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A Review Paper on Biomass Fluidized Bed Gasifier

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Abstract - *In this study experiments were performed on a pilot scale bubbling fluidized bed Gasifier with rice husk as a fuel and air as a fluidizing agent. With the increasing demand of fuel and limited amount of conventional fuel we have to go toward the direction of renewable energy source. Conventional fuel also cause lots of pollution which creates lots of problems like global warming .we try to use renewable energy source to produce combustible gases. Conventional fuels are also costly so we also consider cost of fuel in our project. It also does not affect the climate changes. There are number of technologies which are used for biomass conversion, from that gasification is the best for biomass conversion. Biomass gasification is good technology because it will produce quite clean gas and trouble free operation of Gasifier. Experimentation is carried out to calculate the efficiency of Gasifier, to analyses the produced gas and temperature analyses using different biomass fuel like saw dust, bagasse and rise husk.*

Keywords - *Biomass, Gasifier, Gasification, Biofuels, Bubbling fluidized bed, Process modeling, Gas yield, Carbon conversion, Rice Husk.*

I. INTRODUCTION

1.1. Problem Summary:

Now a days there is increasing demand of fuel due to increase in level of industrialization in world. There is increase in cost with increasing demand of fuel due to there is limited resources of conventional fuel. There is also side effect of this like global warming. Although India produces about 35 million tons of crude oil, import of crude oil is also increasing about 24 million tons as a result of increase in energy demand. This reasons forced us to use renewable resources of energy. Renewable resources are easily available all over the world, replenished naturally, less costly.We use different waste as a fuel like bagasse, saw dust, rise husk and check the performance of fluidized bed gasifier. On December 16, 1921 a new area opened in the history of the generation of energy and power in industries and rural area. Fritz Winkler of Germany introduced gaseous products first demonstration of gasification of coal in a fluidized bed.

1.1.1. Biomass: A source of energy:

There are number of Renewable resources are available all over the world. Among all that biomass is one which is available throughout the year. Biomass gives very less amount of CO_2 emission than fossil fuels. It is observed that there is 93% less emits CO_2 than fossil fuel/coal during Combustion. In present days biomass provides almost 10-14% of total energy demand across the world.
Biomass is an organic matter produced by plants, both terrestrial and aquatic and their derivatives. Biomass constitutes a significant, clean and renewable energy source and has very desirable option.

1.2 Methods of extracting energy from biomass: Basically there are three methods to extract energy from biomass:

1. Bio-chemical conversion
2. Direct combustion
3. Thermo-chemical conversion

1.2.1. Bio-chemical conversion: Bio-chemical is process which converts biomass into a gaseous fuel known as biogas under the action of micro-organisms and bacteria. The produced biogas is a mixture of carbon dioxide and methane.
There are two popular biochemical technologies are:

1. Anaerobic digestion
2. Fermentation.

1.2.1(a). Anaerobic digestion: Anaerobic digestion is the natural biological process which stabilizes organic waste in the absence of air and transforms it into biofertilizer and biogas. Any organic material can be processed with anaerobic digestion like municipal solid waste, food wastes, sewage, poultry litter, animal manure and industrial wastes.
The major disadvantage associated with it is required longer digestion periods and high initial investment cost.

1.2.1(b). Fermentation: Fermentation is another process of bio-chemical conversion of biomass waste. Fermentation is mostly used process to produce ethanol fuel. Under the influence of ferment such as yeast bacteria, enzymes, causes the breakdown off complex molecules in organic compound. Here, conversion of biomass into ethanol is take place in two stage. In First stage biomass is converted into sugars using acid or enzymes. In second stage the sugar is converted into ethanol or other chemicals

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1.2.2. Directcombustion: Direct combustion of biomass is the oldest method. It is simple and straight method for extracting energy means biogas from biomass. In direct combustion, Biomass is directly burnt in a stove or boiler, confined container and combustion is maintained by air flow through the combustion chamber. The Efficiency of combustion process is greatly depend on Proper/optimal air flow and properly dried biomass.

The major drawback of this method is that due to open burning most of the heat will be wasted which result in lower efficiency of the process.

1.2.3. Thermo-chemical conversion: Thermo-chemical conversion process used to convert the biomass into more useful form such as liquid and gaseous fuel. It uses heat as important mechanism to convert biomass into chemical form. Biomass conversion involve combustion, gasification, pyrolysis.

