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Leading Potential of Gasification in India

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ABSTRACT

Presently, the consumption of fossil fuel increases rapidly, and it may exhaust soon. At the same time, we observe that the combustion of fossil fuel increases the level of pollution and hence global warming. Therefore, we must have alternate solutions to generate power in a cleaner way. Renewable energy is the present and/or future demanding technology. Power loss is one of the major problem during its transmission. So, there are two basic problems were identified that first is the selection of renewable energy sources and second is long range transmission loss. Gasification is a process of incomplete combustion of carbon containing fuels. Gasification can be used as a clean energy to generate electric power from fossil fuels like wood, coal; agricultural produce that will help to meet the requirement of demand of electricity in rural and remote areas. Gasification based power generation is more suited for decentralized energy supply and has great potential to be used as a substitute of fossil fuels. This paper reviews the state wise power generation through biomass. Also discuss an idea to integrate a gasification technology with the power generation system.

Keywords*: *coal gasification, biomass gasification

I.INTRODUCTION

India is rapidly developing economy and in future the demand of energy consumption is also increases. India shows a positive mood hence, in the upcoming years, load on power plants increases heavily. In India, the installed capacity of thermal power plant is contributing nearly 75% and gas power plants contribute nearly 10% of total installed capacity [1]. Large numbers of projects are currently in progress to meet the demand of energy. Petroleum products runs not only industries, transports but also provide electricity and affects the number of items. Large number of plants producing electricity by combustion of coal, which produces the harmful gases causing global warming. Burning of coal release harmful gases into atmosphere such as, carbon dioxide, sulphur dioxide, nitrogen dioxide, sulphuric acid, ash etc.

Compared with natural gas, burning of coal emits approx twice the CO_2 and other to produce the same level of heat, this results a clear evidence that the levels of greenhouse gas increases, and also leads to acid rain. Rather than complete combustion, incomplete combustion of carbonaceous fuels is much better, called gasification. Gasification produces low to medium energy gas, occurs in between temperature range 600 to1500 . It may depend on the operating parameters and type of gasification. This paper provides a review of the gasification technology and its application, more focused on biomass gasification and introduction of use of solar energy as a supplement for biomass power generation.

II. LITERATURE REVIEW

Fischer and Schrattenholzer (2001) estimated the global biomass potential to be 91 to 675 EJ/year for the years 1990 to 2060. Their biomass included crop and forestry residues, energy crops, and animal and municipal wastes. [2]

C.Z. Wu et al. (2001), in his review paper shows an experimental investigation on newly constructed 1 MW-scale circulating fluidized bed (CFB) Bio Gasification and Power generation(BGPG) plant and it was found that the unit capital cost of BGPG is only 60–70% of coal power station and its operation cost are much lower than that of conventional power plants. Also gives an idea that why these technology due to the relatively low efficiency of small-scale plant, the current BGPG technology will lose its economic attraction. [3]

Philippe Mathieu and Raphael Dubuisson (2002), this paper presents an original modelling of the biomass gasification process and more particularly the wood gasification. Gasification is one of the more efficient ways to convert the energy embedded in the biomass. The model based on the minimization of the Gibbs free energy is performed in the ASPEN PLUS process simulator. the following conclusions are derived: there exists a critical air temperature above which the preheating is no longer efficient, there is an optimum oxygen factor, the oxygen enrichment of air plays an efficient role under a certain value and the operating pressure has only a slight positive effect on the process efficiency. [4]

Ke Wu et al. (2007) introduces the application of coordinated control strategy to an IGCC power plant to improve pressure and load output dynamic performance. An IGCC power plant model was obtained by integrating the gasifier and combined-cycle model with certain simplifications. Simulation results of the load change test illustrated the good load-tracking and pressure deviation reduction abilities of this coordinated control strategy. [5]

Maria Puig-Arnavat et al. (2010) This paper presents and analyses several gasification models based on thermodynamic equilibrium, kinetics and artificial neural networks. The thermodynamic models are found to be a useful tool for preliminary comparison and for process studies on the influence of the most important fuel and process parameters. They have the advantage of being independent of gasifier design, but they cannot give highly accurate results for all
cases. The kinetic-based models are computationally more intensive but give accurate and detailed results. [6]

III.TECHNOLOGICAL ASPECT OF GASIFIER

Important steps involved in any gasification process are shown below in which gas cleaning and cooling is majorly responsible for further proper working.

