A New Coal Blending System for AES Cayuga

A 50-year old plant continues to meet regional power generation needs following state-of-the-art coal handling improvements.

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The AES Cayuga Plant (previously New York State Electric and Gas' Milliken Station) stands along the shore of Lake Cayuga in New York State. The plant consists of Units No. 1 and 2 commissioned in 1955 and 1958. Each pulverized coal boiler is rated roughly 150 MWe.

The plant is an important community and corporate asset that has addressed changing environmental and market conditions. In 2000, a selective catalytic reduction (SCR) system was added to unit No. 1. Flue gas desulfurization (FGD) systems were added for the plant in 1994 as well as low NO_x burners (LNCFS III), bunker outlet gravimetric feeders and new MPS pulverizers were installed. The coal handling system remained essentially unchanged; the original equipment since the middle 1950's from the rail dumper and reclaim though the belt systems.

AES Cayuga's new coal blending system included changes made to the stockpile area (enlarged coal pile liner area), new second reclaim tunnel, a unique feeder/conveyor, a transfer house and related equipment.

Generating cost is a key factor for plant dispatch. In 2005, plant personnel began to examine how its largest operating cost—the price for fuel—might be reduced. Plant emission control work for the Clean Air Act in the 1990's extended the plant's fuel flexibility, but fuel contracts and design of the existing coal handling system were viewed as constraints. The plant practiced coal blending, using different sources for solid fuels delivered by rail and truck. Lower-cost fuels could be used in discrete quantities to reduce the plant's average fuel cost. In addition, the possibility of using/blending Powder River Basin coal was being considered. Different fuels were segregated and blended by alternatively bulldozing from these piles to the reclaim hopper. While this methodology was encouraging, the lack of precision and control were obvious constraints. System upsets due to fuel variability could not be tolerated.

Coal Receiving/Stacking System

Coal historically has been received at the plant via rail. Trains are split into strings of rail cars, which are stored on ladder tracks. The rail cars are unloaded at a rotary dumper, which is a single, uncoupled car design. A thaw shed stands on the south side of the dumper building. The dumper and its associated equipment within the dumper area are operated from a local control station on the south side of the rotary dumper. The dumper is equipped with a scale and load cells at both ends of the rotary dumper.

Rail cars discharge into two hoppers, each fitted with a Pennsylvania Crusher Series K, single roll frozen coal cracker. The breakers crush frozen lumps to a six-inch product. If the breaker is out of service, the breaker plate can be withdrawn so that the coal passes through to a pan feeder located directly below. Both pan feeders discharge to a single belt, conveyor No. C-1, which elevates coal receipts above grade and stockpiles the coal using a luffing, tower stacker design.

The unloading system is rated 900 tons an hour. Conveyor No. C-1 is a 42-inch-wide belt that has a belt speed of 600 feet per minute. It is fitted with a cross-belt sampling system, a fixed overhead magnet and a luffing boom. The boom luffs from –15 to +18 degrees. Conveyor No. C-1's boom discharges directly over the reclaim hoppers and can stack a pile 70 feet high. The pile is extended with a bulldozer, forming a flat, elevated, relatively level surface. This provides a convenient and safe working platform for the dozer operator.

TABLE 1

Conveyor	Bunker/Outlet
C-3A	Unit 1, hoppers 1A3 & 1A4
C-3B	Unit 1, hoppers 1A1 & 1B2
C-4A	Unit 2, hoppers 2A3 & 2B4
C-4B	Unit 2, hoppers 2A1 & 2B2

Coal Reclaim System

The reclaim system is controlled from DCS operator stations in the plant control room, which interface with the coal handling reclaim system's PLC. The coal is reclaimed by a tunnel/feeder system. The reclaim hopper is fitted with four vibrating feeders that discharge to two single stage, double roll crushers, which reduce coal to a –1-inch size. In this arrangement, two vibrating feeders discharge to one crusher. Flop gates beneath the crushers direct coal to either reclaim conveyor No. C-2A or C-2B. These are the only crossover flop gates on the system. The reclaimed coal is then routed to the plant bunkers via the "A" and "B" conveyors. The reclaim conveyors have 30-inch belts operating at 375 fpm. Each train of conveyors is rated 300 tph, for a total reclaim capacity of 600 tph.

FIGURE 1

AES Cayuga's coalyard with stacker conveyor No. C-1 (left), the concrete tunnel and transfer house for the feeder-conveyor (center) and the power plant (right).

