National Mission on use of Biomass in Thermal Power Plants

Standard Operating Procedure

for

Biomass co-firing in FBC Boilers

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1.0 Introduction

Biomass is an important energy source. Biomass is any organic matter—wood, crops, seaweed, stubble, animal wastes—that can be used as an energy source. Biomass is probably our oldest source of energy after the sun. For thousands of years, people have burned wood to heat their homes and cook their food. Biomass gets its energy from the sun. All organic matter contains stored energy from the sun. Biomass is a renewable energy source as it can replenish in a relatively shorter time. Stubble is the straw-type material that remains after grains, like paddy, wheat, etc., have been harvested. Stubble burning is intentionally setting fire to the straw stubble to clear agricultural residue that is left on the land, to make it ready for the next round of seeding. Stubble burning in fields emits a large amount of ash/soot/ unburnt carbon to the atmosphere which is the real cause of air pollution and elevates the PM 2.5 and PM 10 level in the atmosphere. It is learned that farmers burn stubble as they find it the cheapest, quickest and easiest means to prepare the land for the next crop because of the short time available. Stubble burning in fields also reduces soil fertility by killing the critical bacterial and fungal populations.

But this stubble is a good biomass resource that has the potential to create efficient biomass-to-energy chains. Torrefaction of biomass stubble, combined with densification (Pelletisation or briquetting), is a promising step towards overcoming the logistical challenges in developing large-scale sustainable energy solutions, by making it easier to transport and store. Pellets or briquettes have higher density, contain less moisture, and are more stable in storage than the biomass they are derived from.

When agro residue-based fuel, in the form of pellets, is utilized in coal-fired power plants, it burns completely in the power plant, and ash emitted from its combustion gets absorbed in Electro Static Precipitator (ESP) which prevents air pollution while generating power from it.

The majority of power plants are running on coal. To reduce greenhouse gas emissions from its coal-based power plants, the Power plant intends to utilize agro residue-based pellets/torrefied pellets along with coal for power generation through biomass co-firing which is a technology recognized by UNFCCC to mitigate carbon emission. It is worth mentioning that the equivalent amount of CO2 (carbon-di-oxide) emitted from the combustion of agro residue-based pellets/ torrefied pellets in a power plant gets absorbed in the next crop cycle by photosynthesis. CO2 emission from agro residue-based pellets combustion does not increase CO2 concentration in the atmosphere and thus it is also termed as carbon neutral fuel which is a renewable source of energy. Further, CO2 emission from diesel and electricity consumption for agro residue collection, processing and transportation is quite negligible as compared to saving in CO2 emissions from its utilization in large coal-fired power plants having higher efficiency which makes biomass co-firing a greener alternative.

In addition to reducing carbon emission from the coal-based power plant, the utilization of agro residue-based pellets/ torrefied pellets in the power plant will also reduce air pollution due to the burning of stubble (i.e. paddy straw and other agro residues) in the fields by farmers. Emissions of sulfur and mercury are reduced by the co-firing percentage.

Ministry of Power on 17.11.2017 had issued a policy regarding Biomass utilization for power generation through co-firing in coal-based power plants. This was followed by an advisory dated 24.11.2017 from CEA to all the TPPs to utilize Biomass pellets in coal-based TPPs to the extent of 5-10%. Keeping the above in mind, the National Mission on use of Biomass in TPPs has been constituted by the Ministry of Power in July 2021.

This Standard Operating Procedure for Biomass co-firing in FBC Boilers has been prepared and issued under the Mission for use by all the TPPs in Central Sector, State Sector, and Independent Power Producers.

Further, Ministry of Power vide letter no.11/86/2017-Th.II dtd 7th April 2022 has clarified that the "Revised policy for Biomass Utilization for power generation through Co-firing in coal based power plant " dated 08.10.2021 is also applicable to Bubbling Fluidized Bed Combustion (BFBC) and Circulating Fludized Bed Combustion (CFBC) Boilers. This Standard Operating Procedure is being issued for use by all FBC boiler based TPPs.

