CHALLENGES OF ASH MANAGEMENT IN THERMAL POWER PLANTS OF SINGRUALI REGION: A CASE STUDY

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ABSTRACT:

Coal is used as main source of fuel for power generation in thermal power plants in India. Coal is fired in boilers for steam formation which in turn results in generation of ash. The prime concern for coal based power plants is the quality of Indian Coal, as India coal has low calorific value & sulphur content but has a high ash content in the range of 30 - 45% due to which ash is being generated in abundance. Fly ash generation in India has increased from 70 million tonne per annum (mtpa) during 1996-97 to about 184 mtpa during 2014 - 15. Ash generation is projected to be increased upto 225 mtpa by the year 2017 as various ultra-mega / mega power plants are at various stages of construction. Singrauli region is known as power capital of the country where coal based thermal power plants owned by public & private sectors are operating with installed capacity of more than 20,000 MW of power generation. Singrauli region generates more than 30 mtpa of fly ash annually and due to distant location from the major ash consumption belts, gainful utilization of such a huge quantum of ash in environment friendly manner is a big challenge for the region.

NTPC Vindhyachal is the largest power plant of the country (4760 MW) and is operating in Singrauli Region. This power plant generates around 07 millions of ash annually. Fly ash generated at NTPC Vindhyachal is mainly utilized in cement manufacturing, ash brick manufacturing & other ash based products manufacturing, raising and buttressing of ash dykes, wasteland development works using pond ash etc. Ash utilization scenario is almost similar for other power stations of the singrauli region. Meeting the regulatory norms of ash utilization in environmentally safe manner is the main area of concern for power stations of singrauli region and there is a need to explore and establish new avenues of Ash Utilization in sustainable basis.. This paper discusses the efforts being made by NTPC Vindhyachal for ash management and the associated issues and challenges in respect of effective management of ash.

1.0 INTRODUCTION:

Power, being considered as an engine of growth, has always been a focus area for most of the developing countries, including India. Installed capacity of power generation in India has increased from 1362 MW in 1947 to 3,07,278 MW out of which about 1,86,493 MW (approx. 61% of total installed capacity) is coal based. But still the per capita power consumption in India is far behind the per capita power consumption of developed countries like USA. Hence, Government of India has planned for enhancement of installed capacity of power generation in the years to come.

Coal being abundantly available in India, has been major source of energy till date and is expected to remain so in coming decades also. But, The main concern of coal based power plant of the country is the quality of Indian coal which has though low sulfur but it has also low Calorific value and high ash content in the range of 30-45% resulting in generation of huge quantity of fly ash in power generation process. The annual generation of fly ash has increased from about 1 million tonne in 1947 to about 40 million tonne during 1994 and to about 176.74 million tonne during 2015 - 16 *(Source: CEA Annual Report)*. Utilization of ash has also progressively increased in India from 6.64 million tonne during 1996 - 97 (9.63% of total ash generation) to 107.77 million tonne (60.97% of total ash generation). Details of progressive ash generation and its utilization is given in Figure: 01 below. The modes in which fly ash were utilized during the year 2015-16 along with utilization in each mode are given in Table-01 below:

