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Fly Ash an Alternative for Mine Void Filling in India

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ABSTRACT

Sand is used for filling mine voids in India. Due to high demand of sand for construction and infrastructure grown there will be a shortfall of sand in coming decade and fly ash can be one of the alternatives. Thermal power plant produces ash in large quantity and disposal of the same is a tedious job. Fly ash can be used as a viable option to use a filling material. In turn it will solve the problem of the disposal of ash economically and save sand and dewatering.

Keywords: *Mine Voids, Fly Ash, Sand*

I. INTRODUCTION

Fly ash used for filling of mine voids is an environmental sound process is the most feasible option of bulk utilisation. It saves enormous land requirement for ash disposal but also reduces coupled environmental issues in reclaiming the mined out area for making its gainful use.Fly ash in bulk magnitude can be utilized in stowing of underground mines with fly ash in lieu of sand and filling up abandoned open cast mine voids. This can result in utilisation of high proportion fly ash generated. Fly ash can- Find as a substitute for sand. Reduces water requisite to the tune of 50%. It fills well into the void/cavity as it can easily flow.The water holding capacity, in turn can facilitate aforestation.

As per analysis carried out, fly ashes are relatively inert. High ash content has been observed with the coal used in Indian thermal power plants. As a result enrichment of heavy metal is lesser compared to fly ash production by thermal power plants in developed countries

Fly ash finds its uses in applications such as in Cement/Concrete/Brick making, in highways, and embankments hydro power , irrigation, constructions, and, agriculture value added products like composites/wood substitutes/light weight aggregates/insulate, and abrasion resistant materials, and as effluent treatment agent etc. But none of these applications can consume huge volume that India produces.

One area where large amount of fly ash can be used is mine void filling. Nearly one third of our thermal power plants are pit-head power stations. Most of these mines cart sand for backfilling from river beds, which are normally 50- 80 kms away from the mines.

Apart from the royalty, huge amount of expenditure is also incurred on transportation of sand. In addition, sand is in great demand for many construction projects and is in short supply in many areas. The availability of river bed sand as a void filling material is decreasing. So finding an alternative to this is highly desirable.

At the same time mine voids has strong potential to absorb fly ash in bulk without compromising the roof stability (Kumar, 2003). With the application of current level of technology the percentage of extraction in the underground coal mines is about 40-50% only, which can be increased significantly with change in implementation of higher level of technologies. Increased production through new technologies would also demand higher rates of restoration of mined out areas to ensure safety and ecological balance. The filling of mine cavities would also release millions of tons of coal blocked in support pillars.

2. FUEL ANALYSIS

2.1. FLY ASH AS MINE FILLING MATERIAL:

Typical analysis of Fuel (Coal) and Ash

Fuel	Unit	Ind 'E'	Indonesian	Pet Coke	SA	Philippines	Ind 'D'	Ind 'F' (perf)
Carbon	% wt	37.24	53.10	81.74	59.77	50.48	44.04	35.88
Hydrogen	% wt	2.76	4.19	4.23	3.50	4.07	3.05	3.15
Sulphur	% wt	1.10	1.40	5.70	1.70	1.90	1.00	0.40
Nitrogen	% wt	0.73	0.95	1.41	0.99	0.94	0.83	1.10
Oxygen	% wt	6.66	3.85	0.92	0.04	5.15	6.57	3.56
Moisture	% wt	10.50	27.50	4.450	8.00	28.00	13.50	8.48
Ash	% wt	41.00	9.00	1.50	26.00	9.46	31.00	47.43
Total		100	100	100	100	100	100	100
GCV	Kcal/Kg	3700	5600	8150	6071	5300	4350	3264

ASH ANALYSIS

Coal	Ash Analysis						
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O
South African	43.50	29.00	4.50	10.00	2.00	0.90	0.45
Pet Coke	40.00	27.00	3.00	8.50	2.50	0.60	0.20
Philippines	52.00	21.00	3.70	9.00	2.30	1.65	0.40
Indonesian	50.00	22.50	3.50	7.50	2.00	1.50	0.65
Ind. 'D' Grade	55.00	21.50	4.00	8.00	2.80	1.70	0.50
Ind. 'E' Grade	57.00	20.00	3.70	9.00	3.00	1.65	0.40

