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SEM Analysis of the Agglomeration effects of Real Plant Bubbling Fluidized Bed based on Biomass

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ABSTRACT:

The increasing demand of electricity today can't be completed only by the fossil fuel so it is very much remarkable to use renewable sources of energy such as biomass fuel for the production of the electricity. The biomass contains stored energy from the sun i.e. wood, crop, manure & some garbage so biomass is a renewable energy source because we can always grow more trees, crops, & waste will always exists. The combustion of the biomass fuel due to low density is a problem, but the fluidized bed combustion (FBC) is one of the most promising energy conversion options available today. FBC combines the high efficiency combustion of low grade fuel e.g. rice husk, wood & other biomass agro-waste & municipality waste. The rice husk/rice straw is one kind of renewable energy source which is abundant in agricultural states of India. The combustion of such a fuel in fluidized bed is becoming more & more attractive due to lesser emissions as well increasing price of the fossil fuel. This paper includes the Introduction of biomass fuels, its availability in the region, field study of various industries based on biomass & Co-firing using FBC technology and combustion effects of the biomass fuel using FBC & SEM analysis of the agglomeration of the Industry using 100% Biomass fuel & 90% biomass+ 10% fossil fuel.

Key Word: Biomass fuel, Fluidized bed combustion, Coal, Scanning electron microscope, Co-firing.

INTRODUCTION:

Use of energy in these days is largely dependent on fossils fuels. In future, these fossil fuels make the development very difficult to keep going. During combustion there is rapid release of polluting products from the fossil fuels and these polluting products have effective change in the composition and behavior or our atmosphere. To generate electricity from the fossil fuels, there is a significant amount of the carbon dioxide emissions. Day by day demand for electricity is growing very fast which results in the increase in the use of fossil fuels and increase the carbon dioxide emissions and some other pollutants. So there is a need of some other fuels that can be used in place of the fossil fuels. Biomass or agriculture wastage a non conventional fuel is used and it is ensured that the use of non conventional fuel minimize the environmental degradation and also minimize the stress associated with mining, processing and transporting of conventional fuel.

There are large quantities of residues which can be used for the production of energy. Fossil fuels like coals are limited in availability but residues are not only limited in availability and these are also renewable. Some of the agricultural residues are not economically good to make use of because large investments required for collection, transportation and storage. However there is some biomass residues concentrated at specific location, where demand for energy also exists. They include rice husk at the rice mills, rice straw in the fields and bagasse at the sugar mills [Natarajan et al. 1998]. Utilization of biomass as an energy resource has various environmental advantages such as reduction in the emissions of toxic gases i.e. SOx,NOx. It is due to the low contents of sulphur and nitrogen present in the biomass fuels. Another benefit is to reduction in the amount of solid waste and utilization of agricultural or agro industrial residues and minimization of waste disposal [kulah et al, 2010]. Various types of gases which emits by burning the rice husk as a fuel are as NOx, CO, and negligible SOx. The emissions of SOx in case of rice husk are not a big concern because of low contents of sulphur. The emission of NOx depends on the combustion temperature, fuel composition and stages of air during combustion. By controlling these parameters the NOx emissions if controlled and Cox emissions reduced by controlling the temperature of furnace. There are many ways to control the temperature in the furnace i.e. furnace area, air distribution during combustion and flue gas recirculation.

Rice is also known as paddy. Husk is the outer cover of the rice grain and is in the form of hull. So the other name given and is in the form of hull. So the other name given to rice husk is rice hull or paddy husk or paddy hull. The rice husk is renewable and also it is less polluting due to its low sulphur and heavy metal contents. On weight basis, the weight of rice husk is about 20% of the weight of the rice[armesto et al. 2002]. Rice is cultivated in more than 100 countries in the world. China is at first place in the cultivation of rice and india is on second place. India is basically an agriculture country and in India the production amount of biomass is plenty. So these different biomasses can be used to increase in demand of the electricity. Punjab produces about 11% of country's rice. 2% of world's rice is produced in Punjab. The rice husks from various rice mills are collected and then it will be transported to the rice husk processing plant. A special rice husk combustion unit generates steam and the rice husk ash is separated in hoppers. The main part of the steam is feed into a steam turbine generator set which generates electric energy. The electric energy is either partly used for the RICE mill and for the rice husk processing plant and the main part of electric energy is sold to the public grid. Various types of technologiesare used for the combustion process.