While the "A" and "B" conveyors appear to be a redundant system, this is not really the case. The bunkers are filled by a set of cascade conveyors as follows:

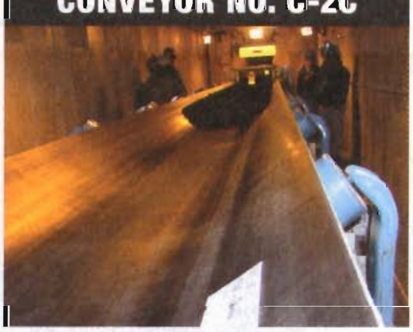
The "A" and "B" designations for the Bunker/Outlet nomenclature refers to the "A" Buss or "B" Buss. As a result, to fill all four hoppers for each unit, both the "A" and "B" system must operate. Storage capacity within the bunkers is also compromised by flow problems. There are relatively narrow active flow channels above each hopper outlet; much of the coal within the bunkers is stagnant and non-flowing.

Coal Receipts and Blending Trials

The plant uses around 900,000 tons of Northern Appalachian coal each year, all delivered by rail. The plant has also received fuel by truck. The plant can utilize coal residues from less efficient plants, reducing waste quantities that would otherwise have to be diverted to a landfill.

FIGURE 2 HAGGLUNDS HYDRAULIC DRIVE MOTOR

FIGURE 3 FIRST RECLAIM LOAD ON FEEDER-CONVEYOR NO. C-2C



The plant has received different coals by rail for blending purposes. The existing luffing stacker is an obstacle to segregating piles because there is only one discharge point. With the discharge point located directly over the reclaim hoppers, blending coal must be immediately bulldozed away from the discharge of the stacker, complicating matters. Otherwise, the reclaim hopper directly below will feed this coal to the bunkers meaning that a slug of low-grade fuel can be fed to the boiler, upsetting plant conditions. Conversely, slugs of higher, more costly-grade fuels frustrate the plant's ability to minimize fuel cost.

The bulldozer was being used to blend coal. Two or three blade loads of one pile were pushed to the reclaim hopper, then a blade load of a second coal. This method was imprecise and affected plant systems as fuel properties swung widely. The bunkers' narrow flow channel quickly conveyed short-term upset conditions in the coal pile directly to the boiler.

Power Supply and Controls

Power for the coal handling systems is supplied from a newer transformer installed during a supportive project in parallel with the new coal blending project. The transformer is located in the original power plant building.

The project's power supply is routed to a new Cutler Hammer Series 2100 MCC. An underground duct routes power to the original receiving portion of the coal handling system and reclaim hopper-related equipment. The new coal blending MCC is fed from new conduit routed above grade, which follows the conveyor system from the original plant to the new MCC within the new transfer house. Power for the blending addition's main feed to the MCC is a 480-volt circuit. The 480-volt service was extended to the transfer house for the new blending system, where a new electrical room was added.

For the new coal blending system, a PLC (Allen Bradley LOGIX5561) was added in the electrical room and communicates with the original reclaim PLC. Control functions then communicated to the control room operator who uses the plant's DCS (WDPF) to control the coal handling system, along with all plant systems.

Blending Schemes

To meet the design constraints presented by the existing coal handling system, a variety of conventional and unconventional concepts were considered. To maintain the simplicity of the existing stacking system and devise an economical retrofit program, a couple of schemes that minimize the number of conveyors/transfers that might be added were investigated in more detail, including the possibility of adding a lowering well as a second stacker. Likewise on the reclaim system, several features (including a feeder-breaker to minimize frozen coal and oversized lump issues) were considered. Plant personnel provided input that proved instrumental in focusing the effort on equipment and system arrangements that might best suit the potential for fuel savings, plant operating conditions and capital improvement budget constraints. The AES Cayuga team decided to defer any work associated with stacking and forgo provisions for handling frozen coal or oversized lumps. It was decided that fuels with oversized lump would be avoided or routed to the existing coal crushers. During the winter months when frozen coal becomes a problem, plant personnel decided they could curtail blending operation rather than increase system cost with components that would only be needed several weeks a year. The coal blending project would focus on adding a single major component: a plant feed/blending conveyor.

The geology of AES Cayuga Plant's site was a factor in the design. The property slopes upward from the shore of Lake Cayuga and bedrock rises very near the surface at the coal stockpile. With bedrock relatively close to the surface, the depth of the reclaim hopper's vault was an issue. Blasting bedrock would increase project capital costs. A shallow vault would be more economical. This was one reason to forgo a feeder-breaker or crushers.

