Precision Unit-Train Loading Systems

Using the experience gained with high capacity rail loading systems in the western United States, a more efficient system has been developed

By Tony Walker and Bruce Miller

High capacity western U.S. surface mines, such as Cordero Rojo's loading system pictured above, have played an integral role in the evolution of unit train loading systems.

Most of the coal mined in America arrives at the power plant by rail. Today, loading coal trains involves more than simply placing coal into the railcars. Rail weights and coal quality specifications are extremely important. The final product is often blended. Several types of railcar loading systems offer varying degrees of economics for different methods of reclaiming, blending, and loading coal into unit trains.

Modern rail loading systems range from basic manually-controlled to totally automated systems capable of reclaiming and accurately blending on a quantitative and qualitative basis. Manual flood-loading systems are now capable of loading up to 12,000 tons per hour (tph). Precision loading systems load, and provide a certified weight for, nearly exact quantities desired into each railcar.

The progression from volumetric to precision unit-train loading evolved relatively quickly. Over the years, many different types of unit train loading systems were constructed. They greatly improved railcar utilization. Room for improvement, however, remained. Coal operators could reduce transportation costs and add value to a coal production operation through the use of precision loading systems.

BATCH WEIGHING SYSTEMS

By weighing coal in batches before loading railcars, it is possible to weigh the coal, and certify the weight, to the static weighing accuracy of 0.1%. In the 1970's the technology was developed to control the transfer of coal from a surge bin into a weigh bin rapidly enough to support unit train loading rates with sufficient accuracy to avoid overloading railcars or allowing railcars to be significantly underutilized. It has been demonstrated that the amount of material transferred into weigh bins can be controlled to well within 0.5% of the desired weight.

Generally the systems constructed in the early 1980's, and the majority of systems in operation today, consist of a 250- to 300-ton surge bin positioned above a 100- to 130-ton weigh bin. Four bi-parting gates usually control the transfer of coal from the surge bin into the weigh bin. All four gates are opened initially to very rapidly transfer coal into the weigh bin. They are then progressively closed to meter coal into the weigh bin as the amount in the weigh bin approaches the desired quantity. After the batch has been weighed and the railcar is in position to be loaded, the weigh bin discharge gate is opened to discharge the contents of the weigh bin into the railcar. The gate is sized to discharge coal into the railcar at a rate sufficient to flood the front of the railcar while it's in motion, typically 4- or 5-feet (ft) square.

Early systems generally met all the performance parameters of present day systems. (Early precision loading systems were designed to load in the range of 3,000 to 4,000 tph.) Although advances have been made in the design of batch weighing systems that increase the loading rate and reduce the capital and operating costs, the accuracy of early systems was sufficient for today's use.

By loading each railcar to within 0.5% of the target weight, the shipper can maximize the amount of coal in each railcar and thereby maximize the quantitive loading efficiency of each train. If a railcar were designed to haul 200,000 lb of coal, it can be loaded to within +/- 0.5% or 1,000 lb.

HIGH CAPACITY LOADING

The rapidly growing production volume of the large surface mines in the Powder River Basin (PRB) required higher loading rates—tens of millions of tons of coal per year. Several of the mines were built with volumetric loading systems that could, by loading each railcar from more than one loading point, load up to 12,000 tph. To load accurately at the higher loading rates, different methods were attempted.

One of the successful methods provided 120-ton weigh bins under train loading silos equipped with four bi-parting, weigh-bin charging gates and one bi-parting, discharge gate each.

To increase the loading rate, these systems can load a train from more than one silo. If a railcar's target load were 110 tons of coal, one silo could load approximately 55 tons and allow the second silo to load the remainder. Since both batches are controlled and certified, each railcar weight is both controlled and certified. The possible loading rate using this method exceeds 8,000 tph. Loading from a single silo, the above described system capacity is determined by the flow rate from the discharge gate or by the time required to transfer and weigh a carload of coal into the weigh bin.

After some mines had been built, it became necessary to retrofit high capacity precision loading systems to the originally designed volumetric loading systems.

Arch Coal's Black Thunder mine retrofitted two train loading silos that were originally built as volumetric loading systems with double-bin, precision batch-weighing systems. Each weigh bin capacity was limited, due to space constraints, to approximately 60 tons. One bin in each silo was equipped with one 76-inch bi-parting charging gate and the other with a 76-inch-square four blade charging gate. Both bins were equipped with 84-inch-square bi-parting discharge gates and 72-inch square, low-head loading chutes and were designed to load one half of each railcar's required capacity. This system achieved a 10,000-tph loading rate while loading each railcar accurately and providing a certified weight.

