Accurate Load Weighing During Coil Handling

From the Bushman AvonTec Engineering Department

Accurate coil weight is becoming increasingly important as customers and manufacturers work to improve the efficiency of their process lines and facilities. A true coil weight is used in a number of different applications including determination of price, line efficiency, and transportation cost.

To obtain this weight, manufacturers and suppliers have used a variety of methods that normally require the coil to be handled multiple times as it is loaded and unloaded from the scale pads. This method of handling reduces the efficiency of the process line while significantly escalating the potential for coil damage. Another method of obtaining the accurate weight of the coil is to integrate the load weighing apparatus into the crane equipment, specifically the Below-the-Hook lifters.

Currently, the most common method of determining weight is using the strain gauge. There are only a few different types of load cells that incorporate strain gauges and are practical for use in Below-the-Hook applications. They include the canister, single ended shear beam, double ended shear beam, cantilever beam, and the S-beam. The canister is usually a hermetically sealed assembly that can be purchased as a tension, compression or universal cell. In the tension application, the mounting device is threaded into the cell, which allows for a positive attachment point when stretching the strain gauge. Conversely, in the compression application, the force is applied to a load button or other raised surface on the cell. Although these are the earliest load cell designs, they tend to be more costly than other types and do not work well with side loading when the forces are not perpendicular to the cell.

Shear beams (single ended and double ended) are manufactured with the strain gauges embedded in a thin membrane inside the cell. These cells are used in low profile assemblies; they come in hundreds of different styles, and are very cost effective. The single ended shear beam is bolted at one end with multiple fasteners and the load is applied at the other end. Double-ended beams are bolted at each end and loaded in the center. Double-ended beams are commonly used in bail pin applications for coil grabs and C-hooks (Figures 2 and 3.) Cantilever beams are similar to shear beams, but instead of mounting the strain gauges on a thin membrane, the beam is machined all the way through, and the gauges are mounted inside the beam along the machined inner edges. Specialty load cells are commonly made in this configuration; an example is shown in Figure 4, a rotating bottom block. The last load cell is the S-cell, which gets its name from its shape. S-beams are commonly used in tension applications and are excellent when cables are used in the assembly.

Typical Below-the-hook Lifting Equipment

There are an infinite number of ways to mount the load cell on Below-the-Hook lifting devices. One of the easiest methods is to put the cell in series between the crane hook and the lifting device. There are many commercially available devices on the market that can provide multiple features with regard to power, display units and controls. Figure 1 shows an MSI-4260 from Measurement Systems International attached to a c-hook. The benefits of these scales are that they are readily available and relatively inexpensive. One of the biggest drawbacks is that for large capacities, they will extend the head height of the load by four to five feet.

To reduce headroom, the load cell is often incorporated into the lifting device. Figure 2 shows a C-hook in which the load cell is built right into the bail pin using a double-ended shear beam style load cell. The crane hook rides on a spool piece that slips around the load cell, making sure that the hook remains centered on the cell. Figure 3 shows a coil grab that uses a canister style load cell to determine the weight of the load and thus protect the cell from the hook.

Bushman AvonTec C-hook

Bushman AvonTec Coil Lifter

There is no design book available that tells you how to design a Below-the-Hook lifting device. Likewise, there is no template that tells you how to solve all your load weighing problems for lifters. However, based on our experience, we use the following guidelines and important considerations when we design load cells into lifters:

1. The load cell capacity must be selected based on the capacity of the lifter (live load), the weight of the lifter that is below the load cell (dead load) and all fittings, slings, chains, etc. All weight that the load cell will be subjected to must be included in the load cell capacity calculation, not just the live load. When sizing the cell, also consider the type of shock loading that will be applied. Most cells have a normal safe overload of 150% of full-scale (F.S.) or more. If your cell is on a production line in a mill or other heavy-duty application where the load cells will have significant shock loads applied, this overload could be challenged frequently. You may want to consider increasing the capacity of the load cell to allow for this service factor.

2. The ASME B30.20 Below-the-Hook Lifting Devices standard governs structural design of a lifter and requires that a minimum of a 3:1 safety factor based on yield is maintained. Many load cell manufacturers design to a 4:1 factor of safety based on ultimate strength, which can be less stringent. Make sure you understand the cell manufacturer's design criteria and adjust to meet the B30.20 requirements.

3. The load cell should be designed so that it can account for the entire load. Sliding mechanisms or guide bars, which align the lifter, can absorb some of the load or can cause friction that would introduce errors in the load readings.

4. The load cell must be loaded in accordance with the design criteria of the manufacturer. Excessive side loading or unequal loading can introduce inaccuracies or damage the load cell.

5. The attachment points of the load cell hardware assembly must be aligned properly, and the assembly should be aligned vertically. Side loading of certain cells will introduce inaccuracies into the load reading. For consistency, consider using spool pieces or other devices to keep the hook or attachment points centered and in the same position during each lift, even with different operators. If the hook can walk on a load pin, the angle of force on the load cell may change slightly, resulting in a change in the output

of the strain gauges.

6. The load cell should be designed to be easily removed from the assembly for calibration and/or replacement. The current commercially available models tend to be bolt-in designs that facilitate this type of installation. If you are using a compression style load cell, the striker plates also need to be designed to be removable. The striker plate contacts the load button of the canister and applies the load to the cell. Over years of use, the point where the striker plate contacts the load cell can become worn and cupped. This irregular shape can cause side loading on the load cell, which may result in discrepancies in the reading or damage to the cell.

