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Pellets Processing and Co-Firing in a Thermal Power Plant

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ABSTRACT

Majority of power plants of India are running on coal. To reduce the greenhouse gas emitted from these coal-based power plants, the power generating stations intends to utilize agriculture residue-based pellets. Agro residue-based pellets combustion is renewable source of energy. The use of agro based briquettes in densified form reduces air pollution which is mainly due burning of stubble. Apart from generation of smog in winter season, stubble burning in fields also reduces soil fertility. Central Electricity Authority, Ministry of Power (MoP) issued an Advisory for utilization of agro remains or residue-based pellets for power generation.

Co-firing in a coal fired thermal power plants states to promote the use of the biomass pellets. All pulverized based coal units of electrical power generating units shall make efforts for using 5-10% blend of biomass-based pellets. These pellets must be primarily fromresidual agriculture waste. The generating unitsmust keep in account of all the technical feasibility, safety aspects etc.In line of these directives,I intended to study pellet firing aspects in a thermal power plant and the parameter which will affect the behavior of thermal plant as compared to their normal operation with coal as raw material. Therefore, a pilot projects was carried out to replace 7% coal with agro based biomass pellets/ torrefied/non-torrefied (density) biomass pellets in thermal power plants. The boiler operating procedures and technical modification required were studied thoroughly, and it was deduced that co-firing can come out as a potential high-efficient energy solution to all the energy problems with added benefits of safer and cleaner substitute to fossil fuels. In addition to that, it will help reducing emissions of greenhouse gases and improve the economic condition of farmers which is a win situation.

Keywords: Torrefaction, briquetting, co-firing, pellets, stubble burning, biomass

I. INTRODUCTION

In 19th century, the process of producing a densified solid out of loose granular raw material on a large industrial scale firstly used to make a fuel out of peat. Since then, it became a widespread technology in many fields, for example animal feedstuffs, fertilizers and iron making. Briquetting is being used on a widespread scale in USA during1930s and in European Union/countries which were suffering from fuel shortages during the World War- II. Thoughwe have recognized the importance of biomass briquettes as a replacement fuel for coal, wood, and lignite. But in most developing countries due to lack of government policies has inhibited their extensive use. Biomass densification represents technologies for the converting the crop or biomass residues into a convenient and ecofriendly fuel.

In context of India, in Delhi-NCR region, the practice of crop burning by farmersin the winter season causes severe smog. When investigated it was found that burning stubble of seasonal crops is an easy and quick solution to what they term as their biggest problem. To solve the issue, advisory issued by CEA for use of biomass pellets in existing thermal power plants. Required modification for co-firing biomass and coal like preparation, handling, milling, combustion, and other issues like ash deposition may be incorporated keeping all technical and safety aspects in mind.

1.1 TORREFACTION

In torrefaction, biomass is heated to a very high temperature of approx. 250-350°Cwith very low contents of oxygen concentrations. Consequently, all moisture and small quantities of the volatile matter in the dry biomassis removed.This processed material changes its property from hydrophilic to hydrophobic. After the removal of the light volatile matters from it, the heating value of material gradually increases from 20 MJ/kg to 25 MJ/kg.Energy available in the released volatiles amounts to the heating requirements of the main process and contributes to achievement of a high thermal efficiency. The main concept torrefaction generally revolves around heat integration.

It is important to dry the available biomass before it makes its way to torrefaction. Thetotal efficiency of torrefaction process is approx. 69 – 97%. It is basically a pre-treatment process in presence of heat. It produces a solidbiofuel which has a superior capacity of milling and handling. The advantages of using torrefied biomass are:

- Easy to transport
- Combustible properties are at par to coal such as grindability, bulk energy density, heating value, and hydrophobicity.

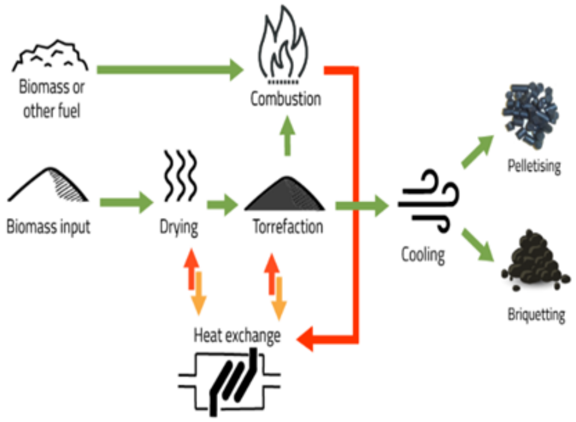

Figure 1.1Torrefaction with heat integration

At worldwide scenario, biomass has the potential and capability to come out as astrongenergy source. It has ability to create biomass and energy chains which is very efficient,manifold increment in densification of biomass.

