Automatic transmission

Anthony Sexton and Duane Bennett, Kanawha Scales & Systems, US, discuss automation trends in truck loading.

Through the years, the technology of loading bulk materials such as coal, iron ore, aggregates, manganese and other bulk materials into trucks has continued to evolve. This evolution has included:

- Manual loading operations using rubber tyre wheel loaders.
- Operator-attended volumetric loading systems.
- Operator-attended semi-automatic loading system that incorporate truck scales under the loading silo.
- Operator-attended semi-automatic pre-weigh systems (more commonly called batch weigh systems).
- Fully-unattended automatic batch weigh truck loadout systems.

To better understand where the technology stands at present, a quick review of past technologies is necessary.

Figure 1. Rubber tyre loader.

Figure 2. Volumetric loader.

Rubber tyre wheel loading

Earlier loading operations involved the use of rubber tyre end loaders to load trucks. Trucks would pre-weigh on a truck scale to establish their empty (tare) weight and then pull to an area close to the stock pile to be manually filled by a rubber tyre loader (Figure 1). It would then take about 4 – 6 minutes or more to fill the truck. The amount of time needed would vary based on the size of the truck, the size of the rubber tyre loader, the distance to the stock pile and the organisation of the truck traffic. Once the truck was loaded, it would travel back to a truck scale to obtain its full (gross) weight. If the truck weight was within an acceptable tolerance – typically a couple of tonnes – the truck would then receive a printed ticket and would exit the site. In many cases, the trucks would not be within an acceptable loaded tolerance and would have to proceed to a load adjustment area, where material would be removed or added as needed. After this adjustment, the truck would return to the truck scale and the load would again be checked to ensure it was within acceptable tolerance limits. If so, a ticket would be printed and the truck would leave the site; however, this process would often be repeated several times before an acceptable tolerance was achieved. In many cases, because of time and frustration, trucks exit the site either under- or overloaded. Overloaded trucks increase maintenance requirements to both the trucks and roads, can be assessed monetary penalties and can create potentially dangerous situations. Underloaded trucks cause additional truck movements to transfer the material to its destination, adding substantial time and monetary costs. This process can have overly heavy site truck traffic, which can be chaotic and a serious safety concern. As archaic as this process seems, because of low initial capital costs, there are many places in the world today where this type of truck loading methodology is still employed to load trucks.

Volumetric loading

A volumetric loading system consists of a silo located overhead, with a discharge gate and loading chute to control the filling of product into trucks as they pass below the system (Figure 2). The volumetric loading system has a faster loading time (about 1 – 2 minutes) than using rubber tyre loaders, does not require the trucks to pull to an open loading area by the stock pile, and generally promotes more organised truck traffic onsite. The amount of material discharged into each truck is directly dependent on the truck capacity, material density, the height of the loading chute above the truck and the point at which the material discharge gate is opened and closed relative to the beginning and end of the truck.

There are a number of problems associated with volumetric loading:

- Trucks are required to be weighed both tare and gross on a truck scale.
- Since trucks are filled by volume, variations in operator control and material density can impact how much material is loaded.
- The low degree of loading precision on a truck-to-truck basis. Variations of 1 – 2 t/truck (or more) are not uncommon.
- Loading variations typically require the truck to pull to a load adjustment area, where material is either removed or added, and the truck again returns to a truck scale to check the truck's gross weight.

Truck scale loading

Loading systems that use a truck scale under the silo (Figure 3) are typically capable of loading rates from 12 – 30 trucks/hour (2 – 3 minutes per truck). This type of loading system commonly uses a telescopic or swing-type flood load chute, and is not affected by fluctuations in material density, as these systems use weight, not volume, as the measurement standard. Material is loaded into trucks using PLC controls, a computer and a truck scale to measure and control the flow of material from the overhead silo into the truck, to reach a pre-determined amount. A precision discharge gate feeds the material from the silo to the truck. Static weighing accuracy meets legal-for-trade requirements and the truck-to-truck loading accuracy is typically within 250 kg. Because the truck scale is located under the silo, the truck's tare and gross weights can be attained at the loading station, eliminating the need for trucks to be weighed on inbound and/or outbound truck scales. Depending on the type and length of the trucks being loaded, truck scale lengths of 30 m or more may be required, so the truck can be continuously weighed as it moves forward under the silo during the loading process.