In thermo-chemical conversion, biomass is exposed to high temperature in the absence of air, causing it to decompose. It is an advanced thermal treatment that converts a material into syngas at temperature around 1000^0C and in the absence of oxygen.

1.3. Gasification of biomass: Gasification of biomass is simply a process to convert solid biomass fuel into combustible gas. Biomass gasification is defined as a “process of converting biomass fuel into gaseous combustible gas which involves incomplete combustion of biomass in the presence of gasification agent including air, steam, oxygen or combination of these.”

In the gasification process, results obtain in the form of combustible gas is a mixture of H_2, CO, CO_2, N_2, CH_4 and other light and heavy hydrocarbons. The resulting gas mixture obtain at the end of gasification is called syngas or producer gas. The composition of final syngas is depend on the input biomass and technique/process by which syngas is produced.

The advantage of gasification over direct combustion is that using the syngas is potentially more efficient than direct combustion of the fuel because it can be combusted at higher temperatures, so that the thermodynamic upper limit to the efficiency defined by carnot’s rule is higher or not applicable.

During the biomass gasification following processes are involved:

1. Drying
2. Pyrolysis
3. Oxidation
4. Reduction

1.3.1. Drying: Drying is the first stage of biomass gasification/ conversion. During drying process only the evaporation of moisture present in the biomass fuel take place and does not involve any decomposition process. This process commonly take place at around 100^0C.

1.3.2. Pyrolysis: Pyrolysis is the process of combustion of biomass in the absence of oxygen. During pyrolysis process, volatile matter and char are released sp it is also known as Devolatilization process. This process takes place around at 200^0 to 400^0. Pyrolysis is decomposition of the biomass into gas liquid and solid. During the pyrolysis process there will be the formation of char and ash solids, tar liquid which is mixture of heavy hydrocarbons and gases such as CO, CO_2 , CH_4 etc…

Pyrolysis: Biomass → Char + Tar + H_2 + CO + CO2 + CH4

There are basically three variations of pyrolysis:

A) Fast pyrolysis
B) Torre faction/mild pyrolysis
C) Slow pyrolysis

By fast pyrolysis there is production of solid fuel, known as bio-oil, Slow pyrolysis produce gas and solid charcoal which are most ancient fuels.

Torre faction, which is currently being considered for effective biomass utilization, is also a form of pyrolysis. In this process, the biomass is heated to 230 to 300 °C without contact with oxygen. The chemical structure of the wood is altered, which produces carbon dioxide, carbon monoxide, water, acetic acid, and methanol. Torre faction increases the energy density of biomass, reduces its weight and its hydrocarbon nature, thus increase the commercial use of wood as energy source. Also there is reduction of transportation cost.

1.3.3. Oxidation: During oxidation process there is production of heat would take place by exothermic reaction. Heat generated by exothermic reaction is useful for the subsequent endothermic reactions. In the oxidation process products obtain by pyrolysis process like char and volatile material are react with oxygen present in the gasification agent and produces carbon monoxide and carbon dioxide.

1.3.4. Reduction: Reduction is process involves major reactions of biomass in oxygen deficient environment. This process utilizes the heat released during oxidation process which leads to the reduction in temperature.

II. LITERATURE REVIEW

Nuno Couto, Valter Silva, Eliseu Monteiro, P.S.D. Brito, Abel Rouboa [1] describe the biomass gasification process in a fluidized bed reactor using coffee husks within the commercial CFD code FLUENT. Both, gas phase and solid phase, were described using and eulerian-eulerian approach exchanging mass, energy and momentum. The study was conducted in a pilot thermal gasification plant, installed at Portalegre's Industrial Park based on the fluidized bed technology, with a processing capacity of 70 kg/h, and operating at around 800ºC. The gasification tests were performed continuously for several days in order to optimize the heat value and composition of produced syngas. The simulated syngas composition is in good agreement with the experimental ones although slight deviation was shown especially on CO and H2.

