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Environmental impact assessment of ash disposal system of a thermal power plant

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ABSTRACT

The disposal of fly ash in the thermal power plant is a challenging task. Presently coal ash with water is transporting through pipeline in ash disposal system with very low solid concentration, result not only consumes huge amount of water and pumping energy but also causes serious environmental problem at the disposal site. The objective of the present study was to investigate the rheological and tracing element characteristics of the fly ash at high solid concentration with an additive of sodium bi-carbonate. The solid concentration of fly ash slurry varied from 40 to 60% (by weight). The slurry suspension of fly ash shows the non-Newtonian flow characteristics. Result data shows that, the addition of small proportion of additive, leads to improve the rheological characteristics and reduced the tracing element characteristics of fly ash. This aspect of the study will also suggest the improvement in ash disposal system of thermal power plant to minimize the environment impact.

Introduction

Coal is the world's most abundant fossil fuel and its reserves are distributed in all the continents. During combustion of coal in the thermal power plants generate large amount of bottom ash and fly ash, which have low value for utilization and several environmental problems associated with their deposition [1–4]. The quality of the coal ash depends on the properties of coal, combustion efficiency, pulverized coal feed and proper quality control in maintaining the particle size etc [3–5]. The available Indian coal quality is very poor; generate the large quantities of ash produced as by-products of combustion [6]. With increasing in the demand of the coal as fuel in thermal power plants, combustion products bottom ash and fly ash become a serious environmental problem due to their leaching characteristics [7–10]. During the hydraulic conveying and disposal, coal ash comes with contact with water. The tracing elements present in coal ash migrate to ground water, surface water and soil over a period of time [2,3,11–13]. Therefore, it is necessary to predict the leaching characteristics of the fly ash of thermal power plant to prevent the environmental effects. In the present study, an attempt has been made to investigate the flow behaviour and tracing metal characteristics of the fly ash disposed in the ash pond of the thermal power plant. The physio-chemical and mineral properties of the fly ash were also analyzed. The leaching test of heavy metals from fly ash was investigated in order to predict the environmental effect from the ash disposal on the ground water quality. Sodium bi-carbonate was used an

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additive in the fly ash. The rheological and leaching characteristics of fly ash also analyzed with addition of additive in the fly ash.

Material characterization

Fly ash sample was collected from the ash disposal system of Guru Gobind Singh Super Thermal Power Plant, Ropar, and Punjab, India. The particle size distribution of fly ash was determined with the help of Malvern 3601 particle size analyzer. The pycnometer was used to find out specific gravity and bulk density as per IS: 2386(Part-3). The gravitational settling method was used to determine the maximum value of static settled concentration of ash slurry suspension. The pH value of the fly ash slurry at any given solid concentration was determined by digital pH meter. The morphology and chemical composition of the fly ash sample was determined by using scanning electron microscopy-energy dispersive X-ray spectroscope (Model: JEOL, 6510LV). The mineralogical composition of fly ash sample has been collected by a Philips X'Pert diffractometer (Model: PW 1710). The rheological characteristic of the fly ash suspension was determined using standard Rheometer (Rheolab Q-C, Anton Paar Company Ltd, Germany). The rheological tests were conducted by changing the shear rate from 50 to 300 s^{-1} for all concentrations at the temperature of 24 °C. The rheology of the fly ash slurry was measure in the solid concentration range of 40–60% (by weight). The leaching characteristic of the fly ash sample was determined by using ASTM D 3987 method. In the ASTM D 3987 method, fly ash sample mixed with the leachant solution (water). The liquid to solid ratio (L/S) was taken 20:1 using 15 g of fly ash with 300 mg distilled water. The Remi orbital shaking lubricator (Model: RS 12 plus) was used for shaking of the solution. The shaking operation was performed with the period of 48 h at 100 rpm. The temperature was maintained at 50 °C. At the end of the leaching experiment, liquid was filtered through0.45 μm micropore membrane filter. The final extracts were stored in a refrigerator in the temperature environment 4 °C until the tracing element determination. The tracing metal elements were analyzed by using atomic absorption spectrophotometer (AAS 4129, make-ECIL, India) following the standard methods [14].