CHEMICAL ANALYSIS OF BED ASH & FLY ASH

Composition	Unit	Bed Ash	Fly Ash
Silica (SiO_2)	%	67.07	59.27
Alumina (Al_2O_3)	%	15.43	30.06
Iron Oxide (Fe_2O_3)	%	12.78	3.27
Titanium Oxide (TiO_2)	%	0.38	0.44
Calcium Oxide (CaO)	%	3.53	4.18
Magnesium Oxide (MgO)	%	0.33	0.56
Sodium Oxide (Na_2O)	%	0.22	0.24
Potassium Oxide (K_2O)	%	<0.01	<0.01
Manganese Oxide (MnO)	%	0.04	0.05
Sulphate (SO_3)	%	0.07	1.04
Phosphorus (P_2O_5)	%	0.11	0.15
Chlorides (Cl)	%	<0.01	<0.01
Loss on Ignition	%	0.69	0.69
Bulk Density, Kg / M^3	%	1663.9	802.3

PHYSICAL PROPERTIES OF FLY ASH

a) Very Fine Free Flowing powder,
b) Moderately Abrasive
c) Highly Fluidisable,
d) Moderately Hygroscopic,
e) Non - Toxic,
f) Non Corrosive,
g) Health Hazard – None Known,
h) Fire Hazard - None

A relatively new technology, high concentration backfilling, enables mining industry to consider fly ash as underground back filling material. The advantages are enormous. Due to over exploitation sand in construction business and non-replenishment of sand in the rivers due to construction of dams at the upstream, sand is slowly but surely becoming a scare material. It is expected that it will be enormously difficult to get ample of sand for stowing purpose in future. So it is important to search in favour of alternate material to substitute sand to be used for underground stowing. As per survey conducted by CMRI indicated that 25 power plants are approximately situated within a distance of 20 Km of underground coal mines who are dependent on sand as stowing material at different coalfields of India. These power plants are producing a huge amount of fly ash which be capable to be used as an alternate stowing material. Ash has several advantages as compared to sand as a stowing material. As the technology of ash stowing is developed with high concentration form, it will be possible to obtain a very high rate of stowing which will eventually increase the coal production from depillaring panels.

The widespread mode of void filling is hydraulic sand stowing in which water is mixed with sand at surface and is allowed flow with gravity to the underground void to be filled. The hydraulic sand stowing process is inherently slow and is marred with other practical difficulties like non-availability of adequate sand, transportation of sand, additional pumping necessary to deal with stowing water, jamming of stowing pipes due to rapid setting of sand, more rapid abrasion of pipes by sand, slow stowing rate etc.

The necessitate is to develop and establish a technology, that will ensure high rate of packing of mine void to meet the higher manufacture requirement. High concentration fly ash slurry disposal system is one such technology. High Concentration Fill Technology involves mainly installation of HIGH CONCENTRATION SLURRY DISPOSAL (HCSD) Plant at the site. The main two components of this technology are:

1. Preparation of paste fill at the site (Ref. Fig. 1)
2. Pump, transportation and deposition of paste fill in underground voids. (Ref. Fig. 2)

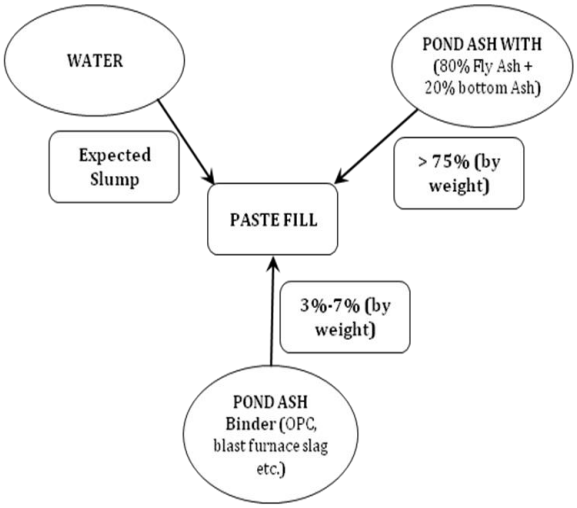

Fig. 1: The different constituent of paste fill is depicted in the figure

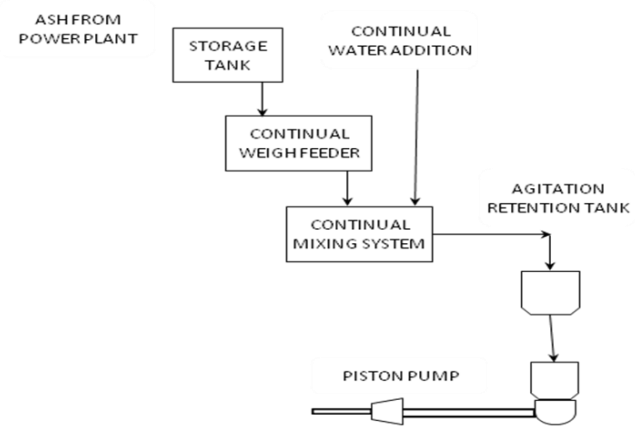

Fig.2: Different modules of HCSD Plant is shown in the figure

PASTE BACKFILL SYSTEM:

It is basically high solids concentration slurry. The term "paste" generally implies mixes containing over 70% solids concentration with less than 4% bleed.