Porametr Arromdee, Vladimir I. Kuprianov [2] Describes a feasibility of the effective energy conversion from peanut shells via direct combustion in the conical fluidized-bed combustor using alumina sand as the bed material. Combustion tests were performed at 60 kg/h and 45 kg/h fuel feed rates, while ranging excess air from 20% to 80% at a fixed combustor load For firing 60 kg/h peanut shells, excess air of 40% can be selected as an appropriate value ensuring high, about 99%, combustion efficiency and rather low emissions of CO and NO: 520 ppm and 125 ppm, respectively. No evidence of bed agglomeration was found during 30-h combustion tests on this conical fluidized-bed combustor using alumina sand as the bed material. However, the timescale effect on the composition of the bed material was found to be substantial. Also, Show that the emissions of CO, CxHy and NO from the combustor are weakly affected by the reactor load showing, however, substantial effects of excess air.

R.C. Saxena, D.K. Adhikari, H.B. Goyal [3] This paper describes the various biochemical processes for conversion of biomass into biological hydrogen gas and Ethanol. The research focuses on hydrogen production through various routes viz. fermentative, photosynthesis and biological water gas shift reaction. As biomass is a potentially reliable and renewable energy resource, biomass-based energy fuel is being considered as one of the most promising energy carrier of the future generation. Considering hydrogen production from biomass through biochemical routes, dark fermentation is more versatile than photosynthesis process as there is high energy demand for the use of nitrogenase enzyme, low solar energy conversion efficiency and substantial land requirement for anaerobic photo-bioreactors. This represents the technology for ethanol production from various biomass sources such as molasses, lignocellulosic feedstock and starch. According to literature, hydrogen will be an important energy carrier in the near future. Instead of fossil fuel, hydrogen production from biomass has to be employed as it is sustainable and renewable.

Zainal Alimuddin Bin Zainal Alauddin, Pooya Lahijani, Maedeh Mohammadi, Abdul Rahman Mohamed [4] Here attentions have been paid to biomass gasification technologies due to their potential to convert biomass waste to bioenergy and biofuels. Among all of the renewable resources, biomass is the only renewable source of carbon which can be converted to solid, liquid and gaseous product through various conversion processes.

Effect of bed temperature

Bed temperature is one of the most important operation parameters which affect both the heating value and producer gas composition. Based on Le Chatelier's principle, the effect of temperature on producer gas composition depends on the thermodynamic behavior of the reactions. High temperatures improve product formation in endothermic reactions whereas they favor reactants in exothermic reactions. The main objective of the gasification process is to generate a combustible gas enriched in CO, H2 and CH4 with medium to high LHV which is suitable for further exploitation in internal combustion engines and turbines. It has been stated that increasing the gasification temperature reduces the gas heating value. The necessary heat for gasification is provided by combustion enthalpy of the biomass, therefore high temperature improves biomass combustion which consequently results in more CO2 and N2 production and low heating value. Also, high bed temperatures improve carbon conversion and steam cracking and reforming of tars which result in less char and tar formation and high gas yields

Nuno Couto, Abel Rouboa,Valter Silva, Eliseu Monteiro, Khalid Bouziane [5] this paper describes about the influence of the biomass kind, reactor type, oxidizer and reactor operational conditions on the final composition of syngas. Gases formed by gasification are contaminated by some constituents such as particles, alkali metals, nitrogen components, tars, sulfurs and chlorides. The level of contamination varies, depending on the gasification process and the feedstock. This study shows that there are some discrepancies in the values given by various authors even considering the same type of biomass and type of gasifier. This highlights the strong dependence of the final composition of syngas from biomass condition, type of gasifier and pressure and temperature conditions

Influence of operational conditions:

Temperature

The increase of gas yield and the decrease in gas heating value with temperature, even when different feed stocks and gasifiers are used. It is expected that the rise of temperature leads to an increase in the rate of the several reactions that take place during gasification process, which, globally, produce hydrogen and carbon monoxide and eliminates hydrocarbons. At higher gasification temperatures lower solids and tar emissions are observed, which means that the produced gas may require a lower cost on gas cleaning processes.

Prabir Basu [6], Effect of different parameters on Fluidized Bed Gasifier

Effect of bed material:

Bed material is the parameter that would affect the quality of the gas as well as the performance of the fluidized bed gasifier. Generally sand is used as a bed material because of its chemical inertness and high melting point. The inert bed material acts as a heat carrying medium and enhances the heat transfer between the fuel particles. Bed material also plays an important role in tar cracking and enhancing the H_2 production by reforming reactions when catalysts are as a bed material.