The system provides improved loading accuracies by determining the precise amount required for each truck; however, the final weight is not sensed until the material is already loaded in the truck. If there is a weighing or discharge gate error, it is not known until after the material is loaded in the truck. Trucks moving during the loading process may cause weighing errors. Additionally, having the truck scale located under a silo can inhibit access to the scale, making it difficult to perform maintenance. Regular housekeeping must be performed to ensure that debris does not build up under the scale, to prevent associated weighing errors.

The loadout operator can also introduce inaccuracies into the process using this method. For example, poor selection of chute height and/or variations in discharge start during loading can produce undesirable load patterns. Although a truck may not be overloaded according to the rated

Figure 3. Loadout with truck scale.

Figure 4. Pre-weigh loadout.

capacity of the truck, individual axles may be overloaded due to poor distribution of the material within the truck. Uneven distribution causes excessive wear and premature failures on both the truck and roadways.

Batch weigh loading

Batch weigh loading systems (Figure 4) are capable of loading rates of 15 – 30 trucks/hour (2 – 3 minutes per truck). Like the loading system with a truck scale, batch weigh loading systems using a telescopic type flood loading chute are not affected by fluctuations in material density, as this system uses weight, not volume, as the measurement standard. The batch weighing is done in conjunction with a precision pre-weigh scale, PLC controls and a computer that collectively control the flow of material from the overhead storage (surge) bin into a weigh bin to a pre-determined amount. A precision charging gate feeds material from the surge bin into the weigh bin to prepare an accurate batch for the truck being loaded. Static weighing accuracy meets legal for trade requirements and the truck-to-truck loading accuracy is typically within 200 kg. The batch weigh system provides superior loading accuracies by pre-determining the precise amount required for each truck, and is generally more reliable and easier to maintain than loading systems that use a truck scale.

Integral test weights allow the weighing system to be easily tested to its rated capacity for compliance to OIML R76-1, a standard by the International Organization of Legal Metrology (OIML), in about 30 minutes. No special testing unit or hired test weights are required to check the weighing system's accuracy. A simple calibration check can be performed in minutes.

However, in non-automated loading systems, the loadout operator can still induce inaccuracies into the process. Again, poor selection of chute height and/or variations in discharge reaction times when loading a truck can produce undesirable and/or inconsistent load patterns.

Figure 5. Automated multiple bay truck loadout.

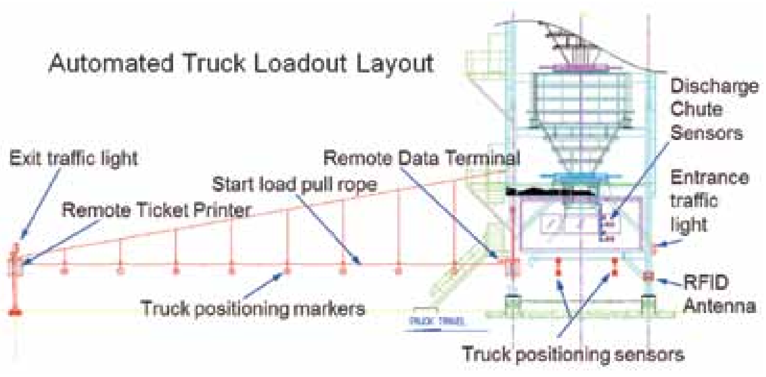

Figure 6. Unattended automated loadout.

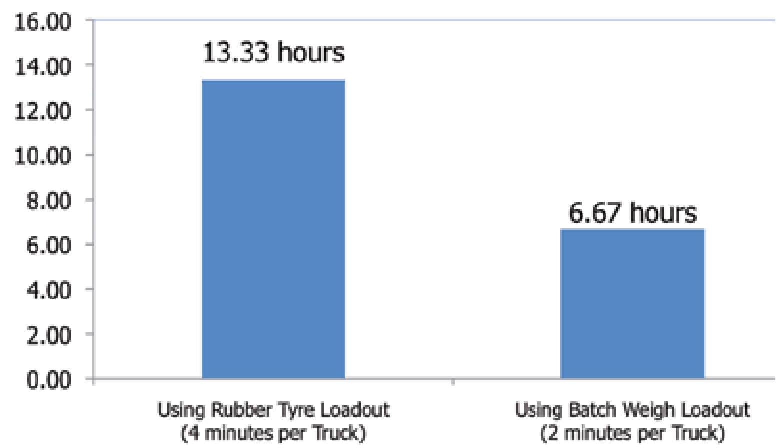

Figure 7. Comparison of estimated hours/day needed to load 200 trucks.

