-charging pipe of the supercharging feeding system of charcoal powder; **45**. a gas-discharging pipe of the supercharging feeding system of charcoal powder; **46**. a pyrolysis gas pipe connected to an outlet of the carbonization furnace; and **47**. a water wall.

[0030] The burner nozzle **6** of the carbonization furnace **3** is connected to the combustible gas pipe **4** and the oxygen pipe **5** respectively. Along the pipes connecting the charcoal outlet of the carbonization furnace **3** with the gasifier **35**, the charcoal cooler nozzle of the carbonization furnace; **6**. a burner nozzle of the carbonization furnace; **7**. a filter; **8**. a combustible gas (functioning as purge gas) pipe connected to the filter; **9**. a pyrolysis gas pipe connected to an outlet of the filter; **10**. a buffer tank; **11**. a pyrolysis gas pipe for transporting charcoal powder; **12**. a pyrolysis gas pipe connected to a burner nozzle of a gasifier; **13**. a control valve; **14**. a heater; **15**. a transport pipe of heated pyrolysis gas; **16**. an ejector of charcoal powder; **17**. a transport pipe of a mixture of charcoal powder and pyrolysis gas; **18**. an outlet pipe of charcoal; **19**. a charcoal cooler; **20**. a transport pipe of cooled charcoal; **21**. a decompression feeding system of charcoal; **22**. a normal pressure charcoal pipe; **23**. a pulverizer; **24**. a charcoal powder pipe; **25**. a normal pressure transport gas pipe; **26**. a normal pressure pneumatic conveying system; **27**. a transport pipe of a mixture of normal pressure transport gas and charcoal powder; **28**. a supercharging feeding system of charcoal powder; **29**.a high pressure charcoal powder pipe; **30**. a fluidizing device; **31**. a fluidizing gas pipe; **32**. a transport pipe of fluidized charcoal powder; **33**. an oxygen pipe connected to a burner nozzle of a gasifier; **34**. a burner nozzle of a gasifier; **35**. a gasifier; **36**. a synthetic gas outlet; **37**. an ash pipe; **38**. a transport pipe of deoxygenated and desalted water; **39**. a saturated vapor pipe; **40**. a gas-charging pipe of the supercharging feeding system of biomass; **41**. a gas-discharging pipe of the supercharging feeding system of biomass; **42**. a gas-charging pipe of the decompression feeding system of charcoal; **43**. a gas-discharging pipe of the decompression feeding system of charcoal; **44**. a gas-charging pipe of the supercharging feeding system of charcoal powder; **45**. a gas-discharging pipe of the supercharging feeding system of charcoal powder; **46**. a pyrolysis gas pipe connected to an outlet of the carbonization furnace; and **47**. a water wall.

[0030]The burner nozzle **6** of the carbonization furnace **3** is connected to the combustible gas pipe **4** and the oxygen pipe **5** respectively. Along the pipes connecting the charcoal outlet of the carbonization furnace **3** with the gasifier **35**, the charcoal cooler

19, the decompression feeding system of charcoal **21**, the pulverizer **23**, and the supercharging feeding system of charcoal powder **28** are disposed sequentially. The ejector of charcoal powder **16** transports the charcoal powder, and connects with the transport pipe of heated pyrolysis gas **15** and the transport pipe of fluidized charcoal power **32**. On the top of the carbonization furnace **3** there disposed an outlet of pyrolysis gas which is connected to the gasifier **35**. The filter **7** is disposed at the outlet of pyrolysis gas. An inlet of purge gas of the filter **7** is connected to the combustible gas pipe **8**.

[0031]Dried biomass is put into the supercharging feeding system of biomass **2** via the inlet of biomass **1**, and then transported to the carbonization furnace **3** by pneumatic booster technology. To the carbonization furnace **3**, external combustible gas from the combustible gas pipe **4** and external oxygen from the oxygen pipe **5** are separately charged. A combustion reaction between the combustible gas and oxygen provides heat for pyrolysis of biomass. The temperature of the carbonization furnace **3** is controlled between 400 and 600°C by adjusting the input amount of external oxygen. By adjusting the input amount of the external combustible gas at between 1 and 5 times that required for a complete combustion with oxygen, the temperature of the burner nozzle **6** of the carbonization furnace **3** can be controlled less than 1800°C. The products of the carbonization furnace **3** are pyrolysis gas comprising CO, H_2, CO_2, H_2O, and CH_4 and charcoal. The crude pyrolysis gas enters the filter **7** via the pyrolysis gas pipe **46** and is filtered, and solid particles containing carbon return to the carbonization furnace **3** via the pyrolysis gas pipe **46**. The purified pyrolysis gas enters the buffer tank **10** via the pyrolysis gas pipe **9** connected to an outlet of the filter **7**.

