

THE BENEFICIAL CHARACTERISTICS OF FLY ASH DISPOSAL IN THE FORM OF THICK HYDROMIXTURE

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Abstract

The paper deals with the results of industrial investigation of fly ash preparation, transport and disposal, in the form of high-density hydromixture, at Thermal Power Plant Nikola Tesla B. This technology enables transport and disposal of high-density fly ash hydromixture, at water to solids ratio 1:1 (50 % of solids), implementing completely different approach in regard to the conventional technology, which is based on low-density hydromixture at water to solids ratio 1:10-1:13 (7-9 % of solids). The novel technology has demonstrated the significant advantages concerning the improved stability of disposal area, increased quantity of fly ash to be disposed at the same site, reduced air pollution as well as considerably decreased quantity of excess water drained from disposal site, together with reduced emission of harmful elements into the underground water and, finally, complete elimination of the necessity to discharge the free water into the ground water streams.

Key words: *fly ash disposal, high-density hydromixture.*

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1. Introduction

Thermal Power Plant Nikola Tesla B has two 620 MW units installed. Fly ash preparation, transport and disposal are identical for both units. The dry fly ash, discharged from electro filters, is washed out by ejectors and collected, together with the bottom ash, into the dredging-type pumping station reservoir. The thin slurry is further hydraulically transported via the pipeline onto the disposal site. Transport system is designed for the nominal production of 165 t/h of fly ash and the quantity of hydromixture of 1630 m³/h, having 9,6% of solids by weight. Disposal site embankments are constructed with the underflow, obtained by double stage classifying in hydrocyclones, while overflows of the primary and secondary cyclone are gravitationally disposed into the accumulation area. Dewatering of cleared oversedimentary water, after sedimentation of solid particles, is performed by overflowing at overflow towers, located at the central part of disposal site, as well as by drainage system.

The new disposal technology involves direct discharge of the thick fly ash hydromixture from the central position (from discharging tower) or from the perimeter embankments (by successive replenishing of the smaller cassettes).

Hydromixture is discharged in turbulent regime, while upon discharging it is expanded into the layer that laminary spreads over already deposited material. The fly ash is disposed, from the discharging point, under the moderate slope Hence, when hydromixture velocity sufficiently decreases, the complete fly ash layer lapses due to the friction supplanting the clear oversediment water on the surface.

The oversediment water rapidly moves over the hydromixture, without mixing or diluting it. The main characteristic of fly ash disposed in this way, is that the disposal slope remains the same for the same weight concentration of fly ash in hydromixture.

One of the main prerequisites for the application of this technology is to replace the wet fly ash collecting system with the dry one.

2. The industrial investigation

2.1. Pilot plant and disposal site

For the purposes of this investigation, a pilot plant was designed and installed at one line of electro filter on Unit 2 at TPP Nikola Tesla B, as well as the construction of the pilot disposal site within the TPP compound.

Technological flowsheet of the experimental plant is presented in Figure 1. The fly ash is transported by pneumatic trough (Position 1), from the receiving hopper under the electro filter to the collecting vessel with two dividing chutes (Pos. 2), equipped with the slide gates (Pos. 3,4). On one of the chutes, the counter-weight shouter (Pos. 5) and ejector (Pos. 6) are installed at the end, while the screw feeder (Pos. 7) is mounted on the other one. Screw feeder (Pos. 7) delivers the fly ash into the conditioner (Pos. 8), where appropriate quantity of water is added, from the existing pipeline (Pos. 9), until the right solids content is achieved. Prepared fly ash hydromixture is further transported by centrifugal slurry pump (Pos. 10), through the pipeline (Pos. 11), to the pilot disposal site (Pos. 12).

