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Part 3

ASH AND SLAG HANDLING

3.2. Ash and slag handling systems at TPPs

3.2.2. Ash removal

3.2.2.9. Environmentally sound ash handling technologies. Case study based on Reftinskaya OJSC "ENEL OGK-5" project

N. Gavlitin, ZAO "INET - Institute of New Energy Efficiency Technology", Moscow, Russia

Y. Kolomiiets, Clyde Bergemann Materials Handling Ltd, Doncaster, UK

ABSTRACT

Thermal power generation is a leading "producer" of anthropogenic emissions in the atmosphere and soil, a major consumer of deficit-valuable natural resources (water and earth).

The combustion of coal in the boiler furnaces produces a significant amount of sulfur and nitrogen oxides and volatile solids constituting the fly ash.

The use of large volumes of water to dispose of the ash and slag and to maintain the appropriate water level of ash disposal pond to settle the slurry and clarify the return water alters the chemical and mineralogical composition of ground water in the area brings the pollution of groundwater and surface.

Recently Russian Government adopted the policy of the tougher measures against violators of environmental law. Negative impact on the environment caused by energy production and coal fired power plant technology cannot be completely ruled out, but the maximum possible reduction of the negative environment impact, becoming more and more urgent task.

Minister of Natural Resources and Ecology Yury Trutnev said recently - "I think, beyond all-doubt the environmental fees will be increased significantly.

Today, the environmental fees constitute a small part in the amount of payments by power generating enterprises. Naturally, this situation does not encourage the introduction of environmental and resource-saving technologies and brings about the policy of preservation of old outdated technology, backwoods mentality and wastefulness that unfortunately we have found everywhere".

This article reveals the main technological solutions to create a system of dry ash handling at the largest coal fired power plants in Russia – Reftinskaya GRES, a pilot project in the electric generating industry in our country that would significantly reduce the influence of an environmental impact of one of the biggest in Europe polluters. The project implemented at Reftinskaya power plant is intended to motivate the investment in Russian energy generating community to carry out large-scale modernization of Russian coal fired power stations and help introduction of environmentally friendly "dry" methods of ash disposal as the only solutions in a contemporary and tight environmental law, limited water and land resources and growing economic competition in the electricity market. The introduction of this technology will create preconditions to recycle man-made materials and their use as substitutes for natural raw materials. The dry ash lagoon will become a repository, with deferred demand of valuable materials that preserve their original properties. Lifespan of Reftinskaya Power Plant will be prolonged; its ash disposal area and the possibility of ash and slag storage would increase for a period of next 40 years.

1. THE MAJOR INVESTMENT PREMISE IN DRY ASH CONVEYING SYSTEMS AT REFTINSKAYA POWER PALNT.

1.1. Resources limitations and constrains

The annual volume of recycled water in the slurry system is more than 60 million cubic m, including consumption of flushing water of 560 m3/ h and 730 m3/ h respectively to remove the ash from ESP hoppers of 300 & 500 MW. Much of the water resources are lost due to evaporation, filtration and saturation. The introduction of dry ash disposal technology will reduce water consumption for the power plant by 16.619 million m3 per year, release additional water resources to a potential increase in power generation capacity in the united energy generating system of the Urals.

Due to the resource termination of the ash disposal lagoon No. 2, and in order to provide the storage of the ash, JSC "ITSEU" (Engineering Centre of Urals Power Industry) to the order of the power plant, carried out the works and put forward the design for the construction of the ash disposal area No. 3 utilizing the traditional method of hydraulic ash slurry. An additional land acquisition of the area of 470 ha would be required for these purposes, as well as deforestation of Category I forest. The implementation of this project for a new ash disposal area № 3 could have lead to the need for large-scale investments worth over U.S. $ 400 million. The application of traditional hydraulic ash handling technology would seriously limit the filling term and the lifespan of a new ash disposal area to ~ 20 years, and the next step – built a new lagoon?

