WEIGHING FEEDER BASICS

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ABSTRACT

In todays industry there are many different applications for continuous weighing systems. The information provided by a continuous weighing system can help minimize the cost of many procedures. With an continuous weighing system it is possible to manage inventory, blend products, and control loadout procedures. However, to do these tasks correctly it is important to understand the fundamentals of continuous weighing.

INTRODUCTION

This paper is intended for people familiar with bulk material handling and conveying. The contents can be related to upgrading an existing weighing feeder or adding a weigh deck to a conveyor not previously used for weighing. The purpose of this paper is to provide the reader with a detailed overview of important application points when considering a weighing feeder applications. It is not intended to provide the reader with all of the information or training required to design the components needed. Particularly, the focus will be on weighing feeders used for both weighing and control where the feed rate is controlled by varying the belt speed. The information is also applicable to non-controlled constant speed weigh belts.

This paper will discuss the consideration between a new feeder and a retrofit kit and then focus on weighing feeder retrofit kits. This focus will include an overview of typically required components, a discussion of application considerations, and a more detailed discussion of other important components. Also, this paper will address the question of stand alone integrator use versus the use of programmable logic controllers. Finally, some important economic considerations will be discussed along with a summary of the main points of the paper.

WEIGHING FEEDER NEEDS

Basically, a weighing feeder needs to perform the function of moving a specific material from one point to another at a known and repeatable controlled rate. While satisfying this requirement, the weighing feeder must also be mechanically, electrically, and electronically reliable. It must also be easy to use, adjust, calibrate and trouble shoot. When a weighing feeder does not meet these criteria, it becomes more and more expensive to operate and thus it becomes necessary to either fix whatever problems can be accurately identified or replace the feeder entirely.

A new weighing feeder can offer many advantages over fixing up an old one. All new idlers, drive train, belting, weighing components, integrator and controller can provide better reliability and lower maintenance costs. Also, a new and modern weighing system can usually offer better accuracy than that obtained with an older feeder or with a retrofit kit. A new weighing feeder can easily be customized to meet a new or somewhat different needs than the existing feeder may have.

A weighing feeder retrofit kit can include items from only the most basic required components to all the components necessary to completely rebuild the feeder. Installation costs can be minimized by designing the retrofit kit specifically for the feeder to be modified. Cost can also be minimized by providing the installers with good instructions and the flexibility required for plant floor installation. This paper will focus on installations requiring basic components.

OVERVIEW OF TYPICAL REQUIRED COMPONENTS

A weigh feeder retrofit kit, in its most basic form, requires the following components:

1) INTEGRATOR AND PID CONTROLLER
2) BELT MOTION TRANSDUCER
3) VARIABLE SPEED DRIVE
4) CUSTOMIZED WEIGH DECK
5) CALIBRATION EQUIPMENT

The integrator and PID controller is one of the most important parts of any weigh feeder retrofit kit. The integrator measures the load of material on the belt via the weigh deck and load cells. It also measures the distance the belt travels via the belt motion transducer. Using these two measurements, the integrator calculates the total weight of material that has passed across the weigh deck. Using the totalized weight, it then calculates the average rate of flow of material. The PID portion of the software then compares the measured flow rate of material against the desired flow rate and adjusts the speed of the belt to achieve the desired flow rate.

The belt motion transducer is used by the integrator to measure the distance the belt travels over any given instant of time. The type of transducer used is determined by the specific requirements of the integrator. Typically used are optical encoders, magnetic pickups and proximity switches. Usually, higher frequency outputs of the belt motion transducer give better resolution.

The obvious function of the variable speed drive is to adjust the belt speed and thus the rate of material flow on the weighing feeder. Typically used are SCR drives with permanent magnet DC motors on feeders requiring one horsepower or less and variable frequency controllers with AC motors on feeders requiring one horsepower and more. Historically, an SCR drive with a DC motor could provide a better turn down ratio for the maximum and minimum feed rates because of the torque capabilities of the DC motors. Recent advancements in the design of VFAC controllers has made this difference less obvious. Most decisions between SCR and VFAC drives are now made based on initial costs and end user personal preferences.