[0032]The charcoal produced in the carbonization furnace **3** is cooled by the charcoal cooler **19** to a working temperature of the decompression feeding system of charcoal **21**, decompressed therein, pulverized by the pulverizer **23**, and transferred to the normal pressure pneumatic conveying system **26** via the charcoal powder pipe **24**. The normal pressure transport gas (CO_2 or N_2) pipe **25** transports the charcoal powder to the supercharging feeding system of charcoal powder **28**. By pneumatic booster technology, the pressure of the charcoal powder is enhanced by the supercharging feeding system of charcoal powder **28** to a working pressure of the gasifier **35**. The high pressure charcoal powder enters the fluidizing device **30** via the high pressure charcoal powder pipe **29**, and is fluidized by external combustible gas from the fluidizing gas pipe **31**. The fluidized charcoal powder enters the ejector of charcoal powder **16** and subsequently transported into the gasifier **35**.

[0033] Part of purified pyrolysis gas from the buffer tank **10** enters the heater **14** via the pyrolysis gas pipe transporting charcoal powder **11** and the control valve **13**. The pyrolysis gas transporting charcoal powder is heated to between 550 and 650°C and enters the ejector of charcoal powder **16** via the transport pipe of heated pyrolysis gas **15**. The solid-gas ratio in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is controlled between 0.03 and 0.45 m^3/m^3 by adjusting the opening of the control valve **13**.

[0034] The other part of purified pyrolysis gas from the buffer tank **10** via the pyrolysis gas pipe **12** connected to the burner nozzle **34** of the gasifier **35** and oxygen via the oxygen pipe **33** connected to the burner nozzle **34** of the gasifier **35** enter the burner nozzle **34** of the gasifier **35**. The fluidized charcoal powder and heated pyrolysis gas are also transported by the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** into the burner nozzle **34** of the gasifier **35**. High temperature gasification reaction happens in the gasifier **35**. By adjusting the input amount of the external oxygen and the heat exchange of the water wall **47** having deoxygenated and desalted water, the temperature of the synthesis gas outlet **36** is controlled between 1200 and 1600°C. The gasification products mainly comprise CO, H_2, a small amount of CO_2 and H_2O, and little CH_4. The deoxygenated and desalted water in the water wall **47** absorbs heat and transforms into sub-high pressure saturated water vapor which is discharged into the saturated vapor pipe **39**. Ash produced during gasification is discharged into the ash pipe

37.

Example 1

[0035]Take wood as a raw material of biomass. The elemental composition and characteristic data of the dried wood are listed in Table 1.

Table 1 Elemental composition and characteristic data of the dried wood

Items	Symbol	Unit	Value
Carbon	C_{ar}	%(Kg/Kg)	39.43
Hydrogen	H_{ar}	%(Kg/Kg)	5.21
Oxygen	O_{ar}	%(Kg/Kg)	38.36
Nitrogen	N_{ar}	%(Kg/Kg)	0.15
Sulfur	S_{ar}	%(Kg/Kg)	0.21
Chlorine	Cl_{ar}	%(Kg/Kg)	0.00
Ash	A_{ar}	%(Kg/Kg)	5.00
Moisture	M_{ar}	%(Kg/Kg)	11.64
Ash fusion point	FT	°C	1436
Low heat value	LHV	MJ/Kg	14.75

[0036]Take natural gas as external combustible gas. The elemental composition and characteristic data of the external combustible gas are listed in Table 2.

Table 2 Components and characteristic data of natural gas

Components	Value
CH_4	91.746%
C_2H_6	4.480%
C_3H_8	2.257%
CO_2	0.070%
O_2	0.040%
N_2	1.406%
H_2S concentration (mg/Nm^3)	20.00
Low heat value (kcal/m^3)	9000.8

[0037]The main operating conditions are set as follows:

[0038]1) The transportation amount of biomass into the carbonization furnace **3** via the supercharging feeding system of biomass **2** is 4.07kg/s.

