Advanced Research in Electrical and Electronic Engineering
p-ISSN: 2349-5804; e-ISSN: 2349-5812 Volume 3, Issue 1 January-March, 2016, pp. 1-3

http://www.krishisanskriti.org/Publication.html

Coal Gasification: An Advance Power Generation Technology

Akanksha Mishra[1], Shalini Gautum[2] and Tripurari Sharma[3]

[1]Department of Mechanical & Automobile Engineering, Sharda University, G.Noida, U.P., India
[2,3]Department of Fuel & Mineral Engineering, Indian School of Mines, Dhanbad, Jharkhand, India
E-mail: [1]6akanksha2@gmail.com, [2]shalini_ism@rediffmail.com, [3]hodfmeism@yahoo.co.in

Abstract—*Conventional energy sources have major contribution in enhancing the pollution levels worldwide. Industries are looking for the advance clean technologies for the product of electricity. Coal has been used as a primary source of fuel for the production of electricity worldwide. Clean coal technologies are bounded to be adopted for electricity generation, which help in reducing level of CO_2 emission and global warming. Now days conventional coal combustion methods are replaced by advance coal gasification technique which is the prominent clean method for coal utilization. IGCC power plant is a successful attempt of power sectors towards clean utilization of coal. IGCC plants enhance the overall efficiency of the power plants and produce CO_2 free emission to the environment. In this paper an attempt has been made to compile the investigations carried out by several researches in the field of coal gasification.*

Keywords*: Coal, Gasification, Power Plant.*

1. INTRODUCTION

In response to the increasing pollution worldwide, an advance power generation technologies are in demand. Coal gasification in power generation sector is in demand now days for the production of clean electricity. Coal gasification is a conversion of solid fuel to liquid fuel. Coal gasification produces electricity with higher conversion efficiency than conventional power generation methods, with significant reductions in the emission products like CO_2, NO_x, SO_x and PM. In another worlds coal gasification is a process of conversion of carbonaceous materials like fossil fuel and biomass into a mixture of gasses like H_2 and CO, mixture of produced H_2 and CO is often term as Syngas or Synthesis. There are some other by products also found such as a tar, benzol etc. Required operating conditions for coal gasification are elevated temperature and elevated. Coal gasification reactions take place inside gasifiers in which limiting amount of oxygen is passed through it. Carbonaceous fuel is reacted with steam & limited amount of oxygen at elevated temperature higher than 750^{o}C and pressure of the order of 30 bar to produce Syngas and other by products. Syngas is used for the production of electricity. Common reactions used in gasification process are:

1. Thermal Decomposition:
   $$HC + Heat = H_2 + C + Organics$$
2. Reaction with Oxygen:
   $$HC + O = H_2 + CO + Heat$$
3. Reaction with Steam:
   $$HC + H_2O + Heat = 3/2\ H_2 + CO$$
4. Reaction with Hydrogen:
   $$HC + H_2 = CH_4 + Heat$$

In this paper an attempt has been made to compile the work of some researchers in the field of coal gasification for power generation.

2. COAL PYROLYSIS

Coal pyrolysis is a first step in the coal gasification process. In the pyrolysis process coal particles first get dried by hot gases, after this pyrolysis of particles starts as temperature exceeds 400^{o}C. The products of pyrolysis are oils, tars, phenol and hydrogen rich volatile HC gases. Residue of pyrolysis is char which contains remaining carbon and mineral matter. After achieving temperature of around 700^{o}C of char particles, gasification reactions start. There are several parameters which effects the coal pyrolysis like coal rank, temperature, heat rate, pressure and particle size [1].

Coal pyrolysis plays a very important role in gasification process. Due to complex structure of coal pyrolysis reactions are very complicated. Coal pyrolysis is sub divided into two categories [1]:

(a) Primary pyrolysis up to 550 to 600^{o}C in which mainly tar and some of the gases are evolved.
(b) Secondary pyrolysis up to 1000 to 1050^{o}C in which only gas is split off.

Among these two stages, primary stage of pyrolysis is most vital. Portion of gas and tar produced by pyrolysis is widely varied with coal rank.

Roberts et al. [2] investigated the effect of pyrolysis pressure on char reactivity. They reported that char made up at elevated

pressure and high heating rate have apparent reaction rates in CO_2, H_2O and O_2 which are of higher magnitude than those of char made up at atmospheric pressure and slow heating rate. They also reported that inherent char chemistry has very little effect of pyrolysis pressure because measured char carbon crystal structure does not affected by pyrolysis pressure.

Liu et al. [3] investigated the effect of pyrolysis time on the gasification reactivity of different chars in CO_2 atmosphere. They concluded that the reactivity of char slower down with longer pyrolysis time because of change of char structure during pyrolysis.

Liu et al. [4] reported that during gasification reactions of char made up with slow pyrolysis, are more stable compared to rapid pyrolysis char.

3. GASIFIERS

There are various gasification technologies. All the gasification technologies mainly can be classified into 3 categories of gasifier configuration as per their flow geometry [1] [5].

(i) **Entrained Flow Gasifier:** Entrained Flow gasifiers are most commonly used. In these gasifiers pulverized coal particles and gas flow concurrently at high speed. In these gasifiers coal can be feed either in dry or wet condition to the gasfiers. They usually operate at a temperature of 1200-1600^oC and pressure 2-8 MPa with most likely at 2.5 MPa. These gasifier can be operated on both types of fuels solid as well as liquid fuels with high operational temperature (above ash slagging temperature), which ensures high carbon conversion and syngas without tars and phenol.

(ii) **Fluidized bed gasifiers:** In fluidised bed gasifiers solid fuel of around 0.5 to 5mm size is introduced into gasifier in upward flow of gas which fluidized the bed of fuel while the reaction is taken place. Bed is made up of coke/char/sand or ash.