The customized weigh deck required for the weighing feeder retrofit kit is the most important component and its design forms the basis for the ease of installation and the overall system accuracy that will be achievable. Simple in theory, the weigh deck forms the part of the weighing feeder that supports a section of the belt and material being conveyed. The weigh deck typically is built using mounting hardware, one or more strain sensors, and one or more weighing idlers. When designing the weigh deck for a retrofit kit, care must be taken to size the load cells appropriately for the weight of the material to be weighed along with the weight of the weighing idler(s), belt, etc. During the design process, the span of the weigh deck is usually optimized to allow for the best possible resolution for the load cells to be used.

After installing all of the required components for a weighing feeder retrofit, it is necessary to calibrate the modified machine. The calibration process includes "zeroing" and "spanning". The "zero" is used to establish the empty weight of the belt as it moves across the weigh deck. Spanning the feeder involves passing a known amount of weight across the weigh deck and adjusting the calibration of the integrator so that it reads the weight correctly. The most accurate way to span a feeder is to perform a material test. Material weighed by the weighing feeder is compared to the weight as measured by a reference scale. The reference scale is typically a truck scale or other type of static scale. After running several tests and obtaining repeatable results, the integrator span factor is adjusted so the weighing feeder totals will match the reference scale.

Another method for spanning a weighing feeder uses a calibration chain to simulate the effect of material on the belt. Next to the material test, this method is the most accurate. Also used are static weights that simply hang from the weigh deck to simulate the load of material on the belt. This method is slightly less accurate because the static weights do not include the effects of the belt tension. Finally, an increasingly popular method of span calibration is the electronic method. For this type of calibration, a resistor is switched in parallel with part of the load cell circuit to simulate a load on the weigh deck. The electronic calibration is useful for checking the calibration of the integrator and belt motion sensor, but is less useful for verifying the function of the load cells. The other methods actually move the weigh deck and load cells and thereby confirm that the weigh deck is functioning both electrically and mechanically. Care must be taken when electronic calibration is used so that the users are not lulled in to a false sense of security regarding the calibration of the machine.

APPLICATION CONSIDERATIONS

When considering a weighing feeder retrofit or upgrade, it is important to thoroughly evaluate and work through the following ten important items:

1. ADDRESS ANY MATERIAL HANDLING PROBLEMS
2. DEFINE OVERALL ACCURACY REQUIRED
3. DEFINE MAXIMUM AND MINIMUM FEED RATES
4. DEFINE BELT SPEED
5. CALCULATE BELT LOAD
6. DEFINE WEIGH SPAN
7. CALCULATE LIVE LOAD
8. DETERMINE DEAD LOAD
9. DETERMINE LOAD CELL CHOICE
10. EVALUATE OPTIMAL WEIGH SPAN

The first and most important item to address is the material handling aspect of the weighing feeder. Does the feeder have any trouble pulling the material out of the bin? Are there any problems containing the material on the belt? Does material jam under the side skirts? Does product leak out of the inlet? Does excessive dust buildup on components of the feeder and cause belt tracking problems or slippage at the drive pulley? Any of these types of problems must be addressed and solved before or as part of the modification to the feeder. It is very important to realize that the weighing part of the weigh feeder cannot function if the material handling portion of the feeder is having problems. Most suppliers of weighing feeder retrofit kits and upgrades do not specifically address material handling problems as the end user is usually most familiar with both the product to be weighed and the weighing feeder itself.

The process using the weighing feeder usually dictates the weighing accuracy required of the weighing feeder. With this in mind, it is necessary to understand the criteria that is typically used to measure accuracy. Most companies building continuous weighing equipment define system accuracy according to the following statement:

> The system will weigh a totalized amount of material being fed at a rate between 30% and 100% of the system design capacity to an accuracy of +/- 1/2 of 1% over a test duration that is the longer or larger of the following: three (3) complete belt revolutions, five hundred (500) counts of the least significant digit on the totalizer, or ten minutes of running time.

It is very important to understand how the accuracy statement of the manufacturer of the weigh feeder or retrofit kit relates to the end user's actual process.

Once any existing material handling problems have been addressed and the required system accuracy has been established, it is time to begin sizing the load cells required for the retrofit kit. This is an iterative process using the main points (3) through (10) as listed above. For example calculations, a weighing feeder and application with the following parameters are used:

Old maximum feed rate: 30.0 t/h
New maximum feed rate: 40.0 t/h
Minimum feed rate: 25.0 t/h
Existing maximum belt speed: 30 ft/min
Nominal belt width: 36 in with 3 in flanged walls

First, establish the maximum and minimum feed rates as required by the process using the weighing feeder. Do not use zero as the minimum feed rate. The process must have an actual minimum feed rate such that the process would not run below the minimum. The maximum rate divided by the minimum rate establishes the turn down ratio required. Typically, turn down ratios should not exceed 10:1. The weighing feeder's exact turn down ratio is a function of the maximum belt speed, the ability of the variable speed controller to run the weighing feeder under load at slow belt speeds and the degree of control that is required at low feed rates.