[0039]2) The pressure of the carbonization furnace **3** is 3.1MPa, and the temperature is 500°C.

[0040]3) The input amount of the external combustible gas (mole) is 2 times that required for a complete combustion with the input oxygen.

[0041]4) The heating rate of pyrolysis of the biomass in the carbonization furnace **3** is 50°C/s.

[0042]5) The charcoal is cooled by the charcoal cooler **19** to 80°C.

[0043]6) The pyrolysis gas is heated by the heater **14** to 600°C.

[0044]7) The solid-gas ratio in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is $0.03m^3/m^3$.

[0045]8) The pressure of the gasifier **35** is 3.0MPa, and the temperature is 1300°C.

[0046]Based on the above conditions, the main flow rate and performance parameters of the system are as follows:

[0047]1) The mass flow rate of the external combustible gas (40°C) entering the carbonization furnace **3** is 0.28 Kg/s.

[0048]2) The mass flow rate of the external oxygen (160°C) entering the carbonization furnace **3** is 0.63 Kg/s.

[0049]3) The flame temperature of the burner nozzle **6** of the carbonization furnace **3** is 1800°C.

[0050]4) The total weight of the pyrolysis gas produced in the carbonization furnace **3** is 3.69 Kg/s.

[0051]5) The total weight of the charcoal produced in the carbonization furnace **3** is 1.19

Kg/s.

[0052] 6) The combustible gas which is transported by the fluidizing gas pipe **31** and used for fluidizing the charcoal powder has a temperature of 300°C and a mass flow rate of 0.03 Kg/s.

[0053] 7) The mass flow rate of the pyrolysis gas used for transporting charcoal powder in the pyrolysis gas pipe **11** is 0.89 Kg/s.

[0054] 8) The mass flow rate of the mixed gas in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is 2.1 Kg/s.

[0055] 9) The mass flow rate of the pyrolysis gas in the pyrolysis gas pipe **12** connected to the burner nozzle **34** of the gasifier **35** is 2.8 Kg/s.

[0056] 10) The external oxygen transported into the gasifier **35** by the oxygen pipe **33** connected to the burner nozzle **34** of the gasifier **35** has a temperature of 160°C and a mass flow rate of 1.5 Kg/s.

[0057] 11) The total weight of the synthesis gas from the synthesis gas outlet **36** is 6.5 Kg/s, and the dry basis of CO and H_2 is 87.2%.

[0058]12) The carbon conversion rate of the system is 99.9%, and oxygen consumption of effective synthesis gas is 0.3mol/mol.

Example 2

[0059] Take wood as a raw material of biomass (as shown in Table 1). Take natural gas as external combustible gas (as shown in Table 2). The temperature of the carbonization furnace **3** is 600°C. The heating rate of pyrolysis of the biomass in the carbonization furnace **3** is 100°C/s. Other operating conditions are the same as that in Example 1.

[0060] Based on the above conditions, the main flow rate and performance parameters of the system are as follows:

[0061] 1) The mass flow rate of the external combustible gas (40°C) entering the carbonization furnace **3** is 0.33 Kg/s.

[0062] 2) The mass flow rate of the external oxygen (160°C) entering the carbonization furnace **3** is 0.63 Kg/s.

[0063] 3) The flame temperature of the burner nozzle **6** of the carbonization furnace **3** is 1700°C.

[0064] 4) The total weight of the pyrolysis gas produced in the carbonization furnace **3** is 3.84 Kg/s.

[0065] 5) The total weight of the charcoal produced in the carbonization furnace **3** is 1.19 Kg/s.

[0066] 6) The combustible gas which is transported by the fluidizing gas pipe **31** and used for fluidizing the charcoal powder has a temperature of 300°C and a mass flow rate of 0.03 Kg/s.

[0067] 7) The mass flow rate of the pyrolysis gas used for transporting charcoal powder in the pyrolysis gas pipe **11** is 0.89 Kg/s.

[0068] 8) The mass flow rate of the mixed gas in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is 2.1 Kg/s.