1.2. Investment Opportunity

When making an investment decision on the advantages of the dry disposal over traditional hydraulic system the most appropriate and accurate method of investment analysis is WITH-WITHOUT (with the project - without the project). This method of investment analysis provides the effective investment evaluation ration based on traditional NPV, IRR, DPB, PI indexes where the investments are the capital costs of the project (in total and by major technological nodes), and discounted cash flow, determining the return on costs incurred and defined as the difference in the repair and maintenance costs (aggregated over the years) that

would occur under traditional hydraulic or the introduction of advance dry ash disposal technology.

Repair and maintenance are a key factor affecting the value of cash flow for the project, so it is critical to analyze these costs. With regard to the Reftinskaya PP the traditional expenditures relating to the operation of hydraulic ash system (electricity, water, maintenance) should be considered as well as major investments (as costs) associated with the construction of a new ash disposal area and utilizing the "traditional" hydraulic system. Taking this into consideration this factor the return on investment was only 2 years. In general, within this public article, it will be necessary to give the following specific characteristics of the investment costs of the project: the specific capital investments in the installed capacity totaled to more than $ 70 per 1 kW of installed capacity, the specific capital investments to the amount of ash, stacked in a "dry" ash lagoon to $ 60 per 1 ton of ash.

2. TECHNOLOGY CONCEPT AND SOLUTIONS ADOPTED FOR DRY ASH DISPOSAL AT REFTINSKAYA GRES

2.1. Brief description of existing wet technology at Reftinskaya PP

Reftinsakay Power Plant is the affiliate of Joint Stock Public Company “Enel OGK-5”. Power Plant is located in 80 km south-west of Yekaterinbourg and represents the part of Urals power grid system.

Total electric Power Plant capacity is 3800 MW.

Power Plant consists of 6 power Units by 300 MW each (units 1-6) and 4 power units by 500MW (units 7-10). When operating at full capacity the power plant produces:

- 886.3 tons of fly ash per hour or 5760845 tn per year;
- 46.74 tons of bottom ash per hour or 303810 tn per year.

Existing ash disposal technology is wet slurry hydraulic. The water used in wet slurry system after it is settled is returned from ash lagoon into the system.

In the first main building there are three dredging pumping stations and four in the second. From dredging pumping stations, the ash in form of wet slurry is transported by pipes ø530x12 mm (seven working pipelines and five reserves) and fed to the dredging pumping station of the second elevation, located at the ash disposal area number 2.

Ash disposal area - lagoon number 1, is located 2 km from the power station and has been filled to capacity of the second and third tiers of the lagoon dam. Ash disposal capacity of the lagoon has long been exhausted, and reclamation of the lagoon is completed. Through the efforts of the power plant and Sukholozhsky forestry together with scientists of the Botanical Garden, Ural Branch of Forest Research Institute for the first time in the world it has become possible to conduct reclamation of waste ash dam number 1, an area of about 370 hectares. The experimental planting began in 1992 and in 2005 young trees were planted in the last 47 acres of waste ash disposal area. Ash disposal area number 2 is located in 4.5 km from the power plant and has been commissioned in 1974. The total area of the lagoon is 995 hectares. The initial lagoon capacity has been exhausted in 1985; the subsequent filling of ash disposal area was carried out and the additional three lagoon dam tiers were built for this purpose.

Further exploitation of the ash lagoon, after filling the banks up to the third tier is now prohibited due to dam stability.