Second, using the known maximum belt speed from the existing weigh feeder drive or the belt speed from any intended modifications and the maximum feed rate, calculate the design belt loading.

$$\text{BELT LOAD (lb/ft)} = \frac{\text{FEED RATE (t/h)} * 2000 \text{ (lb/t)}}{\text{BELT SPEED (ft/min)} * 60 \text{ (min/h)}}$$

EXAMPLE CALCULATION:

$$\text{BELT LOAD (lb/ft)} = \frac{40.0 \text{ (t/h)} * 2000 \text{ (lb/t)}}{30 \text{ (ft/min)} * 60 \text{ (min/hr)}}$$

$$= 44.4 \text{ lb/ft}$$

It is important that the design belt loading be at least 10 lb/ft. If the application parameters do not give a loading of at least 10 lb/ft, lower the maximum belt speed by changing chain drive sprocket ratios or gear reducers.

Next, using the density of the product as it is conveyed on the weighing feeder, calculate the volume of material to be carried by the feeder.

$$\text{PRODUCT UNIT VOLUME } (\text{ft}^3/\text{ft}) = \frac{\text{BELT LOAD (lb/ft)}}{\text{MATERIAL DENSITY } (\text{lb/ft}^3)}$$

EXAMPLE CALCULATION:

$$\text{PRODUCT UNIT VOLUME } (\text{ft}^3/\text{ft}) = \frac{44.4 \ (\text{lb/ft})}{60.0 \ (\text{lb/ft}^3)}$$

$$= 0.740 \ \text{ft}^3/\text{ft}$$

This product unit volume is the volume of material to be carried per lineal foot of belt. Using the product unit volume, check that this volume of material will fit on the weighing feeder.

$$\text{REQUIRED PROFILE AREA } (\text{ft}^2) = \frac{\text{PRODUCT UNIT VOLUME } (\text{ft}^3/\text{ft})}{(\text{ft})}$$

$$\text{REQUIRED PROFILE AREA } (\text{ft}^2) = \frac{0.740 \ (\text{ft}^3/\text{ft})}{(\text{ft})}$$

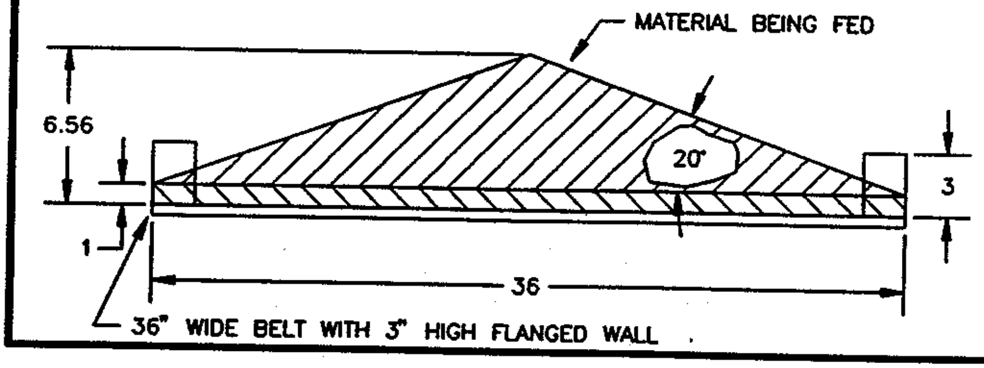
EXAMPLE CALCULATION (see figure 1):

$$\text{AVAILABLE PROFILE AREA} = (1 \text{ in} * 36 \text{ in}) + (\tfrac{1}{2} * 5.56 \text{ in} * 36 \text{ in})$$