1.2 COMBUSTION CHARACTERSTICS

The wood which is torrefied can have a calorific value as close to coal and it can be very dry i.e., the moisture content can be less than 5%. Also, the ash contents are less as compared to coal (0.6 to 4% db, when compared to 11 to 20% db in case of coal). The torrefied wood has a much high reactivity, mainly due to high content of volatile matter (55 – 65% db compared to 10 – 12% db for coal). They can significantly reduce the volume for both storing and handling of pellets. Due to the densified form of the torrefied pellets, for same amount of energy requirements less mass is needed. Another important factor is the hydrophobic property of torrefied wood material. It makes the available fuel less sensitive and prevent it from degradation or rotting. It also helps preventing self-ignition and moisture uptake. The process of pelletizing the torrefied biomass produced will make the product easy for larger distance transportation. As in the case more energy can be transported with the same amount of volume. Consequently, a significant amount of savings can be done for the handling and their storage. Based on current market values of wood pellets, the amount increased due to added cost of palletization are break-even by the reducing the transportation charges.

1.3 TORREFACTION APPLICATIONS

Torrefied wood pellet has long list of various applications. The most likely ones, co-firing in coal fired power plants and in kilns of cement industries, combustion in small pellet burners and gasification flow gasifiers. The main advantages of torrefaction are application for use in older and already operational pulverized coal based TPPs. With minor modifications in operating parameters. The main factors that make torrefaction technology interesting for gasification is having relatively low contents of moisture, grindability should be good and C/H/O ratios should be attractive. In gasifier which make use of biomass, the particle size and moisture contents are main factors for good operation. However, all these factors usually make the biomass feedstock relatively expensive

I. LITERATURE SURVEY

In recent years, the use of biomass as a source of energy became of great interest world-wide because of its environmental advantages. Every year about 22 million tons of rice straw is burnt in Punjab and Haryana. Due to which for the last several years, even Delhi/NCR regions has been getting covered under the blanket of smog in the month of October-November after harvesting of paddy. The use of biomass in production of energy like biofuels has been increasingly proposed as a substitute for fossil fuels.

Biomass offer an immediate solution for the reduction of the CO2 content in the atmosphere. There are mainly three advantages of using biomass: firstly, it has an unlimited availability, secondly it is produced locally and thirdly it has no negative environmental impact and can be used essentially without damaging it. It has positive global effect when compared with other energy sources. In addition to that, it has zero risk of major accidents, when compared with nuclear and oil energy. However, due to heterogeneous nature of biomass materials it possesses inherently low bulk densities. This makes it is very hard to handle large quantities of feed stock in an efficient manner.

Therefore, expenses in large sum are incurred to carry out material handling (transportation, storage, etc.). We all know that coal is a non-renewable source of energy, and it isnearextinction. Thus, there is an immediate need to find a suitable substitute to cater out energy needs. We need to co-fire biomass in our existing boiler furnace of TPPs. This provides usbest possible alternate solution. It a win-win situation as it will also help our farmers by providing them an economic value to their farm/crop residue. Since biomass is labeled as a “carbon Neutral” fuel. The process of co-firing of biomass will help in preventing air pollution which is due to burning of farm-residue. It will also reduce the carbon emission from the coal-based power plants which generates Sox, Nox and other particulate matter.

The procedure uses technology in which biomass pellets are fed to boiler furnace via coal conveyor and bunkers. The blended fuel which is mix of biomass and coal is sent to milling system and then fired into the boiler furnace. The noted parameters for boiler furnace must be maintained like the mechanism for feeding of fuel, mill outlet temperature and the ratio of biomass and coal while blending.

Biomass fuels are hygroscopic, contains 60 -70 % volatile, soft in nature and have lower ash fusion temperature as compared to coal. It requires well designed handling procedure to prevent it from ambient moisture and transport it through coal conveyor. It can create milling problem if fed beyond a value in conventional mill. High volatile content in biomass can cause fire hazard in mill, it is important to assess VM release from biomass during milling operation. Biomass ash contains high alkali content with respect to coal and can cause slagging in the boiler.

