Ash reducing measures during combustion of ash rich fuels engineering essay

Engineering

AbstractIn this paper we say about the ash reducing techniques carried out with the experiments for the solid fuel (coal), liquid fuel (petroleum) and gaseous fuel(). Also we discuss about the consequences of the inorganic compounds in the fuel.

Introduction

The revolution of civil society brings invention of electricity. Nowadays electricity plays an important role in the human society. In order to produce that electricity we need to depend on the resources such as minerals and fossil fuels available on the earth. Fuels are classified into solid, liquid and gas. Not all the power plants use same fuel to produce electricity for e. g. Thermal power plant uses coal to produce electricity. Even though we get the outcome electricity at the same time we get the byproduct Ash during the combustion process and cleaning process. The fuel used is of two grades namely High grade and low grade fuels. Ash is nothing but an inorganic waste matter. Ash is got from either solid or liquid or gaseous fuels [1].

Problems arise due to the ash content in fuels:

Decreased efficiencyUnscheduled outagesEquipment failuresHigh cleaning costsThe above mentioned things are considered as the major problems. But there are also some detrimental effects caused by the inorganic compounds on the combustor or gasifier like slag tapping problems, fire side ash deposition, corrosion and erosion of system parts , formation of hazardous air pollution etc[2]...

Ash reduction technique in Raw coal using Alkali and Acids[3]:

It is estimated that 550 million tons of coal is produced worldwide. Many hazardous elements are released into the atmosphere during the usage of coal e. g. in thermal power plants to generate electricity. Therefore to reduce the amount of toxic elements released into the atmosphere during the combustion process different chemical pretreatments are carried out like acid leaching, which is to decrease the metal contents. This case study tells about the treatment of coal using hydrochloric acid, sulfuric acid and sodium hydroxide. Many experiments are conducted by varying the parameters such as concentration of leachants, time and temperature of leaching. The properties and composition of ash content in coal depends according to the type and origin.

Experiment carried out:

Coal samples are taken and are crushed using the rollers followed by the grinding process. Three different fractions of sizes are sieved 1.) 2. 3mm to 1. 0mm; 2.)1. 0mm to 0. 15mm; 3.) < 0. 15mm. The coal samples and the feed coal are analyzed for the presence of moisture content, ash, volatile matter and fixed carbon. Then solutions are prepared for the experiment. Weigh (10 g) coal sample along with 100mL leachant solution, taken in conical flask fitted with a water cooled condenser. The leaching experiments are conducted on magnetic stirrer with heating facility. Parameters varied during the leaching process. Time of leaching which is varied from 15 min to 60 min. Temperature between the room temperature and boiling temperature. Concentrations of the leachants between 1. 5M to 6. 0M. Size

fractions. The contents in the conical flask are filtered and washed with the water after the leaching process got over. Ash analysis is carried out after the leaching by conducting serious of experiments.

Discussion:

After conducting as many leaching experiments using hydrochloric acid, sulfuric acid and sodium hydroxide it is analyzed the coal of size fraction <0. 15 mm has more percentage of ash when compared to the other fraction and the feed coal. The reduction of ash content in leached coal by using the acids is due to soluble components like carbonates, iron oxide and sulfides present in it. The results of the experiments shows that 57 % of ash reduction is possible during the leaching with 6. 0M hydrochloric acid at boiling temperature experimented for 60 minutes. Whereas 40 % of ash reduction is possible when treated with sulfuric acid and 75 % of ash reduction is possible with the sodium hydroxide leachant. Since sodium hydroxide is a alkali, it easily reacts due to the presence of acid insoluable silicates, aluminates and pyrites in the coal.

Effect of hydrochloric acid on leaching of ash:

Temperature oCConcentration , M% size fraction 2. 3mm to 1. 0mm% size fraction 1. 0mm to . 15mm% size fraction < 0. 15mm15 min stirring30 min stirring60 min stirring15 min stirring30 min stirring60 min stirring15 min stirring30 min stirring60 min stirring271. 57. 248. 6210. 3419. 3620. 6321. 5823. 4324. 2125. 4670318. 1019. 3121. 2027. 6128. 7330. 1531. 7132. 8133. 59100643. 1043. 9645. 5151. 2652. 2253. 4954. 6855. 9357. 18

Effect of sodium hydroxide on leaching of ash:

Temperature oCConcentration , M% size fraction 2. 3mm to 1. 0mm% size fraction 1. 0mm to . 15mm% size fraction < 0. 15mm15 min stirring30 min stirring60 min stirring15 min stirring30 min stirring60 min stirring15 min stirring30 min stirring60 min stirring271. 515. 5116. 5517. 9324. 7625. 5527. 1428. 4329. 5330. 9370337. 9338. 9640. 3445. 7146. 6648. 4149. 3750. 0051. 25100666. 8967. 5868. 9671. 5872. 3873. 6574. 3775. 0075. 50Similarly, experiments are carried out for sulfuric acid on leaching of ash.

Particle size:

It is noted that leaching of ash increases with decrease in the size of particles, which is due to the fact that reduction in size of coal results in increased liberation of ash.