$$= 136.08 \ \text{in}^2$$

$$= 0.945 \ \text{ft}^2$$

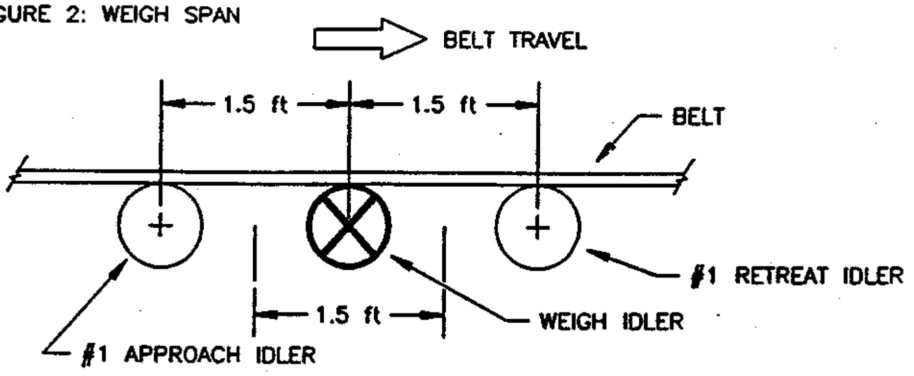
FIGURE 1: CROSS SECTION OF BELT AND MATERIAL



As the available profile area for material on the belt exceeds the required profile area, these application parameters will allow the feeder to be used without any modifications to the belt speed or belt itself. The existing shear gate will be modified or a new shear gate must be made to allow a profile opening of 0.740 ft^2.

After the design belt loading and required and available profile areas are firmly established, the feeder's weigh span is evaluated. The weigh span on feeders using flat idlers is typically one half of the distance between the fixed idlers (see figure 2). A feeder using a weigh deck consisting of more than one idler will have a different weigh span (see figure 3). For t example calculations, the configuration using the single weighing idler is used. The distance between the fixed idlers is 36 in or 3 feet. With the weighing idler centered exactly in between the two fixed idlers, the weigh span equals 18 in or 1 1/2 feet. Using the belt load and the weigh span, the design live load is calculated.

FIGURE 2: WEIGH SPAN

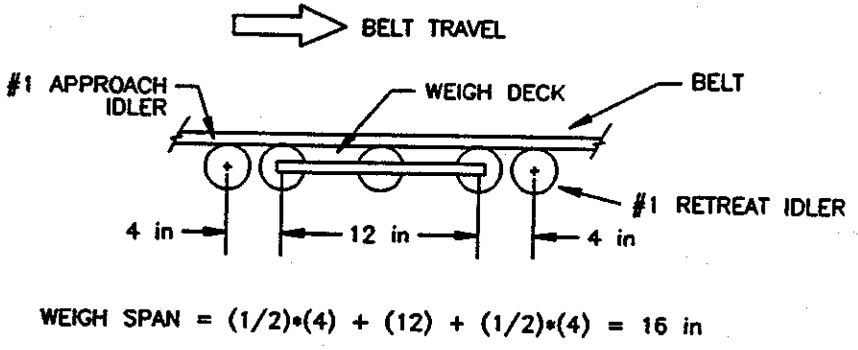


DESIGN LIVE LOAD (lb) = BELT LOAD (lb/ft) * WEIGH SPAN (FT)

EXAMPLE CALCULATION:

DESIGN LIVE LOAD (lb) = 44.4 (lb/ft) * 1.5 (ft) = 66.6 lb

FIGURE 3: WEIGH SPAN WITH WEIGH DECK



Next , add up the weight of the components used to form the weigh section. This includes the weigh idler or weigh deck and components, the section of the belt as defined by the weigh span and any of the components and hardware required to attach the weighing idler to the load cells.

The values for the example are listed below:

Weigh idler:	28.1 lb
Belt:	10.8 lb
Mounting brackets:	6.5 lb
Mounting hardware:	1.7 lb
TOTAL DEAD WEIGHT:	47.1 lb

With the design live load and dead load known the load cells can be selected. Choosing the load cells involves working with the live and dead load, any safety factor desired and the sizes of standard load cells available.

Deciding on a safety factor for the load cells is difficult. Any excess capacity built in to the load cell results in lower resolution for the material being weighed. If it is possible for the weighing feeder to be somehow overloaded with material, it is better to handle that problem separately from load cell size. If it is possible for maintenance workers to walk on the weigh feeder, it is better to find a way of preventing them from stepping on the weigh deck. Most load cells have a minimum safe overload rating of 150% of their rated capacity. The goal is to get the best possible signal and resolution from the load cell without risking damage and eventual failure.