Figure: 01

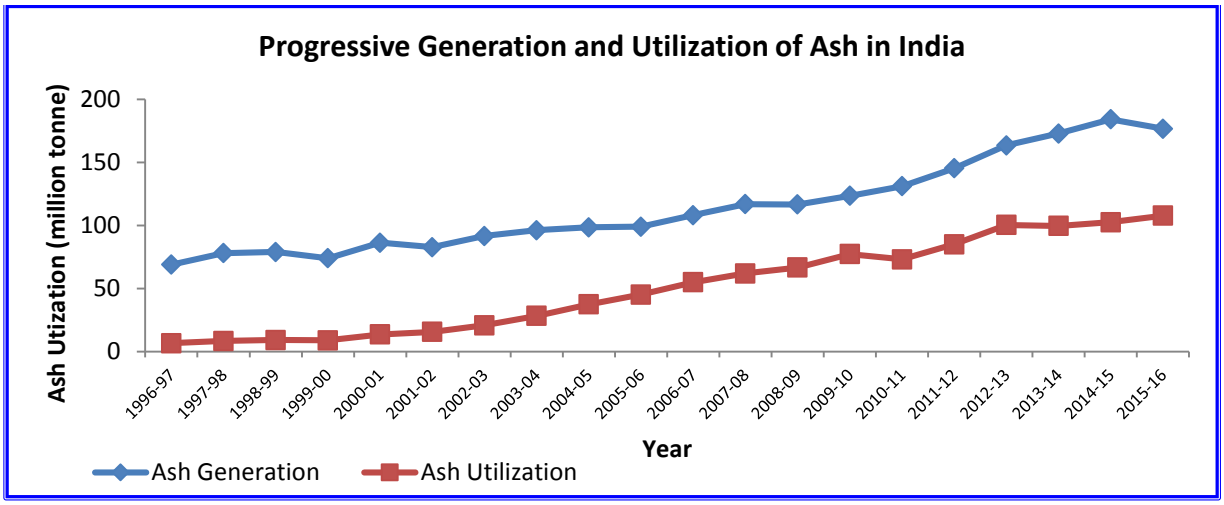
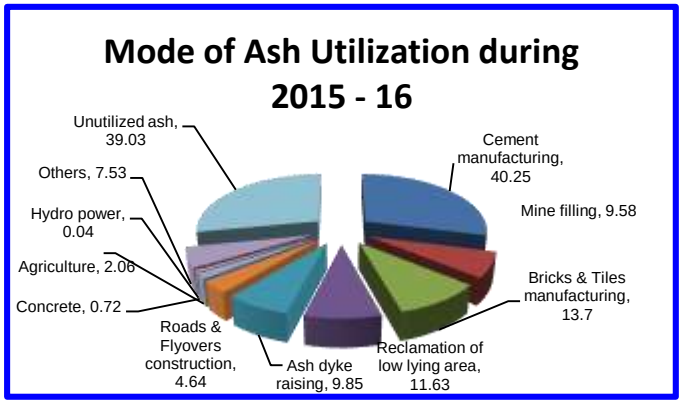


Table: 01

Sl.	Mode of ash utilization	Quantity of ash utilized	
		Million tonnes	**% of total ash generation**
1.	Cement manufacturing	43.38	24.54
2.	Mine filling	10.33	5.85
3.	Bricks & Tiles manufacturing	14.76	8.35
4.	Reclamation of low lying area	12.53	7.09
5.	Ash dyke raising	10.61	6.00
6.	Roads & Flyovers construction	5.00	2.83
7.	Agriculture	2.22	1.25
8.	Concrete	0.78	0.44
9.	Hydro power	0.04	0.02
10.	Others	8.12	4.60
11.	Unutilized ash	68.98	39.03
	Total	**176.74**	**100.00**

From above table: 01 it is evident that during the Year 2015-16, the maximum utilization of fly ash to the extent of 24.54% of total fly ash generated was in the Cement sector, followed by 8.35 % in making bricks & tiles, 7.09 % in reclamation of low lying area, 6.00 % in ash dyke raising, 5.85 % in mine filling, 2.83 % in roads & embankments, 1.25 % in Agriculture, 0.44 % in Concrete, 0.02 % in Hydro Power Sector, 4.60 % in Others and 39.03% remained as unutilized fly ash.

Figure: 02



From Figure: 02, it is evident that like previous years, utilization of fly ash in manufacturing of fly ash based cement is continued to be the largest mode of ash utilization for the year 2015 - 16 and it has constituted for 43.38 million tonnes of ash utilization which is equivalent to 40.25% of total ash utilization in different modes. Manufacturing of fly ash bricks, blocks, tiles etc. have gained importance in recent years and this sector was the second largest mode of ash utilization during 2015 - 16 and it has accounted for 13.70% of total ash utilization. Reclamation of low lying areas, raising of ash dykes, filling of ash in mines were other major areas of ash utilization during 2015 - 16. Use of ash in cement manufacturing is an established avenue of ash utilization in India and manufacturing of ash bricks, blocks, tiles etc. have also gained

importance in the recent past. But, in order to ensure 100% utilization of ash on sustainable basis, other avenues of ash utilization are needed to be explored and established for achieving ash utilization targets in environment friendly manner.