2.0 Superseded Documents

Nil

3.0 Scope

This SOP shall apply to all FBC boiler based stations in operation.

4.0 Types and Properties of biomass:

There are three types of pellets:

a. Non-torrefied biomass pellets
b. Torrefied biomass pellets
c. Briquetted Biomass

4.1 Non-Torrefied biomass pellets are pellets made from agro based residue without torrefaction. The main disadvantage with these pellets is that they are hygroscopic in nature and absorbs moisture readily.

The typical properties of non-torrefied pellets are as follows:

1. Carbon Content: 10-20 %
2. Volatile Matter: 60-66%
3. Moisture: 9-14%
4. Density: 700 kg/m3
5. Ash content: approx. 20%
6. GCV: 3400-4000 Kcal/kg

These properties are indicative in nature; however, the properties of pellets should be taken from torrefied pellets procurement terms and conditions.

The main constraints with these pellets are

1. Release of volatiles at lower temperature than coal at around 240 ^{O} Celsius
2. Moisture affinity: Very high

To overcome these constraints, the torrefaction process will greatly help.

4.2 Torrefied biomass pellets:

Torrefaction is a thermal process to convert biomass into a coal-like material, which has better fuel characteristics than the original biomass. Torrefied biomass is more brittle, making grinding easier and less energy-intensive. Compared to fresh biomass, storage of the torrefied material can be substantially simplified since biological degradation and water uptake are minimized. Torrefaction involves the heating of biomass in the absence of oxygen to a temperature of typically 200 to 400°C. The structure of the biomass changes in such a way, that the material becomes brittle and more hydrophobic. Although the weight loss is about 30%, the energy loss is only 10%. The main product is solid, torrefied biomass. During the torrefaction process combustible gas is released, which is utilized to provide heat to the process.

4.3 Briquetted Biomass:

The briquettes are generally bigger in size than pellets, the typical briquette size is 75 mm or higher.

In CFBC boilers, biomass briquettes shall be used with adequate precaution in crusher system, feeding system to maintain desired size range recommended by OEM.

For CFBC Boilers, feeding these bigger particles into furnace directly may be carried out in consultation with OEM. Alternatively, these bigger size particles can be crushed to the desired size range along with primary fuel. Hence, adequate precautions are to be taken while crushing briquettes as biomass fuel is fibrous in nature.

For **BFBC** boilers, briquettes are not suitable for feeding along with primary fuel (under the bed). Feeding over the bed is suggested by providing a separate bunker & feeding system as per the recommendation of OEM.

Table: Comparison of biomass pellets and briquettes

Biomass Pellets	Biomass Briquettes
During pelletisation process, the raw biomass fuel are chopped into finer size (1 to 6 mm).	During briquetting process, the raw biomass fuel is not processed to the finer size.
The size of pellet is typically less than 20 mm diameter and up to 150 mm length	The size of briquettes are more than 75 mm and varied length
Easier to use in crusher and range of particle size after crusher fall into the desired size ranges of CFBC/BFBC boiler	Difficult to crush to the desired size in the crusher due to fibrous nature (less brittle). Adequate precautions to be taken while using in CFBC boilers and it is not recommended for BFBC boilers

5.0 Handling, storage and blending of Biomass:

a. The following steps are involved in handling
   i. Receipt
   ii. Unloading
   iii. storage
   iv. Feeding to Bunkers

b. Receipt and unloading:
   i. The truck containing Biomass pellets / briquettes enters plant premises
   ii. The vendor test report accompanied the lot shall be checked.
   iii. Sample collection and result at station end by chemistry group.
   iv. Necessary arrangements for safe sample collection like platforms etc., are to be ensured at the site.
   v. Acceptance of the lot based on the result given by the chemistry group
   vi. After acceptance, the truck shall be weighed.
   vii. After weighment truck to be unloaded at designated unloading point.
   viii. Truck unloading mechanism: truck unloader should be available at the site if more quantity of pellets is used for blending.
   ix. The empty truck shall be weighed.
   x. After weighment empty truck to be released from plant premises.