In the early 1990's, Kennecott Energy's Cordero Rojo mine needed to convert its four volumetric train loading silos to precision loading silos. Since each of their silos were similar to Black Thunder's, they wanted to retrofit similar loading systems. Unfortunately, the geometry of Black Thunder's silos and Cordero Rojo's silos are different. There was not enough vertical clearance between the top of rail and the underside of the existing silos at Cordero Rojo to accommodate 60-ton weigh bins. Since it was necessary to load 120-ton railcars, this created a slight problem.

The solution was to install two 45-ton capacity weigh bins under each silo and deposit two batches into each railcar from the first weigh bin and one batch into the same railcar from the second weigh bin. On first consideration, it seems this scheme should decrease the loading rate. To explain why it did not, requires details concerning precision loading systems be reviewed.

Since Cordero Rojo's loading system requires the use of two weigh bins, loading the front of each railcar at the required loading rate is not difficult. Partially loading the front of each railcar from the first bin reduces the volume required from the second bin to insure the front of each railcar is fully loaded.

Batching, weighing, and loading multiple batches from one weigh bin into a railcar moving at a speed sufficient to load 10,000 tph is challenging. To load a train of 110-ton capacity railcars that are 53-ft long overall at 10,000 tph requires the train to be moving at 1.34 feet per second. If the inside length of the above mentioned railcar were 45 feet and the loading chute were 7-ft square, the available time to discharge two batches in one railcar would be approximately 28 seconds.

It's therefore necessary (in the available 28 seconds) for the system to discharge the first batch into the railcar, close the discharge gate, obtain a tare weight of the weigh bin, open the weigh bin charging gate, transfer a quantity of material into the weigh bin, close the weigh bin charging gate, obtain a gross weight of the weigh bin, open the discharge gate, and discharge the second batch into the same railcar.

A time motion study proved that time was sufficient provided the second batch of coal loaded into the weigh bin be prepared using only one set point to close the weigh bin charging gate. To make an accurate batch requires the use of multiple set points to sequentially close the weigh bin charging gates as the coal in the weigh bin approaches the target capacity. Also, the set points must be far enough apart to allow the previous action to be completed prior to the amount of coal in the weigh bin reaching the next set point.

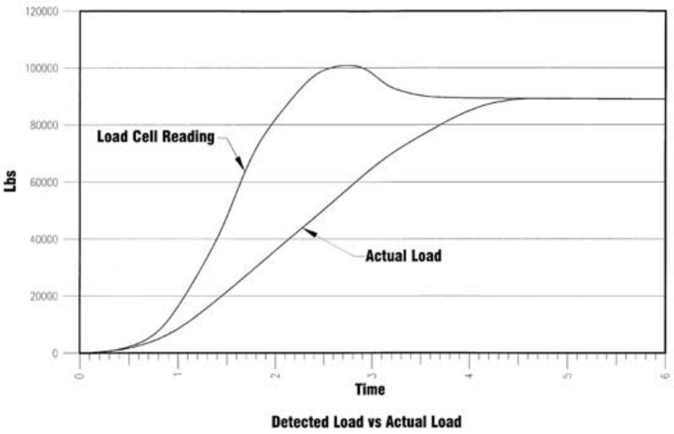
Cordero Rojo's triple batch loading system.

Only the last batch of a multiple batch precision loading system affects the railcar loading accuracy. It is therefore necessary to be concerned only with the batching accuracy of the second bin in a 2-bin, multiple-batch precision loading system. As long as the weights measured by the first bin are certified, subtracting the weight of the first two batches from the target weight of the railcar and batching precisely the resultant into the second weigh bin insures the amount loaded into each railcar closely approximates the desired amount and is certified.

High flow rates between the silo and weigh bin and the weigh bin and railcar must be achieved for this system to operate in the time allowed. By using 84-inch square weigh bin charging and discharge gates on the first weigh bin, flow rates of more than 12 tons per second (tps) were achieved. The opening time and closing time of the gates were also critical. The gates were designed to operate at 30 inches per second (ips). The mass of the gate blades and the required gate speed necessitate the use of hydraulic actuators with oversized cushions.

The second weigh bin receives its target weight information after the second batch of the first weigh bin is weighed. This allows plenty of time to accurately batch the required amount of coal as the railcar coupling passes under the second weigh-bin. Since the required flow rate into and out of the second weigh bin is lower than the first weigh bin and since the charging accuracy of the second weigh bin is critical, the second weigh bin charging and discharging gates are only 72-inch square. The second weigh bin charging gate is a four-blade gate that uses two set points. At the first set point, three of the four blades are closed and at the second set point the last gate blade is closed. The discharge gate is a bi-parting gate.