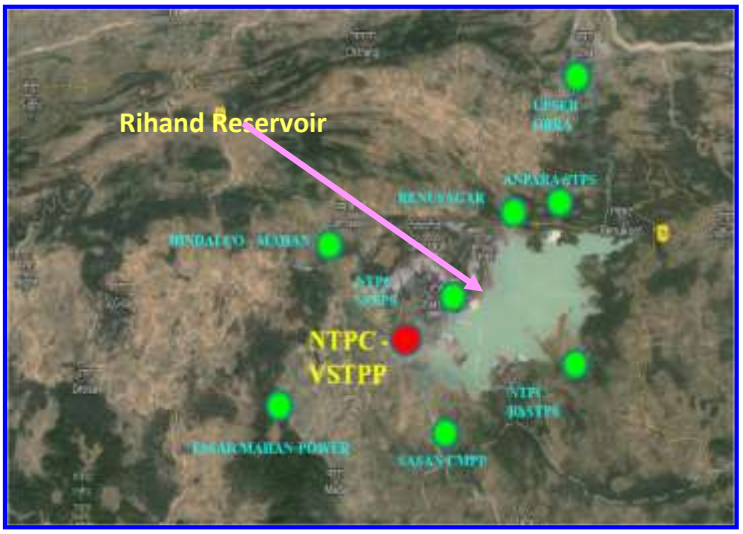
2.0 SINGRAULI REGION

Singrauli region spreads along the Singrauli district of Madhya Pradesh and Sonebhadra district of Uttar Pradesh and is known as the power capital of India Coal based thermal power plants owned by public & private sectors are operating in this region with installed capacity of more than 20,000 MW of power generation. Most of these power plants are pit head stations in which coal to these power plants is mainly fed from the linked opencast mines of M/s Northern Coalfields Limited (NCL). Details of the power plants of Singrauli region and their capacity is given below in Figure: 04. Power plants of Singrauli region generates more than 30 million tonnes of ash (on pro rate basis). As per the CEA report power plants of Singrauli region have achieved ash utilization level of 32.32% during the year 2013 - 14. Providing fly ash to cement industries, use of ash in ash bricks / blocks manufacturing, raising of ash dykes, development of low lying areas were the major modes of ash utilization in Singrauli Region. NTPC Vindhyachal with its installed capacity of 4760 MW has generated about 7.8 million tonnes of ash during the year 2015 - 16 of which 1.4 million tonnes of ash was utilized in different areas and the balance unutilized ash has been disposed off in its captive ash dykes in environmentally safe manner. The main areas of ash utilization at NTPC Vindhyachal are:

i. Issue to cement, ready mix concrete (RMC), asbestos and other industries,
ii. In-house manufacturing of fly ash - cement bricks,
iii. Issue of ash to ash fly ash bricks/blocks manufacturing agencies
iv. Use of ash in Ash dyke raising works & in other works.

Figure: 03

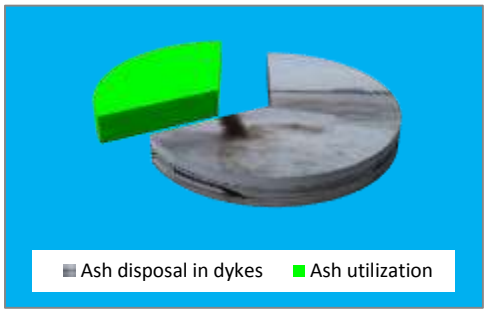
Sl.	Name of Station	Capacity (MW)
1	NTPC Vindhyachal	4760
2	NTPC Singrauli	2000
3	Hindalco Renusagar	750
4	Sasan UMPP	3960
5	UPSEB-Anpara	2630
6	Hindalco Mahan	1200
7	Essar Power	1320
8	NTPC Rihand	3000
9	UPSEB - Obra	1322
	TOTAL	**20942**



