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COAL GASIFICATION TO GENERATE POWER WITH GREEN HOUSE GAS EMISSIONS

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ABSTRACT
An integrated gasification combined cycle (IGCC) is a technology that turns coal into gas synthesis gas (syngas). It then removes impurities from the coal gas before it is combusted and attempts to turn any pollutants into re-usable byproducts. This results in lower emissions of sulfur dioxide, particulates, and mercury. Excess heat from the primary combustion and generation is then passed to a steam cycle, similarly to a combined cycle gas turbine. This then also results in improved efficiency compared to conventional pulverized coal. It is the most environmentally friendly coal fired power generation technology. This paper presents the advances in gasification technology to generate power with zero green house gas emission.

Key words: Gasification, pre-combustion, emission syngas combined cycle etc.

INTRODUCTION

Coal gasification is the process of converting coal to a gaseous fuel through partial oxidation. The coal is fed into a high-temperature pressurized container along with stem a limited amount of oxygen to produce a gas. The gas is known as synthesis gas or syngas and mainly consists of carbon monoxide and hydrogen. The gas is cooled and undesirable components, such as carbon dioxide and sulphur are removed. The gas can be used as a fuel or further processed and concentrated into a chemical or liquid fuel.

The first stage is the coal gasification process as mentioned above. The second stage takes the cleaned gas and burns it in a conventional gas turbine to produce electrical energy, and the hot exhaust gas is recovered and used to boil water, creating system for a steam turbine which also produces electrical energy. In typical plants, about 65% of the electrical energy is produced by the gas turbine and 35% by the steam turbine.

COAL GASIFICATION

There are three basic gasifier designs used for coal gasification in IGCC plants.

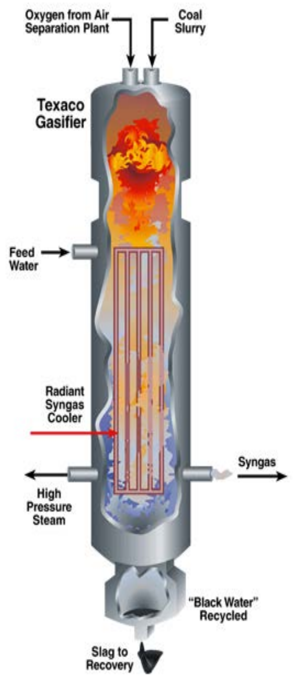
- Entrained flow gasifiers,
- Fixed bed gasifiers
- Fluidized bed gasifiers.

Entrained flow Gasiifer

Entrained flow is the most aggressive form of gasification, with the pulverized coal and oxidizing gas flowing concurrently. High reaction intensity is provided by a high pressure (20-30 atm), high temperature (>1400-1500°C) environment. Extremely turbulent flow sees the coal particles experience significant backmixing, and residence times are measured in seconds.

Advantages

- Extremely high temperatures shorten refractory life.



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- There is a limit to the heat that can be recovered from the raw fuel gas, without water quench becoming necessary
- A cost is incurred in providing oxygen and coal to sustain the gasifier temperature

Fixed Bed Gasifier

Basically two types of fixed bed gasifiers are used: -

Counter-current fixed bed ("up draft") gasifier

A fixed bed of carbonaceous fuel (e.g. coal or biomass) through which the "gasification agent" (steam, oxygen and/or air) flows in counter-current configuration. The ash is either removed dry or as a slag. The slagging gasifiers have a lower ratio of steam to carbon, achieving temperatures higher than the ash fusion temperature. The nature of the gasifier means that the fuel must have high mechanical strength and must ideally be non-caking so that it will form a permeable bed, although recent developments have reduced these restrictions to some extent. The throughput for this type of Gasifier is relatively low. Thermal efficiency is high as the gas exit temperatures are relatively low. However, this means that tar and methane production is significant at typical operation temperatures, so product gas must be extensively cleaned before use. The tar can be recycled to the reactor.

In the gasification of fine, undensified biomass such as rice hulls, it is necessary to force air into the reactor by means of a fan. This creates very high gasification temperatures, at times as high as 1000 C. Above the gasification zone, a bed of fine, hot char is formed, and as the gas is forced through this bed, most complex hydrocarbons are broken down into simple components of hydrogen and carbon monoxide.