Different combustion processes for biomass are as

1. Fluidized bed combustion
2. Stoker bed combustion
3. Grate technology

Proper technology must be selected base on the required cost, available fuel, required steam conditions, and emissions to be reached. BFBC technology is more advanced than other available technologies.

FLUIDIZATION AND BUBBLING FLUIDIZED BED TECHNOLOGY

Fluidization is a well established fluid solid contacting technique. Fluidization is a process where the solid particles are transformed from a static solid like state to a dynamic fluid like state through contact with fluidizing medium like air.

Types of fluidization technologies:

1. Bubbling fluidized bed combustion
2. Circulating fluidized bed combustion
3. Pressurized fluidized bed combustion

When the air velocity is gradually increased, a point is reached when the individual sand particles are forced to move upwards these particles begin to move about within a bed, which were supported by the air stream. With further increase in the air velocities the change occurs, due to the rapid mixing of the particles the bed becomes very turbulent. A bed of solid particles in this state is said to be fluidized, because it has not only the appearance, but also some of the properties of a boiling fluid. There are two limits of air velocity that is lower and upper limits between which fluidization of sand will take place. The velocity of the air stream causing fluidization is termed fluidizing velocity.

In these days, bubbling fluidized bed is mostly used for small scale applications. Bubbling fluidized bed as a combustion method is suitable for wide range of fuels even those fuel quality can be dealt with ease [jokivirta, 2010]. Solids fluidization occurs when the air passes through a bed of solid particles at high velocity that is above the minimum fluidization velocity. Primary air is injected through the bottom grid to fluidize the bed. Primary air is about thirty percent of the combustion air and the remaining air ports above the furnace. The velocity of fluidizing air is 1.2 m/sec at full load. Combustion temperature is typically between 800^0 and 950^0c, and the usual bed temperature is 850c [Alberto and Pena, 2011].

LITERATURE SURVEY

Grubor et al. [1] reported agglomeration and defluidization problem in 150 KW continuously straw- fired FBC even through the temperature was maintained below 700°C. further it was suggested using alternative bed materials like ferric oxide to avoid formation of low melting temperature eutectic of alkali-silicates.

Skrifvas et al. [2] and Nordin et al [3] tested the agglomeration behavior of different biomass ashes in a pilot scale fluidized bed combustor systematically with programmed temperature change without combustion. Further it was examined that the defluidization temperature, at which the sand bed containing biomass was de-fluidized was close to the initial sintering temperature of the ash determined by compression strength method.

Ryabov et al [4] reported that traditional way to reduce the negative effects of bed agglomeration was lied in increasing the bed drain with the addition of fresh inert material. Further it was elaborated that chemical and physical characteristics of bed materials must be interpreted to a suitable form for the boiler operation.

Weiganag et al. [5] described that agglomeration and defluidization phenomenon in fluidization bed combustors based on wheat straw. They found that defluidization was caused by the high content of potassium in straw ash. During combustion the potassium in straw was transformed from organic and inorganic forms to various salts and amorphous of K_2O-SiO_2.

The compounds were clearly identified as the coating layer on the sand surface, which caused the formation of agglomerates and eventually defluidization.

Elisabet at al. [6] studied the mechanisms of bed agglomeration during fluidized-bed combustion of biomass fuels. The low-melting calcium-based silicates including minor amounts of for example potassium were formed with subsequent viscous-flow sintering and agglomeration. For high alkali containing biomass fuels, direct attack of the quartz bed particle by potassium compounds in a gas or aerosol phase formed a layer of low-melting potassium silicate. Thus, formation and subsequent viscous-flow sintering and agglomeration seemed to be the dominating agglomeration mechanism for these fuels.