3.0 CHALLENGES OF ASH MANAGEMENT IN SINGRAULI REGION

Utilization of fly ash is entirely dependent on the location of its generation. Singrauli region although has a cluster of large coal based thermal power plants and these plants collectively generates a huge quantum of ash but owing to its remote location from the ash consumption belt, gainful utilization of ash generated in Singrauli region is a major challenge for the power plants of the region. Nearest cities from Singrauli region are Varanasi located at a distance of 225 Kms and Rewa located at a distance of 250 Kms. Providing fly ash to cement industries of Rewa-Satna-Katni region is the only

major area of ash utilization for the power plants of Singrauli Region. Total peak demand of fly ash by above cement plants is around 25000 MT/Day whereas singrauli region generates more than 70000 MT of fly ash every day. There is no substantial demand of fly ash in road construction work in the region. Due to low population density in the region there is no substantial demand of fly ash in construction works. However, around 20 ash brick plants are operating in the region to partially meet the requirement of ash bricks but due to existence of red brick clamps (pajawa) in the region demand of ash bricks is not increasing. Most of the coal mines of M/s NCL are in operation hence there is no demand of fly ash in back filling of abandoned mines. NCL has only one abandoned mine named as 'Gorbi' for the purpose of ash filling. Due to these challenges a large quantity of ash remains unutilized and is being disposed off in the ash dykes.



Ministry of Environment, Forests & Climate Change(MoEF & CC), notification dated 03-11-2009 which is an amendment to its earlier notifications dated 14-09-1999 and amendment dated 27-08-2003 stipulates that all coal based power stations/ units commissioned before 03-11.2009 have to utilize at least 50% of ash generated within 1 year, 60% within 2 years, 75% within 3 years, 90% within 4 years and 100% within 5 years. Above notification have provisions of mandatory use of fly ash in manufacture of bricks & other building products, road embankment construction, reclamation of low lying area and mine stowing/ backfilling. It also stipulates about the monitoring for compliance of the provisions.

Amendment dated 205-01-2016 to above notification of MoEF & CC also stipulates that the cost of transportation of ash for road construction projects or for manufacturing of ash based products or use as soil conditioner in agriculture activity within a radius of 100 kilometers from a coal or lignite based thermal power plant shall be borne by such coal or lignite based thermal power plant and the cost of transportation beyond the radius of hundred kilometers and up to three hundred kilometers shall be shared equally between the user and the coal or lignite based thermal power plant. Additionally, The coal or lignite based thermal power plants shall within a radius of three hundred kilometers bear the entire cost of transportation of ash to the site of road construction projects under Pradhan Mantri Gramin Sadak Yojna and asset creation programmes of the Government involving construction of buildings, road, dams and embankments.

4.0 INITIATIVES TAKEN BY NTPC VINDHYACHAL FOR ASH UTILIZATION & MANAGEMENT.

For enhancing ash utilization levels following initiatives have been / are being taken up by NTPC Vindhyachal.

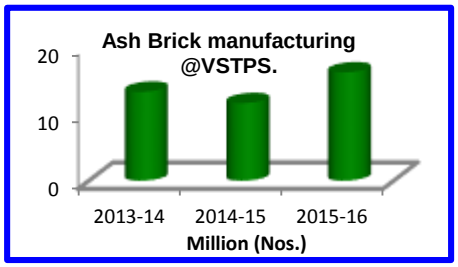
4.1 Providing fly ash to cement, asbestos & other industries

Fly ash is being provided to cement and asbestos industries of Rewa-Satna-Katni region through the dedicated Dry Ash Extraction System and dry fly ash silos of Stage - II (3x500MT) and Stage - III (2x1250 MT) in closed bulkers and trucks. During the year 2015-16 total 2.14 Lac MT of fly ash has been provided to above cement & asbestos industries free of cost. Presently fly ash is being provided to users through road bulkers & trucks but the high freight charges of Rs. 800/MT - Rs. 1200/MT being borne by the users for fly ash transportation by road is a limiting factor for enhancing ash utilization. Hence NTPC Vindhyachal is in the process of installing rail loading system of Fly ash