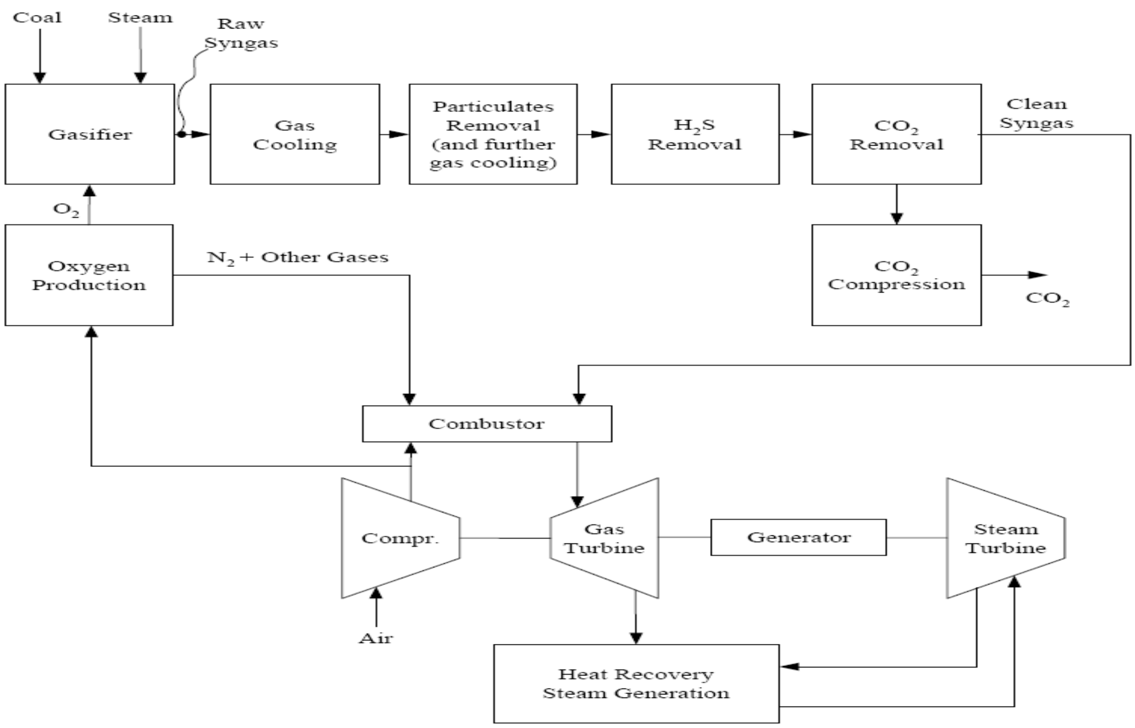
Co-current fixed bed ("down draft") gasifier

Similar to the counter-current type, but the gasification agent gas flows in co-current configuration with the fuel (downwards, hence the name "down draft gasifier"). Heat needs to be added to the upper part of the bed, either by combusting small amounts of the fuel or from external heat sources. The produced gas leaves the gasifier at a high temperature, and most of this heat is often transferred to the gasification agent added in the top of the bed, resulting in energy efficiency on level with the counter-current type. Since all tars must pass through a hot bed of char in this configuration, tar levels are much lower than the counter-current type Fixed bed gasifier operate at 26 bar and closely resemble a blast furnace. Coal and fluxes are placed on the top of a descending bed in a refractory lined vessel. On moving downwards, the coal is gradually heated and contacted with an oxygen enriched gas flowing upwards counter currently.

The temperature at the top of the bed is typically 450°C, and at the bottom approximately 2000°C. All coal mineral matter melts and is tapped as an inert slag. Ash melt characteristics influence bed permeability, and fluxes may need to be added to modify slag flow characteristics.

Integrated gasification combined cycle

Modern gas cleanup technology requires the gas to be



cooled before processing. This cooling can be achieved more efficiently using heat recovery heat exchangers that produce steam; however this adds operational complexity. Gas cooling is typically integrated into the gasifier design. Particulate removal equipment (e.g., a venturi scrubber) can also provide additional gas cooling. An alternative to extensive gas cooling is to use hot gas cleanup technology, which is still in a developmental stage.

If the syngas is at a relatively high pressure compared to exhaust gases, the more efficient process of physical absorption can be used instead of chemical absorption. Physical absorption is discussed later in more detail. Carbon dioxide is removed from the syngas after H2S is emoved. A few different processes could potentially be used to remove the CO2. These options Gasifier Gas Cooling Particulates Removal (and further gas cooling) H 2 S The removed CO2 is compressed and is then ready for sequestration. The synthesis gas is burned as fuel in the gas turbine combined cycle power plant. If the gasifier is fired with oxygen and fuel nitrogen compounds are removed during gas cleanup then the NOx is formed exclusively in the combustion turbine, which produces relatively little NOx.