Effect of Reactor temperature

The effect of reactor temperature on the reactions that occurs in the gasifier depends upon the nature of the reactions. As most of the gasification reactions are endothermic in nature so the high temperature would increase the rate of this reactions and produce the gas with high H_2 content but at the same too high reactor temperature would reduce the heating value of the producer gas due to cracking of the CH_4 and other hydrocarbons like tar and it would also lead towards the operational difficulties due to formation of clinkers and bed agglomerates. The increase in reactor temperature would increase the carbon conversion and gas yields because of the reduction in the tar and char yields.

Effect of equivalence ratio

Equivalence ratio controls the amount heat that would release during the exothermic reactions. Too small value of ER will give lower bed temperatures and gas with too high tar contents while too high value of ER will produce gas with lower heating values because of the cracking of hydrocarbons and dilution of gas with N_2. Increase in ER would reduce the H_2 and CO content while it would increase the CO_2 content in the producer gas because of the increase in the rate of oxidation reaction.

Effect of gasification agent

Function of the gasification agent in fluidized bed gasifier is to keep the bed in the Fluidized state at the same time provide the necessary oxygen for the occurrence of the Gasification reactions.

The different gasification agents that could be employed in the fluidized bed gasifier are as follows:

1. Air
2. Steam
3. Oxygen

Use of air as the fluidizing agent is a most common and economical way and it is generally employed in the industrial applications. The disadvantage of using air is that producer gas that leaves the gasifier would consist 45-55 vol.% of nitrogen and only 3- 17 vol.% of H_2 [9,14] in it which would limit the LHV in the range of 4-6 MJ/m3.

Using steam as a gasification agent would increase the hydrogen content in the producer gas due to increase in the steam reforming reactions and water gas shift reaction rate which results in increase in the LHV of the producer gas. The disadvantage of using steam as a gasification agent is that the steam reforming reactions are endothermic in nature so it would result into decrease in the bed temperature therefore it is necessary to either supply the steam at the higher temperature or use an external source of energy like electric heater in order to maintain the temperature of the bed sufficiently higher.

Effect of biomass Particle size:

Particle size of the selected biomass is another operating parameter that would affect the quality of resultant producer gas. It was investigated that the biomass particles of smaller size were more effective than the biomass particles of larger size because smaller particles provided larger surface area compare to the larger particles which resulted in increase in the heat transfer rates in the gasifier which increased the char burning rate and moisture evaporation rate.

Effect of bed height:

Bed material in the fluidized bed gasifier would act as a heat carrying medium; it is the highest temperature zone in the fluidized bed gasifier. With the increase in the bed height the residence time of the producer gas in the bed would increase. At the same time too high bed height would have adverse effect on the producer gas because at the higher bed height there would be the formation of larger bubbles which would result in faster bubble velocity and a shorter gas/solid contact time also increase in bed height would result into increase in pressure drops across the bed.

Suresh P. Babu Gerald L. Anderson Satyendra P. Nandi [7] Invention is relates to a process for gasification of cellulosic biomass, such as plants and trees, in a single gasification vessel to produce low and medium Btu fuel gas, that is, gases varying in composition from those rich in CO, H_2, and N_2 to those rich in CO, H_2 and CH_4, respectively. The medium Btu fuel gas may be readily treated to form high Btu substitute natural gas, it can be processed as synthesis gas for methanol production, or may be directly used as an industrial fuel gas. The process utilizes available renewable energy resources. The are converted by the process of this invention to clean and energy-intensive substitute fuel gases and for use as raw materials for desired chemicals or fuels. The process of this invention results in a high percentage of methane in the very rapid hydrodevolatilization of the cellulosic biomass feed i.e. trees and plants. The fluidized bed used in the process of this invention is highly backmixed to maintain little temperature variation throughout the height of the bed. The fluidized bed has a hydrogen-containing gas region which results in rapid hydrodevolatilization of the introduced biomass forming methane, heavier hydrocarbons, carbon oxides, steam, hydrogen and devolatilized biomass.

Amirale Rehmat, Richard kao [8] This research describes the process for a waste-to-synthesis gas system including: a first gasifier for receiving biomass; a gas distributor for delivering reactant gas and oxygen into the first gasifier in a countercurrent direction to the biomass flow and to define a plurality of reaction regions including a drying region, a pyrolysis region, a gasification region and a combustion region; and, a second gasifier for receiving gases from the plurality of regions of the first gasifier and a gas distributor for delivering reactant gas and oxygen into the second gasifier in a concurrent direction to the flow of gases from the first gasifier. As a result, no carbon chars, oils or tars are expected to be present in the synthesis gas produced.