(iii) **Moving bed gasifier:** Moving bed gasifier can be of either dry ash or slagging. These kinds of gasifiers are only suitable for solid fuels and can process coal with waste/ biomass.

4. GASIFICATION FOR POWER GENERATION:

Minchener [5] Reported that the most of IGCC projects are based on shell and Texaco gasification technology. They reported that there is a project in the Czech Republic to develop an IGCC which is based on the HTW technology of gasification to replace old moving bed gasifier. For the processing of waste and coal, there is one coal IGCC power plant operating with moving bed gasifier in Germany (Schwarze Pumpe, BGL Technology).

Table 1: Primary products produced by fossil fuel gasification [5]

Product	Primary product		Secondary product
	Operating plant	Planned plant	
Electricity	35	25	6
Hydrogen	11	1	11
Ammonia	34	3	1
Syngas	14	1	2
Methanol	12	1	11
Oxy-chemicals	22	0	1
Carbon dioxide	7	0	5
Others (FT liquids, fuel gas)	25	4	0
Total	160	35	37

Breault [6] reported IGCC power plant converts carbonaceous fuel into electricity. In IGCC plants carbonaceous fuel along with gasification medium like O_2 and steam goes to the gasifiers which produces raw syngas. The produced raw syngas goes for the cleanup from PM & sulfur. Clean up syngas then fed to the combustion turbine with the products going to the steam turbine and steam generator of heat recovery.

They also reported that there are two types of IGCC plants with carbon capture (Fig 1) & without carbon capture (Fig 2). The primary difference between these two processes is that clean syngas passes by a shift reactor and an absorption tower in order to remove the carbon in the form of CO_2. The function of the shift reactor is to convert the carbon monoxide in the syngas by reacting it with water to form CO_2 and H_2 and then CO_2 goes to sequestration.

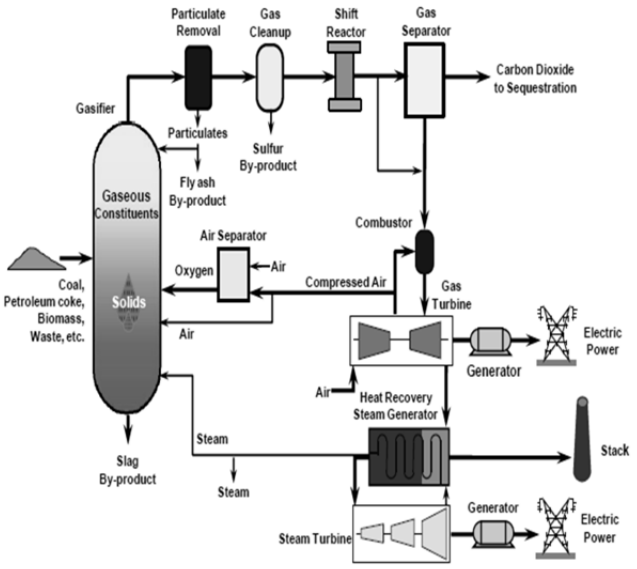

Fig. 1: IGCC plants with carbon capture

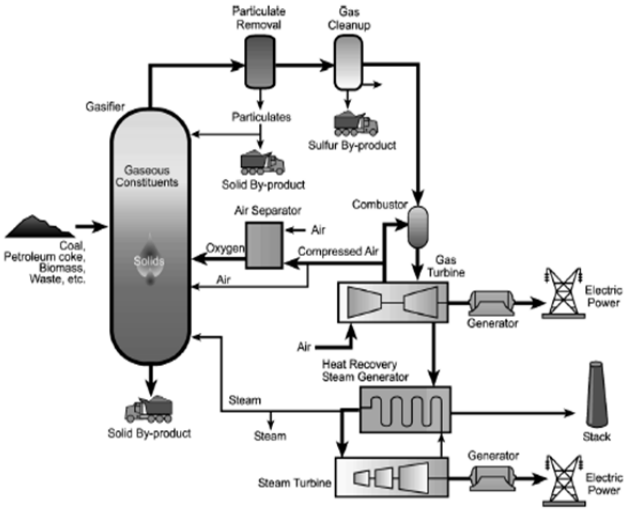

Fig. 2: IGCC plants without carbon capture

5. CONCLUSION

Increasing awareness towards effects of power generation on environment, scientists are looking for advance environment friendly power generation technologies. Coal gasification has been considered as an important clean coal technology for power generation. Integrated gasification combined cycle (IGCC) technology has been developed for the most efficient and clean utilization of coal.

REFERENCES

[1] Saha, S., "Study on physical properties of Indian coals and its effect on coal gasification kinetics", Ph.D thesis, Indian School of Mines, 2013.

[2] Roberts, D.G, Harris, D.J, and Wall, T.F, "On the effects of high pressure and heating rate during coal pyrolysis on char gasification reactivity". Energy & Fuels, 17, 2003, pp. 887-895.

[3] Liu, H., Kaneko, M., Luo, C., Kato, S., and Kojima, T., "Effect of pyrolysis time on the gasification reactivity of char with CO2 at elevated temperature", Fuel, 2004, pp. 1055-1061.

[4] Liu, T-F, Fang, Y-T, and Wang, Y., "An experimental investigation into the gasification reactivity of chars prepared at high temperatures", Fuel, 87, 2008, pp. 460-466.

[5] Minchener, A. J., "Coal gasification for advance power generation", Fuel, 84, 2005, pp. 2222-2235.

[6] Breault, R.W., "Gasification processes old and new: A basic review of the major technologies", Energies, 3, 2010, pp. 216-240.