[0069] 9) The mass flow rate of the pyrolysis gas in the pyrolysis gas pipe **12** connected to the burner nozzle **34** of the gasifier **35** is 2.96 Kg/s.

[0070]10) The oxygen transported into the gasifier **35** by the oxygen pipe **33** connected to the burner nozzle **34** of the gasifier **35** has a temperature of 160°C and a mass flow rate of 1.5 Kg/s.

[0071] 11) The total weight of the synthesis gas from the synthesis gas outlet **36** is 6.6 Kg/s, and the dry basis of CO and H_2 is 87.5%.

[0072]12) The carbon conversion rate of the system is 99.9%, and oxygen consumption of effective synthesis gas is 0.308mol/mol.

Example 3

[0073] Take wood as a raw material of biomass **5** (as shown in Table 1). Take natural gas as the external combustible gas (as shown in Table 2). The input amount of the external combustible gas (mole) is 5 times that required for a complete combustion with the input oxygen. Other operating conditions are the same as that in Example 1.

[0074] Based on the above conditions, the main flow rate and performance parameters of the system are as follows:

[0075] 1) The mass flow rate of the external combustible gas (40°C) entering the carbonization furnace **3** is 0.78 Kg/s.

[0076] 2) The mass flow rate of the external oxygen (160°C) entering the carbonization furnace **3** is 0.604 Kg/s.

[0077] 3) The flame temperature of the burner nozzle **6** of the carbonization furnace **3** is 1200°C.

[0078] 4) The total weight of the pyrolysis gas produced in the carbonization furnace **3** is 4.3 Kg/s.

[0079] 5) The total weight of the charcoal produced in the carbonization furnace **3** is 1.19 Kg/s.

[0080] 6) The combustible gas which is transported by the fluidizing gas pipe **31** and used for fluidizing the charcoal powder has a temperature of 300°C and a mass flow rate of 0.02 Kg/s.

[0081] 7) The mass flow rate of the pyrolysis gas used for transporting charcoal powder in the pyrolysis gas pipe **11** is 0.89 Kg/s.

[0082] 8) The mass flow rate of the mixed gas in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is 2.1 Kg/s.

[0083] 9) The mass flow rate of the pyrolysis gas in the pyrolysis gas pipe **12** connected to the burner nozzle **34** of the gasifier **35** is 3.4 Kg/s.

[0084]10) The external oxygen transported into the gasifier **35** by the oxygen pipe **33** connected to the burner nozzle **34** of the gasifier **35** has a temperature of 160°C and a mass flow rate of 2.05 Kg/s.

[0085] 11) The total weight of the synthesis gas from the synthesis gas outlet **36** is 7.6 Kg/s, and the dry basis of CO and H_2 is 90.4%.

[0086] 12) The carbon conversion rate of the system is 99.9%, and oxygen consumption of effective synthesis gas is 0.295mol/mol.

Example 4

[0087] Take wood as a raw material of biomass (as shown in Table 1). Take natural gas as external combustible gas (as shown in Table 2). The temperature of the carbonization furnace **3** is 400°C. The charcoal is cooled by the charcoal cooler **19** to 200°C. Other operating conditions are the same as that in Example 1.

[0088] Based on the above conditions, the main flow rate and performance parameters of the system are as follows:

[0089]1) The mass flow rate of the external combustible gas (40°C) entering the

carbonization furnace **3** is 0.23 Kg/s.

[0090] 2) The mass flow rate of the external oxygen (160°C) entering the carbonization furnace **3** is 0.44 Kg/s.

[0091] 3) The flame temperature of the burner nozzle **6** of the carbonization furnace **3** is 1800°C.

[0092] 4) The total weight of the pyrolysis gas produced in the carbonization furnace **3** is 3.55 Kg/s.

[0093] 5) The total weight of the charcoal produced in the carbonization furnace **3** is 1.19 Kg/s.

[0094] 6) The combustible gas which is transported by the fluidizing gas pipe **31** and used for fluidizing the charcoal powder has a temperature of 300°C and a mass flow rate of 0.03 Kg/s.

[0095] 7) The mass flow rate of the pyrolysis gas used for transporting charcoal powder in the pyrolysis gas pipe **11** is 0.833 Kg/s.

[0096] 8) The mass flow rate of the mixed gas in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is 2.04 Kg/s.

