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Characterizations And Frequency Dependent Conductivity Of Fly Ash

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ABSTRACT

Thermal power plant, generate in huge amount of waste material, these waste materials are very hazardous for human being as well for nature. The fly ash is the residual waste, which obtained as a by-product after combustion of coal in thermal power station. The fly ash can be reused, recycled and can be compounded with suitable inorganic chemicals to get value added product it can be converted into hard and strong tiles and many more value added products hence fly ash has prime importance in waste management. In this paper fly ash, powder collected from thermal power plant Durgapur (M.S.) India. Fly ash powder investigated using X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM). A.C. electrical conductivity in a frequency range of 100Hz-10 KHz studied and experimentally it found that the a. c. electrical conductivity depend on the frequency and conductivity increases with increasing frequency.

Keyword: Fly Ash, Characteristics, SEM, XRD and Electrical Conductivity

I. Introduction

Fly ash (FA) is a waste product of coal combustion in thermal power plant it is an alkaline grey powder with pH ranging from 9–9.9 contains many hazardous substances such as heavy metals and toxic organic compounds and is a major source for environment pollution. In India, this waste material utilized for the manufacture of concrete, cement and brick products, and the remainder directly buried in fly ash ponds or landfills, which is an unsatisfactory solution both from the ecological and economical points of view. Therefore, new economical and reliable means have found out in order to safeguard the environment and provide useful way for its disposal because the fly ash contains large amount of SiO_2 and Al_2O_3, many research and development investigations recently have conducted in its utilization as a starting material for glass and glass-ceramic production [1].

Thermal Power Plants and Fly ash:

In India, main source of electrical energy is coal based thermal power plants, which contributes 53 % share of total electrical power produced. The major problems faced by coal based thermal power plants are the handling and disposal of fly ash because of the huge quantity of fly ash produced. The amount of fly ash generated in India is 130 million ton per year. The fly ash disposal problem has assumed such an important issue in the India that the Ministry of Environment and Forests (MoEF) issued a regulation on 14 September 1999 specifying normative levels for progressive utilization of fly ash. It is mandatory for the coal based thermal power plants to utilize 100% of the fly ash produced in a stipulated time horizon. According to Central Electricity Authority (CEA) Report India has achieved only 63.28% of the target in terms of fly ash Percentage Utilization in the year 2016-17. The utilisation of fly ash is itself a big problem. The fly ash generated by the thermal power stations transported to the ash pond, which takes a large quantity of fertile land for dumping. The demand and requirement emphasis on application of Fly ash in road embankments, filler, building materials, bricks, in agriculture, in paint industry and many more. The effective use of fly ash it is decided to make an alkali activated fly ash composites which can be converted into some useful in civil construction using these materials such as fillers, tiles etc. with good compressive strength[2]. In India for every megawatt of power, being generated approximately 0.6 to 0.7 tonnes of fly ash created every day [3]. Delhi alone contributed nearly 5600 tonnes of fly ash every day from its three thermal power plants [4]. India's total installed capacity for electricity generation is 83.288 mw (year 1996) out of which coal fired thermal power plants contribute 53.819 mw [5]. First time fly ash was utilized in the preparation of cordierite [6] because of the presence of SiO_2 and Al_2O_3 in high proportions. Fly ash treated hydrothermally and the performance of this material as cracking catalyst investigated with heavy oil fraction as the cracking feedstock [7]. There were many experimental analyses on FA to undertake basic compositional, physical and chemical properties for technical studies and applications [8, 9]. Raw fly ash consists of quartz and mullite as crystalline phases and some quantity of glassy phase effort has taken to understand the electrical conductivity of fly ash [10].

Table 1.1: A typical composition of fly ash.

Constituents	% Amount
Silicon	50-58
Aluminum oxide	16-31
Iron oxide	6-20
Calcium oxide	0-8.4
Magnesium oxide	1-4
Sodium oxide	0.8-2
Potassium oxide	0.7-1

II EXPERIMENTAL

A. C. Conductivity Measurement:

A C Conductivity is an important experimental tool to identify and quantify the disorder level in polymeric materials. The most interesting feature is that the a. c. electrical properties of conducting polymers reveal a common behavior as function of frequency [12]. The a. c. conductivity of fly ash calculated with the data available from dielectric measurement and by using the relation

$$\sigma ac = 2\pi f \tan\delta \, \varepsilon_0 \, \varepsilon_r$$

where f is a frequency of applied field , $\tan\delta$ is the loss tangent available from dielectric measurement , ε_r is the relative permittivity of the sample and ε_0 is the dielectric permittivity of the vacuum (8.854×10^{-12} F/m) [13].