in its Stage - I and Stage - IV. As per the Freight Operations Information System (FOIS) of Indian Railways fly ash has been identified as Class-120 material for full rake load and as per the latest rates railway freight charges for transportation of fly ash to a distance of 301 - 350 Kms shall be in the range of Rs. 393/MT - Rs. 419/MT. Most of the cement plants of Rewa-Satna-Katni region are within 250 - 350 Kms of NTPC Vindhyachal and have the facility of unloading fly ash pneumatically from the road bulkers and they also have fly ash storage silos of adequate capacity, hence by some modification in the existing system of fly ash unloading these cement plants may develop the facility of fly ash unloading through railway wagons. Indian Railways has already approved BTAP wagons for transportation of alumina powder. This wagon is identical to fly ash road bulkers hence, BTAP wagons may also be utilized for for transportation of fly ash. Railway freight charges are less than 50% of the cost of transportation of fly ash by road, hence rail transportation of fly ash will not only encourage cement plants of Rewa-Satna-Katni to take more fly ash from NTPC Vindhyachal but it will also enable entrepreneurs to transport fly ash to distant ash consumption belts in cost economic manner.

4.2 Use of fly ash in manufacturing of Ash Bricks/Blocks/Tiles etc.

NTPC Vindhyachal has 07 nos. of Semi-Automatic ash brick plants in its premises. During the year 2015 - 16 more than 16 million bricks have been manufactured at NTPC Vindhyachal which has been utilized in all construction activities including 100% use of ash bricks in project works, township area and in CSR activities. Additionally around 20 ash brick plants are installed in the vicinity of NTPC Vindhyachal, in which approx. 0.75 Lac MT of fly ash of NTPC Vindhyachal has been utilized during the year 2015 - 16. Manufacturing of ash based bricks / blocks / tiles have gained popularity in last few years and large scale utilization of these ash based products has been started. During the year 2015 - 16 this sector has contributed for 13.7% of total ash utilization. But this mode of ash utilization is mainly confined to large cities of India and it has a vast potential to consume much more ash compared to present consumption level. Use of ash in manufacturing of ash bricks not only enhances ash utilization but it also save the fertile top soil as well as coal required in the manufacturing of conventional red (clay) bricks. As per the report of Central Pollution Control Board (CPCB) there is a requirement of 240 - 260 billion brick annually in India. If, production of conventional clay bricks is stopped totally and only fly ash based bricks is used in construction works across the country then total requirement of fly ash by the brick industry shall be around 330 - 360 million tonnes (details given below) which is more than 200% of present total ash generation in India.



i.	Wt. of ash brick = 2.5 Kgs (approx.)	ii.	Ash percentage in the brick = 55%
iii.	Ash consumption / ash brick = 1.375 Kgs	iv.	Total brick requirement = 240-260 billion
v.	**Total ash requirement = 330 - 358 million tonnes. ($1.375 \times 240 \times 10^{9} * 10^{-9}$)**		

4.3 Ash Utilization in Mines

4.3.1 Use of ash in back filling of abandoned mines pit.

Use of ash in back filling of abandoned pit of opencast mines is one of the major avenues of ash utilization for pit head stations like NTPC Vindhyachal. Gorbi Mines of M/s NCL is available for back filling with fly ash generated from the thermal power plants. Above referred MoEF & CC stipulates for mixing of at least 25% fly ash on volume to volume basis of the total material used in external overburden dumps and same percentage of fly ash to be used in upper benches of backfilling of opencast mines and these activities are required to be carried out under the guidance of DGMS (Director General of Mines Safety). The abandoned voids of Gorbi Mines have combined volume of

63 million cubic meter, hence Gorbi Mines is capable of accommodating ash generated in approximately 10 years at NTPC Vindhyachal.

NTPC Vindhyachal has obtained the consent of NCL as well as of Coal India for back filling of Gorbi Mines. To assess environmental Impact of disposal of fly ash in backfilling of mine, NTPC Vindhyachal is in the process of conducting following studies:

a. Characterization of ash and leachate studies
b. Impact assessment of ash filling on ground water resources
c. Impact assessment of ash filling on flora and fauna
d. Testing of fly ash for trace elements and radioactivity
e. Neutralization of water present in the mine pits and its dewatering.