For the example, the total load on the load cells is calculated to be 113.7 lb. If the retrofit or upgrade kit uses one load cell, it is likely to require a 150 lb load cell as that would be the closest size available. For our example, the design utilizes two load cells. Each load cell will require a capacity of at least 60 lb. As this is not a commonly available size, the use of a load cell rated in metric units is considered. A commonly available load cell is 30 kg. Two of these load cells would give our weighing system a total capacity of 60 kg or 132.3 lb. This is a good choice as it is close to the total weight required.

With the load cells chosen, the next step is to calculate the live load millivolt signal expected from the load cells and then evaluate the benefits of optimizing the weigh span.

Load cells signal output is typically given in terms of millivolt output per volt of excitation at the load cells' rated capacity. All load cells specify a recommended and maximum excitation voltage. With this information, it is a simple matter to calculate the live load millivolt output of the weigh deck.

As a general rule, most integrators require at least 6 mV of live load signal to achieve the resolution necessary to meet the overall accuracy requirements of the weighing feeder. If an application evaluation results in a live load signal of less than 6 mV, it is necessary to repeat the iterative design process. Obviously, for accurate weighing, it is better to have higher belt loading and lower dead weight. If it is not possible to lower the dead weight, reducing the maximum belt speed may provide a desirable solution. It is important to consider the implications of a very slow belt on the control portion of the application. With the load cells chosen and the live load signal calculated, deciding whether or not to optimize the weigh span is the final step. This simple procedure uses the capacity of the chosen load cells and the dead weight to calculate the optimum weigh span. If optimizing the weigh span results in a good increase in the live load millivolt signal, this benefit is measured against the difficulty of actually moving the fixed idlers. In performing this evaluation, it is necessary to take in to consideration the maximum practical spanning distance of a flat, loaded belt. As a general rule, the distance between any two idlers should not exceed 24 inches.

INTEGRATOR AND PID CONTROLLER

An earlier section provided an overview of the typical required components needed for a weighing feeder retrofit kit and included an overview of the integrator and PID controller. The overview included a description of the basic function of the integrator/controller. This section will describe important features to look for in an integrator/controller and why they are necessary for the weighing feeder upgrade.

Initial set up of an integrator/controller for a weighing feeder upgrade requires specific information and data to be entered into the integrator's memory. This includes calibration test distances, belt speed calibration, weigh deck calibration and PID control parameters. Because these procedures will require the entry of various data and would require calculations to be performed by the operator, it is imperative that the integrator/controller have menu driven set up procedures with plain and simple instructions clearly displayed to prompt the operator for the needed data. The set up parameters for the PID control portion of the integrator must include all of the features typically found in a PID controller. This includes parameters corresponding to proportional, integral and derivative terms as well as input and output offsets used for clamping feed rates at a maximum or minimum. Especially important is the feed forward term that allows the system to regain control quickly when the feed rate set point is changed. The integrator/controller must also be capable of displaying all of the measured process variables so that any trouble shooting required during set up or later in the operation of the weighing feeder can be easily accomplished. This includes measured excitation voltage of the load cells, load cell output signal and the belt motion transducer output signal. Also necessary is a function to display and allow manual control of the PID output signal and the analog input control signal.

Analog signals to communicate with other computers or PLCs are also required of the integrator/controller. This includes two 4-20 mA signals. One signal corresponds to the rate of flow of material while the other is the signal used to control the belt speed. A discrete voltage pulse or dry contact closure will correspond with the increment of totalized weight by one unit of value. While serial communication capabilities may provide some usefulness, there is no standard protocol for communication. Because of this, it is often required that end users write software specifically to communicate between whatever computer or data logging device they are using and the integrator/controller. The time and effort required to do this usually makes this feasible only on relatively large projects. There are integrators which can interface through remote I/O to a PLC.

Also necessary are output alarms corresponding to high and low feed rates. These alarms should include an adjustable dead band so that the alarms do not chatter when the system is operating near the alarm trigger point. Typically, the alarm outputs are solid state or double pole, double throw relay contacts.

BELT MOTION TRANSDUCER

As mentioned earlier, the main function of the belt motion transducer is to provide a signal to the integrator that corresponds to the distance the belt has travelled. The type of transducer to be used is determined by the requirements of the integrator. Typically the integrator will have requirements regarding the voltage level, maximum and minimum frequency of the input signal and the shape of the voltage pulse.

With the supplier of the retrofit kit or upgrade supplying the belt motion transducer, they will make sure that the signal meets all of the requirements of the integrator being used. The last item to consider is where to mount the transducer.