Sr. No	Sample	Conductivity (S/cm) at 100Hz	Conductivity (S/cm) at 1000Hz	Conductivity (S/cm) at 10000Hz
1.	Fly Ash	1.36×10^{-11}	2.73×10^{-11}	1.09×10^{-10}

III RESULTS AND DISCUSSION

[A] Scanning Electron Microscopy (SEM)

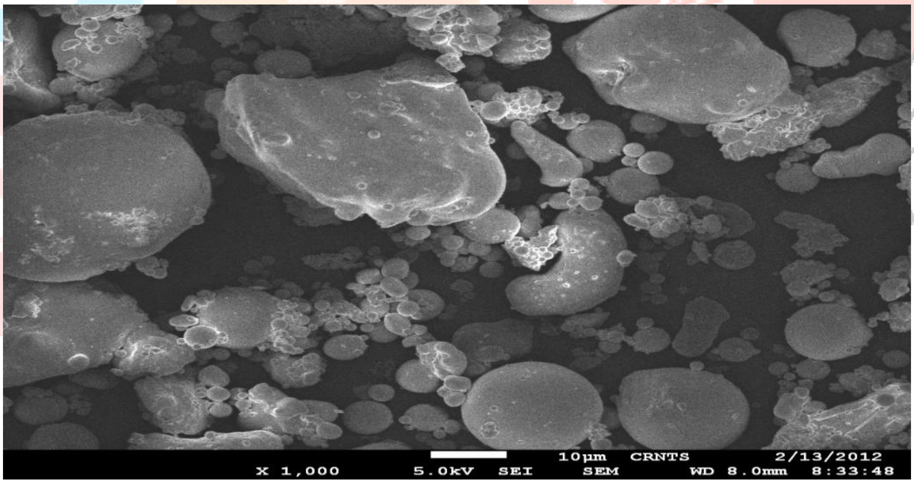

Fig. 1 SEM Image of Fly ash

The SEM image indicated intermixing of Fe and Al-Si mineral phases and the predominance of Ca non-silicate minerals. The fly ash samples consist of mainly of amorphous aluminosilicate spheres with a lesser number of iron-rich spheres. The majority of the iron-rich spheres consisted of two phases: an iron oxide mixed with amorphous alumino-silicate and calcium-rich material was distinct in both elemental composition and texture from the amorphous alumino-silicate spheres. It was clearly a non-silicate mineral possibly calcite, lime, gypsum or anhydrite. In spite of the inherent variability of fly ash samples, this analysis indicated that the primary mineral/morphological structures are common. Quartz and alumino-silicates found as crystals and as amorphous particles.

[B] - X-ray Diffraction Spectroscopy (XRD)