A waste-to-synthesis gas system comprising:
A first gasifier for receiving biomass; a gas distributor for delivering reactant gas and oxygen into said first gasifier in a countercurrent direction to said biomass flow and to define a plurality of reaction regions comprising a drying region, a pyrolisis region, a gasification region and a combustion region; and, a second gasifier for receiving gases from said plurality of regions of said first gasifier and extracting carbon chars, oils and tars therefrom.
A process for converting biomass waste to synthesis gas comprising:

feeding said biomass waster into a first gasifier in a first direction, said first gasifier comprising a drying region, a pyrolysis region, a gasification region and a combustion region; delivering reactant gas and oxygen into said first gasifier in a second direction countercurrent to said first direction and in a prescribed manner to said reaction regions; and, providing gases from said reaction regions to a second gasifier suitable for extracting carbon chars, oils and tars therefrom.

Wayne A. LePori, Calvin B. Parnell [9] In this, System is disclosed for converting unconditioned biomass, such as cotton gin trash, into usable energy. This is accomplished by gasifying the biomass, removing the particulate char from the combustible gas using cyclonic separators, burning the gas, and using the heat to generate steam. Here,Two stage combustion helps to minimize NO_x formation.

A system for converting biomass to usable energy, including:
(a) a biomass feed apparatus includes a feed hopper with an agitator, at least one auger to carry biomass feed from the hopper, and an airlock to prevent backflow of combustible gases into the hopper;
(b) a fluidized bed gasifier which receives biomass feed from the feed auger and which has a fluidizing air inlet, and which produces combustible gas and particulates containing activated carbon;
(c) a plurality of solids removal cyclones which are arranged in series and which receive the products of the fluidized bed gasifier and remove at least 99% by weight of the particulates from the combustible gas; and
(d) two stage combustion apparatus which includes a first stage cyclonic combustion chamber with a single gas inlet for receiving a combined stream of combustible gas from the solids removal cyclones and primary combustion air, a second stage which has an inlet for receiving gases exiting the first stage and a secondary combustion air stream, and a boiler which receives combustion gases from the second stage and in which the heat from the combustion gases converts water to steam.

The present invention has several benefits. It takes what in the past has been a waste product and generates usable energy from it. It can convert a wide range of biomass fuels including difficult fuels such as cotton gin trash because of the following:
1) thermal reaction (gasification) takes place in a high thermal inertia, controlled and relatively low temperature (1400° F.) environment.
2) the char is removed prior to combustion.
3) approximately 85% of the enregy in the biomassis converted to chemical energy in the gas, allowing for gas cleaning while minimizing sensible heat loss.
4) staged combustion can reduce NO_x to environmentally accepted levels.
5) the first stage combustor provides for continuous ignition (stability) while burning low calorific value (LCV) gas.

6) In contrast, combustion processes
   (1) convert all energy to sensible heat disallowing cleanup prior to introducing hot gases to the boiler.
   (2) would not allow for staged combustion to be used to reduce NO_x concentrations in the flue gas.
   (3) would have no temperature control in the thermal reaction chamber, resulting in slagging, fouling and metal corrosion.

Esteban Chornet, Boris Valsecchi, Sébastien Rheault, Martin Gagnon[10] this invention is related to a process of producing synthesis gas from biomass in which biomass is contacted with oxygen and steam, wherein the oxygen is present in an amount effective to oxidize the biomass partially and to heat the biomass to a temperature of at least 500° C. and no greater than 750° C. At least a portion of the partially oxidized biomass then is treated with oxygen and steam to heat the biomass to a temperature of at least 800° C., thereby producing a synthesis gas, which then is recovered.
A process for producing synthesis gas from biomass, comprising:
(a) contacting said biomass with oxygen and steam, wherein said oxygen is present in an amount effective to oxidize said biomass and to heat said biomass to a temperature of at least 500° C. and no greater than 750° C.;
(b) treating at least a portion of the oxidized biomass produced in first step with oxygen and steam to heat said biomass to a temperature of at least 800° C., thereby producing synthesis gas; and
(c) recovering said synthesis gas produced in second step.

