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Role of specific gravity of fly ash in evolving slurry density set point for high concentrated slurry disposal system

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High Concentrated Slurry Disposal (HCSD) of fly ash is currently being followed in many power plants in India. To evaluate the effectiveness of HCSD pump and slurry disposal system, density of fly ash and concentration of fly ash in the slurry being transported has to be known. Slurry percentage with its density is not provided by any original equipment manufacturer. Attempts have been made to obtain the slurry concentration and density for safe operation of HCSD pump. Inferences show that the specific gravity of fly ash varies from 1.9 to 2.25 and bulk density from 0.82 to 0.97 g/cc. The optimum ash percentage in slurry was found to be around 50 to 65% for any HCSD pump. Slurry density up to 1.44 g/cc with 65% slurry percentage (±1%) for fly ash of specific gravity 1.9-2.25 was found to be the safest for any HCSD pump operation.

Keyword: Fly ash, specific gravity, slurry disposal, bulk density, HCSD.

1. Introduction

Coal based Thermal Power Plants have a major issue with the disposal of fly ash. This disposal system consists of two methods: Lean Concentration Slurry Disposal (LCSD) and High Concentration Slurry Disposal (HCSD). Conventional Lean Slurry Disposal System and Ash Water Recovery system have some limitations and/or disadvantages such as huge amount of water is wastage, groundwater contamination, potential ash pond collapse, vast land required for ash dykes, higher costs for ash pond construction and higher power consumption. Recent advances and these limitations have lead to the adaptation of new environment friendly ash disposal technique like HCSD which is being followed in many power plants. A HCSD pump is for the disposal of fly ash to ash ponds. HCSD has more objectives such as,

1. Water consumption is reduced due to the high concentration in HCSD (60-70%) in comparison with LCSD (15-25%).
2. HCSD is highly impermeable, leaching, erosion and wear tendency is very less.
3. Specific energy consumption is very less.
4. Fugitive dust is minimal as compared to LCSD.
5. No breach of dyke as less water is used.
6. Environmentally safe and economically attractive.

The major drawback of any HCSD pump is it requires very strict quality control on all the process parameters to ensure trouble free working of the system. Specific gravity (SG) plays an important role in the operation of HCSD pump. In general, specific gravity of coal ash is around 2.0 but can vary to a large extent (1.6 to 3.1). The variation of specific gravity of coal ash is due to the combination of various factors like gradation, particle shape and chemical composition. The importance of specific gravity of fly ash in HCSD is not known to be reported in any literature.

2. Materials and Methods

2.1 Characterization of Fly Ash

Different fly ash contains the same basic chemical elements, but in different proportions. The properties of the fly ash sample under study are presented in Table 1. All the analysis was carried out as per IS:

1727-1967. All the constituents are in percentage except specific gravity.

Table 1: Properties of Fly Ash samples

Constituent (%)	Range
SiO_2	58.50–63.10
Fe_2O_3	7.40–10.10
Al_2O_3	17.70–22.20
CaO	1.80–2.60
MgO	0.21-0.25
LOI	0.5-3.40
Specific gravity	1.9-2.25

2.2. Calculation of Bulk Density

Fly ash samples were collected from first and second rows of ESP hoppers for Bulk density (B/D) calculation. For this a 250 ml cylinder was used in the entire experiment. Pass a quantity of powder sufficient to complete the test through a graduated cylinder. Note the weight of the cylinder. The bulk density of a powder depends on how closely individual particles pack together. The bulk density is affected not only by the true density of the solids, but by the particle size distribution, particle shape and cohesiveness. It is an important property in packaging and powder handling.

2.3. Calculation of Ash Slurry Density

Different ratios of ash-water samples were taken for analysis. A 1000 ml cylinder was used for this analysis. First, ash of known quantity (say 650 gms = 65% of ash) was filled in the cylinder and was well compacted. Then the remaining part of the cylinder was filled with water (say 350 gms = 35% of water). The weight of the ash slurry and the initial level of the water were noted. The level of the water in the cylinder kept reducing due to water absorption capacity of fly ash. The slurry was left undisturbed. Almost after 20 to 30 minutes, the water level in the cylinder stopped reducing indicating the saturation point of that fly ash sample. The time taken for this was found to be the same for all ash-water ratios taken for analysis. The final level of water was noted. The difference in initial and final water level was concluded as water holding capacity of ash. The similar procedure was carried out for different ash-water ratio samples. The density of fly ash calculated was cross checked with a nucleonic density meter (say Smart Series LB 414 - Gamma Densitometer). Concentration of slurry (weight %) was measured according to the following equation.

$$\textbf{Concentration of slurry (weight \%)} = \frac{\textbf{weight of ash}}{\textbf{weight of slurry}}$$

3. Results and Discussion

Fly ash slurry of different concentrations was prepared in the laboratory and their densities were measured. Results are presented below. Bulk density (g/cc), Ash % in slurry and Ash density for different densities are listed in Table 2 and Table 3. It was observed that Bulk density of ash of the first field (boiler end) varies from is 0.82 g/cc to 1.1g/cc and specific gravity of ash was also varies from 1.9 to 2.15. Ash slurry percentage and density reported by Bagchi *et al.* is based on bulk density of 0.85-0.95 g/cc. [4]. In general, specific gravity of coal ash lies around 2.0 but can vary to a large extent (1.6 to 3.1). The variation of specific gravity of coal ash is due to the combination of various factors like gradation, particle shape, and chemical composition. Since specific gravity is an important physical property [5]. Specific gravity has a definite relation with bulk density as shown in the characterization of ash sample CTPS by Rai et al. [6]. The same characteristics are observed in fly ash under study at VIPL Butibori for different types of coal received. Slurry density with respect to bulk density and specific gravity was carried out and results are shown in Table-2 and Table-3.