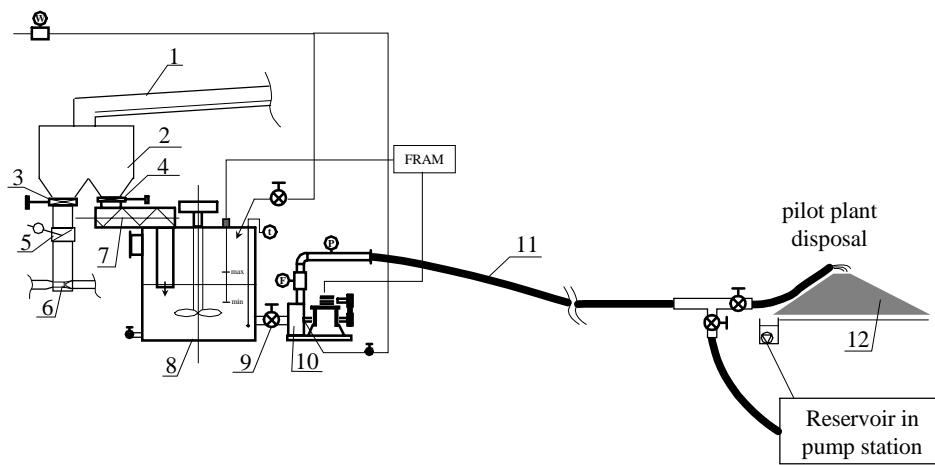


Fig. 1. Technological flowsheet of the experimental plant

Pilot disposal site consisted of two cassettes, each 20 by 20 m, were divided by the partition embankment 1,4 m high, from which the discharging of the hydromixture was performed. Both cassettes were surrounded by peripheral embankment 0.8-1.2 m high. Cassettes were constructed with the 2% inclination towards the partition embankment and hydro-insulated with the protective PVC foil. Drainage system is set up at the base of the partition embankment and drainage pipeline is connected with the main drainage shaft, which is equipped with the submerged pump.

The appropriate control and regulation equipment was used to provide and maintain the efficient work of the pilot plant and overall process control as well as to collect and analyze the operational parameters. The measuring and acquisition of the following data was provided: water consumption, the level of hydromixture in the conditioner, hydromixture temperature, hydromixture density, engaged pump motor power and RPM, differential pressure and hydromixture flow.

2.2. Physical, chemical and mineralogical properties of fly ash

Fly ash characterization was based on results of the analysis of the physical, chemical and mineralogical properties of fly ash samples. Samples were taken from all four zones of electro filter as well as on the composite sample.

The particle size analysis has shown that fly ash is considerably fine grained material, regarding the mean particle diameter (d_{50}) that amounts 0,12 mm while the top particle size (d_{95}) is 0,37 mm. Size fraction -0,044 mm participates with 28% by weight. The average fly ash density is 2,1 g/cm³, the bulk density 652,4 kg/m³ and the volume density 795,1 kg/m³.

According to the results of the chemical analysis, this particular fly ash belongs to the silicate fly ash group, considering the high content of SiO₂ (55,09-57,58%) and low content of CaO (5,97-6,74%) with only 0,17 to 0,29% of active (free) CaO. The reaction of the fly ash is very acid. The content of heavy metals and other harmful elements (As, Hg, Cu, Pb, Zn, Cr) are also determined.

Mineralogical analysis determined that beside dominant presence of amorphous phase, the crystal phase also occurs mostly as quartz (SiO₂), less

as feldspar from the plagioclase group (Na,Ca - alumo-silicate) and mullite ($\text{Al}_6\text{Si}_2\text{O}_{13}$) in minor quantities.

2.3. The results of pilot plant investigation

The pilot plant investigation enabled determination of all main process parameters, necessary for future designing of the transport system and disposal site, such as:

- Pressure drop in a 150 and 200 mm diameter pipelines in the function of flow velocity and solids concentration in hydromixture ($\Delta p = 0,03 \text{ m}_{v.s.}/\text{m}'$ for DN 200 and $v = 1,6 \text{ m/s}$);
- Possible restart time period (2 h);
- Angle of disposed material (6% for $C_m = 0,48$);
- Quantity and quality of the free water at the disposal site (around 25% of water used for transportation system with minor concentration of harmful elements)

Furthermore, the parallel tests were performed at pilot disposal site and existing active disposal site (used for fly ash disposal according to conventional technology based on the low density hydromixture) in order to determine the differences in various relevant parameters and point out the major advantages. Determined technological, ecological and stability parameters as well as the ones influencing the operational life of disposal site are presented in Table 1.

