International Journal of Engineering Research and General Science Volume 3, Issue 5, September-October, 2015
ISSN 2091-2730

Integrated Biomass Gasification Combined Cycle

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Abstract-- Acknowledging the limitations of numerous incumbent biofuel production technologies, in terms of resource potential, greenhouse gas savings and economic viability, there is considerable involvement in second generation routes. These offer the potential for a diversification of feedstocks to be used, lower greenhouse gas impacts, and lower costs. Gasification is a cardinal constituent of several of the proposed second generation paths, such as catalytic routes to diesel, gasoline, naphtha, methanol, ethanol and other alcohols, and syngas fermentation routes to ethanol. Prodigious technical procession are made that allows substantially augmented usage of biomass as a fuel. An appealing and executable possibility of biomass utilization for energy production is gasification integrated with a combined cycle. In biomass gasification, there is greater experience with gasifiers for heat and power applications than for fuels yield. This technology seems to have the hypothesis to reach utmost efficiencies based on fundamentally pristine and renewable fuel. The plants utilize low grade fuels at reasonable overall efficiencies of 35%-50% based on gross heating value. Integrated Biomass Gasification Combined Cycle (IBGCC) systems supplant the conventional combustor with a gasifier and gas turbine. Biomass gasifiers have the potency to be up to twice as efficient as using conventional boilers to generate electricity. Progressive gas turbine and combined cycle technology is commercially explicated and manifested with natural gas as well as solid fuels such as coal through the use of gasification technology. These melioration in efficiency can make environmentally clean biomass energy available at costs more competitive with fossil fuels. The gas and steam turbines operate together as a combined cycle

KEYWORDS-- Biomass gasification, biomass, Syngas, combined cycle, IBGCC, Gasifiers, Power generation

I. SIGNIFICANCE OF IBGCC

Profound concern exists over relatively high monetary value of electricity for citizens and businesses Worldwide, which enforces a financial in cumbrance and impairs countries ability to contend effectively. On the other hand, there is a prodigious cost to shield our environment and the starring factor of that cost is electricity. New environmentally favoured technologies and strategies are postulated to develop and deliver electricity at depressed cost and decreased environmental impacts. The potential problem is further compounded by a fact that systems reliableness and the price of electricity are adversely stricken by existing big inventory of superannuated steam power plants. Moreover, it is further amplified by a requirement for new cost-effective pollution control technologies needed to reduce the health and environmental impacts from power plant emissions. Therefore, an imperative demand

exists to evolve superior, but economical methods to produce electricity while scaling down the wood and green waste landfills with the state-of-the-art control emanation of fine particles and va por-phase toxics. The combination of progressive technology and meliorate fuel supply has in a way increased the feasible biomass power plant size into a range appealing to utilities, and thus inflate the market for biomass power beyond the independent power producers and co-generators who have, to date, been the master players in the biomass power industry.

II. INTRODUCTION

The Integrated biomass gasification combined cycle (IBGCC) produces electricity from biomass which can be expounded in two major parts as follows:

A. *Biomass gasification*

Biomass gasification implies partial combustion of biomass ensuing in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen (H_2) and traces of Methane (CH_4). This mixture is called producer gas which can be used to run internal combustion engines , can be used as backup for furnace oil in upfront heat applications and can be used to produce, in an economically viable way, methanol – an exceedingly attractive chemical which can be used as a fuel for heat engines as well as chemical feedstock for industries. Since any biomass material can undergo gasification, this process is much more inviting than ethanol production or biogas where only selected biomass materials can produce the fuel. Besides, there is a problem that solid wastes are seldom in a form that can be readily utilized economically e.g. Wood wastes can be used in hog fuel boiler but the equipment is expensive and energy recovery is low. As a result it is often beneficial to commute this waste into more readily usable fuel from like producer gas and so the gasification process is victimized. However under present conditions, economic factors seem to provide the reinforced argument of considering gasification. In many situations where the cost of petroleum fuels is high or where provisions are unreliable the biomass gasification can be an economically viable system – provided the suitable biomass feedstock is easily accessible.