2.2. Technological scheme of Reftinskaya power plant ash handling system, the developers of the concept and the main suppliers of technology and equipment

The concept of Reftinskaya power plant dry ash handling system has been developed by a team of Russian engineers, under the direction of the Honored worker of the Ministry of Fuel and Energy Mr. Nikolay V. Gavlitin. At the moment, the main concept and project development team are working at the Institute for New Energy Efficient Technologies (JSC "INET") - a specialized engineering company that actively promotes technology of dry ash conveying in the power industry of Russia and CIS countries (Kazakhstan, Ukraine). At the request of JSC "KazNIPIEnergoprom institute is developing a detailed project design of pneumatic conveying system for Units 7 & 8 of Astana-2 power and heating plant, located in the new capital of the Republic of Kazakhstan. The examination of a number of coal-fired stations has been carried out and the Institute is currently developing the conceptual projects to introduce new technologies of pneumatic dry ash handling.

Mr. Vyacheslav J. Putilov, the director of the Information and Analytical Center "Ecology of Energy" of the Moscow Power Engineering Institute took an active participation in development of technological concept of Reftinskaya power plant ash handling system reconstruction.

The new dry ash handling system of Reftinskaya power plant would consist of several subsystems:

- existing hydraulic ash slurry pumping system that to be retained as the reserve system;

- pneumatic fly ash conveying system. Fly ash is collected from electrostatic precipitators’ hoppers and pneumatically conveyed to a storage silos. The development and design of the technological scheme and supply of equipment is carried out by "Clyde Bergemann» (Great Britain);

- silo storage, consisting of the storage silos for temporary storage of the dry fly ash, dry ash discharge equipment for shipping of ash to rail and road transport, unloading system of conditioned ash into enclosed pipe conveyor. The development of the technological scheme and supply of equipment is carried by Claudius Peters (Germany);

- compressed air plant for supply of conveying & control air for pneumatic conveying system and silos aeration and discharge equipment;

- mechanical conveying system of conditioned ash to ash disposal area number 2. System consists of enclosed pipe conveyor and distributing belt type conveyor. Development of technology and supply of equipment is carried by Takraf (Germany);

- system for distribution of conditioned ash in the "dry" section of the ash disposal area. System is intent to lay and compact dry fly ash. Dust suppression equipment is incorporated into the distribution system. The technology is developed by Takraf (Germany) and JSC "Giproshakht" (Russia);

2.3. Specific Technological features of Reftinskaya dry ash handling system

The main purpose of this project is to provide a non-stop operation of Reftinskaya power plant for a long period without construction of new ash disposal area.

The project provides a dry ash removal of ESP fly ash to a storage silo and further shipment of dry ash to potential consumers. Possible dry ash consumers are the enterprises of building industry. Unclaimed ash to be stacked in dry condition at ash disposal area.

Transportation of dry ash from silos complex to a dry section of the ash lagoon number 2 has been considered by pipe belt conveyor. The pipe belt conveyor is deployed inside the enclosed gallery.

Distribution and further stacking of the dry ash at ash disposal area to be provided by “Takraf” stacking trailing conveyor which would disperse the ash up to 90.0 m abreast with maximum height of stack up to 20.0 m.

2.4. The technological solutions of the fly ash pneumatic conveying system at Reftinskaya power plant designed and provided by «Clyde Bergemann» company.

Technological scheme and design of pneumatic conveying system is based on «Clyde Bergemann Materials Handling Linited» (further CBD) pneumatic equipment. Pneumatic conveying systems and equipment of CBD are installed and successfully working in 20 countries at more than 400 power plants with total installed capacity of 150,000 MW.

The company has completed projects and installed pneumatic conveying equipment at the units capacity of 600 and 1000 MW at Tuoketuo I Thermal Power Plant (China), 8 x 600MW at Dezhou Power Station, 2x600 (China) and 4x 1,000 MW at Yuhuan Power Plant (China). In Russia, Clyde Bergemann, based on concepts developed by engineers working today in the company, "INET", provided the design and technological solution, supplied the equipment for pneumatic conveying system to convey more than 5.5 million tons of fly ash at Reftinskaya Power Plant. The supplied pneumatic system is fully automated and could be switched and operated from power plant central control room. Clyde Bergemann pneumatic equipment is installed and successfully working at unit 7 of OGK-2 affiliate Troitskaya GRES.