Table 1. The comparative review of the conventional and novel fly ash disposal technologies

Parameters	Existing technology	Novel technology	Advantages
Technological parameters			
Capacity, Q (t/h)	350	350	-
Mass concentration of solids in hydromixture, C _m (%)	10,16	50	-
Volume concentration of solids in hydromixture, C _v (%)	5,12	32,26	-
Quantity of water used for hydromixture transport, V _v (m ³ /h)	3093	350	Reduction of water consumption for 89%
Quantity of hydromixture pumped to disposal site, V _{hm} (m ³ /h)	3260	516	Reduction of electric power consumption for 30%
Inherent water in the form of moisture, W (m ³ /h)	280	230	-
Water exiting disposal site, V _{sv} (m ³ /h)	2813	120	-
Water reused in hydromixture preparation, V _{rv} (m ³ /h)	0	60	-

Ecological parameters			
Water discharged into surface water streams, Vnv (m ³ /h)	2716	0	Water discharge is eliminated
Seepage water (infiltrated into the soil and underground water streams), Vpv (m ³ /h)	97	60	Reduced emission of heavy metals into the soil
Total dust emission at disposal site at the wind velocity of 1, 3 and 5 m/s at 0,05 m above the ground level, mg/m ³	96,82 436,625 740,00	1,85 7,45 16,88	Dust emission reduced more than 40 times
Emission of respiratory dust at disposal site at the wind velocity of 1, 3 and 5 m/s at 0,05 m above the ground level, mg/m ³	8,545 11,520 21,520	0,155 0,275 0,460	Emission of respiratory dust reduced 40 times
Geo-mechanical properties and parameters influencing the operational life of disposal site			
Maximal level of safe disposing (m above sea level)	107	116	Prolonged operational life of disposal site
Bulk density of dry disposed ash (kg/m ³)	667	900	Increased storage capacity for 35%
Compressibility module for vertical load of 300 kN/m ² , kN/m ²	9302	13333	Increase compaction of disposed ash
Relative compression for vertical load of 300 kN/m ² ,	0,046	0,032	Disposal site consolidation in shorter period of time
Water permeability coefficient in vertical direction, m/s	1,5 x 10 ⁻⁵	9,4 x 10 ⁻⁷	Reduced water permeability
Water permeability coefficient in horizontal direction, m/s	7,5 x 10 ⁻⁵	4,5 x 10 ⁻⁶	-

On the basis of results presented in Table 1 as well as data not discussed in this paper, the following can be highlighted:

- The fly ash disposed in the form of high density hydromixture represent the non-coherent and extremely compacted material, characterized by the uniform particle size distribution and significant volume density when disposed, which results in increased storage capacity and prolonged operational life of disposal site.

- This material retains the surface moisture for a long period of time and forms the thin crust, predominantly consisted of gypsum, therefore reducing the dusting influenced by the wind, from the disposal site for over 40 times.

- Reduced quantity of water, necessary for the fly ash hydrotransport, completely eliminates discharging of oversediment water and decreases the quantity of infiltration and seepage water and therefore reduces the environmental pollution.

- Although the concentration of harmful elements is slightly increased

in the seepage water, reduced quantities of the water provide lesser total pollution.

- Drainage system will more easily achieve the protection of surrounding terrains. As this technology doesn't predict the water pond, the overall stability of disposal site is considerably increased.

Figure 2 and 3 show disposal site in the moment of hydromixture discharging and after conclusion of the pilot plant trial.



Fig. 2. Discharging of the high density hydromixture at pilot disposal site



Fig. 3. Disposal site after conclusion of pilot plant investigation

3. Conclusions

The main characteristic of high-density hydromixture disposal is depositing of fly ash in a cone-shaped hill. As disposed material accumulates, it remains on a slope at its natural angle of repose. The solids to water ration is maintained at optimal consistency, permitting the material to be spread

within disposal site in layers, gradually increasing the height and diameter of the conical deposit. In this way, the disposal site blends naturally with the surrounding terrain.

The transport and disposal of fly ash in the form of thick hydromixture was shown to be very advantageous comparable with the technology in common use heretofore. This novel technology for fly ash disposal at TPP Nikola Tesla B, which will be applied in 2006, provides considerable savings in water and power consumption as well as in maintenance costs. Increased storage capacity and prolonged operational life of disposal site due to increased material compaction and reduced quantity of water retained contributes to overall disposal site stability. Even more important is reduced water, air and land pollution as a result of complete elimination of water to be discharged into the recipients, reduced seepage and decreased dust emission, thickening and filtering.

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