B. Combined cycle

The producer gas is commuted to electricity in a combined cycle power block comprising of a gas turbine process and a steam turbine process which also includes a heat recovery steam generator (HRSG).The combined cycle technology is connatural to the technology used in modern natural gas fired power plants.

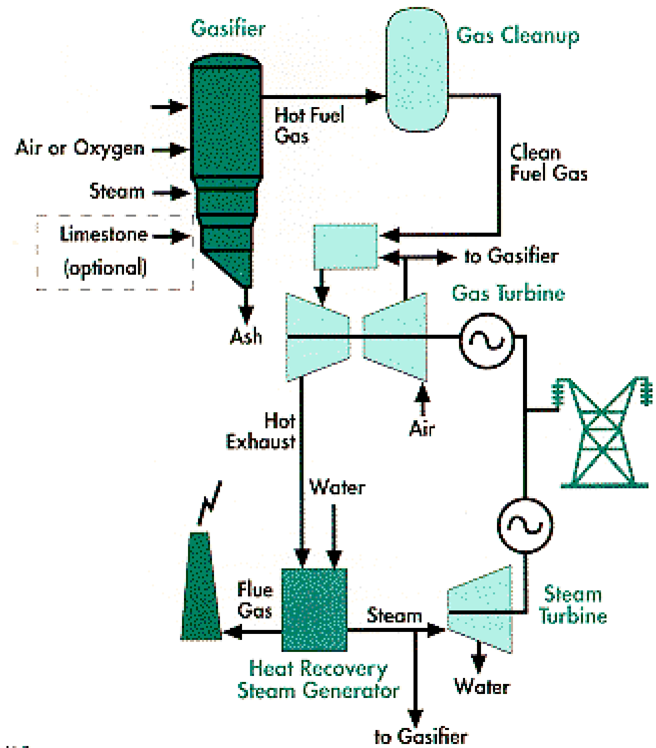

Figure1.Integrated Biomass Gasification Combined Cycle

III. CHARACTERISTICS OF IBGCC

The Integrated biomass gasification combined cycle offers distinctive features which the other competing technologies lack as:

1. It is environmentally superlative to conventional green biomass fired power plants and can be designed to meet the most rigorous ordinance;

2. Surmounts thermal efficiencies of the existing conventional technologies;

Also, IBGCC Power Generation technology proves its outstanding characteristic in a way that it has the potential applicability to a variety of fuels. The most pressing need for advanced gasification technology is for repowering of older coal-, and gas-fired boilers that typically have low efficiency and high discharge levels.

IV. WORKING OF IBGCC

IBGCC systems are antiseptic and it is based on an advanced technology - a gasifier used instead of the traditional combustor conjugated with a key enabling technology, the advanced gas turbine. The overall system is an integrated biomass gasification combined-cycle conformation that renders superior system efficiencies and ultra-low discharge levels.

4.1 Syngas formation

Syngas or the producer gas is the product of the gasification process which can be delineated as a thermochemical operation, denoting that the feedstock is ignited to high temperatures, producing gases which can undergo chemical reactions to form a synthesis gas. The biomass gasification process is a combination of four phases and the literal sequence depends on the gasification system applied. The phases of gasification are:

A. Drying

Biomass contains usually a large amount of water. Wood chips, for example, may easily achieve moisture values around 55% in weight. Drying is the gasification phase that occurs at lower temperature (100-150°C), ideally purely physical. At this temperature the water in the fuel evaporates and the steam diffuses towards the external atmosphere due to a negative gradient of concentration. In the case of gasification, if the drying process is retarded (low drying speed) the amount of unburnt carbon becomes larger, which is of course an unwanted effect. The drying speed is affected by thermal conductivity of the fuel and by the fuel packing.

