Automation trends in train loading

Through the years, the technology of loading bulk materials, such as coal, iron ore, aggregates and phosphates, etc., into open top railcars has continued to evolve. The evolution has gone from manual loading operations using rubber tyre wheel loaders to volumetric loading systems, semi-automatic prefill systems (more commonly called batch weigh systems) and, finally, fully automatic unattended batch weigh train loadout systems. To better understand where the technology is to date, a quick review of past technologies is in order.

DUANE BENNETT AND ANTHONY SEXTON, KANAWHA SCALES & SYSTEMS INC., US, PRESENT THE BENEFITS OF PRECISION LOADING THROUGH AUTOMATION.

Rubber tyre wheel loading method

Earlier loading operations involved the use of rubber tyre end loaders to load trains. Empty cars were dropped off at a rail siding to be manually filled. To fill a 70 to 100 car train typically took a couple of end loaders 10 – 14 hours or more. Unless the minesite had a yard engine or cable pulling system to move the empty train set as it was filled, the cars remained stationary or were loaded in cuts of several cars at a time. This created constant shuffling of loaded cars away from the loading siding to be replaced with empty cars. Once all of the cars were loaded, the mine would have to wait for the railroad to come back with locomotives to pick up and reassemble the loaded train. Meanwhile, this train set was out of circulation for 24 – 36 hours or more. In many cases, railroads were forced to limit the number of trains allocated to mines because of rolling stock shortages. This created bottlenecks at the mine as it was normally able to produce much more than it could ship. Manually loading with end loaders from open stockpiles often resulted in very erratic loading with numerous under loads and overloads, as well as uneven distribution of the load within the individual cars (Figure 1). As archaic as this seems, there are many places in the world today where this methodology is still employed to load trains.

Figure 1. Filling rail cars with rubber tyre loaders.

Figure 2. Volumetric loading system.

Volumetric loading method

A volumetric loading system (Figure 2) consists of a silo or large volume surge bin located over the tracks with a discharge gate and loading chute to control the filling of the railcars as they pass underneath the system. The volumetric loading system has a faster loading time (about 2 – 3 hours for a 100 car train). It does not require starting or stopping of trains and is generally much safer. The actual amount of coal discharged into each railcar is directly dependent on the height of the loading chute above the railcar and the point at which the product discharge gate is opened and closed relative to the beginning and end of the railcar.

Problems associated with volumetric loading include the following:

- Operators tend to vary the loading chute trim height during loading operations, resulting in inconsistent loading from car to car.
- Operator reaction times on the opening and closing of the discharge gates can bias the front-to-back load distribution within the car. Variations in train speed can also impact load distribution and the total amount of coal discharged into each car.
- Since the cars are filled by volume, variations in product density can impact how much is loaded.
- Low degree of loading precision on a car-to-car basis. Variations of +/- 3 t/car are not uncommon.

While it is possible to automate a volumetric loadout to take the operator out as a variable, the result is that cars are still loaded volumetrically. Volumetric loading systems cannot provide any degree of precision or control of the total weight that is loaded into individual cars.

Most operating railroads have policies that discourage overloading of individual railcars by assessing penalties for overloaded railcars. These penalties can quickly compound and be very costly to mine operations. To avoid overload penalties, many mines intentionally underload the railcars. In the last ten plus years, mine production has continually increased due to market demands; however, the availability of most rail operator's rolling stock inventory has dramatically decreased. The combination of inefficient loading practices, coupled with shortages in rolling stock and rising fuel prices, has really challenged the serving railroad's bottom line.

Because of these shortages, most railroads are encouraging mines to increase their loading efficiency on a car-to-car basis in order to move more coal with fewer railcars and fewer train movements. Several railroads throughout the world now penalise shippers if they are not fully utilising the available capacity of the delivered railcars.

Batch weigh loading method

Batch weigh loading systems (Figure 3) are capable of loading rates of 3000 – 12,000 tph. Batch weigh loading systems with a telescopic-type flood load chute are not affected by fluctuations in material density, as these systems use weight, not volume, as the measuring tool. The batch weighing is done in conjunction with a precision scale, a PLC control system, and a computer that collectively control the flow of material from the overhead storage bin into a weigh bin to a predetermined amount. A series of hydraulically controlled precision charging gates feed material from the surge bin to the weigh bin to prepare an accurate batch for loading the next railcar. Static weighing accuracy meets legal for trade requirements with desired car-to-car target weights within +/- 250 kg.

The batch weigh system provides superior accuracies by predetermining the precise amount required for each car; however, the train loadout operator can still introduce inaccuracies into the process. For example, poor selection of chute height and/or variations in discharge reaction times when loading a railcar can produce undesirable load patterns. Although a car may not be overloaded according to the rated capacity of the railcar, individual axles may be overloaded due to poor distribution of the material within the car. Uneven distribution causes excessive wear and premature failures on both the railcar and the rail line.