Unattended automated batch weigh truck loadout

Unattended automated batch weigh loading systems are capable of loading at rates of 25 – 50 trucks/hour (1 – 2 minutes per truck). Multiple loading bays, as shown in Figure 5, can be added to increase truck loading rates. Adding unattended automation to the batch weighing system described above eliminates operator entry of truck information and the operator-induced inaccuracies, while maintaining all of the benefits of pre-weighing the material before loading the truck. The automation produces faster loading, minimises human errors and produces more consistent loading.

In addition to monitoring the loadout status, a camera system can also be deployed in the loading area to provide plant personnel with remote visual indication of the loading operations. The camera display can be integrated into plant SCADA workstations, allowing monitoring of the loadout operation from any SCADA/HMI workstation.

A typical sequence of operation is as follows:

- With the green entrance traffic light illuminated, trucks enter the loadout area. The green light indicates that the loadout is operational with no faults.
- The truck is then identified by one of the following available devices as it enters the loadout:
  - RFID tag.
  - RF proximity card.
  - Bar code card.
  - Hand entry via keypad on a remote data terminal.
- Truck ID, driver, hauler, product, destination information and pre-determined batch amount is looked up in the computer database.
- The loadout system batches the pre-determined amount of material for that specific truck.
- Truck driver pulls up to the learned position for that truck by using the numbered marks on the start load pull rope.
- Once in position, the driver pulls the rope, confirming that they are ready to be loaded.
- Sensors ensure that the truck is in the correct loading position.
- The discharge chute is lowered to the proper loading height via chute height sensors, the discharge gate is opened, and material chokes up in the discharge chute.
- The exit traffic light signals the driver to slowly pull forward by flashing the green/red lights. The discharge chute height is controlled automatically via chute height sensors and is raised at the end of the truck.
- After the truck is loaded, its ticket is automatically printed. The truck driver is signalled to proceed via the exit traffic light to the remote ticket printer for retrieval of printed ticket.
- Reports are automatically generated and can be viewed in real time, automatically printed, emailed or exported.

Benefits of automation

- Minimised loading time, allowing more trucks to be loaded in a given period.
- Load every truck to within 200 kg of its target weight, allowing for the maximum amount of material to be shipped with the least amount of truck movements.
- Even and consistent loading distribution within each truck, minimising truck and road repairs.
- Lower annual transportation cost as a result of maximising loading efficiencies (more material is moved with the same amount of truck loads).
- Provides 24/7 operation with minimal manpower requirements.
- Automatic record of all loading data for fast and accurate reporting.
- Increased annual revenues based on the ability to ship more material/year with the same or fewer truck movements.

Efficiency summary

Most companies are limited by the number of trucks hauling and/or the time period for loading trucks. If trucks are consistently underloaded, revenues are continually deferred, year after year. This may be considered deferred revenue, as material is not lost and may be recovered when the material is eventually shipped. Figure 7 illustrates the potential deferred revenue that can be experienced, if trucks are not loaded within 200 kg of their capacity.

A mine operation will produce 200 trucks/day worth of material. If there is a potential inaccuracy in the truck load weighing of 800 kg, this means that up to 160 tpd (200 x 800 kg) of material is not shipped. Divided by a target truck load amount of 30 t, this means that 5.3 truck loads are wasted every day.

This can be extrapolated to 32 trucks (960 t) across a six day week; 138.7 truck loads (4610 t) in a month; and 1663.9 truck loads (49,916 t) in a year of potential material that is not shipped. At US$ 60/t, the loss equates to US$ 57,600/week (six days); US$ 249,581/month; and US$ 2,994,970/year.

Note that this example does not consider any reduction in labour, truck usage or maintenance, fuel or efficiencies in reported savings.

Today's unattended automated truck loading systems provide the ability to quickly and efficiently load each truck to near 100% of its available capacity. This increased loading efficiency minimises transportation costs by necessitating less truck movements, lowering operational costs by decreasing manpower needed to operate loading systems. As costs continue to rise in the transportation of coal and other bulk materials, the need to develop systems capable of providing faster loading rates with even tighter loading tolerances will be needed. Technological advancements being made today will meet these demands now and in the future.