[0097] 9) The mass flow rate of the pyrolysis gas in the pyrolysis gas pipe **12** connected to the burner nozzle **34** of the gasifier **35** is 2.72 Kg/s.

[0098] 10) The oxygen transported into the gasifier **35** by the oxygen pipe **33** connected to the burner nozzle **34** of the gasifier **35** has a temperature of 160°C and a mass flow rate of 1.5 Kg/s.

[0099] 11) The total weight of the synthesis gas from the synthesis gas outlet **36** is 6.3 Kg/s, and the dry basis of CO and H_2 is 87.1%.

[0100] 12) The carbon conversion rate of the system is 99.9%, and oxygen consumption of effective synthesis gas is 0.3mol/mol.

Example 5

[0101] Take wood as a raw material of biomass (as shown in Table 1). Take natural gas as the external combustible gas (as shown in Table 2). The temperature of the pyrolysis gas is heated by the heater **14** to 650°C. The solid-gas ratio in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is 0.45m^3/m^3. Other operating conditions are the same as that in Example 1.

[0102] Based on the above conditions, the main flow rate and performance parameters of the system are as follows:

[0103] 1) The mass flow rate of the pyrolysis gas used for transporting charcoal powder in the pyrolysis gas pipe **11** is 0.63 Kg/s.

[0104] 2) The mass flow rate of the mixed gas in the transport pipe of a mixture of charcoal powder and pyrolysis gas **17** is 1.8 Kg/s.

[0105] 3) The mass flow rate of the pyrolysis gas in the pyrolysis gas pipe **12** connected to the burner nozzle **34** of the gasifier **35** is 3.1 Kg/s.

[0106] 4) The oxygen transported into the gasifier **35** by the oxygen pipe **33** connected to the burner nozzle **34** of the gasifier **35** has a temperature of 160°C and a mass flow rate of 1.5 Kg/s.

[0107] 5) The total weight of the synthesis gas from the synthesis gas outlet **36** is 6.5 Kg/s, and the dry basis of CO and H_2 is 87.2%.

[0108] 6) The carbon conversion rate of the system is 99.9%, and oxygen consumption of effective synthesis gas is 0.3mol/mol.

[0109] Results analysis

[0110] 1) The effect of temperature of carbonization furnace on the result:

[0111] When the carbonization temperature is less than 400°C, the produced pyrolysis gas contains too much tar, which may result in the condensation of the pyrolysis gas and affect the transportation of charcoal powder. When the carbonization temperature is more than 600°C, ordinary alloy steel materials cannot bear such high temperature, but specific alloy material will increase the cost of the carbonization furnace.

[0112] 2) The effect of input amount of external combustible gas on the results:

[0113] If the input amount of the external combustible gas (mole) is equal to that required for a complete combustion with the input oxygen, a complete reaction between the combustible gas and the input oxygen happens, and the flame temperature of the burner nozzle of the carbonization furnace will be more than 2000°C. Working for a long time at such a high temperature will destroy the internal mechanical components of the carbonization furnace, and even lead to safety accident. With the increasing charging of the external combustible gas, the flame temperature of the burner nozzle of the carbonization furnace will decrease. When the input amount of the external combustible gas (mole) is 5 times that required for a complete combustion with the input oxygen, the flame temperature of the burner nozzle of the carbonization furnace will decrease to 1200°C. If the input amount of the external combustible gas is further increased, the flame temperature of the burner nozzle of the carbonization furnace will decrease accordingly, which increases the gas velocity of the outlet of the burner nozzle and leads to unstable combustion. Furthermore, increased gas velocity of the outlet of the burner nozzle of the carbonization furnace will lead to the sharp increase of CH_4 content at the outlet of the gasifier. In order to reduce to the content of CH_4, the gasification temperature needs enhancing, which will lead to a high investment cost on the gasifier.

[0114] 3) The effect of solid-gas ratio in the transport pipe of a mixture of charcoal powder and pyrolysis gas on the results:

[0115] When the solid-gas ratio is less than $0.03m^3/m^3$, the pyrolysis gas for transporting charcoal powder accounts for a large proportion, and the pyrolysis gas reacting with oxygen in the gasifier accounts for a small proportion, which will affect the stable operation of the burner nozzle of the gasifier. When the solid-gas ratio is more than $0.45m^3/m^3$, the charcoal powder may subside or block during transportation, which will lead to the fluctuation of charcoal powder amount and affect the stable operation of the burner nozzle of the gasifier.