Temperature and time of leaching:

Increase in temperature increases leaching; also 1000C is the maximum leaching temperature. From the results it is know that leaching increases with increase in time. The main advantage of using leaching method is that various toxic elements can be leached out by using different leachants; sodium hydroxide is known as the better leachant than the hydrochloric acid and sulfuric acid [3].

Ash reduction technique in petroleum fractions [4]:

Ash reduction in petroleum hydrocarbons is a simple and in expensive method. Petroleum hydrocarbon fractions contain components boiling above 9500F such as petroleum crude oil fractions, heavy gas oil fractions, deasphalted oil fractions etc... normally contain significant quantity of ash

components. The ash components which are characterized by the presence of metals such as nickel, vanadium, iron. The purpose to remove from petroleum fractions is the ash components adversely affect the susceptibility of heavy fraction in improvement by catalytic treatment such as catalytic cracking etc…

Experiment carried out:

The heavy petroleum hydrocarbon is treated within a temperature of 500 F to about 2100 F. Also about 5 to 35 volume percent based on the hydrocarbon charge of an aqueous solution containing about 5 percent to 20 percent volume of phenol. Heavy hydrocarbon feedstock is stored in a storage tank. The heavy hydrocarbon may be a gas oil fraction, a coal oil residuum fraction, a deasphalted oil fraction etc…About 5 volume percent of components boiling above 9500 F are present in a heavy fraction. The feed stock from the storage tank is discharged through a line controlled by a valve passed to the pre heater. The temperature can be adjusted to the desired treating temperature it it's necessary. After the pre heating the hydrocarbon is charged into the incorporator which contains baffle plates in it. Simultaneously phenol which is stored in the storage tank is passed to the line through a control valve and feed inside the pre mixer. Water is discharged into the pre mixer. The purpose of water is to make a aqueous solution of phenol containing from about 5 to 20 percent of phenol. Later the solution is discharged from the pre mixer into the pre heater where the temperature can be adjusted. Then the solution is transferred into the incorporator where the hydrocarbon feed stock and the aqueous solution of phenol is mixed. Therefore significant quantity of ash components can be

removed from the feed stock. Finally the mixture in transferred into the separation zone from the incorporator. The separation zone holds many settlers in it where the mixer is separated into low aqueous phase and supernatant oil phase. But the oil phase contains partial quantity of delashed oil, which is taken back for further processing. The solution spent in treating is discharged through a line.

End result:

Therefore, built up of ash in the solution is prevented using this experiment and also partial recovery of phenol is possible from the spent solution using the distillation process. The important advantage is that minor amount of phenol and water is dissolved in the feedstock. Therefore the feed stock can be partially deashed using this experiment. The figure shown below is the process carried out in the ash reduction of petroleum fractions [4]. Heavy hydrocarbonSeperation zonePhenolPremixerIncorporaterDeashed oilPre heaterPre heaterWaterspentSolution

Fig 1. Ash reducing process in petroleum [4]

Ash reduction technique in perennial grasses [5]:

The perennial grasses have been identified as one of the lowest cost agricultural feedstock used for the energy and agri-fiber markets. But the ash content present in this gives trouble for achieving efficient combustion when it is used in bioenergy, paper and pulp industry. The main remedy in the component is the presence of silica. The warm season (c4) grasses have lower silica than c3 grasses. This is because they utilize water 50% more efficiently. A fact says that clay soils produce higher silica containing

feedstock than sandy soils. Silica level is less at the stem fractions in the grass. Also reductions in the potassium and chlorine contents of the feedstock improve the combustion efficiencies. The chlorine content can be reduced by using the chlorine free fertilizers. But the herbaceous biomass material is not suitable for electricity and heat when it is compared to the wood. In order to overcome the obstacle we need to improve the combustion systems for the high ash fuels.

Characteristics of various bio fuel feedstocks

Element

Wood chips

Wheat straw

Switch grass (fall harvest)

Switch grass (spring harvest)

Potassium0. 11. 00. 950. 06Nitrogen0. 30. 70. 460. 33When we compare the spring harvested grass with the fall harvested grasses, spring harvested grasses are 19% less expensive. Therefore selecting less brittle switch grass with higher stem ratio will increase the economy in the spring.

Discussion:

Both the quality and cost in a biomass are to be considered when developing bio energy feedstock production systems. Therefore ash content in grasses can be affected by many factors such as soil type, location, species & variety, fertilization practices and time of harvest. Also plant breeding is needed to increase the stem fraction of grasses is helpful to reduce the ash

levels, provide an excellent opportunity to emerge a supply option for renewable energy [5].

What are the consequences of inorganic compounds in the fuel? [6]

CorrosionDeposition (fouling)EmissionSlagging/agglomeration. But depending on the element composition there often are problems withVaporisation (ZnCl2 melt 283°C boiling 732°C)Entrained particles (Particles stuck on the surface of other larger particles. Especially liquid and gas phase compounds contributes toAgglomerationFoulingCorrosionErosion

Conclusion

As discussed above many fuels have different percentage of ash content in it according to the components present in the fuel. Therefore the reduction of the inorganic components will alter the percentage of ash content in it. Also many future techniques are to be carried out in order to reduce the ash content, increase the combustion efficiencies and reduce the toxic substances released into the atmosphere. These reductions in ash contents is carried out in all the fuels such as gaseous, liquid and solid fuels which are mainly used in generating electricity and heat.