Bunn (1989) observed that at a concentration of less than 60% with a maximum flow rate of 0.03 m^3/s resulted in 1.7 m/s velocity, enough to facilitate pipe line transportation smoothly. Approximately 900 tonnes of fly ash paste with Cw<64% was transferred to the disposal site in a period of 21 pumping days with an average of paste mass flow rate of 30 t/h. The angle of inclination of the deposited material was 2 to 3 degrees. Even the heavy rainfall during monsoon has produced no erosion at the observed site.

Mahlaba et al., (2011) compared the behaviour of pastes by varying brine composition mixed with two types of fly ashes. The results showed that fly ash played a more prominent role in the behaviour of pastes than brines. Therefore they concluded

that the constituent of paste play a major role in the development of an environmentally sound paste backfill practice.

Paste backfill of coal ash has following advantages over conventional hydraulic backfill systems:

• In paste backfilling mine dewatering cost is substantially very less as no or minimum dewatering is necessary and solidification can be achieved by pozzolanic properties of coal ash in addition to with addition of cementing materials of requisite quantity.
• In general, all of the coal ash can be used for paste so surface disposal may be remarkably reduced; whereas only coarse particles (bottom ash) are appropriate for hydraulic backfill. Bottom ash generation is 18-20% only, of the full amount of ash generated and its hydraulic backfilling will not fully add to the cause of 100% ash utilization.
• Paste backfill is denser that it's conventional counterpart and have higher confined strength. This means more of the coal ash can be returned underground, in this manner surface ash storage requirement is reduced.
• The system is able of handling bulk slurry for stowing resulting higher production.
• The same system can be applied in situation where conventional stowing is not feasible due to unfavorable hydraulic gradient.
• Problems on housekeeping and wear/corrosion on mine dewatering pumps caused by fines draining as of hydraulic backfill operations does not exist with paste backfill
• Shorter fill cycle time can be achieved by means of paste backfill system because of early strength gain. This may be able to lessen the number of active work face required.
• Low water content of paste backfill eliminates extensive preliminary work for the erection of confined underground drainage barricades.

3. CONCLUSION

The Indian coal is high in ash content (40-50%). The ash utilization potential are low and the ash disposal will require few thousands of Acres of private/ government/ forest /agricultural land for disposal of ash, in addition to land requisite for coal mines and power plants. It will, therefore, be a win-win condition for all the stakeholders if the ash is filled in mine voids and the voids are reclaimed through vegetation.

✓ The mine closure plan for various mines (coal mines, stone quarries and other mines) should comprise a compulsory provision that ash shall necessarily be used for backfilling& reclamation.

✓ In the concern of environment and saving the valuable agricultural and forest land, the filling of mine voids with ash must be encouraged.

✓ It can however, be stipulated that an earth cover of 300 mm must be provided on top. Mining company / thermal power plants or the agency responsible for refilling should be responsible for raising afforestation, maintaining it till maturities furthermore return the same to concern authority.

✓ Studies undertaken by agencies on impact of ash filling in the mine voids (ash characterization, leach ability studies, hydro geological studies and analysis of mine pit water and ground water) concluded that the coal ash is not perilous for filling in mine voids and has no significant impact on ground water quality of surrounding area.

✓ Fine particles of ash are likely to block the pores of the soil/ aquifers and reduce its permeability due to its pozzolanic property.

✓ The trace elements in leachate from voids, if some, are likely to go through chemical adsorption reaction with clay material present in soil and transportation get restricted.

✓ Mine voids lining is not feasible due to deep cuts, steep slopes and water present in voids.

✓ Excess water from the voids following disposal of ash (mine pit water or decanted slurry water), if some may be used in afforestation activities, dust suppression, and or recycled to the power project for ash slurry reuse.

✓ Ground water quality in the neighbouring areas of mine voids as well as sources of ground water in the downstream path is necessary to be monitored on periodic basis.

✓ Mine void filling using fly ash will not only help in reducing huge land requirement, but also help in creating vegetation cover. This will also help in increase in biological activities in addition to above the area leading to increase in organic content of the soil, enhancement of flora and fauna and overall ecological restitution of the area, improving the biodiversity of the area.

It will be in feasible that abandoned mine voids be allotted to the Thermal power plants on application and completion of site specified studies on a fast track basis for disposal of fly ash into the mine voids. A detail guideline for the studies and disposal methodology may be developed by appropriate authorities.

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