[0116] 4) The effect of the outlet temperature of the charcoal cooler on the results:

[0117]When the charcoal temperature at the outlet of the charcoal cooler is less than 60°C, the area and volume for heat exchange of the cooler must be large, which means a high cost. Furthermore, the lower the charcoal temperature, the lower the system efficiency. When the charcoal temperature at the outlet of the charcoal cooler is more than 200°C, some devices of the decompression feeding system of charcoal may not run smoothly.

CLAIMS

1. A method for producing synthesis gas from biomass, comprising:

feeding dried biomass as raw material to a pressurization feeding system of biomass;

pneumatically boosting the dried biomass, and transporting the dried biomass to a carbonization furnace;

introducing an external combustible gas and external oxygen via pipes into the carbonization furnace for conducting a combustion reaction;

controlling the temperature of the carbonization furnace to a temperature between 400°C and 600°C by adjusting the input amount of external oxygen;

controlling the temperature of a burner nozzle of the carbonization furnace to a temperature less than 1800°C by adjusting the input amount of the external combustible gas between 1 and 5 times that required for a complete combustion with the external oxygen; the products of the carbonization furnace being pyrolysis gas comprising CO, H_2, CO_2, H_2O, CH_4, and charcoal;

reducing the temperature of the charcoal produced in the carbonization furnace to a working temperature of a decompression feeding system of charcoal for reducing pressure;

decompressing the charcoal in the decompression feeding system of charcoal;

pulverizing the decompressed charcoal in a pulverizer to charcoal powder;

transporting the charcoal powder to a pressurization feeding system of charcoal powder for increasing the pressure of the pulverized charcoal via a normal pressure pneumatic transportation system;

increasing the pressure of the charcoal powder to a working pressure of a gasifier for gasification by pneumatic booster technology; and

transporting the pressurized charcoal powder to the gasifier.

2. The method according to claim 1, characterized in that a high-temperature charcoal at the outlet of the carbonization furnace is cooled to 60-200°C by a cooler, and transported into the decompression feeding system of charcoal to be depressurized.

3. The method according to claim 1 or 2, characterized in that said pressurized charcoal powder is ejected to the gasifier by an ejector, pyrolysis gas produced from the carbonization furnace is used as a carrier gas, and that the ratio of solid to gas in the transportation pipe for said charcoal powder is controlled at between 0.03 and 0.45 m^3/m^3 by adjusting the amount of said pyrolysis gas for transportation.

4. The method according to claim 1 or 2, characterized in that the method further comprises a step of fluidizing said pressurized charcoal powder, wherein said pressurized charcoal powder is fluidized by said external combustible gas.

5. The method according to claim 1 or 2, characterized in that an outlet of said pyrolysis gas is disposed on the top of the carbonization furnace and connected to the gasifier, a filter is disposed at the outlet of said pyrolysis gas, and a purge gas of said filter is said external combustible gas.

6. A system for producing synthesis gas from biomass using the method according to any one of claims 1-5, comprising a pressurization feeding system of biomass; a carbonization furnace having at least a burner nozzle; a pulverizing system; a gasifier; a pneumatic conveying system; and a plurality of connecting pipes thereof; characterized in that

the gasifier comprises a burner nozzle, a synthesis gas outlet, an ash pipe, a transport pipe of deoxygenated and desalted water, and a saturated vapor pipe;

the system further comprises an inlet of biomass for putting dried biomass into the pressurization feeding system of biomass;

the pressurization feeding system of biomass is connected to the carbonization furnace;

a combustible gas pipe for charging external combustible gas and an oxygen pipe for charging external oxygen are connected to the burner nozzle of the carbonization furnace;

a charcoal outlet of the carbonization furnace is connected to a charcoal cooler;

the charcoal cooler is connected to a decompression feeding system of charcoal;

the decompression feeding system of charcoal is connected to the pulverizing system;

the pulverizing system is connected to a normal pressure pneumatic conveying system via a charcoal powder pipe;

an outlet of the normal pressure pneumatic conveying system is connected to a pressurization feeding system of charcoal powder;

an outlet of the pressurization feeding system of charcoal powder is connected to an ejector of charcoal powder;

an outlet of the ejector of charcoal powder is connected to the gasifier; and

a pyrolysis gas outlet of the carbonization furnace is connected to the burner nozzle of the gasifier via a pyrolysis gas pipe.

