Challenges & Solution for Usage of Biomass & Bio Solid waste as fuel in boiler in form of pellets and briquette.

A. Introduction:

Biomass combustion has a huge potential to produce power and heat in a sustainable way. Biomass is continuously gaining interest for use as a sustainable energy resource, and is available in many forms and can be obtained from different sources. With further development, utilization of bioenergy can be expanded to meet the increasing energy demands, reduce the carbon dioxide emissions and global warming, with the benefit of urban and rural wastes disposal. Currently, biomass combustion is still the dominating conversion technology for heat and power production.

Some biomass fuels contain a significant amount of potassium, Sodium and silicates and other inorganic elements as well. The release and transformation of these inorganic elements lead to different ash related operational problems during energy conversion processes. These ash related operational problems reduce the efficiency of the combustion systems, cause extra costs for boilers cleaning and maintenance, and hinder further utilization of biomass materials as combustion fuels.

Several methods have been proved efficient to abate the different ash related issues during biomass combustion. They are:

(1) Utilization of additives (ALTRET Combustion Monitoring chemicals),
(2) Fuel mixing,
(3) Leaching out the problematic elements from fuels before combustion.

Among these methods, applying additives to mitigate ash related problems in biomass combustion applications is one of the most promising options. Further application and selection of the proper additives (From Range of ALTRET Combustion monitoring chemicals) for a certain biomass combustion process or utility, it is necessary to gain a better understanding about chemistry and interactions between additives and problematic ash species.

B. Ash related operational problems during biomass combustion applications:

Ash forming matters in biomass fuels can be grouped into four types:

a. Water soluble salts
b. Elements associated with the inorganic materials of the biomass
c. Minerals included in the fuel structure
d. Inorganic material added to biomass from extraneous sources

During biomass combustion, complex transformations and chemical reactions of ash forming matters may occur including: (1) release and volatilization of inorganic species (e.g. alkali metals and some heavy metals) from burning fuel and char particles, (2) interaction of inorganic elements with formation of salts (e.g. chlorides, sulphates, hydroxides and phosphates) in liquid and gas phases, (3) interactions between solid phase particles and released volatile inorganic species, (4) fusion or partial fusion of low melting ash components (i.e. alkali silicates) with formation of a molten phase, (5) sintering of unburned char residues and inert solid ash residues due to presence of molten phase.

Various operating problems can be encountered in biomass combustion processes and are often associated with the presence of problematic species in combustion systems. Potassium is the key element that results in formation of troublesome species via different routes at combustion temperatures, including Formation of potassium salts (i.e. KCl, K_2SO_4 and K_2CO_3) during fuel particles devolatilization and char burnout. The potassium salts have melting temperatures as low as 770 °C. All of the salts may be carried out by the gas flow and cause fouling deposits on heat exchange tube surfaces. Formation of different potassium silicates via reactions between the potassium salts and silicon/silicates in the fuel. Potassium silicates with certain chemical compositions may melt at biomass combustion temperatures and cause ash sintering

It has been reported that formation of potassium rich melts is the main cause of severe ash slagging during combustion of P-rich agricultural residues and cereal grains. As results of release and formation of different problematic ash species, different operational problems may occur in a combustion system using biomass as fuel such as

(1) Formation of slag and aggregates caused by fused or partly fused ash at high temperature in combustion appliances
(2) Fouling and slagging deposits on heat exchange components surfaces due to condensation of alkali salts and binding of fine ash particles carried by the flue gas
(3) Gas and deposits induced fireside corrosion and accelerated metal wastage of furnace and boiler components
(4) Reduced performance of flue gas cleaning equipment due to formation of aerosols and fine particulate matters.

Ash related problems interfere with biomass combustion processes, reduce energy conversion efficiencies and heavily hamper the further application of biomass materials as fuels for heat and electricity production.

C. Utilization of additives to prevent and abate ash related operational problems:

3.1. Additives and anticipated effects to abate ash issues:

Additives refer to a group of minerals or chemicals that can change the ash chemistry, decrease concentration of problematic species and raise ashes melting temperatures in biomass combustion processes.

Additives in different forms have been tested in previous studies, and were introduced into the biomass combustion systems by:

(1) Blending with the fuel before combustion such as pelletizing the fuel together with additives or mixing the additives with the fuel as it is transported by a convey. or

(2) Feeding into the combustor as powders or solutions via installed spraying systems.

Various methods have been applied to monitor and give real time signals for the release/formation of relevant ash forming matters. According to available results and interpretations, different mechanisms for additives to abate biomass ash related problems have been proposed, including:

- Chemical reaction (i.e. alkali-getter effects). By means of chemical reactions with additives, the low melting temperature elements in biomass fuels can be converted into high temperature melting substances.

- Physical adsorption. With additive addition, condensable vapours, melted ashes as fine particulates, i.e. aerosols, can be captured by porous additive particles with large surface areas and transported out of the combustion systems.

- Enhancement of ash melting temperatures by introducing more inert materials and elements (i.e.SiO2 and Al2O3) into ash residues.

- Diluting the ash and restraining ash melts formation and accumulation.

3.2. Main chemical reactions between the additive and biomass ash:

Chemical binding is a preferred effect from an additive to mitigate ash issues during biomass combustion. Most of the tested additives are applied to capture and convert KCl into high temperature melting species via chemical reactions. Chemical capturing of KCl (g) and (l) is related to a series of solid/gas or solid/liquid reactions that occur normally after the KCl has volatized from fuel particles as vapors.