NTPC is already using ash for reclamation of South Balanda mine of Mahanadi Coalfields Limited (MCL) from its Talcher-Thermal power station (TTPS) since 2005 and similar studies have been carried out there. The results of the studies shows that ash disposal would have no adverse impact on the various attributes of environment.

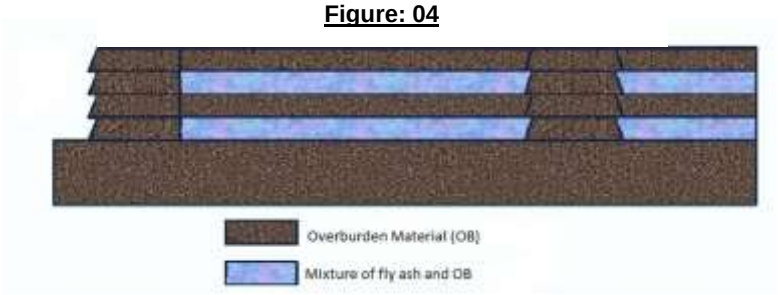
4.3.2 Mixing of ash in external overburden dumps.

Mixing of 25% of ash on volume to volume basis in external overburden dumps of operating opencast mines as per provisions of fly ash notification of MoEF & CC is another major avenue of ash utilization for pit head power stations of Singrauli region.

Northern coalfields limited has produced 80.22 million tonnes of coal during the year 2015-16. Considering stripping ratio of 1:4 total 320 million tonnes (approx.) of overburden has been produced during the year. Hence, there is a potential of approx. 80 million tonnes of ash utilization annually in the overburden dumps of NCL coal mines. NTPC Vindhyachal generates around 08 million tonnes of ash annually which equivalent to 2.5% of OB generated annually by NCL.

M/s Jindal Steel & Power Limited is utilizing fly ash generated from its power plant in the nearby captive coal mines located at Tamnar in Raigarh district of Chhattisgarh state. Studies on mixing of fly ash in OB dumps of this mine has revealed that the dump formed with alternative layer of overburden material and overburden mixed with fly ash (25%) are found to be stable with safety factor of 1.78. Geometry of the stable dump has total height of 120 m, 4 number of decks, individual deck height of 30 m, and slope of each deck as 32° (Figure: 04). Therefore, the above geometry of the back filling material may be used for mixing of fly ash along with OB material in external dumps without any safety or stability concern. Displacement pattern of above dumps have been monitored regularly for one year and no significant displacement in the Overburden dumps mixed with fly ash was observed.

Figure: 04



4.4 Use of pond ash in Ash Dyke Buttressing

Buttressing of Ash Dyke is a process whereby ash dykes are strengthened through providing lateral support to existing ash dykes by means of laying of ash in layers, compacting and providing sand as a filter medium along with earth cover on the downstream face of ash dykes. Due to strengthening of ash dyke through Buttressing, it is possible to construct a few more raisings over and above the initial design of three/ four or more raisings, which will result in further increasing life of ash dykes by a few years (Fig.-4). The Buttressed ash dyke can further be raised for more heights as its lateral support

acquired by Buttressing improves its stability and strength, enhances its capacity and can further be taken in to use for disposal of ash slurry.