Transferring coal at very high rates into and out of small weigh bins has some interesting effects. The impact from opening and closing the gates, if the hydraulic cylinder cushions are not properly set and maintained, can cause vibrations that delay the weighing operation. Each gate blade of an 84-inch, double-blade gate weighs



As can be seen from this Impact Load Graph, the impact of coal charging the weigh bin at 12 tps is significant.

approximately 1 ton. Stopping a 1-ton gate blade moving at 30 ips can result in significant forces. If properly cushioned, the forces are easily handled and normal gate operation is uneventful.

The impact of coal charging the weigh bin at more than 12 tps is also significant. In a conventional weigh bin, the flow rate is initially only slightly less than that through an 84-inch square charging gate. The load cells detect the impact load of coal transferring into a conventional 120-ton capacity weigh bin but since that impact load does not occur close to a critical set point, it usually goes unnoticed. The impact load on a triple batch weigh bin, however, occurs at the single set point that closes the weigh bin charging gate and must be considered.

BLENDING REQUIREMENTS

It is sometimes necessary for coal operators to store different qualities of coal and blend to the market specification as the coal is being reclaimed and loaded for shipment. Since the arrival of trains cannot always be accurately predicted, the ability to blend the specified product while loading greatly simplifies the logistics of loading coal.

If the quality of coal in each storage area is known, it is possible, using adjustable reclaim gates or feeders and monitoring the amount of coal reclaimed from each stockpile, to control the quality of the product to approximately that desired. By using the output of an on-line elemental analyzer capable of providing real time analysis of coal being loaded to adjust relative reclaim rates, it is possible to adjust the blend precisely and accurately reclaim the desired quality.

Technology exists to control the reclaim rates of coal very accurately by several different means. Selection of the most cost effective reclaim method is dependant on the characteristics and quantity of coal to be reclaimed.

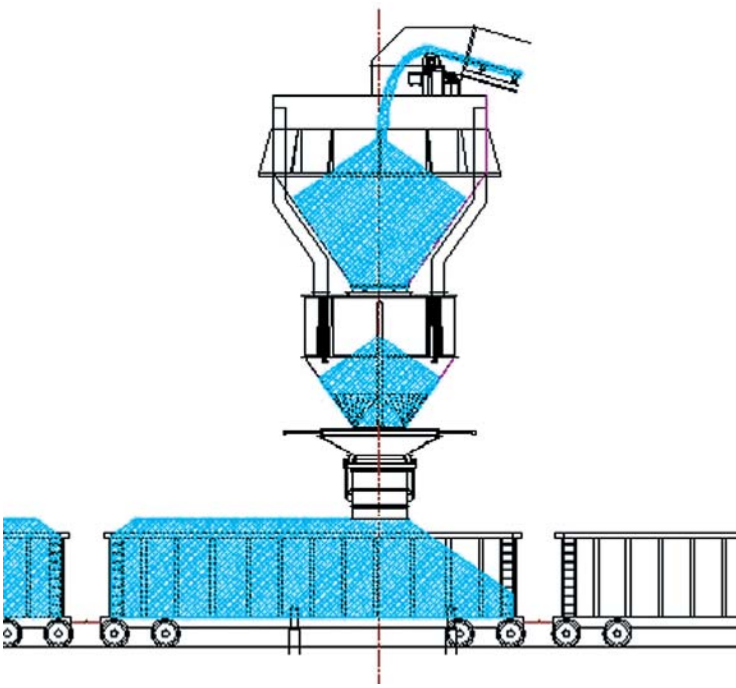
Properly designed, a reclaim blending system can be controlled to within 2% quantitatively. If the quality of coal in each stockpile were known perfectly, it would therefore be possible to blend to within 2% of a target blend without fear of exceeding any quality specification. Since the exact composition of a stockpile is seldom known and the composition of coal in a stockpile varies throughout, it is necessary to take that variation into account when determining the blend.

By installing an online analyzer on a reclaim conveyor, the output from the analyzer is available to adjust the quantitative reclaim control system thereby allowing the reclaim blending system to precisely meet the qualitative target. The reclaim blending system, properly designed, would be as precise qualitatively as the analyzer. Since on-line elemental analyzers are improving in accuracy over the entire periodic table and are currently suitable for monitoring certain elements for blending purposes, it is expected that they will be increasingly used to control precision blending systems.