c. Storage:
   i. Area for Biomass storage needs to be identified by the site. This area should have firefighting facilities.

ii. The volatile matter in biomass is very high and can easily catch fire. Hence continuous monitoring of the area needs to be done.

iii. The Biomass storage area should be different from the coal stockyard.

iv. Facilities should be developed to transport the biomass from the storage area to the blending area.

v. The maximum percentage of blending allowed is only 5% to 10% (blending by heat value) depending on plant operating conditions and combustion and other operational issues.

vi. The bunkers in which blended coal with biomass pellets need to be identified along with the operation group and all necessary interlocks to be ensured before dumping coal in bunkers.

vii. Avoid giving Hot work permits on/near biomass feeding path

viii. Don't spray water / dry Fog / plain water fogging system on the biomass and its bunker feeding path. The biomass pellets are hygroscopic in nature. After absorbing water or moisture, the pellets lose their shape and converts to powdery form, so water cannot be used. However, the system for dust suppression like dry fog/plain water and spray water should be available and for use in case of emergency.

ix. Don't compact the pellets.

d. Bunkering and blending

i. The bending ratio needs to be maintained at 5 to 10 % only (Blending by heat value).

ii. Site-specific Bunkering methodology is to be formulated by considering the following points

1. Point of blending
2. Methodology of feeding pellets
3. TP or chute where blending shall be done.
4. Control methodology for blending like using belt weigh scales etc.,
5. No of bunkers to be used for pellets blending
6. Level to be maintained in bunkers in which pellets are bunkered

iii. The pellets do not require crushing; hence blending is to be done after crusher output. Briquettes need to be blended before the crusher. Depending upon the type / size of bio mass particles, feeding of biomass briquettes into furnace (over bed feeding) directly may also be carried out in consultation with OEM

iv. Feeding to be done only along with the coal, as the biomass pellets are highly inflammable as volatiles release at lower temperatures due to high

VM content. Hence conveyor interlock is to be modified so that pellets go only when coal is in the conveyor, and not otherwise.

v. Conveyor streams and chutes used for pellet firing must be thoroughly emptied after feed operations. Left-over pellet blends in conveyors and chutes must be emptied to minimize fire hazards.

e. Safety

During receiving and internal operations, special precautions should be taken so that ignition and explosion can be avoided.

Considering all the above factors, the site should develop an SOP to be followed right from receipt to bunkering and blending with thrust on site specific systems and procedures.

6.0 Monitoring of chemistry parameters:

Biomass Pellets / Briquettes:

a. Sample collection:

   i. Done from every truck arriving at the station.

   ii. Sample collection is done from truck-top. The top 25 cm is removed and then randomly samples are collected from 4-5 spots and should be kept in air tight bags.

b. Sample Preparation:

   i. The collected sample is brought immediately to the Chemistry lab premises and all portions collected are thoroughly mixed followed by coning-quartering until the sample quantity reduces to approximately 3 kg.

   ii. This 3 kg sample is divided into 3 equal parts - one part for power plant Owner, one part for the seller, third part for referee purpose.

c. The Power Plant Owner part of the sample is to be made homogeneous powder by mortar and pestle method. Moisture, ash and, GCV determination are done with this sample.

d. If moisture value (ARB*) exceeds Specified %, the consignment shall be rejected.

e. GCV value (ARB*) is less than Specified kcal/kg, the vendor is cautioned against any such deviation in subsequent lots. In case of repeated/frequent deviations in GCV or other technical parameters, a warning letter is issued to the supplier by EIC and the contract may also be canceled if the supplier continues with the practice.

ARB: As-Received Basis.

