Physical Chemical and Leaching Properties of Rolling Mill Fly Ash

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Abstract

Fly ash is produced as a result of the combustion of coal in coal-based thermal power plants. In the present work physical, chemical and leaching properties of fly ash have been investigated. Fly ash particles are generally in spherical shape. They consist mostly of silicon dioxide (SiO2), aluminum oxide (Al2O3) and iron oxide (Fe2O3). Fly ash like soil contains trace concentrations of the following heavy metals: nickel, chromium, iron, zinc and lead. The leaching test result shows that the concentration of heavy metals element nickel, chromium and zinc is within the permissible limits of Indian standard (IS 10500; 2004) while elements concentrations of lead and iron have crossed the standard limits. These may cause the many harmful effects on the human health.

Keywords: Fly ash, physical and chemical properties, rheology, leaching, trace element.

I. INTRODUCTION

Power generation in India is primarily coal based in the present scenario. The coal used in our thermal power plants produce a large amount of ash, which is around 160 millions tons per year, at present in India. Out of this, 120 million tonnes of fly ash and 40 million tonnes of bottom ash are transported every year to disposal sites (ash ponds) by pipelines at various thermal power plants situated across the country (Biswas et al. 2000). Generally fly ash is disposed to ash pond. The Indian coal having very high ash content and low calorific value, generate the large quantities of ash produced as by-products of combustion (Mishra, 2004).

During the combustion process of coal, some tracing elements like Cr, Fe, Ni, Cu, Cd, and Pb are leached out from the solid phase. The trace elements also associated on the surface of the ash particles, in the condensation and evaporation process. The tracing metal elements of the coal ash have direct influence with the physical, chemical and minerogical characteristics of ash (Steenari et al. 1999, Ugurlu 2004, Singh et al.2012 and Popovic et al.2013). Most of the small scale steel re-rolling mills in India are based on pulverized coal (fuel) for heating of raw materials like mild steel scrap, ingot etc. There are around 1200 rolling mills in India, out of around 300 steel rolling mills are operating in the state of Punjab. In the present study, an attempt has been made to investigate the extensive physical, chemical and leaching properties of the fly ash of rolling mill.

II. PHYSICAL AND CHEMICAL PROPERTIES OF FLY ASH

The fly ash has collected from Boparai steel rolling mill, Mandi Govind Garh, Punjab, India. The particle size distribution of fly ash sample was determined by using sieve analysis and are plotted in Figure 1. Figure 1 shows that the biggest particle size of fly ash is 180 µ m and 81% particles are finer than 90µ m.

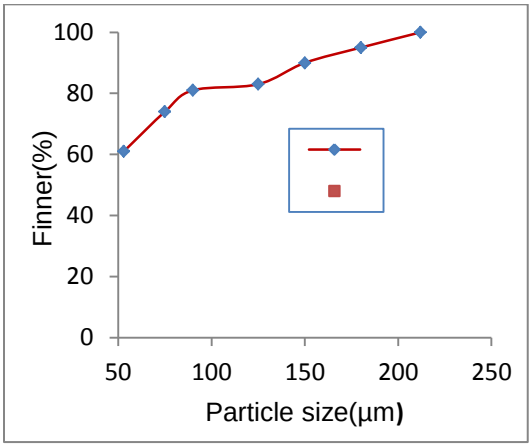

Fig. 1**:** Particle distributions of the fly ash

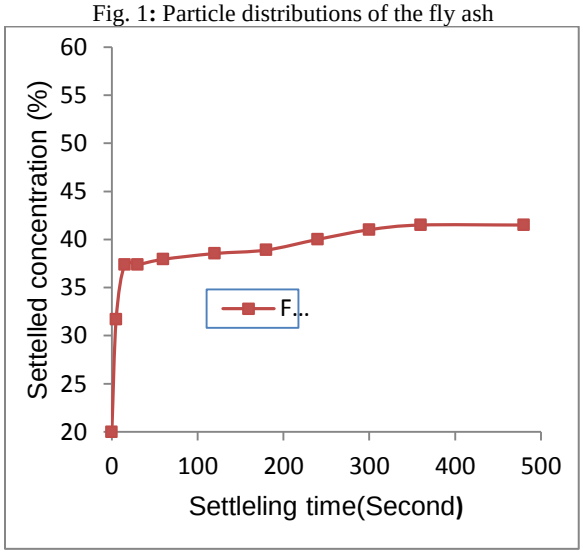

Fig. 2: Settled concentration of fly ash

The static settled concentrations of the fly ash was measured by taking an initial concentration mixture of 20% (by weight). The final static settled concentration of fly ash observed as 41.5 % (by weight). The static settled concentration of the fly ashes lead to low value of static settled concentration owning to fine spherical shaped particles as shown in Figure. 2. The pH value of the bottom ash suspension was measured by pH meter. The electrode of the meter was first moistened with tap water and then calibrated with a buffer solution of a known pH value. The measured values of pH at various concentrations in the range of 10 to 50% (by weight) lie in the range of 7.65 to 7. 44

The chemical compositions of non-magnetic parts of the coarsest fraction of the fly ash sample was determined using EDX (Energy-dispersive X-ray spectroscopy) are shown in Table1. From the Table-1 it is observed that fly ash samples contain carbon, oxygen, aluminum, silica and sulpher etc. The carbon, oxygen, aluminum, silica and sulpher percentage in the fly ash are 81.25%, 15.35%, 0.66%, 1.05%, 1.09% and 45.18 % respectively. The SEM photograph o f the ash sample is shown in Figure 3. The SEM photographs shows that all the ash samples are in spherical shape.