On the other hand, some additives may also react with melted potassium silicates and phosphates and alter the ash chemistry to generate other chemicals and reduce the amount of ash melts.

Based on reactive components contained in additives, they can be divided into four groups,

A. **Zeolite based additives:** the main products between the Zeolite based additives and potassium chloride are potassium Zeolate. One representative of Zeolite additive is kaolin. Kalsilite and leucite are two main products from reactions between Zeolite and KCl(g), and have melting temperatures of about 1600 °C and 1500 °C, respectively. Zeolite showed ability to increase biomass ashes sintering temperatures and reduce fouling deposition in different studies.

B. **Ammoniacal based additives:** The main effect from this additives is to convert KCl into K2SO4. Compared to the KCl, the K2SO4 has a rather high melting temperature, about 840 °C, Further this sulphate convert in ammoniacal sulphate which having higher temperature which makes less problematic in terms of deposition. Moreover, as a result of sulphation of KCl, the Cl will be released and flows away with flue gas. It will considerably reduce the amounts of Cl in the fouling deposits, which mitigate Cl induced high temperature corrosion, consequently.

C. **Alkaline earth metals based additives:** As an alkali earth metal, Such as the Mg (as Mg^{2+}) can dissolve into potassium silicate melts and force K release to gas phase. As a result, more Si will react with Mg with formation of Magnesium silicates that have higher melting temperatures than potassium silicates. It will restrain ash melts formation and ash sintering and slagging as well. Alkaline earth metal based additives are more active in combustion of biomass fuels that are rich in phosphorus and potassium. Enhancement of Mg in potassium phosphates can strongly increase the melting temperature of phosphate. However, Alkaline earth metals based additives e are more efficient in abating ash sintering and slagging in bottom ash, since the solid-liquid reactions more likely occur at high temperatures and prolonged time.

D. **Phosphorus rich additives:** For biomass fuels containing high contents of K and Si and a certain amount of Ca, phosphoric acid has been tested as an additive to reduce ash sintering and bed agglomeration in a fluidized bed reactor. With introduction of more P in the ash residues, K may react with P forming K- rich phosphates that may further react with CaO(s). In this way, the potassium available to form low melting temperature silicates is reduced, which is observed as a reduction of low temperature melting potassium silicates.

4. Significance of ALTRET CMC additives:

Studies on the potential additives for reducing biomass ash related problems have been conducted the last decades. There are many possible additives candidates reported, but the choice of a proper additive is not always straightforward. The major challenge is to choose an ideal or the most optimal additive for solving ash related problems taking place in real combustion applications.

The difficulties in selecting an applicable additive are:

A. Ash transformation and interaction are quite complicated during biomass combustion and are affected by fuel/ash chemical compositions, combustion temperature, residence time, etc.

B. It is hard to predict property changes of additives in a biomass combustion system along with reaction temperature and time.

C. Interactions between additives and biomass ashes are complex and difficult to control.

5. Properties of ALTRET CMC additives:

An ideal additive must have the following properties:

(1) High reactivity to reduce the amount of problematic ash species irreversibly,
(2) High temperature stability,
(3) Large enough surface area for rapid adsorption and high loading capacity,
(4) Relative high melting point itself without contributing to any new operating problematic issues.

- Any additive to the fuel must not significantly increase costs of the plant operation such as pre-treatment of the additives before feeding them into combustion systems. On the contrary, with utilization of additives, the operation and maintenance cost should be lower.
- The use of additives should not give rise to ash handling problems or increased environmental problems. The amount of an additive applied should be as small as possible with optimized effects.

Fuel Briquette Type	Fuel Characteristics	ALTRET Products	Product Future
Rice Husk	Slagging & Fouling tendency because of present of K	**ALTRET 95 SBR**	Powerful anti-fouling agent for high silica, high iron & high alkalinities
Mustered Husk	High Chlorine, High Calcium, High Silica	**ALTRET 95 SBM**	Zeolite based additive to control adverse effect of chlorine
Bagasse	Present of Pole particles, High Silica and Potassium, High Moisture	**ALTRET 95 SB 1**	Ammonical Based additive is key to clean heat transfer surfaces of Sugar boilers.
Common Agro waste/ Wood	High Fouling Index , B/A ratio extremely high, High Moisture	**ALTRET 95 SB**	Combination of Zeolite, Alkaline earth and Ammonical compound based additive
MSW	High Chlorine, Toxic materials, Heterogeneous Composition & Relative Poor Heating Value, High Silica	**ALTRET 95 SBW**	Zeolite based Advance catalyst, Abate pollution related plastic burning

6. Conclusions:

Additives based on different chemical compositions and possible counteracting effects can be used to abate ash related problems during biomass combustion. Chemical binding is the most important effect of additives, and converts problematic ash elements into high temperature stable substances. Since utilization of additives is related to costs, the amount of additives used for different scenarios are important. Normally, the input amount is based on stoichiometric calculation.

ALTRET offers state of art , highly effective Combustion monitoring chemicals / fuel additives for bio mass with multi-functions, have high stability and reactivity and cost effective.

With effective usage of ALTRET biomass additive / Agro Briquette additive ALTRET ensures long terms application and boiler operation. ALTRET also offers after sales services to monitor performance and provide relevant test (Such as biomass / Briquette Ash Analysis, Flue gas analysis, XRD analysis, prediction of ash behaviors based various indices calculation etc.)

ALTRET will provide best solution for long term application of alternate fuel such as biomass, Briquette and Municipal Solid waste (MSW).