Result and discussion

Physical and chemical characteristics of fly ash

The particle size distribution of fly ash sample is shown in Fig. 1. From the Fig. 1, it is observed that maximum size of fly ash particle is 355 μm. Only 5.75% particles are coarser than 250 μm and 72.49% particles are finer than 75 μm. The weighted mean diameter (d_{wn}) d_{10}, d_{30}, d_{50}, d_{70} and d_{90} of ash sample were determined as 50.95, 57.92, 65.98, 74.05 and 189.64 μm respectively. The specific gravity, bulk density, porosity and water holding capacity of the ash sample was determined as 2.113, 1.45 g/cm^3, 27.95% and 29.66% respectively. The static settled concentration value has been determined by preparing a solid–liquid suspension of initial solid concentration i.e. 30% (by weight). The final settled concentration of fly ash slurries was found as 62.55% (by weight). The pH value of fly ash-water suspensions have been measured in the range of solid concentration 10–60% (by weight). The pH value of fly ash varies in the range of 7.26 to 7.08 with the solid concentration, which is shown in Fig. 2. The pH value of sample shows non-reactive nature of fly ash slurries. It can be inferred that the concentration of the coal ash-water suspensions show negligible effect on pH value [2–4].

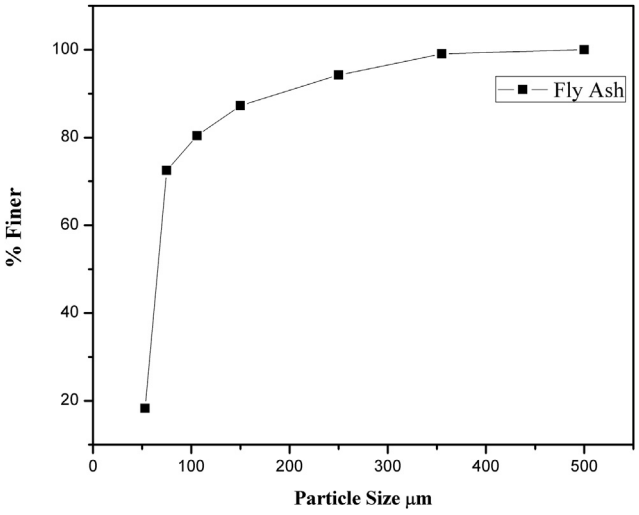

Fig. 1 – Particle size distribution of fly ash sample.

Mineral and morphological characteristics of fly ash

The scanning electron micrograph (SEM) of the fly ash sample at ×350 magnification is shown in Fig. 3. From the Fig. 3, it is seems that fly ash particles are regular in shape, having smooth surfaces, spherical morphology along with cenospheres (hollow spheres). Energy-dispersive X-ray spectroscopy (EDX) was used to find the chemical composition of fly ash sample. The elemental composition percentage of ash

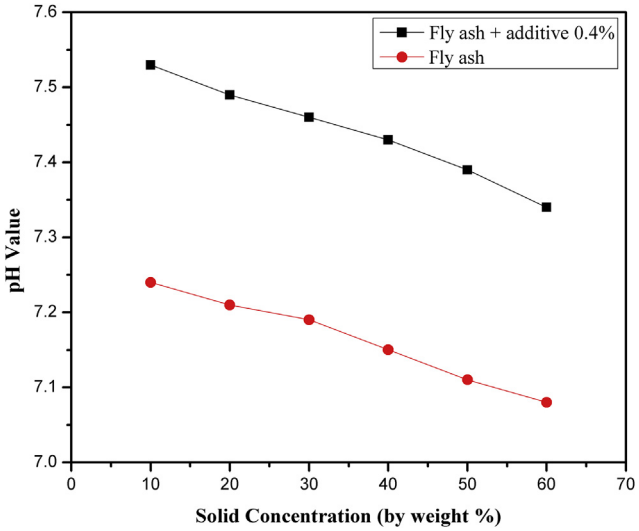

Fig. 2 – pH value of fly ash with and without additive.