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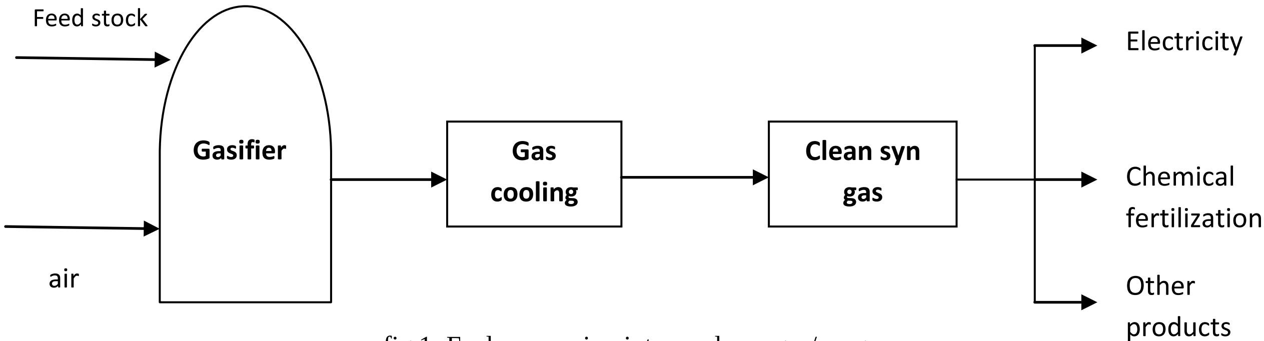

fig 1: Fuel conversion into producer gas/syngas

$C_6H_{10}O_5 + 1/2O_2 \longrightarrow 6CO + 5H_2$ (Gasification) [7]

$C_6H_{10}O_5 + 6O_2 \longrightarrow 6CO + 5H_2$ (Combustion)

In modern technology basic gasifier designs have not changed, it advances in their applications and variability with fuels. Keeping various aspects in mind a designer should designed a gasifier.

A) UP DRAFT GASIFICATION: fig 2.1 a shows a simplest type among all type gasifier. Its simplicity is its identity. In this type fuel is fed in at the top and moves downwards. The air is intake at the bottom and the gas leaving at the top. As the motion of air and gas flow is in opposite direction, it is termed as counter current flow. Starting from top, drying zone followed by pyrolysis zone, reduction zone, and combustion zone. Up draft gasifier have higher thermal efficiency. The exit temperatures of the gas are in the range of 100 to200 . Major disadvantage is that it produces a dirty gas unless a tar free fuel is used. Therefore it may be concluded that it is restricted to direct heat applications only. It is not suitable very much for engine applications. Some of this type gasifier may operate at extremely high temperatures, 1300 and above in order to melt ash, called as slagging type gasifier. [8,9]

At the ENEA Trisia Research Centre, a range of values for each gas component in the producer gas is summarized with the 150 kWh updraft fixed bed gasification plant is tabulated [10]

Table 1: volume percentages of different components

Gas Component	%-v(Dry Basis)
H_2	**18-20**
CO	**25-27**
CO_2	**10-12**
CH_4	**3**
N_2	**40**

B) **DOWN DRAFT GASIFIER:** fig 2.2 shows one of the simplest types of gasifier. Starting from the top, conical hoppers used to feed the fuel, followed by drying zone, oxidation zone and then reduction zone. Fuel is introduced from the top and air flow downwards through combustion and reduction zones. In this type the motion of air flow and fuel movement is in same direction and hence it is also termed as co-current type gasifier. Most of the mobile gasifier are down draft type is used at the time of World War II [9]. In most of the cases, a throat sections near the combustion zone is created i.e.; internal diameter decreases in the combustion zone and then expanded in reduction zone. Air inlet nozzles are arranged in such a manner that it may provide air uniformly as much possible. Aim is to ensure that enough temperature are created around the whole diameter of the combustion zone. The temperatures are decreases on moving away from the air inlet. This shows that there is some practical limit to the distance between inlets and diameter of hearth. As it is clear that gas leaves directly from the reduction zone, it must contain some ash particles. Hence gas cleaning is required. The exit temperature is also high as compared with the updraft gasifier. It can produce relatively tar-free gas under proper working environment.