B. Pyrolysis

It is a thermal process that converts the fuel, in the current case biomass, into char, ashes and volatiles. Pyrolysis evaporates the volatile ingreidient of the feedstock as it is heated. The volatile vapors contain hydrogen, carbon monoxide, carbon dioxide, methane, hydrocarbon gases, tar, and water vapors. As biomass feedstock's have more volatile components (70-86% on a dry basis) than coal (around 30%), pyrolysis plays a significant role in biomass gasification than in coal gasification. Byproducts also include solid char and ash.

C. Oxidation:

In the zones that are rich in oxygen, which is under-stoichiometric anyway, oxidation occurs between 700°C and 2000°C. Part of the char is combusted. Oxidation is the main source of energy for the gasification process, being strongly exothermic.

D. Reduction

It is the conversion of char into ash and gases, in a virtually oxygen-free atmosphere, thanks to carbon dioxide, water or hydrogen. Water may be inserted in the form of steam, mixed with the gasification agent flow.

4.2 TYPES OF GASIFIERS

Mainly the following five types of the gasifiers are used and they are:

A. Updraft gasifier (countercurrent)

In the countercurrent reactor the biomass is inserted from the top, while the gasification agent, usually steam and air, from the bottom, through the grate. The producer gas is extracted from the top.

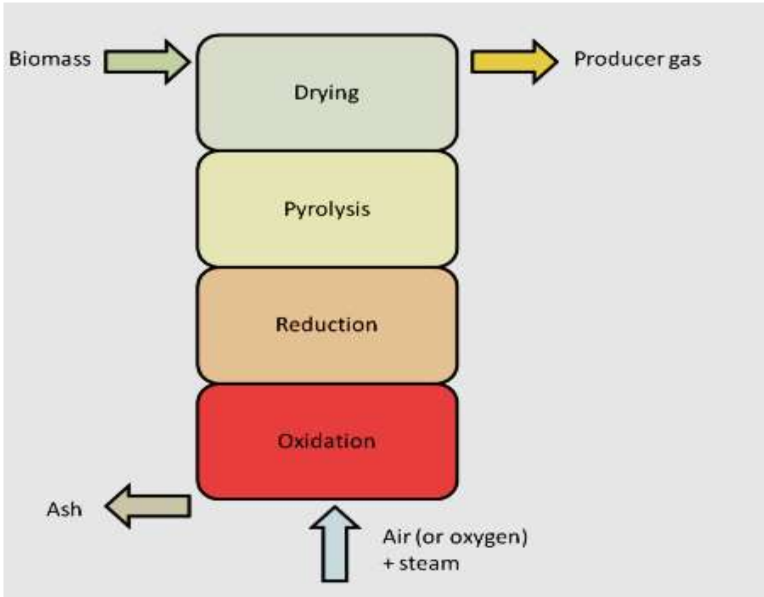

Figure 3. Updraft gasifier.

B. Downdraft fixed bed

The biomass along with air,oxygen or steam is fed from the top of the gasifier oxygen or steam, hence the biomass and gases move in the same direction. Some of the biomass is combusted, falling through the gasifier throat to form a bed of hot charcoal which the gases have to pass through the reactive zone. This ensures a fairly high quality syngas, which leaves at the base of the gasifier, with ash collected under the grate.