7.0 Impact of biomass co-firing on combustion:

a. The process of biomass combustion may be associated with certain risks that do not occur during the combustion of coal. These include fuel pre-processing (fire-explosion risk), combustion e.g. including excessive bed agglomeration, slagging and ashing, and chlorine corrosion. Therefore, knowledge of the physicochemical properties of plant biomass helps to determine its potential application in heat or electricity production. The knowledge of these parameters allows proper selection of the amount of combusted biomass to ensure its minimal impact on the boiler system or the use of preventive measures minimizing the negative impact on biomass combustion.

b. The content of Oxygen in biomass is very high compared to coal.

c. The substantial proportion of volatile matter in the biomass fuel can be a positive factor in the improvement of ignition and flame stability. However, volatile matter enhances the fire explosion risk in the pre-processing system.

d. Biomass pellets may have a very low content of Sulphur and nitrogen compared to coal which makes them environmentally friendly by reduced SOX levels.

e. Burning biomass fuels or biomass-coal mixtures containing low Sulphur content is valuable for major reduction of SOx/SO2 emissions but might negatively influence the ash deposition behavior, in particular Chloride's deposition. It has been generally accepted that the occurrence of Sulphur can alleviate corrosion problems associated with chloride deposits via the following sulphation mechanism

f. An important consideration in the use of biofuels in the power plant arises due to higher alkaline content in biomass w.r.t. coal. In particular, during the combustion process, biomass ash has a high tendency for slagging and fouling due to its low melting temperature caused by presence of alkalis. Ca and Mg compounds usually increase the ash melting temperature, while K and Na reduce it. In combination with potassium, silicon can induce the formation of low-melting silicates in volatile ash particles that may deposit on the walls of furnaces or heated surfaces.

g. Another effect of biomass co-firing with coal is the emission of vapours of potassium compounds and subsequent condensation on the surface of ash particles and boiler pipes. For example, sodium and potassium may react with SO_2 or SO_3 in the gas to form alkali sulphates, K_2SO_4 and Na_2SO_4, which can condense and deposit on surrounding surfaces. The affected surface acquires a characteristic thin, dense, and reflective deposit layer and may accelerate fouling & corrosion phenomenon found in boilers.

h. Estimating the amount of water-soluble alkalis can give us an approximation of amount of alkalis present that can be readily volatilized. This would give us an understanding of the scale of impact of the above effects of co-firing biomass.

i. Increased levels of potassium & chlorine compounds in biomass are a highly unfavorable phenomenon due to the process of slagging, ashing and corrosion. However, the effect of other elements such as Calcium is relatively benign or neutral.

j. In biomass, elements such as chlorine and potassium are mostly present as water-soluble inorganic salts, and primarily as chloride, nitrates, and oxides, etc. which can be easily volatilized during the combustion, resulting in high mobility for alkali materials and, consequently, may pose a pollution hazard.

All the stations should get the biomass pellets/briquettes ultimate analysis done and get the consultation of OEM regarding co-firing proportion before the start of the biomass pellets/briquettes co-firing and understand the impact on the combustion based on the ultimate analysis. Ash elemental analysis is also to be done during the initial days of firing in the boiler and furnace temperature measurement is to be done frequently during the initial days of biomass co-firing. The Boiler is to be monitored for the ash build-up and slagging during the biomass co-firing. Combustion has to be monitored closely while biomass co-firing takes place.

8.0 Unit Operational issues while handling Biomass:

a. In view of detrimental effects of alkali (present in the biomass) on the refractory, suitability / usability of existing refractory while co-firing of biomass with primary fuels shall be checked with OEM.

b. Replacement provision of appropriate quantity of Bed material (alkali free) to avoid agglomeration issues during biomass co-firing is recommended.

c. Monitoring of Halides content (Cl, F) in biomass to be ensured in addition to Alkali content to enable trouble free operation.

d. Fuel Feeding capacity when mixing biomass pellets with coal after crusher should be checked with OEM due to lower bulk density of biomass than coal.

e. Increased Flue gas volume at higher proportion (more than 10% by weight) of biomass co-firing to be checked for any draft side limitation (ID Fan & Motor). However, it depends on the fuel characteristics.

f. Ash particle size distribution (PSD) to be checked after ESP while biomass co-firing, if there is a significant deviation in PSD from 100% coal, it may be discussed with OEM.