Table 1: Composition of the fly ash

Sample	***Chemical composition (by weight %)***
Elements	*Weight%*
C	*81.85*
O	*15.35*
Al	*0.66*
Si	*1.05*
S	*1.09*

Totals	*100*

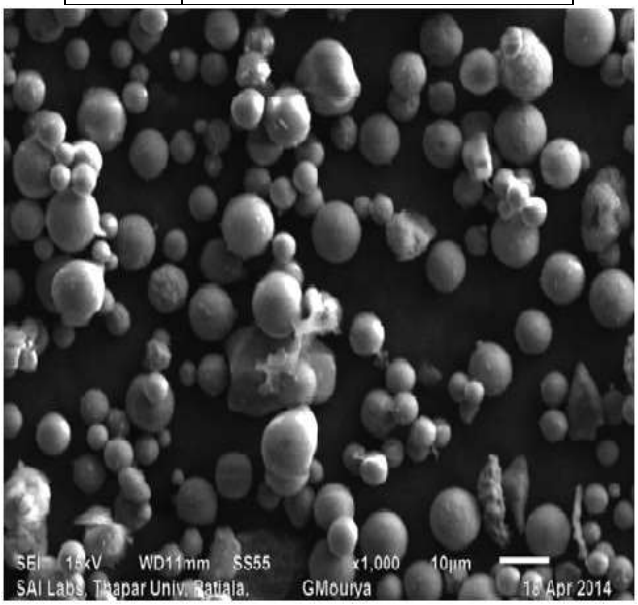

Fig. 3**:** SEM of Rolling mill ash Sample

Zeta potential is a physical property which is exhibited by any particle in suspension. It can be used to optimize the formulations of suspensions and emulsions. The magnitude of the zeta potential gives an indication of the potential stability of the colloidal system. Zeta potentials was measured with a Zeta Plus instrument manufactured by Brookhaven Instruments Corporation (U.S.A). The ZetaPlus instrument utilizes the shift in frequency of scattered laser when, due to an applied electric field, particles move perpendicularly to the laser beam (Doppler effect). From the Zeta potential result, it is observed that zeta potential value was negative -24.9 mV and -23.3 mV at concentration 10% and 20 %(by weight). The main constituents of fly ash are silicon, aluminum, iron and calcium. The fly ash zeta potential value becomes more negatively charged at concentration 10% as compared concentration 20 %(by weight).

III. LEACHING TEST

Leaching is a methodology to remove the soluble components from a solid. It is depend on the physical chemical and mineralogical characteristics of the solid materials. It is also depend the surface area of the solid, pH value, solubility of the chemical compound and composition of the leachant. The collected sample was dried at 120º C for 12 hour duration and then cooled. The leaching characteristics of the fly ash sample was determined by using ASTM D 3987 (American Society for Testing and Materials) and Extraction procedure method. In the ASTM D 3987 method, fly ash sample mixed with the leachant solution (water). The shaking lubricator was used for shaking of the solution. The test was performed by using liquid to solid ratio 20:1, 10 gm of fly ash was taken in extraction bottle & then 200 ml extraction fluid (water) was added & agitated continuously at 29 rpm for 18 hours. The Atomic Absorption Spectrophotometer (Make: GBC) was used to determine the exact concentration (mg/kg) of heavy metal present in the leachates. The results of the heavy metal content are given in Table 2. The harmful effect of the different metal elements is given in table 3. The result data shows that the tracing elements of lead and iron are presence in major concentrations while elements while nickel, chromium and zinc are presence in minor concentrations.

Table 2: Concentration of Heavy Metals

Parameters	***ASTM Samples (mg/Kg)***
Fe	*2748*
Zn	*26.91*
Ni	*11.08*
Pb	*18*
Cr	*9.87*

Table 3: Harmful effect of Heavy Metals on Human Health

Heavy Metals	***Health Effects***
Zinc	*Loss of appetite , nausea, Anemia, Respiratory Disorder, Skin Irritation*

Iron	*Choroiditis , Conjunctivitis , Siderosis*
Nickel	*Lung cancer, Larnyx Cancer, lung embolism, Birth defect*
Lead	*Miscarriage, Brain damage, Disruption of nervous system, Behavioural disruption*
Chromium	*Respiratory Disorder, Lung Cancer, Kidney damage*

IV. CONCLUSION

Based on the present work on physical, chemical and leaching properties of the rolling mill fly ash, the following conclusions were drawn.

(1) Rolling mill fly ash particles are finer and spherical in shape.

(2) The measurement of zeta potential indicates that the fly ash slurry stability is very minor with concentration.

(3) The leaching test result shows that the concentration of heavy metals element nickel, chromium and zinc is within the permissible limits of Indian standard (IS 10500; 2004) while elements concentrations of lead and iron have crossed the standard limits. These may cause the many harmful effects on the human health.

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