7. The system according to claim 6, characterized in that the outlet of the pressurization feeding system of charcoal powder is connected to the ejector of charcoal powder via a fluidizing device.

8. The method according to claim 1 or 2, characterized in that after the pressurized charcoal powder is transported to the gasifier, the pressurized charcoal powder is gasified by the gasifier to produce synthesis gas.

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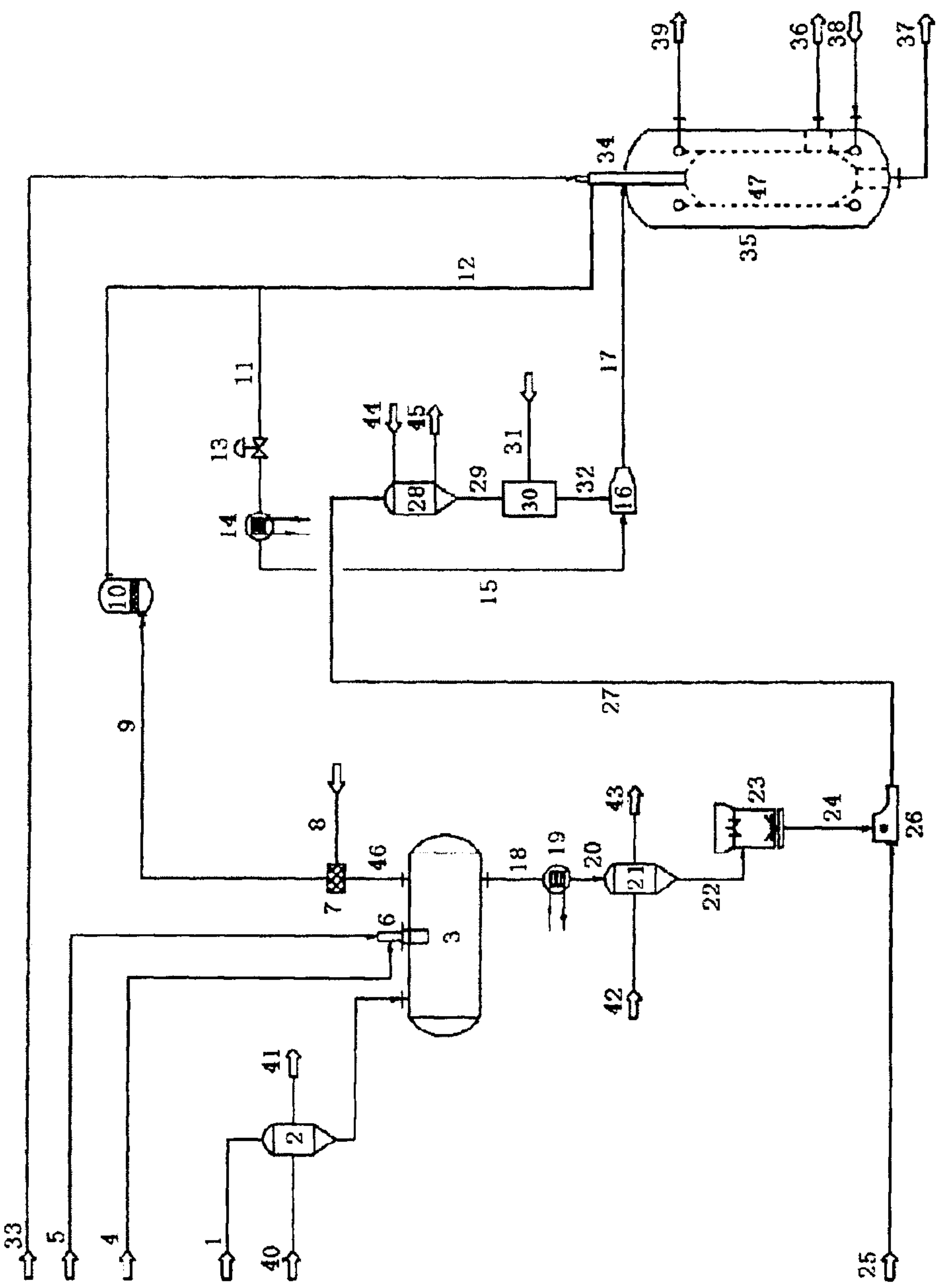
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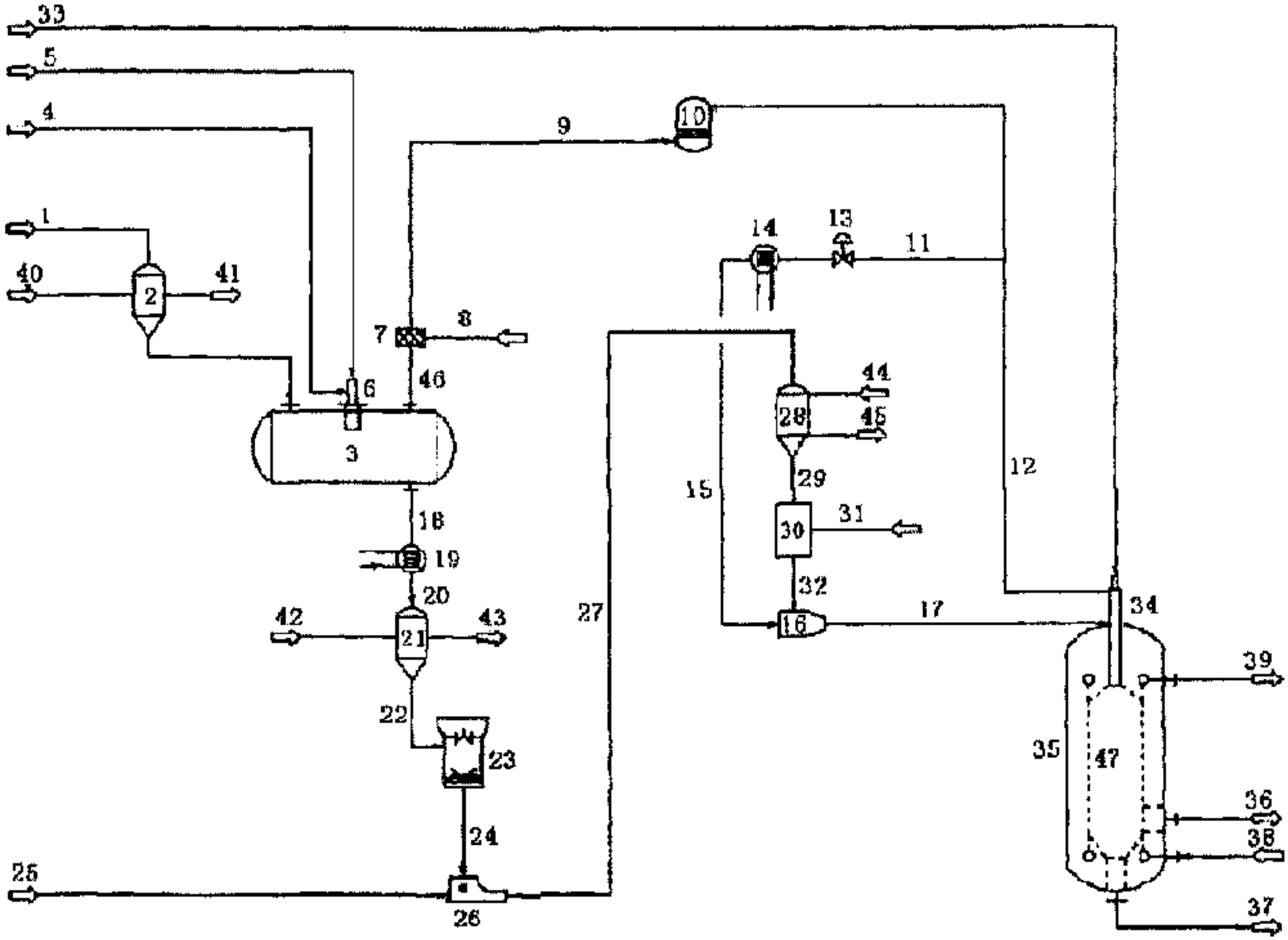
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