At the ENEA Trisia Research Centre, a range of values for each gas component in the producer gas is summarized with the 150 kWh updraft fixed bed gasification plant is tabulated [10]

Table 2: volume percentages of different components

Gas Component	%-v(Dry Basis)
H_2	**10-15**
CO	**15-25**
CO_2	**15-20**
CH_4	**1-3**
N_2	**40-12**

C) **ENTRAINED FLOW:** fig 2.3 shows entrained flow type biomass. Biomass is fed into gasifier in powered form with the pressurised oxygen and/or steam. This results a dense cloud of mixture. i.e.; a turbulent flame developed and providing large amount of heat. The reactions involved in this type is occurs at high temperature with high carbon conversion efficiencies (98 to 99.5%) [11] Due to its high temperature involvement it may reduce the life of the component of a gasifier itself. At the bottom of the gasifier, ash melts on to the gasifier walls and discharge as molten slag.

D) **FLUID-BED GASIFIER:** Fig 2.4 shows Fluidized bed gasifier was developed to overcome the limitations of fixed bed gasifier. It is suitable for larger capacities. Compared with fixed bed gasifier the gasification temperature is relatively low. Air/oxygen and steam is supplied from the bottom of the system at some velocity due to which a turbulent motion of particles takes place and solid fluid particles act as fluid and random mixing takes place. If pure oxygen is supplied (absence of nitrogen) the high calorific value of producer gas is obtained but providing pure oxygen is an expensive process. [12]

At the ENEA Trisia Research Centre, a range of values for each gas component in the producer gas is summarized with the 150 kWh updraft fixed bed gasification plant is tabulated

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Table 3: volume percentages of different components

Gas Component	%-v(Dry Basis)
H_2	**30-33**
CO	**28-32**
CO_2	**22-27**
CH_4	**9-11**
N_2	**5**

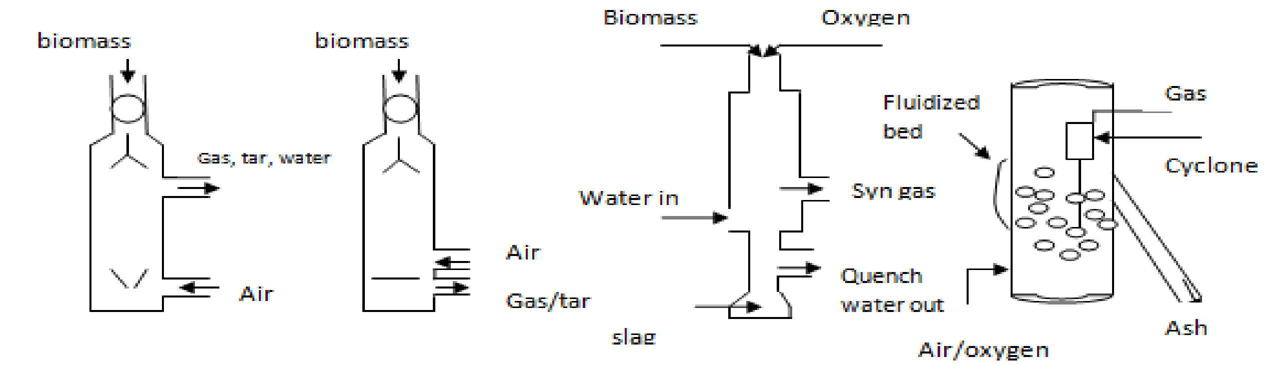

Fig 2: Types of Gasifier

As an important decentralized power technology, biomass gasification and power generation (BGPG) has a potential market in making use of biomass wastes. Carbon is the main constituent of coal whereas biomass is a mixture of complex compounds such as cellulose, lignin, minerals, etc. biomass produces char, condensable volatile tars and other dirty gaseous products. Char is mainly carbon and it follows the reactions discussed above.

Compared to coal gasification, biomass gasification offers more promising scope. For remote areas gasification technology is much more suitable than any other technology. There are no proper transmission lines or proper transportation where commercial methods can be employed. For such locations this technology helps to lighten the remote areas easily at lower cost.

Decentralized energy supply from biomass provides better options as compared to centralized electricity supply. Even small engine driven irrigation pump set can be powered through producer gas. [13]

Presented the biomass gasification reaction in a single equation can be expressed as:

CHxOyNzSs + Air (79% N_2 and 21% O_2) + H_2O (steam) = CH_4 +CO +H_2 +H_2O (unreacted steam) + C (char) + ash + tar.