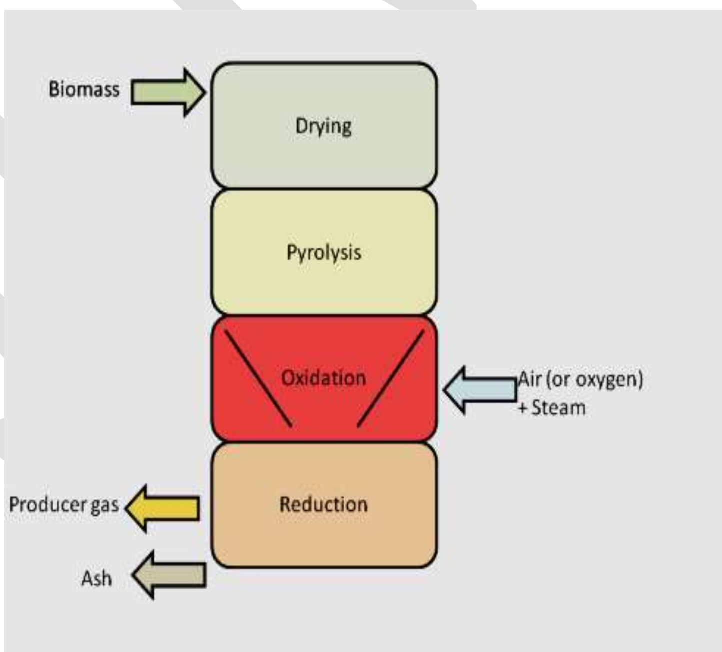

Figure 4. Downward gasifier .

C. Dual fluidized bed (Dual FB)

Dual fluidized bed system contains two chambers – a gasifier and a combustor. Biomass is fed into the CFB / BFB gasification chamber, and regenerated to nitrogen-free syngas and char using steam .The char is combusted in air in the CFB / BFB combustion chamber, heating the accompanying bed particles, further which is fed back into the gasification chamber, providing the indirect reaction heat .Cyclones remove any CFB chamber syngas or flue gas. It also operates at temperatures below 900°C to avoid ash melting and sticking and can be pressurized.

D. Circulating fluidized bed (CFB)

A bed of fine inert material has air, oxygen or steam blown upwards through it fast enough (5-10m/s) to set aside the material through the gasifier. Biomass is fed in from the side, is suspended, and ignites providing heat, or reacts to form syngas .The mixture of syngas and particles are isolated using a cyclone, with material returned into the basal part of the gasifier .

E. Fluidized bed gasifier

The fluidized bed gasifier is a completely different concept. The flowing gasification agent, which is blown at high velocity from the bottom, mixes biomass particles, oxidizer, hot gases and the bed material. The bed material consists of very small particles of inert material (a siliceous sand), which avoid sinterization, and catalysts, which decrease the tar amount and control the syngas composition. The temperature is very homogeneous and usually lower than in the fixed bed gasifiers, being around 750-900°C. The gasification phases are not spatially localized. This type of gasifier generates a high tar amount, due to the low temperature, difficulties in controlling the process and the need for creating a pressure in the reactor, usually. The main advantages are a very high heat transfer and high reaction velocity, thanks to the high turbulence, that assures compactness, useful especially in large scale plants. The carbon conversion is high and it is flexible to the changes in biomass moisture and fast to turn on and off.

4.3. POWER GENERATION

As it is fully customary, highly effective, combined cycle power plant is competent of reliable operation on natural gas or other fuel. The accession of the Integrated Biomass Gasification Combined Cycle (IBGCC) converts biomass to a clean fuel gas, which is burned in the progressive, high efficiency combustion turbine .The combined cycle concept includes the two main cycles that is the Brayton cycle (top cycle) and a Rankine cycle (bottom cycle), consists the recovery of the hot flue gas, which is generated by the Brayton cycle, through a Heat Recovery Steam Generator (HRSG) which is basically a set of heat exchangers that produces steam for the Rankine cycle. The steam generated by the HRSG is expanded in a steam turbine, generating power. Afterwards the steam, usually saturated, condensates and heat is released to the environment (or to the district heating system, if present). Finally the feed-water is compressed by a pump and sent again to the HRSG. Combining the two cycles and recovering part of the thermal energy of the flue gases result in high efficiency between 47% and 52%. A gas engine may also be combined with a Rankine cycle . Under this condition, since the flue gas temperature is lower than in the Brayton cycle, an additional firing helps to achieve the temperature required by the steam superheating.