II. OBJECTIVES

- To use biomass briquettes with a calorific value of around 2500 – 3200 kcal/kg in a thermal power plant
- To utilize the crop residues of surrounding regions in preparing the biomass briquettes.
- To see the effect of burning of biomass briquettes with a lower ash content as compared to that of coal
- To explore the useof pellets in densified form of density by using torrefaction technology.
- To make arrangement for pellet firing in power plant which would burn for longer period as compared to that classical densified biomass
- To see the effect of pulverization of biomass milling system.
- Handling and conveying of pellets
- To ensure availability of alternate fuel for thermal power plants
- To provide economic value to farmers for their agro -residue
- Reduced burning of farm-waste leading to less pollution
- To encourage co-firing which in turn reduces Carbon emission as biomass is considered as carbon-neutral fuel.

III. EXPERIMENTATION

The required raw material is easily available, and it can be handled in simple ways. The pellets used for firing in furnace share many of the same properties as coal:

- The pellets are transported, stored, and handled the same way
- There is no risk of explosion or spontaneous combustion
- Most important and significant aspect of use of pellets is that the same equipment is used for pulverizing and combustion
- Energy dense is 76 % of the heat value of coal
- Reducing CO2 emissions with more than 90 %.

To considered it on commercial use, it's efficiency can be improved effectively.Electrical energy consumption is less for saw dust, briquettes produced &it can be operated without any electricity.Power screw concept is the main fundamental on which briquetting system used.It is also much suitable for briquetting agricultural waste for household fuel.

The system showed a very good production rate. The production rate of this system is found to be 120 kg/hr. (when operated by a motor) & 60-80 kg/hr.(manually), The binder content required by this system was lower. which means a big reduction in the total production cost, and better quality due to the lower smoke generation. In phase 1, the moisture content of the slurry was reduced to 35% instead of 50%. That resulted in reducing the time for drying the briquettes. Rice harvesting by combine harvester provides residual straw of size 10-12 Inch. In case of manual harvesting, it was cut from bottom and was used as source of energy and sometimes as animal fodder. Even after availability of cutter and baler machine for removing this paddy straw, farmers find it labour- and capital-intensive job with no return as rice straw has negligible market value. With a short period, available (15-20 days) between harvesting of rice and plantation of wheat, farmers deem that burning is the easiest andquickest. It is the most economical way for farmers to get rid of rice straw despite there is a law in place in Punjab and Haryana to prevent the pollution from its open burning.

4.1 IMPACT OF CO-FIRING

Case studies from the power plants have been gathered where the effect of slagging, fouling has been studied and noted observations were made in the standard operating procedure.

- Through some experiences, it was suggested that slagging and fouling are highly unlikely while using pellets blended with same quality of coal. The related problem does not pose significant issue for co-firing ratios up to 10%.
- There was another case which states that at higher co-firing ratio, alkali, and other alkaline-earth metals there is relative decrease in fusion temperatures (the temperature at which a substance melts).

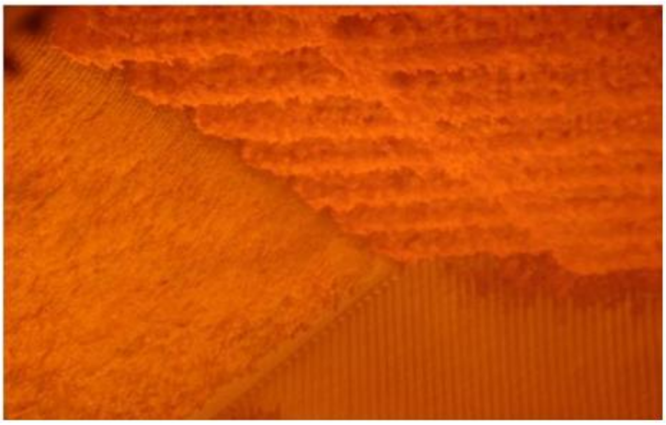

Figure 4.1Unit slagging with 90% co-firing of straw

- Alkali presence reduces ash melting point of ash whereas chloride increases the corrosion of SH/RH tubes.
- Presence of sulfur in flue gas causes sulphation reaction and convert KCl to K_2SO_4, thereby increases the melting point of deposit, thus prevents slagging / fouling of heat transfer surfaces.

4.2 CORROSSION AND OTHER IMPACT

- Ash deposits in biomass ash tend to contain high potassium contents andrelatively larger chloride to sulphate ratios. This results in a significant effect on corrosion. The phenomena are particularly observed at high metal temperatures on surface of superheater if co-firing ratio is higher.
- At low co-firing ratio, the extent and degree to which corrosion happens can be limited as SO_2 is present in the flue gas. This SO_2 can react with condensed alkali and alkaline-earth chlorides. This results in formation of corrosive sulphates. These compounds of sulphate can only be established under oxidizing conditions.