Other functions required of the operator include ensuring that the car's bottom doors are closed and checking for any carry back material in incoming empty cars. He or she is also responsible for monitoring and alerting the locomotive engineer of any possible problems occurring during loading operations (spillage, low surge bin level, required adjustments in train speed, derailment of railcars, etc.). These tasks can become overwhelming, especially for new operators. Automation of the loading process can help overcome these inefficiencies.

Unattended automated batch weigh coal loadout

When Xstrata Coal began planning for the Goedgevonden mine near Witbank, South Africa, its design requirements called for building a state-of-the-art, unattended, fully automated batch weigh train loadout with precision weighing and loading capabilities. After the first railcar in a train set was remotely spotted under the loadout chute, the train was to be loaded in a fully automatic mode without the need of human intervention. This is keeping within the operational philosophy established at Xstrata's other mining operations of maximising automation while minimising operator intervention. Xstrata has learned that the best way to ensure consistant results is to totally automate the process and minimise the need for human involvement.

Solutions/technology chosen for train loadout system

The loading rate of the Xstrata Goedgevonden (GGV) automated batch weigh coal loadout system is 5000 tph. The only operator intervention required is the verification of train information to ensure that the correct train has entered the loading loop, confirmation that the first railcar is in position under the loadout chute, and initialisation of the loading operation from the remote SCADA station. The train loadout operation

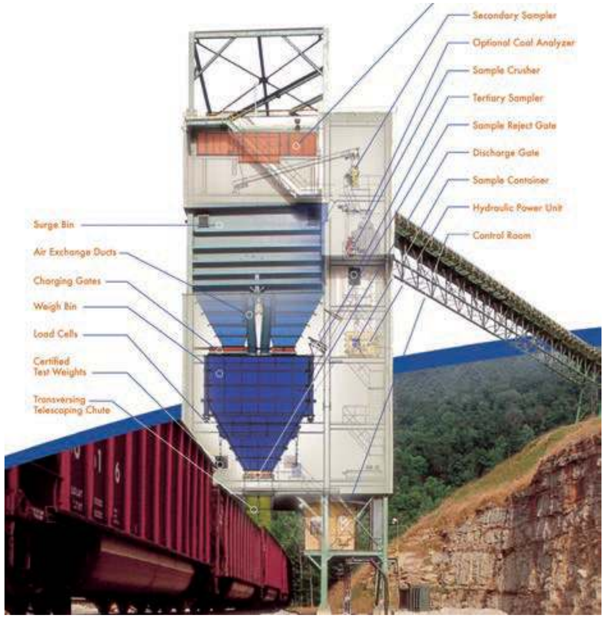

Figure 3. Batch weigh loadout system components.

Figure 4. GGV train loading loop.

screens are incorporated into the plant's SCADA system, so that all operation, equipment status and alarms can be monitored and controlled from any plant SCADA workstation.

In order to meet Xstrata's operational goals of a fully automated, unattended system, Kanawha Scales & Systems integrated various technologies. These included a RFID (radio frequency identification)/tare scale interface, a train speed monitoring and indication system, loadout monitoring devices and integration with the reclaim system.

RFID/tare scale interface

As the train enters the loading loop (Figure 4), a signal is given to plant personnel to inform them that a train has arrived. After entering the loading loop, the train crosses a coupled in-motion rail scale with RFID readers, which capture the empty car weights and the individual car identification from the RF tags that are mounted to each railcar. This information is then forwarded to the plant SCADA system, where a train manifest is created. Plant personnel can then verify that the train is expected and enter any pertinent order information. Once verified, the train data is communicated to the computer in the control room.

The batch weigh system uses this information to establish the order of railcars in the train and calculate how much coal will be loaded into each car. The calculated amount is based on the maximum allowable gross car weight minus the empty car weight recorded by the in-motion scale.

Train speed monitoring and indication system

While the train information is being interrogated, the train engineer picks up a radio telemetry unit (Figure 5) before entering the loadout. This unit displays instruction and speed information to the locomotive engineer from the PLC control system. As the locomotive approaches the loadout building, a series of photoelectric sensors provide feedback to the PLC to calculate the current train speed. The target train speed, entered by the operator, is transmitted to the receiver unit in the locomotive via UHF band radio. Additional instructions are automatically communicated to the locomotive engineer during the train loading process, such as increase/decrease train speed, emergency stop conditions and when the train loading is complete. A bar graph provides visual indication of the current speed vs target speed. This gives a simplistic, but powerful method of controlling the train as it proceeds through the loading process.

Loadout monitoring devices

In order to provide a safe working environment in the loadout area during operations, several field devices are installed to monitor operations. Microwave detection units are used in a spill pit area located under the loadout to detect spillage of coal. Activation of these sensors causes an immediate shutdown of the system operation to ensure safety of the rolling stock equipment. Sensors are also placed before the loadout area to detect any open car doors or derailment situations. This again ensures safety of the area during loading operations.

Figure 5. The train speed monitoring receiver in the cab of a locomotive.