TRIPLE BATCH SYSTEMS

Solving the problem of high capacity precision loading of coal into railcars in the restricted space allowed under Cordero Rojo's silos forced engineers to examine the operation of large, high speed transfer gates, the behavior of coal at high transfer rates for short periods of time, methods of decreasing the time required to batch and weigh a quantity of coal, and various other considerations of loading railcars using multiple batches of coal.

Rethinking the mechanics of precisely loading coal into railcars revealed a much more economical method of loading coal at up to 6,000 tph into railcars with the same quantitative accuracy as was being accomplished. That method was loading three batches of coal into each railcar from one weigh bin.



This engineering sketch shows the third batch ready to discharge. Just above triple batch subhead, could you change "tons per hour" to "tph."

As each railcar arrives under the loading chute, the amount of coal necessary to load the front of the railcar must be available to be loaded and the weigh bin discharge gate must be large enough to provide a flow rate sufficient to load the front of the railcar

The newest precision rail loading system at the Century mine uses the latest technology

before it moves out of position. After that is accomplished, the flow rate of coal from the weigh bin into the railcar needs to be sufficient to fill the railcar without voids. Finally, the quantity of coal loaded into the railcar must approximate the target weight and must be weighed in accordance with National Institute of Standards and Technology Handbook 44.

By selecting a precision loading system that uses three batches to load a railcar, all of the above requirements are met.

A triple batch precision unit train loading system achieves its high throughput, loading accuracy, and certified weights for coal loaded into each railcar as follows:

- By using a weigh bin that holds approximately 50 tons, it is possible to make the first batch for each railcar large enough to fully load the front of the railcar and the loading chute.
- There is sufficient time, using a 72-inch square four blade weigh bin charging gate, to make the first batch large (50 tons) and accurate while the coupling moves under the loading chute.
- By using a 72-inch, fast-acting, bi-parting discharge gate, the first batch discharges at over 7 tps leaving approximately 8 tons of coal in the loading chute when the weigh bin is empty and the weigh bin discharge gate closes. Coal is then discharged from the chute as the train moves.
- The time available to make the second batch is the time required for the railcar to move far enough to unload the coal from the first batch remaining in the chute and move the loaded coal profile from under the loading chute. At a loading rate of 6,000 tph, the train speed is approximately 0.5 mph and the loading rate into the railcar after the front of the railcar is flooded is approximately 2 tps. Approximately 12 seconds are therefore available to close the discharge gate, obtain a tare weight for the weigh bin, open the weigh bin charging gate, transfer an amount of coal, weigh the loaded weigh bin, and open the discharge gate. Since it is not necessary to make the second batch a precise quantity, that time is sufficient to transfer and weigh a relatively large batch.
- The third batch target weight is preset at approximately 25 tons and modified by the combined weight of the first two batches. Since the first batch was made to within 0.5%, the variation of the third batch size depends only on the second batch accuracy. The batch that determines the overall batching accuracy and loading rate is therefore small and relatively consistent.

By loading three batches per railcar, the required capacity of the weigh bin is reduced from 120 tons to 50 tons, the required capacity of the surge bin is reduced from approximately 300 tons to approximately 150 tons, the feed conveyor can be significantly shortened, and the power required to elevate coal to the top of the loading system is reduced. The number of mechanical components required to operate the system is reduced thereby reducing maintenance cost. Since the weight of the loading system as well as the capacity of the bins is reduced, the foundation cost is reduced.

Due to variability of train speeds, operating a loading system at relatively high loading rates with a small surge bin requires monitoring the amount of coal in the surge bin and modulating the reclaim rate to maintain that level relatively constant. A method of monitoring the surge bin level at the time the charging gate opens to load the first batch for each railcar has been developed. This method automatically adjusts the total reclaim rate to maintain the level of coal in the surge bin within acceptable limits while allowing significant train speed fluctuations. This can be accomplished while maintaining automated qualitative blending system accuracy.

By using an automated reclaim system capable of blending two or more coals to make a qualitatively precise product the producer can maximize the value of their reserves and insure customer satisfaction. By adding a precision loading system to the precision blending system, the producer can maximize the utilization of the railroads resources making possible transportation cost savings for the customer.

In today's coal market, it is necessary for a coal producer to fully consider how coal reclaim and loading systems can add value to an operation. By providing a precision unit train loading system that is precise both quantitatively and qualitatively, it is possible for a mine to minimize its capital investment and operational costs while simultaneously maximizing the value of its reserves.

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