9.0 Actions to be taken in bunker/ feeder system having a fire during Biomass firing:

a. Call the fire personnel in the plant for immediate assistance.

b. Site-specific SOP to be prepared for handling bunker/feeder fires in stations

c. Do not get in contact with any part of the bunker/feeder (observe components for any inspection until the temperature comes down to normal value)

10.0 Combustion issues in Biomass firing

a. Clinkering and slagging tendency to be observed by any rise in SH zone FG temperatures. Frequency of Soot blowing and LRSB to be determined accordingly.
b. Flue gas temperature profile change, increased unburnt, changes in Spray and metal temperature to be monitored, and any abnormality to be discussed with OEM.
c. Elemental analysis of biomass for each sample/lot to be done to keep a check on the chlorine and alkali content which have high slagging and fouling tendencies.

11.0 Impact of ash and usage in the cement industry

If fly ash from a plant is currently being sold to the market, that impact needs to be studied during co-firing.

12.0 Safety aspects of Biomass firing:

a. Pellets have got very high amount of volatile matter
b. The storage area must be predefined and proper barricading is to be ensured. No cutting and welding works should be carried out near that area. The area should be clearly demarcated a “No Smoking Area”.
c. Conveyor firefighting system should always be healthy as the fuel is highly inflammable; hence all protection needs to be healthy.
d. The storage areas should have proper firefighting provisions like hydrants and water monitors.
e. MSDS for these pellets are to be displayed near the storage area

13.0 Infrastructural requirements of biomass handling

a. Truck tippler – 60 tons two nos.
b. Closed shed (from sides also) covering feeding Area as well as Storage space as the fuel is highly susceptible to atmospheric moisture if left in open for a reasonable amount of time. The Shed should cover the feeding point and the storage yard and should allow the movement of dozing equipment like pay-loader or bob-cat. The site team shall decide the dimensions / size and location of the shed. The shed should be provided with flameproof lighting
c. Long storage of biomass pellets/briquettes are to be avoided as it may undergo biological degradation and even it may rot in presence of wet conditions.
d. Weighbridges calibrated for weighing of the trucks
e. Belt weighing scales for proper blending
f. Pay-loader or more preferably by Skid Steer Loaders for feeding and for achieving finer control over the feed rate.
g. Safe Working Platform for collecting a sample from the truck.

h. Methane, CO, Multi-gas detectors at the storage location
i. CCTVs for monitoring at different points like unloading Points, Blend points, Feed points, and conveying path.

14.0 Site-specific SOP's to be prepared against this Model SOP

a. SOP for unloading, storage and bunkering, and blending for use in CHP with all precautions to be taken.
b. SOP for main plant operation activities from bunker/feeder to ESP including parameters to be monitored, Emergency instructions and logic modification, etc., is to be done.
c. SOP for chemistry for sample preparation to analysis.

15.0 Further actions required:

a. Proximate and Ultimate analysis of biomass pellets to be done.
b. Ash elemental analysis after biomass firing and ash fusion temperature monitoring.
c. Impact of biomass on the quality of ash as required for cement industries.
d. Effect of pellet-ash on the performance of wet/dry ash handling system to be checked periodically by stations. (like scaling inside pipes, hoppers, sumps, silos, etc. and evacuation & flowability of dry ash from hoppers)
e. All parameters impacting heat rate shall be recorded and Heat rate before the start of biomass co-firing and during biomass co-firing should be recorded to analyse its commercial impact.

16.0 Combustion and clinkering issues

An important element in the use of biofuels in the power industry, in particular in the combustion process, is their adverse effect on the agglomeration, slagging and fouling processes.

17.0 Review

The Head of the respective TPP, will be responsible for reviewing this SOP on yearly basis or as necessary.