Comparative analysis of slurry density with respect to its specific gravity and percentage of fly ash is shown in Table-4. HCSD pump operation ranges from 50% to 65% ash and it also depends on rheological characteristics of ash to predict drag reduction behavior of fly ash slurries [7]. As per the data of ash slurry percentage and specific gravity, it is observed that for 50% slurry concentration and specific gravity of 2.25, density is 1.38. Whereas for the same percentage, slurry density is 1.31 for specific gravity of 1.9. Therefore, if the pump is designed for 60-65% ash slurry delivery, the slurry density set point should be 1.44-1.45 g/cc because in any case the slurry concentration will not exceed above 65%.

Table 2: Specific gravity of fly ash 1.9 and 2.0 and ash slurry percentage.

Specific gravity 1.9 BD = 0.82±0.01 g/cc		Specific gravity 2 BD = 0.86±0.01 g/cc	
Ash % in slurry	Ash slurry density (g/cc)	Ash % in slurry	Ash slurry density (g/cc)
50	1.31	50	1.33
51	1.31	51	1.34
52	1.32	52	1.35
53	1.33	53	1.36
54	1.34	54	1.36
55	1.35	55	1.37
56	1.36	56	1.38
57	1.36	57	1.39
58	1.37	58	1.40
59	1.38	59	1.41
60	1.39	60	1.42
61	1.4	61	1.43
62	1.41	62	1.44
63	1.42	63	1.45
64	1.43	64	1.47
65	1.44	65	1.48

Table 3: Specific gravity of fly ash 2.15, 2.20 and 2.25 and ash slurry percentage

Specific gravity 2.15 BD = 0.93±0.01 g/cc		Specific gravity 2.20 BD = 0.95±0.01 g/cc		Specific gravity 2.25 BD = 0.97±0.01 g/cc	
Ash % in slurry	Ash slurry density (g/cc)	Ash % in slurry	Ash slurry density (g/cc)	Ash % in slurry	Ash slurry density (g/cc)
50	1.36	50	1.37	50	1.38
51	1.37	51	1.38	51	1.39
52	1.38	52	1.39	52	1.40
53	1.39	53	1.4	53	1.41
54	1.40	54	1.41	54	1.42
55	1.41	55	1.42	55	1.44
56	1.42	56	1.43	56	1.45
57	1.43	57	1.45	57	1.46
58	1.44	58	1.46	58	1.47
59	1.46	59	1.47	59	1.48
60	1.47	60	1.48	60	1.5
61	1.48	61	1.49	61	1.51
62	1.49	62	1.51	62	1.52
63	1.5	63	1.52	63	1.53
64	1.52	64	1.53	64	1.55
65	1.53	65	1.54	65	1.56

Table 4: Comparative analysis of different slurry density with same percentage of ash

Ash % in Slurry	SG = 1.9	SG = 2.0	SG = 2.15	SG = 2.25
	BD = 0.82±0.01 g/cc	BD = 0.86±0.01 g/cc	BD = 0.93±0.01 g/cc	BD = 0.97±0.01 g/cc
	Slurry density	Slurry density	Slurry density	Slurry density
50	1.31	1.33	1.36	1.38
60	1.39	1.43	1.47	1.50
62	1.41	1.45	1.49	1.52
65	1.44	1.48	1.53	1.56

4. Conclusion
It was concluded that the density of fly ash played a great role in ash disposal by HCSD method and ash percentage in slurry depends upon the specific gravity of fly ash. It was also found that most of the HCSD pumps operate between 50-65% slurry concentrations with fly ash bulk density varying from 0.82 to 1 g/cc. Slurry density up to 1.44-1.45 g/cc with 65% slurry percentage (±1%) for fly ash of specific gravity 1.9-2.25 was found to be the safest for any HCSD pump operation.

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6. References
1. Bulk density: http://www.who.int/medicines/publications/pharmacopoeia/Bulk-March 2012.
2. Gamma densitometer: https://www.berthold.com/en/pc/gamma-densitometer-smartseries-lb-414. 1st September, 2014.
3. Abbi YP. Energy Audit: Thermal Power, Combined cycle and cogeneration plants. TERI Press, New Delhi, 2012.
4. Bagchi SS, Velmurugan S, Neha M. Study of Ash Slurry Percentage in High Concentration Slurry Disposal System. Universal Journal of Environmental Research and Technology 2013; 3(5):607-609.
5. Pandian NS, Rajasekhar C, Sridharan A. Studies of the specific gravity of some Indian coal ashes. Journal of Testing and Evaluation 1998; 26(3):177-186.
6. Kumar AR, Paul B, Singh G. A short note on the characterization of fly ash from Chandrapura Thermal Power station, Bokaro, Jharkhand, India. Journal of Environmental Research and Development 2011; 6(1):139-144.
7. Naik HK, Mishra MK, Rao K. Rheological Characteristics of Fly ash slurry at Varying Temperature Environment with and without an Additive. World coal ash conference, World of Coal Ash Conference Lexington, KY, USA, 2009, 1-12.