Huseyin Yamankaradeniz, Mustafa Tolay[11] Describes the system for gasification of solid fuels such as coal, lignite, petro coke, dangerous solid wastes, domestic solid waste, industrial solid waste, biomass covering wood charcoal, wood wool, wood shaving, agricultural wastes, treatment sludge, leather wastes, leather industry treatment sludge and cleaning of the produced gas. The solid fuel gasifier comprises: a drying zone, a pyrolysis zone, a first gasification zone comprising an oxidization zone, a reduction zone, a strait zone, a screen zone, a second oxidation zone. Furthermore the system comprises an ash extraction system and a wet discharge system, where the ash is extracted from the water bath. The purpose of the invention is to develop a solid fuel gasification and gas cleaning system which can be used in gasification of any solid wastes such as coal, lignite, petro coke, dangerous solid wastes, domestic solid wastes, industrial solid wastes, biomass covering wood waste, wood chips, wood chipping, agricultural wastes, treatment sludge, leather wastes, leather industry waste sludge and is alternative to fixed bed down flow gasification reactors. Also, to prevent occurrence of supply or feeding problems by means of operation of solid fuel supply unit free of problems. Integration of the solid fuel supply unit with entire system automation provides full automatic operation of the system, to prevent problems such as overflowing, missing that might occur in regard to raw material in the system by help of controlling the raw material level in the solid fuel gasifier, to prevent ash and soot clogging in the gas output pipes by means of preliminary dust separator and dust separator cyclone of the produced raw gas provided around the solid fuel gasifier in order to prevent the clogging of soot, ash, grains in the solid fuel gasifier, to provide supply of air to gas by means of saving in the heat near the gasification since the oxygen needed for gasification is supplied from the air, and to develop a unique system having feature of the highest efficiency in terms of power and heat economy etc..

III. CONCLUSION

From our research we concluded that,
Equivalence Ratio:
- Gas yield increase with increase in ER.
- HHV going to decrease with increase ER.
- CO, H2, CH4 decrease with increase ER.
- Carbon conversion is higher at Higher ER.

Minimum Fluidization Velocity:
- Increase with weight % of biomass.
- Feed particle size cannot affect fluidization.

Temperature:
- H and CO yield with temperature increase.
- Shape of chips or particle cannot affect temperature distribution.

Tar and Char content is lower at higher temperature.

REFERENCES

[1] Nuno Couto, Valter Silva, Eliseu Monteiro, P.S.D. Brito, Abel Rouboa,"Experimental and Numerical Analysis of Coffee Husks biomass Gasification in a Fluidized bed Reactor"(2013)

[2] Porametr Arromdee, Vladimir I. Kuprianov," Combustion of peanut shells in a cone-shaped bubbling fluidized-bed combustor using alumina as the bed material"(March-2012)

[3] R.C. Saxena, D.K. Adhikari, H.B. Goyal,"Biomass-based energy fuel through biochemical routes: A review" (July-2007)

[4] Zainal Alimuddin Bin Zainal Alauddin, Pooya Lahijani, Maedeh Mohammadi, Abdul Rahman Mohamed, "Gasification of lignocellulosic biomass in fluidized beds for renewable energy development: A review(July2010)

[5] Nuno Couto, Abel Rouboa,Valter Silva, Eliseu Monteiro, Khalid Bouziane," Influence of the biomass gasification processes on the final composition of syngas"(2013)

[6] Prabir Basu,"Gasification in Fluidized Bed"

[7] Suresh P. Babu, Gerald L. Anderson, Satyendra P. Nandi, "Process for gasification of cellulosic biomass" US Patent(Application no: US06519744)(June-1986)

[8] Amirale Rehmat, Richard Koa, "Process and apparatus for biomass gasification" US Patent (Application no:US10980714)(May-2005)

[9] Wayne A. LePori, Calvin B. Parnell,"System and process for conversion of biomass into usable energy" Us Patent(Application no: US07126832)(July-1989)

[10] Esteban Chornet, Boris Valsecchi, Sébastien Rheault, Martin Gagnon,"Production of synthesis gas thorough controlled oxidation Biomass" US Patent(Application no: US12653564)(Sep-2010)

[11] useyin Yamankaradeniz, Mustafa Tolay,"Solid fuel gasification and gas cleaning system" WO Patent(Application no: PCT/TR2007/000122)(Feb-2009)