Clyde Bergemann Dense phase pneumatic conveying equipment provides the most efficient way of pneumatic material conveying with a minimum velocity of the material in the pipe lines, which reduces the abrasion and minim energy consumption, reducing the overall operating costs.

The major advantage of Clyde Bergemann pneumatic equipment is that it has got minimum moving parts. Each CBD pressure vessel is equipped with dome valve which provides pressure seal of the process with minimum wear parts.

CBD Pneumatic equipment is designd to be fully automated and remotely operated from the power plant Central Control Room.

In this report, Table 1 shows some technical characteristics and images of CBD pneumatic equipment that was used in fly ash pneumatic conveying systems at Reftinskaya GRES.

Fig. 1. CBD pneumatic pump type MD.

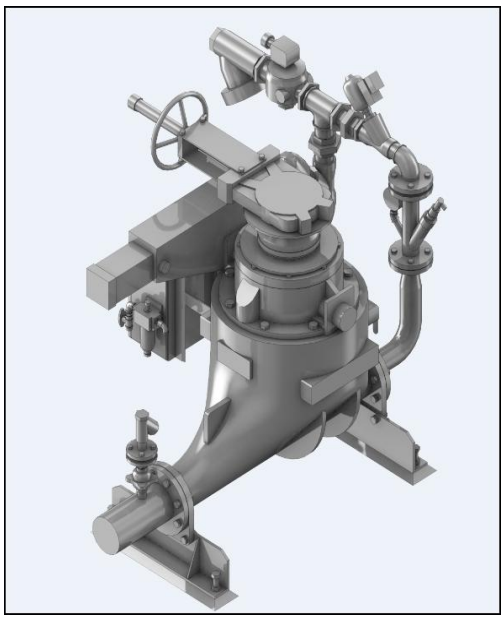

Fig. 2. CBD pressure vessel type Ash Vessel.

- Multi-vessel systems available for continuous conveying
- Low conveying pressures and power consumption
- Longer distance capability – up to 1000 metres
- Reliable simple construction ~ One moving part Clyde Bergemann Dome valve
- Multiple vessels connected to one pipeline
- Distance capability – up to 500 metres

CONCLUSIONS

The transition to a dry ash conveying system, with preservation of the existing hydraulic slurry as a reserve system, allows Reftinskaya PP to provide stacking of the ashes utilizing the existing ash disposal area and to void expensive land planning permission for the construction of a new ash disposal lagoon.

Reconstruction of the ash handling system at Reftinskaya Power Plant and the transition to modern dry ash handling technologies as well as a significant reduction in the amount of material transported to the ash lagoon hydraulically in from of slurry (only boiler bottom ash) helped to dramatically reduces the usage of technical and the clarified water:

- the need for technical and clarified water at the joint hydraulic slurry pumping of fly and bottom ash constitutes ~ 9500 t/h, including a technical water 2750 t/h;

- with introduction of new dry ash removal technology, and the hydraulic removal of a boiler ash only, the total demand for clarified and process water reduced to 1986.3 t/h, including technical water to - 238.7 t/h accordingly.

The economic effect from the reconstruction of slurry system and application of the modern dry ash handling technologies is ~ 300 million rubles per year on operating costs alone and accounting for savings on environmental payments in the event of an imminent tightening of environmental legislation in Russia, would considerably enhance the economic benefits of the project.

The abandonment of the plans for the construction of new ash disposal area number 3 at Reftinskaya power plant brought the economy of financial resources amounting to more than 400 million U.S. dollars. This fact alone claims an exclusive investment attractiveness of the transfer of Russian coal generation to the contemporary dry ash conveying systems. Increasingly more owners of Russian coal generating companies are making such conclusion, and hopefully the triumph of Russian engineers' ideas that for decades proved the effectiveness of dry ash conveying technologies would come true.

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