Figure 6. Train speed and rail car position sensors.

Photoelectric sensors are used in the chute area in order to detect the leading edge of railcars as they pass under the loadout chute. Once the leading edge has been detected, the batch weigh system discharges the batch of material into the car. Additional sensors detect the trailing edge of the cars to ensure that the weigh bin has been completely emptied before the end of each railcar (Figure 6).

As the railcars pass under the loading chute, a chute/car collision sensor monitors for any unexpected high railcars. In the event a high car is detected, the system automatically closes the discharge gate (if open), raises the loading chute to the full up position, and sounds an alarm for both plant personnel and the locomotive engineer. Additionally, in the event of power loss, the system closes all gates and raises the discharge chute to the full up position. As a redundant safety measure, if a loading chute/car collision occurs, the lower section of the loading chute incorporates a breakaway section that detaches and falls away, minimising damage to the rest of the discharge chute, loadout structure and railcar.

The loadout system also incorporates a surge bin level indication system. This surge bin level signal, along with the tonnage left to load into the train set, is communicated to the reclaim conveyor control system, so that the reclaim system can deliver the correct amount of coal to the loadout at the required rate. During loading operations, the reclaim system constantly adjusts the flow of material to meet the needs of the loading process. Should the surge bin material level fall below a level required for proper system operation, the control system notifies the locomotive to stop via the telemetry system. Once the required level of material has been delivered to the surge bin, the locomotive will be sent a "proceed signal" to recommence loading operations.

The fully automated loading system ensures that every railcar is quickly and consistently loaded to its maximum allowable gross capacity, without fear of under or overloading. In addition, the system ensures that each railcar has an even distribution of coal (Figure 7).

As each car is loaded, its net load and identification information is logged as a record in the train manifest report. This train manifest report is electronically stored and can be printed or automatically sent to a customer upon completion of the train loading cycle.

A camera system is also deployed in the loading area to provide the plant personnel with a visual indication of the loading operations. The camera display is integrated into the plant SCADA workstation to allow for ease of operation. Pan-tilt-zoom cameras are strategically placed to allow the plant operators to remotely monitor train loading operations. Once the final railcar has been loaded and visually inspected to be clear of the loadout structure, plant personnel will use the train speed indication system to notify the locomotive engineer that the loading process has been completed. The telemetry unit is then placed in a drop box as the train departs the train loop for pickup by the next train.

Figure 7. Typical loading profile.

Figure 8. GGV train loadout.

The loadout system design provides easy access to all system components for ease of maintenance and service. Built-in test weights allow the system to be easily tested to its rated capacity for compliance to OIML RL76 (International Organization of Legal Metrology) requirements in 30 – 45 minutes.

Benefits derived from automation

The benefits realised by implementing an unattended, fully automated batch weigh loading system are as follows (Figure 8):

- Eliminates penalties and legal liabilities of overloading.
- Minimises loading time.
- Consistently loads every railcar to within +/- 250 kg of each car's target weight.
- Even front to rear distribution of the coal in each railcar.
- Provides "custody transfer weight" at the completion of train loading.
- Automatic record of all train and car data.
- Ships the maximum tonnage with the least amount of trains.
- Lower annual transportation cost as a result of maximising loading efficiencies.
- Increased revenues based on the ability to ship more coal/year with fewer train movements.
- Provides 24/7 operation with minimal manpower requirements.
- Enhances safety as there is no need for personnel to work in the same area of train loading.

Next steps in the evolution of train loading technology

As control system technologies improve and become more affordable, new possibilities exist for advancements in train loading operations. Today, such technologies as laser scanners and video imaging systems enable capabilities that were not feasible in the past.

Now, car profiling systems can provide unique characteristics of each individual railcar. Profiling before the loadout can alert of residual materials, open doors or objectionable materials in each railcar (tree limbs, boards, machinery, etc.). Once cars are loaded, profiling systems may also be used to confirm that the material is optimally loaded and that maximum loaded height restrictions are not exceeded.

Advanced technologies can now offer solutions to better determine flow of material into the railcars as they are being loaded. This capability can provide instantaneous feedback, enabling real time process control adjustments and even greater loading performance, as material flow characteristics vary from changes in moisture content, density or other properties.

Future systems may also provide 3-D modelling of the loaded car profiles. This can give remote system operators the visual images needed to ensure proper material distribution of the railcar. Such images could be stored for later analysis, reporting or verification of loads. Should a derailment or accident occur with the loaded train set after leaving the mine, this data may be valuable for protecting the mine's interests.

Summary

Today's unattended train loading operations provide the ability to quickly and efficiently load each railcar to near 100% of its available capacity, minimising transportation costs associated with the delivery of the product and operational costs by decreasing manpower needed to operate the loading process. As costs continue to rise in the transportation of coal and other bulk products, there are ever greater requirements to develop systems capable of providing faster loading rates with even tighter loading tolerances. Technological advancements being made today will meet these demands now and in the future.