Korbee et al. [7] reported an early agglomeration recognition system(EARS) for small scale bubbling-fluidized bed combustors. The small scale bubbling-fluidized-bed gasification and combustion tests with various fuels have shown that agglomeration can be recognized 30-60 min earlier with EARS than with conventional methods based on change in pressure drop or temperature difference. EARS may help plant operators in preventing agglomeration-induced plant shut down and minimizing bed material makeup and residue production.

Natrajn et al. [8] studied the agglomeration tendencies of some common agricultural residue in fluidized bed. The agricultural residue chosen for the study were rice husk, baggase, cane trash and olive flesh. The results showed that the initial agglomeration temperature was less than the initial deformation temperature predicted by the ASTM standard ash fusion test for all fuels considered. The initial agglomeration temperature of rice husk and baggase were more than 1000°C. The agglomeration of cane trash and olive flesh was encountered at relatively low temperature and their initial agglomeration temperature in gasification was lower than those in combustion with both bed material. The use of lime as bed material instead of quartz improved the agglomeration temperature of cane trash and olive flesh in combustion and decreased the same in gasification. The results indicated that rice husk and baggase could be used in the fluidized bed for energy generation since their agglomeration temperatures are sufficient high.

Mansaray and Ghaly [9] investigated the agglomeration characteristics of alumina sand-rice husk ash mixture at various levels of temperature (750.850, 900,950 and 1000°C) and ash content (0.0, 5.0, 10.0, 15.0, 20.0 and 25.0) using light microscopy, scanning electron microscopy, and energy dispersive X-ray analysis techniques. The scanning electron microscopy and X-rays analysis were also used for the identification of the rice and elemental makeup of rice husk ash. These was no indication of melting at all the levels of temperature and ash content studied. However, weak and friable agglomerates were observed at 950 and 1000°C. The structure of the particles was not altered and bonding by surface diffusion may be a possible mechanism for the formation of the weak, friable agglomerates. Physical entrapment by minute whiskers at the surface of rice husk ash was also a factor. The use of alumina sand as an inert fluidizable material in fluidization bed system will prevent the formation of these easily breakable structures because of particle friction caused by mixing and fluidization. Thus these friable structures were not expected to cause any problem during the normal operation of fluidized bed gasification system that are normally operated at temperature in the range of 700-800°C.

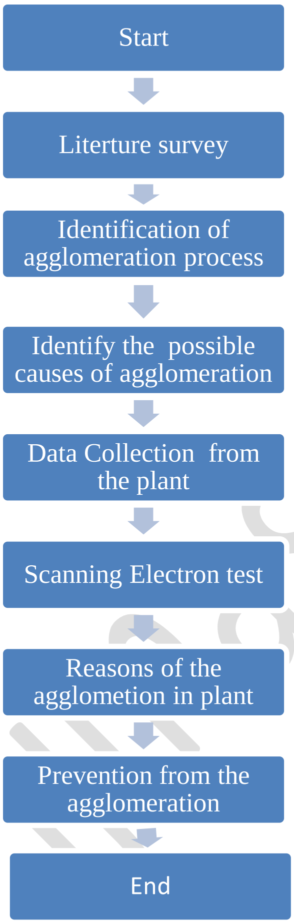
The followings are the some of the plants which are using biomass FBC technology

1. 10 MW power plant using FBC at JalkheriFatehgarh Sahib Punjab.
2. 12.5 MW Satia Industries Ltd. (SIL) Plant, ShriMuktsar Sahib Punjab.
3. 12 MW Power plant at Baghaura Punjab.

AGGLOMERATION

The agglomeration is the most commonly occurred problem in the fluidized bed combustion which is frustrating for the operator and sometimes the operation has to be stopped leading to the production and money loss. Normally using only Biomass fuel the agglomeration is very soft in nature & can be broken with the hand only. But while using the Co-firing the agglomerationformed are very hard in nature which can be broken by the application of large forces on agglomerate. The two plants which were focused for the study are 75 TPH Satia industry limited, Muktsar & 15 TPH Ladhar paper mill, Nakodar. The Satia Paper Industry is using co-firing of having 90% husk +10% coals and Ladhar paper Mill is using only the rice husk as fuel. At both the plant defluidization are the common problem observed. The problem of agglomeration is occurred in both of the plant. But while using the rice husk only rice husk the agglomerate formed is soft in nature& while using the Co- firing the agglomerate formed is hard in nature.