The conventional method to add reclaim capability is to use a feeder that discharges to a belt conveyor. The plant already had two apron feeders (rail dumper) and four vibrating feeders (existing reclaim hopper). A belt feeder would be another option. None of these alternatives was considered. Instead, a feeder/conveyor was selected in which the belt conveyor functions as both a feeder and a conveyor. One advantage is that the depth of the reclaim vault is reduced, since an intervening device (a separate feeder) is eliminated. This allowed the reclaim vault to basically "sit" on bedrock, eliminating any concern for costly rock excavation/blasting.

Blending capability could have been added by installing a low-capacity system that might augment the reclaim of one of the 300 ton per hour (tph), 30-inch-wide reclaim conveyors with a low rate; say, 150 tph blending feeder-conveyor. With such a design, the plant could create 50/50 blends of Northern Appalachian coal with lower quality solid fuels. Such a design would be generous, since most low-quality coals might be less than 20 percent of the blend. Because much of the cost of a reclaim system is, for example, in the cubic yards of excavation, cubic yards of concrete, tons of steel needed to construct conveyor and transfer structures, these vary little regardless of whether a 30-inch-wide or 42-inch-wide conveyor is selected. As a result, it was decided to invest in capability for reclaim of the entire plant. This provided the project with added value.

System Design

A sophisticated coal stockpile liner and runoff collection/treatment system was added to AES Cayuga up to and through the 1990's. This system segregates coal pile runoff and provides treatment prior to discharge into Lake Cayuga. To reduce capital cost, the 1990's-vintage "liner" modification reduced the coal stockpile footprint. This was not an issue at that time, since larger inventories of fuel increase plant operating cost. With the addition of coal blending, an enlarged footprint, similar to the plant original coal pile outline, was needed to handle multiple stockpiles. This first step in the blending program was to extend the existing coal stockpile liner system.

While a 30-inch-wide feeder-conveyor might have satisfied minimal blending requirements, a 42-inch-wide belt was selected for the feeder-conveyor. This duplicates the width of conveyor No. C-1 and was a logical choice to coordinate spares. The capacity of each reclaim conveyor is 300 tph. Because both the "A" and "B" systems must operate to fill all the bunker hoppers, both systems usually run together, to reduce total operating time. This means the normal reclaim rate is really 600 tph (2 x 300 tph). The 42-inch-wide feeder-conveyor was designed to reclaim at 600 tph to match the reclaim rate of the existing system with both "A" and "B" sets of conveyors running.

This rate is lower than the 900 tph rate for 42-inch-wide stacking conveyor No. C-1. This design allows the feeder-conveyor to be used as the primary fuel feed to the plant, a back-up to the existing system. It now will be possible to shut down the existing reclaim hopper for longer time periods to replace liners or perform other tasks. It also will allow the plant to more easily handle unexpected events. An undetected concrete boulder once was delivered with a load of coal and plugged one of the vibrating feeders. The addition of feeder-conveyor which can serve as an independent, emergency reclaim system is advantageous.

Because lower quality coal may be only 10 percent of the blend (or 30 tph of the 300 tph rate of a single conveyor), a 20:1 turndown ratio (600tph/30tph) was required. This ratio is beyond the capability of many variable speed drive options. The choice was to use a Hagglunds hydraulic drive, which matches a variable displacement hydraulic pump driven by an 1,800 rpm electric motor to a fixed displacement, shaft mount hydraulic drive.

The feeder-conveyor has a hopper designed using mass flow concepts to help ensure continuous, regulated flow onto the loading section. A Merrick watertight, manual maintenance gate, similar to those on the plant's outlet bunkers, is fitted to the bottom of the reclaim hopper, so the feeder-conveyor can be isolated from the stockpile for maintenance.

The single 42-inch-wide feeder-conveyor must be able to feed both the "A" and "B" reclaim conveyor systems. To provide the plant with the most operating flexibility, a splitter gate was selected. This gate allows the operators to route coal from the feeder-conveyor to:

- Only the "A" system with the gate set at one far stop
- Only the "B" system with the gate set at the opposite far stop
- Equally to both the "A" and "B" systems (a 50/50 split) with the gate in the vertical "split" position, or
- An infinitely variable, unequal split to both the "A" and "B" systems with the gate in some intermediate position.