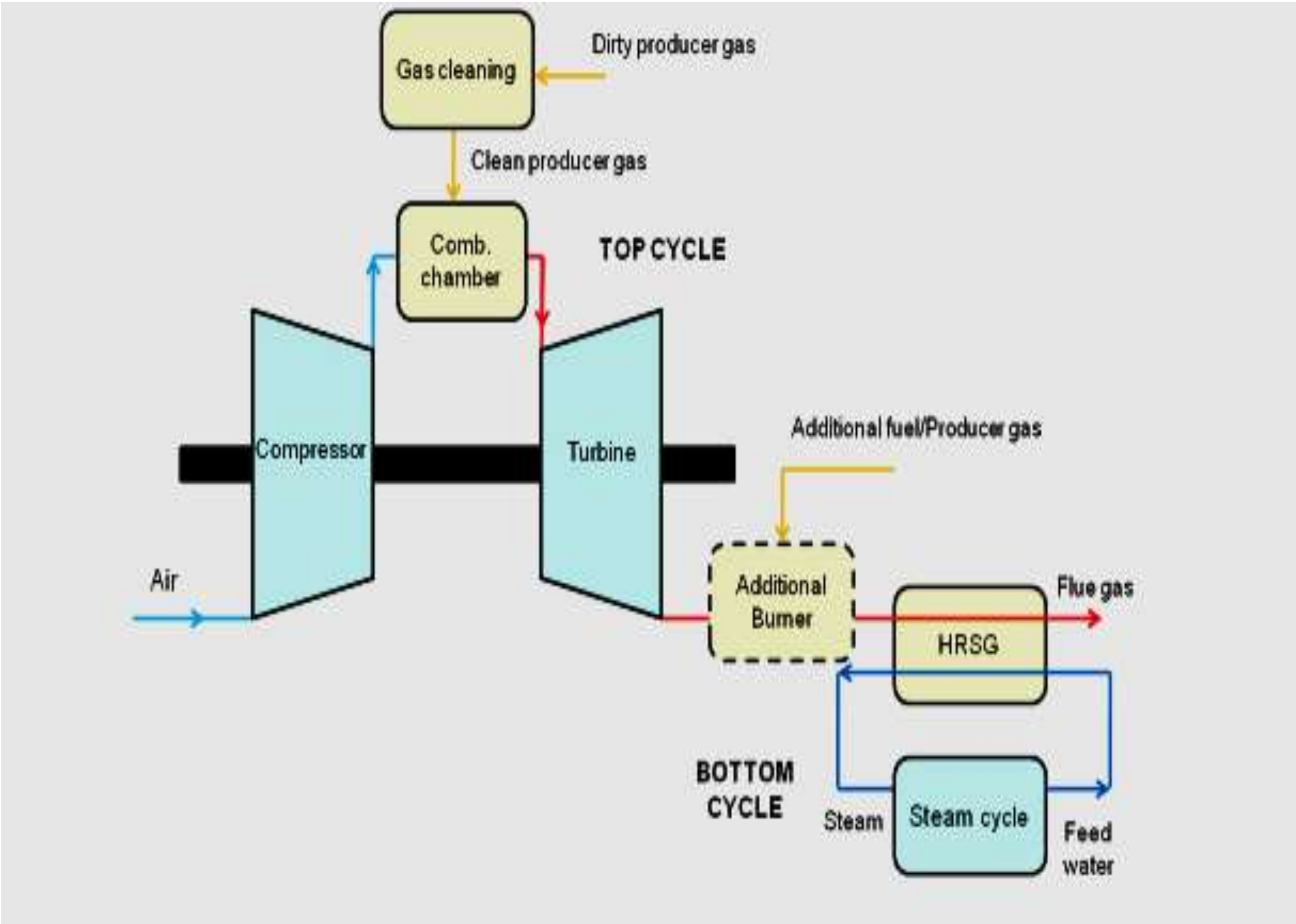

Figure 5. Combined plant with Brayton and Rankine cycle.

V. CONCLUSION

Moreover, these biomass power systems will further encourage research by directly and substantially benefitting from the technological procession being made by authorities and industry funded gas turbine and fuel cell development programs. These utilization technologies are the subject of substantial evolution endeavours, and are being showcased in integrated systems with coal gasifiers.

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