The main purpose of this study is to determine the causes of the agglomeration while using the rice husk only and for co-firing. Figure 1 show the flow chart methodology involved in this work.



As shown in the chart Scanning Electron Microscope Test is done on the Sample obtained from the plant agglomerate

RESULT & ANALYSIS

The Scanning electron Microscope(SEM) test has been done on the agglomerates sample collected from the Satia Paper Industry, Muktsar & Ladhar Paper Mill Nakodar. The SEM test has been done on the sophisticated instrument centre at Punjabi university Patiala on JSM 6510 LN(JEOL) microscope as shown in figure 2.

Figure 2

Figure 3 and figure 4 shows the SEM results of the agglomerate collected from the bottom of the Furnace from Satia Paper Industry, Muktsar

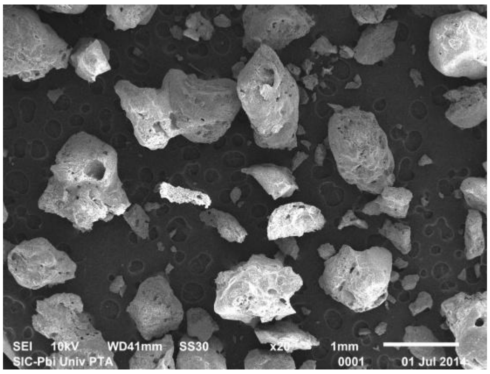


Figure 3

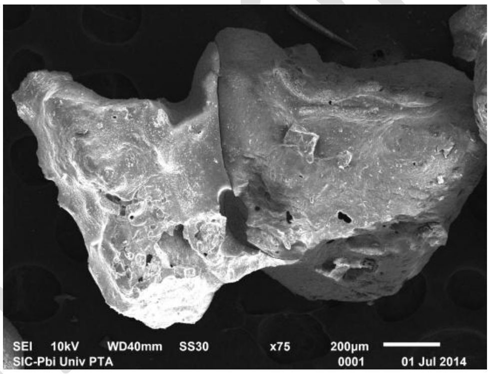


Figure 4

Figure 5 and figure 6 shows the SEM results of the agglomerate collected from the bottom of the Furnace from Ladhar paper mill Nakodar.

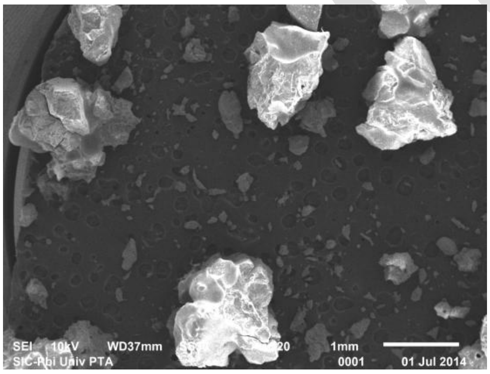


Figure 5

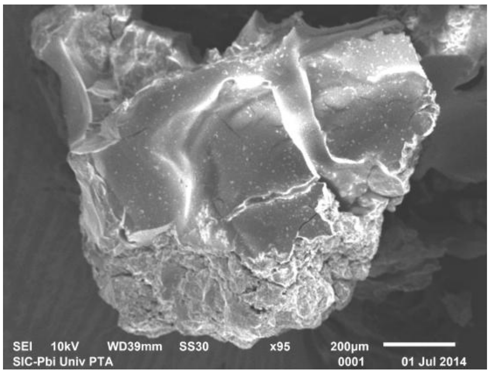


Figure 6

As shown in the above test result it is clear that while using the co-firing of the rice husk with the coal bonding between the particles is very high and one particle is merged into the other particle. While analyzing the SEM test of Ladhar paper mill, Nakodar where we are using only rice husk bonding between the particle is less strong agglomerates can be easily broken hand on the other hand a large quantity of force is needed to break the agglomerate by using co-firing of the Rice husk with the Coal.

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