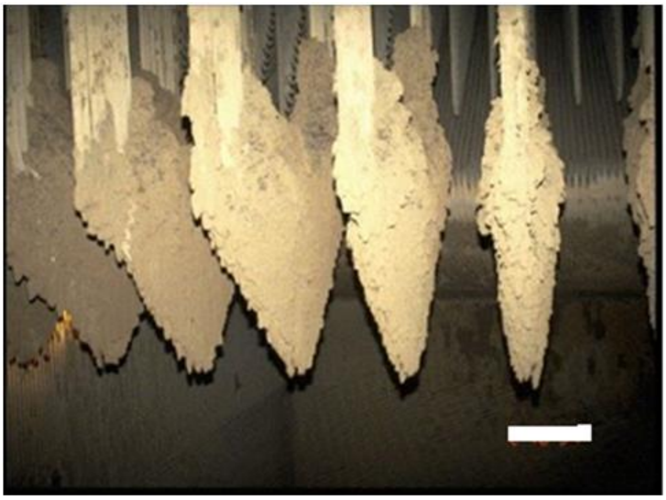

Figure 4.2Description of slagging in other power plantsslagging with 90% co-firing

IV. RESULT AND DISCUSSION

5.1 LOGIC MODIFICATION IN COAL MILLS AND FEEDERS

In normal mode

- Mill out temp is monitored (80-90 Deg.C) and inlet temp. is around >200˚C
- At 110 ˚C mill O/L temp. HAG closes.
- Feeder Start Permissive: Mill Outlet Temp > 65˚C

In Pellet mode

- Mill inlet temp. to mill is monitored.
- Alarm at 185˚C. HAG Closes 195˚C.
- Normal I/L temp is in 165-170˚C.
- Mill O/L temp is in between 60-70˚C.

- Feeder Start Permissive: Mill Outlet Temp > 45˚C
- During pellet feeding local operator is alerted. Based on rise in mill outlet in case of fire, HAG is closed and action is required for steam inerting in Mill by opening valve.

5.2 EXPERIENCES IN MAIN PLANT OPERATION

- Co-firing field trials were carried out as a part of pilot project. The co-firing process was completed as proposed.
- To start up to 7% biomass was co-fired with first four mills (B, C, D, E) at full load of the boiler.
- There is no observable change in boiler performance.
- The ash analysis during the co-firing indicates no major change in its composition.
- Mills are being run on modified logic, with provision for Pellet Mode on/off.
- No observable changes in Mill current, pulveriser outlet temperature were observed.
- No pellets were found in Mill reject

Table 5.2.1 Sample-1 analysis of pellets

Sample ID	Fines Wt. % (< 3 mm)	Total moisture (ARB)	Ash % (ARB)	GCV Kcal/ Kg (ARB)
	<=5 %	<=14%		>=2800
0020/BMS/2022		10.65		
0021/BMD/2021	1.77	13.57	29.8	2973

Table 5.2.2 Sample-2 analysis of pellets

Sample ID	Fines Wt.% (< 3 mm)	Total moisture (ARB)	Ash % (ARB)	GCV Kcal/Kg (ARB)
	<=5%	<=14%		>=2800
0022/BMS/2022	2.24	12.43	32.92	2790

V. CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

Referring the recent study which was conducted by MNRE (Ministry of New and Renewable Energy), an estimated figure of around 750 million metric tons per year of biomass is available in India. The study alsoindicated that there isan availability of about 230 million metric tons of biomass per annum which is in surplus. This figure covers all the agricultural waste and crop residues which will correspond to an untapped potential of about 28 GW. Apart from this, about 14 GW of additional power could be produced in the coal-based power plants through bagasse-based cogeneration without much altering the performance of thermal power plant. The only change required is in milling system which can be very easily incorporated in the process parameters. If all power plants in country are mandated for adopting technically and economically the use of crop residues to an optimal level of cogeneration for extracting power, most of the farmers woe can be resolved with positive environmental impacts.

6.2 FUTURE WORK

To encourage the bioenergy in power industries on a larger scale is the main vision and mission. The utilization of biomass in the form of bioenergy is going to have a very significant role towards the worldwide energy transition. It will also keep a check on adverse effects which leads to climate change. Considering this, pursuing torrefied wood biomass can be crowned as a potential and highly efficient energy solution to all the energy problems with added benefits of safer and cleaner substitute tonon-renewable fuels.

The uniqueness which is inherent in using and implementing this interesting technology of torrefied biomass is to cut down the CO2 emissions. Moreover, the densified wood pellets biomass counts on a same calorific value as of coal and it is indeed very easy to use and store, even in an open environment. I truly believein the unlimited and untappedpotential of torrefied biomass, and this is the reason I am engaged in related academic studies.

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