7. Power to the load cell must be considered. Many commercial load cells come with battery powered displays. (Figure 1 is an example.) The positive feature is that this eliminates the need for cables and cable reels on the crane. The negative feature is that you may be replacing batteries frequently, and the limited power supply may eliminate the ability to have a number of useful features such as large displays (scoreboards), modems, and anti-sway programming. If electrical power is brought to the load cell, this power supply should be protected and continuous. Protected power means using high quality surge protection and/or a Universal Power Supply. Continuous power is defined in this context as not having the power routed through the lifter control system and cycled when the lifter is opened and closed.

When considering the design and type of load cell, the engineer will need to determine if he wants to use a certified load cell and if the application needs to be Legal-for-Trade. Legal-for- Trade is an ambiguous term that broadly says that the load cell and equipment conforms to Handbook 44, "Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices." Handbook 44 is not a federal law, but it carries the same weight. It is a set of comprehensive requirements for weighing and measuring devices that are supported and published by the government and adopted by all 50 states. If the load cell application that you are designing will be used in commerce (selling material based on weight), then the load cell should conform to Handbook 44.

Bushman AvonTec Coil Lifter Equipped with a

Verifying that a load cell conforms to Handbook 44 is an enormous task and would be insurmountable for most designers. Instead, the designer should look for load cells that have an "NTEP" certification. The National Type Evaluation Program (NTEP) is a nation-wide program with an approved process for testing, examining, and evaluating weighing equipment to ensure its compliance with the provisions of Handbook 44. Load cell manufacturers submit the necessary documentation, load cell samples and payments to have a third party laboratory test the load cell and issue a Certificate of Conformance (C of C) for the load cell. (Note: NTEP is a voluntary program that is not required by all states; however approximately 37 states require a C of C for devices used in commercial weighing applications within their jurisdiction.) The NTEP program is useful to the designer because it provides a bench mark to compare different load cells. However, it does not eliminate the need for a quality design for mounting the load cell or the requirement for periodic calibration of the system once it is installed in the field.

One of the biggest problems with Below-the-Hook load weighing is the swing of the load as the crane raises, lowers or traverses with the load. There are a number of different products on the market for minimizing the effect of swing on the load readings being displayed to the operator. They use a combination of electronic filtering to reduce the effect of normal crane movement on the load output. Some of the techniques used include:

- Analog filtering which helps smooth the shape of the incoming load cell signal by eliminating electrical noise or interference that is riding on top of the DC signal provided by the load cell. By removing the higher frequency interference components, analog filtering aids in lessening the influence of this noise and interference.
- Digital filtering averages weight readings mathematically to minimize the effect of any bumps seen by the indicator. It works by averaging a pre-determined number of readings and outputting the average of these settings. This can increase the settling time, but does not affect the analog-to-digital (A/D) converter measurement rate, display update or output rates.
- Display filtering is a feature that can be adjusted so the update rate of the display is reduced to minimize the rapid turnover of the scale, but it does not affect the actual A/D converter. This allows for easy screen viewing and does not affect the accuracy of the system.

When adjusting the electronic filtering capabilities, make sure that you do not negatively affect the output of the processor to an extent that invalidates the system for use in a Legal-for-Trade application.

Once we have created an accurate load reading from the processor, the data needs to be transmitted in a useable form. The standard method to display the weight is with a digital display. Many vendors can supply these displays off the shelf with ½ inch to four inch high characters. We have seen people use mechanical flip-number displays, but they

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should only be used on a stationary fixture with the load data transmitted via a modem to the remote scoreboard.

The load data can also be used to support the maintenance department and help reduce equipment downtime. One example is that crane cables, lifters, bottom blocks and trolleys are frequently damaged when an operator picks up a load that exceeds the crane capacity or a coil that is still attached to a rail car. By using one of the data export connections on the load cell processor, a signal can be sent to a relay in series with the crane hoist control that prohibits further up-motion if the load's weight exceeds a pre-determined set point.

With today's business environment requiring data to be available instantaneously to a wide spectrum of users, alternative methods need to be employed to disseminate the data. Most load cell processors can be connected to a computer network by either a cable or a modem. This data stream can be exported into an unlimited number of ERP/MRP systems for input into shipping reports, bills of lading, automatically printed tags, production efficiency reports, etc. If the load of each coil needs to be tightly controlled, the information can be fed back into a process control system to change the necessary coil parameter to achieve the desired performance. In addition, this electronic data can be easily transmitted via the Internet to the customer in the form of advanced shipping notices or faster invoices.

Our customers regularly require accurate load weighing that does not negatively affect delivery schedules or increase damage to the coils. As more and more companies standardize their processes under quality programs and require additional data on their purchases, this trend is only going to increase. As manufacturers, we need to be flexible to adapt the latest technology into our processes and provide the additional services that our customers demand. If the technology is incorporated into the design of the lifter from the beginning, quality load weighing data can be achieved and transmitted to a multitude of users.

References:
"Load Cell Handbook; A Comprehensive Guide to Load Cell Theory, Construction, and Use," Rice Lake Weighing System, 1999.

ASME B30.20 "Below-the-Hook Lifting Devices," 1999.

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