Waste heat contained in the turbine exhaust gas is captured for steam production using heat recovery steam generation. The steam is sent to a steam turbine for additional production of electricity. The compressor for the gas turbine also supplies compressed air to the oxygen production unit, which separates air into separate streams of oxygen and nitrogen combined with other gasses using the method described for oxygen-fired combustion. Near-term technology involves cryogenic based oxygen production whereas ion separation membranes have potential for long-term (2010) application. The oxygen is an input to the gasifier and the nitrogen is sent to the combustion chamber to reduce NOx emissions by decreasing combustion temperatures.

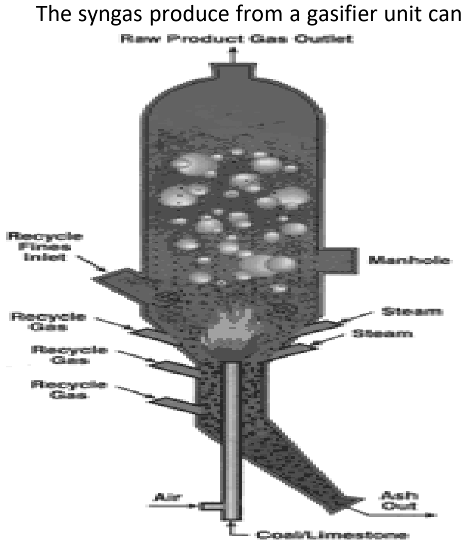
Fluidised bed gasifier

In a fluidized bed gasifier, the bed material can either be sand or char, or some combination. The fluidizing medium is usually air; however, oxygen and/or steam are also used. The fuel is fed into the system either above-bed or directly into the bed, depending upon the size and density of the fuel and how it is affected by the bed velocities. During normal operation, the bed media is maintained at a temperature between 1000EF and 1800EF. When a fuel particle is introduced into this environment, its drying and pyrolyzing reactions proceed rapidly, driving off all gaseous portions of the fuel at relatively low temperatures. The remaining char is oxidized within the bed to provide the heat source for the drying and de-volatilizing reactions to continue. In those systems using inert bed material, the wood particles are subjected to an intense abrasion action from fluidized sand. This etching action tends to remove any surface deposits (ash, char, etc.) from the particle and expose a clean reaction surface to the surrounding gases. As a result, the residence time of a particle in this system is on the order of only a few minutes, as opposed to hours in other types of gasifiers.

The large thermal capacity of inert bed material plus the intense mixing associated with the fluid bed enable this system to handle a much greater quantity and, normally, a much lower quality of fuel. Experience with EPI's fluidized bed gasifier Fluidised bed gasifier has indicated the ability to utilize fuels with up to 55 percent moisture and high ash contents, in excess of 25 percent. Because the operating temperatures are lower in a fluid bed than other gasifiers the potential for slagging and ash fusion at high temperatures is reduced, thereby increasing the ability to utilize high slagging fuels.

Advantages of IGCC (Integrated Gasification Combined Cycle)

- It can achieve up to 50% thermal efficiency. This is a higher efficiency compared to conventional coal power plants meaning there is less coal consumed to produce the same amount of energy, resulting in lower rates of carbon dioxide (CO2) emissions
- It produces about half the volume of solid wastes as a conventional coal power plant.
- It uses 20-50% less water compared to a conventional coal power station.
- It can utilise a variety of fuels, like heavy oils, petroleum cokes, and coals.
- Up to 100% of the carbon dioxide can be captured from IGCC, making the technology suitable for carbon dioxide storage.
- carbon capture is easier and costs less than capture from a pulverised coal plant
- A minimum of 95% of the sulphur is removed and this exceeds the performance of most advanced coal-fired generating units currently installed.
- Nitrogen oxides (NOx) emissions are below 50ppm. This is lower than many of today's most advanced coal-fired generating units.
- The syngas produce from a gasifier unit can be



burned in a gas turbine for electricity generation,

CONCLUSION

Advances in gasification technology and improved methods of separating oxygen will be required before this option can be used. Power plants that use pre-combustion capture are additionally attractive because of based on a combined cycle design which is inherently more efficient than the Rankine cycle that traditional coal plants use. Since hydrogen production is a potential option, pre-combustion capture is also compatible with hydrogen economy.

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