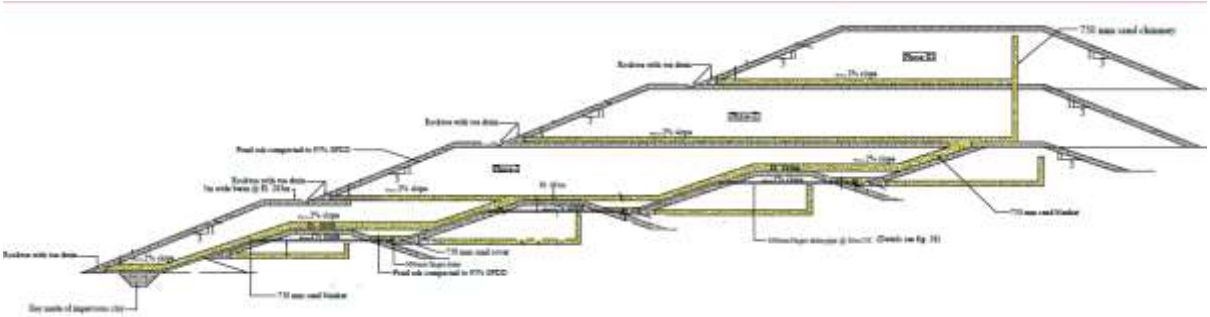


Fig.-5: Buttressing of ash dyke

Buttressing also facilitates evacuation of ash from existing ash dykes for providing ash on downstream face which creates space in ash dyke and this results in enhancing life of existing ash dykes by a few more years. Thus, Buttressing not only enhance capacity of ash dykes through feasibility of construction of more number of raisings but also help in increasing Ash Utilization. NTPC Vindhyachal is in the process of undertaking buttressing of its V1 ash dyke in which utilization of approx. 2.26 million tonnes of ash shall be utilized. Similarly buttressing of other ash dykes of NTPC Vindhyachal shall be taken up in phased manner after their maturity.

4.5 Development of low lying areas

MoEF notification have provisions of mandatory use of fly ash in reclamation of low lying area. NTPC is taking up the work of low lying area development at its own cost within 50 Kms of its premises in phased manner through inviting expression of interest. Low lying area development works are being carried out by excavating and transporting pond ash from the ash dykes, its filling and compaction in low lying area. Earth cover of 500 mm thickness is being made on the ash filled area by excavating soil from the low lying area filling site itself.

NTPC stations of singrauli region are incurring cost of Rs. 75/MT - Rs. 85/MT (excluding the cost of land and manpower) in disposing ash from ash slurry pump house to ash dyke. This extra cost of ash disposal in ash dyke may be saved if the ash required for low lying area development works is taken from the HMDC chutes of the fly ash silos after proper conditioning with water to avoid any fugitive dust emission and to ensure required water content for compaction. Utilization of fly ash taken from HMDC in low lying area development works will also save the cost of extra lead distance required to be travelled to take ash from the ash dykes.

By implementation of above measures large scale enhancement of ash utilization to meet ash utilization targets can be achieved by the power plant.

5.0 CONCLUSION & RECOMMENDATIONS

Management & utilization of fly ash is one of the major challenges being faced by the coal based power stations of the country. Fly ash is a waste but it is a resource material and by adopting / implementing following measures, challenge of fly ash management may be converted into opportunities.

a. Pit head power stations located distantly from the ash consumption belt may develop fly ash rail loading facility under the silo chutes. This will not only ensure ash utilization in bulk quantity but it will also ensure utilization of fly ash by the users situated at long distances from the power plants.

To facilitate this mode of ash utilization, power station may own specialized railway wagon which may be provided to users for transporting fly ash.

b. Use of ash in brick manufacturing has got a great potential of ash utilization and this avenue is not yet explored fully. Hence, utilization of ash in ash based brick manufacturing may be maximized with proper awareness and support to entrepreneurs. Some incentive schemes and sharing of ash transportation cost may be done by the power plants for establishment of more and more ash brick manufacturing units in the vicinity.

c. Utilization of ash in mines is the largest avenue of ash utilization for the pit head stations. Mixing of fly ash along with OB material in external OB dumps is an area having great potential for ash utilization and the studies have revealed that there no adverse impact on the stability of OB dumps by mixing of fly ash. 02 - 25% mixing of fly ash with OB is capable of achieving 100% ash utilization of any power station.Similarly, ash utilization in back filling of abandoned mines pit in environmentally safe manner is also possible and coordinated effort of power stations, mining companies and regulatory bodies is required to establish this avenue of ash utilization.

d. Buttressing of ash dyke is another major avenue of ash management in which ash utilization in bulk quantities can be achieved with proper engineering design.

NTPC Vindhyachal is committed for maximizing ash utilization and adopting environmentally safe practices for disposal of unutilised ash.

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