This gives plant operators a wide range of flexibility to simultaneously direct different coal blends to different plant bunkers (boiler burner levels) and accommodate different rates from the existing vibrating feeders, which may occur do to their individual settings or set-up.

The rotating splitter gate is designed to center flow to minimize dust. The rotating gate plate is fitted with wing plates to chamber the coal flow and avoid having coal contract the gate/chute casing. This eliminates the possibility of coal build-up between the rotating gate and casing. Such coal build-up can freeze and impede the free rotation of the splitter gate, which would be detrimental to the effective logic control of blending. The gate actuator was a feature of importance. The Beck Drive design was selected for its features, control attributes, and successful history at the plant.

To minimize the height/cost of the transfer from the feeder-conveyor to the existing reclaim conveyors, it was decided to route the chutes through a couple of existing hatches in the concrete roof of the reclaim tunnel for conveyors No. C-2A and C-2B. These hatches provide a geometric target. But their location was a challenge to snake the chutes to reclaim conveyors No. C-2A and C-2B. Another objective was to control coal flow and avoid angular chute plates where falling coal would impact plates at odd angles, creating a dust problem. Rounded chute sections were selected, since they help to center/guide flow to a natural flow path. A series of duplicate pipe sections was used to create a snaking flow path from the outlets of the splitter gate to the existing reclaim conveyors No. C-2A and C-2B.

The heart of most blending systems is the control mechanism. For AES Cayuga, blending is weight controlled, which is more precise than volumetric control. The accepted tolerance is the accuracy of the belt scales, which is 0.50 percent for the single idler belt scales added for AES Cayuga's coal blending system. Four belt scales were added, two to each of the existing reclaim conveyors (Nos. C-2A and C-2B). The first set of scales, near the tail of these conveyors, measure what is reclaimed from the original reclaim hopper and four vibrating feeders. Feedback from these lower scales is key to adjust syntron feeders to avoid belt overloading. The second set of belt scales, located after the transfer form feeder-conveyor No. C-2C, measure the total load on conveyors (Nos. C-2A and C-2B). Scale outputs are compared to operator set points. The speed of feeder-conveyor No. C-2C and the splitter gate position are modulated to adjust flow to the operator's settings.

In other words, the Hagglunds Drive for conveyor No. C-2C and Beck Drive for the splitter gate are slaved to the output of the original vibrating feeders. The feeder-conveyor and splitter gate are more easily controlled than the existing vibrating feeders. AES Cayuga may option to automate/upgrade the controls for the vibrating feeders in the future, if they perceive that additional control advantages can be gained with the range of blending being implemented. With this blending arrangement, AES Cayuga has the option to blend as little as 5 percent of a low-cost fuel with its Northern Appalachian coal and higher percentages as dictated by coal qualities and plant capabilities. In a pinch, the coal blending system can feed the plant 100 percent Northern Appalachian coal when needed.

The reclaim hopper is designed with relatively large-opening, steep hopper slopes and expanding geometry mass flow concepts to help ensure a smooth operation. The load onto the feeder-conveyor is formed by a curved gate to contour the loaded belt. With the hopper normally full, there is no drop/impact of coal onto the feeder-conveyor as would be the case with a chute from a feeder to a separate conveyor. With this design, the reclaim vault is relatively quiet and dust free.

The Hagglunds hydraulic drive controlled belt speed through the full design range. At speeds as slow as 15 fpm, the feeder-conveyor is barely moving. At the top speed of 300 fpm, it runs more like a conventional conveyor.

The 50-year old AES Cayuga Plant continues to contribute to regional power generation requirements making state-of-the-art technology improvements. For the new coal blending system, the existing stockpile liner system was extended, the redundancy of the plant's fuel supply system was improved and the ability to precisely utilize a wide range of solid fuels was gained with the addition of feeder-conveyor No. C-2C. The new addition of a coal blending system, and the plant's continuing improvement efforts help to make AES Cayuga a well-run and economically competitive local energy supplier.

Authors: Jacob Peter has over 25 years of experience in the power industry as a mechanical engineer. He is currently with AES Cayuga. His engineering projects have included material handling upgrades and plant improvement projects such as emission reductions, cycle optimizations and plant life extensions. His engineering experience includes a significant performance and power generation project background for firms including: AES Deepwater, El Paso, Coastal Power, Foster Wheeler and New York State Electric & Gas.

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