4.4 BIOMASS GASIFICATION PLANTS IN INDIA

The energy consumption is one of the major factors to decide the growth and wellness of a country. India has wide potential in field of Biomass Production. India is a tropical country blessed with sunshine and rains and thus offers an ideal environment for Biomass production. Further, the vast agricultural potential, also makes available huge agro-residues to meet the energy needs. With an estimated production of about 460 million tonnes of agricultural waste every year, Biomass can supplement the coal to the tune of about 260 million tonnes. This can result in a saving of about Rs 250 billion, every year

VARIOUS TYPES AGRO FIELD / INDUSTRIAL RESIDUES [14]

Table 4: General types of agriculture residues

Type of Agro residues	Quantity(Million Tonnes / annum)
Straws of various pulses & cereals	225.50
Bagasse	31.00
Rice Husk	10.00
Groundnut Shell	11.10
Stalks	02.00
Various Oil Stalks	04.50
Others	65.90
Total	350.00

The estimated potentials of Biomass based renewable energy options in India are as follows

Table 5:Estimated power generation [14]

Biomass Energy	16,000 MW
Bagasse Co-Generation	3,500 MW
Total	19, 500 MW

4.4.1 State-wise Installation of Biomass Power Plants [15]

Table 6: State wise energy generation through biomass

State	Biomass	Bagasse Cogeneration	Waste to Energy	Total
Andhra Pradesh	578	300	123	1001
Arunachal Pradesh	8			8
Assam	212		8	220

Bihar	619	300	73	992
Chhattisgarh	236		24	260
Goa	26			26
Gujrat	1221	350	112	1683
Haryana	1333	350	24	1707
Himachal Pradesh	142		2	144
Jammu & Kashmir	43			43
Jharkhand	90		10	100
Karnataka	1131	450		1581
Kerala	1044		36	1080
Madhya Pradesh	1364		78	1442
Maharashtra	1887	1250	287	3424
Manipur	13		2	15
Meghalaya	11		2	13
Mizoram	1		2	3
Nagaland	10			10
Orrisa	246		22	268
Punjab	3172	300	45	3517
Rajasthan	1039		62	1101
Sikkim	2			2
Tamil Nadu	1070	450	151	1671
Telangana	NA			
Tripura	3		2	5
Uttarpradesh	1617	1250	176	3043
Uttarakhand	24		5	29
West Bengal	396		148	544
Andaman & Nicobar				
Chandigarh			6	6
Dadra & Nagar Haveli				
Daman & Diu				
Delhi			131	131
Lakshadweep				
Puducherry			3	3
Others			1022	1022
Total	17518	5000	2554	

Table 7: Total Biomass Potential in Uttar Pradesh [16]

Biomass Type	Crop Production(KT/Yr)	Area(kHa)	Biomass Generation(kT/Yr)
Agro-residue	138945.5	15950.9	60338.9
Forest and wasteland residue	0.0	3856.7	5478.6
Total	138945.5	19807.5	65817.7

IV.BIOMASS GASIFICATION POWER PRODUCTION

Biomass can be used in power generation through various thermos chemical process (i.e., combustion, pyrolysis and gasification) or bio chemical process like anaerobic digestion. It was mentioned in annual report of world ban that for India by 2031-2032, Power generation capacity must increase to nearly 800 GW from the current capacity of around 183 GW, inclusive of all capacitive plants to meet the basic energy needs of its citizens. Hence it becomes necessary to use alternate energy sources such as biomass other than conventional fossil fuels as limited availability and environmental concerns have made the need to have transition from fossil fuels to other alternate energy sources.

Gasification can be used as a best alternative technique of combustion. Because of its environment friendly nature. A gas turbine consists of compressor, combustion chamber and a turbine unit with generator. Generally, a coal combustion is used for the power generation in thermal power plants. But gasification is a promising technology in which partial burning of fuel is take place. A biomass gasifier produces a gas, known as producer gas, which is used to in combustion chamber to mixed with a compressed air coming from compressor and this high pressure and temperature gas can expands in gas turbine. Integration of gasification with gas turbine/steam turbine and /or combined cycle is possible with the environment friendly nature.

V. CONCLUSION

Complete combustion of coal creates too much pollution, causing acid rain, greenhouse gases, etc therefore decentralized power generation technology are switch towards gasification technology. From above discussion we conclude that gasification technology is not new technology but needs some improvement to optimizing the cost and make it suitable for remote locations. A latest but old technology, generating power without damaging the environment. Gasification can system integrated either with simple gas turbine or with steam turbine or cogeneration. Gasifier produces syn gas/Producer gas which needs to be clean and cool as per requirement, just before entering power generating cycle.

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