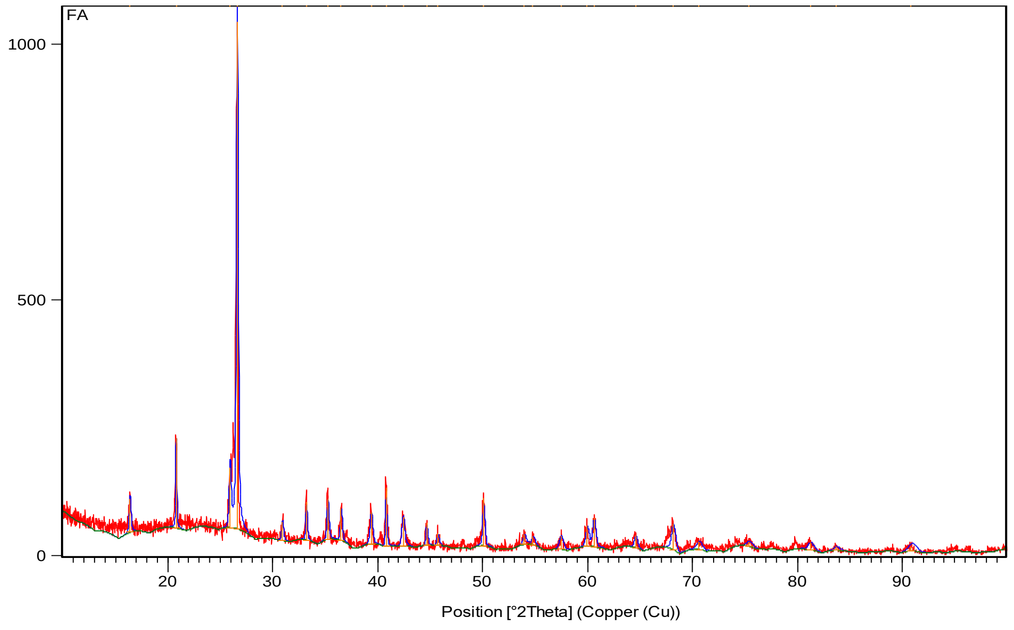

Fig. 2 XRD Spectra of Fly ash

Fig.2 show the XRD pattern of FA it consists of quartz (SiO_2), mullite ($3Al_2O_3$, $2SiO_2$) and hematite (Fe_2O_3) are major crystalline substances in the fly ash. It can be seen that a wide peak in the angle range of 2θ=18 to 23 appears in XRD pattern, which is due to influence of amorphous phase of the fly-ash cenospheres. From the XRD pattern of FA cenospheres the diffraction peaks of SiO2,Fe2O3 and Al2O3 are clearly seen because the main component of FA cenospheres are siliceous oxide, Ferreous oxide and aluminous oxide [11].

[C] A.C Conductivity

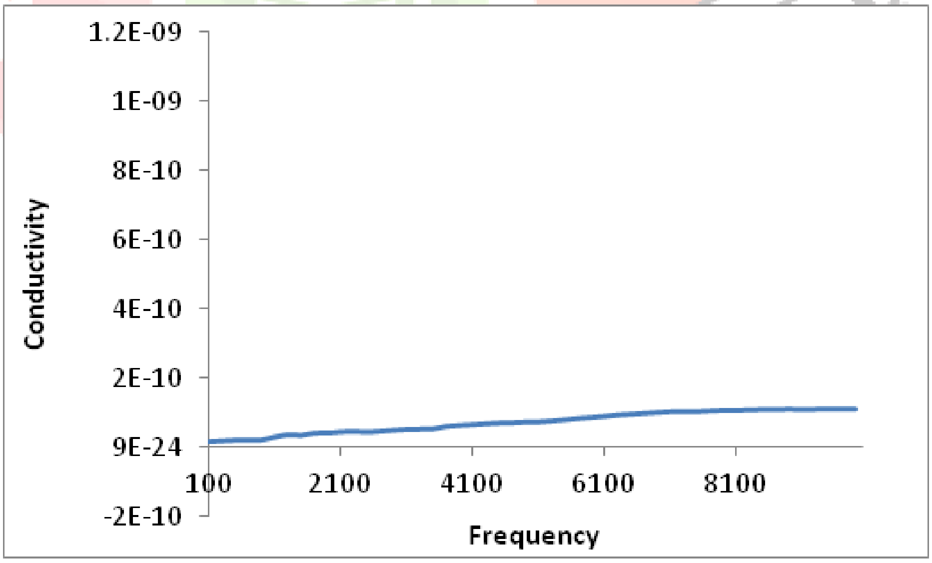

Fig.3. Variation of conductivity with frequency

The frequency increments create the oscillating nature of sample, creating the intermolecular activity increase and the conductivity increases as shown in fig.3. The Conductivity curve show linear relation and become in saturated after the frequency 10 KHz. On the experimental investigations, the following observations made Fly ash is a complex mixture of inorganic compounds similar in characteristics to certain insulating materials which in the pure state have high electrical resistivity of the order of 10^{14} to 10^{15} ohm-cm [14]

[IV] Conclusion

In this paper characterization of fly ash successfully carried out through SEM and XRD. The various type of fly ash resulted in different characterization results. Generally, fly ash consists of Si-based compound and quartz, hematite, magnetite CaO etc. XRD patterns of fly ash showed the major peak at 20-30 two-theta degree. The surface morphology of fly ash particles was mostly in spherical shape. A.C. electrical conductivity in a frequency range of 100Hz-10 KHz studied and it found that the conductivity depend on the frequency and conductivity increases with increasing frequency. Fly ash conductivity increased with the increase in Fe, K, Na, and Li contents by contrast, conductivity decreased with increase in percent of Ca and Mg. Si and Al has less effect on fly ash conductivity.

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