On the weighing feeder, the belt motion transducer can be mounted on either a driven or non-driven pulley. Each mounting position has advantages. Ideally, the transducer should be mounted on a non-driven pulley. With this type of mounting, if the belt were to stop moving even though the drive pulley is turning, the belt speed would be properly measured and the flow rate would be correctly measured as zero. This is a very important consideration for weighing feeders that are generally unattended or feed critically important material. A good example of this situation is the feed of material in to a kiln where starving a fired kiln of material could cause very serious problems. An optical encoder assembly is typically used for this kind of installation. As these are very precise devices with high resolution capabilities, they are sometimes not rugged enough for very difficult applications. Another potential problem can arise if the belt speed of the weighing feeder is slow or the non-driven pulley is large and requires the encoder to have a very high number of pulses per revolution. With a high number of pulses per revolution, the encoder could emit a signal if the feeder is stopped but is being vibrated or shaken by another plant process.

To avoid these problems, a magnetic pickup or proximity switch can be used. These types of transducers are often mounted in a NEMA standard C-flange adapter that is bolted in between the motor and reducer and provides for a very rugged and durable installation. Obviously, this type of arrangement has the drawback of being mounted directly on the motor. If the belt were to slip or break, the flow of material would stop but material would still be on the weigh deck and the integrator would indicate flow. To avoid catastrophes, a zero speed switch should be used and mounted on a non-driven pulley.

MOTOR SPEED CONTROLLERS

In many instances, the existing weighing feeder has a functioning motor speed controller. In these cases, it is not necessary to replace the controller because the weighing section is being upgraded. As long as the controller can accept a 4-20 mA signal as setpoint for the motor speed and can provide the turn down ratio in belt speed that the application requires, the controller can successfully be used with the upgrade.

If the motor speed controller needs to be upgraded, the choice between an SCR and DC motor drive package and a VFAC and AC motor drive package comes down to a matter of cost and personal preference. Both types of drives are becoming less expensive and almost any brand will provide the necessary features for a weighing feeder.

WEIGH DECK CONSIDERATIONS

While a previous section discussed application considerations of the weighing feeder retrofit and covered load cell sizing, this section will discuss the other components required for the weigh deck.

A single weighing idler weigh deck typically includes the following components: idler, idler mounting brackets, one or two load cells, load cell mounts and a shipping and installation bracket. A multiple weighing idler weigh deck will have the same components as the single idler weigh deck, but will also include one or more additional idlers and could utilize as many as four load cells.

The idler or idlers used to form the weigh deck should be high quality CEMA idlers sized suitably for the design belt loading. Most suppliers of retrofit kits do not use idlers that are more rugged or heavy duty than the application requires as this only adds to the dead load of the weigh deck. Often, these idlers need to be custom made for the specific installation. The idlers are usually chosen or fabricated to have total indicated runout of less than 1/64". This helps to minimize the effects of the belt moving across the weigh deck.

In choosing or evaluating a weigh deck design for a weighing feeder retrofit or upgrade, one of the most important features to look for is built in flexibility to facilitate plant floor installation. There must be some method of aligning the weigh deck after it is installed on the feeder. It is not likely that the installers will be able to hold the tight tolerances required when working with the types of tools available on the plant floor. Properly aligning the weigh deck with the other idlers on the feeder is one of the most important procedures performed during the installation of the upgrade. A bad alignment can cause serious errors in weighing accuracy. The weigh deck design must also be capable of tolerating minor discrepancies in important dimensions. Usually, the weigh deck is designed based on field measurements made by the user.

The weigh deck should also be provided with a means of protecting the load cell(s) during shipping and installation. This could be a bolt screwed directly into the load cell or a bracket or strap that prevents the load cell from deflecting. Usually, these are painted orange to avoid confusion with the overload stops.

Mechanical overload stops should also be provided on the weigh deck. These are usually factory set at anywhere from 125 to 150% of the load cell capacity. Ideally, the stops could be adjusted on the plant floor if it ever became necessary to replace the load cells. These overload stops help protect the load cells from incidental overload. This type of overload can result from too much product on the belt or mistakenly leaving the calibration weights on the scale while having product on the belt. By no means are these overload stops intended to (nor is it possible for them to) fully protect the load cells from a person walking or climbing on the scale or dropping heavy objects on the weigh deck.

STAND ALONE CONTROLLERS vs USE OF PLC

Many plants have sophisticated programmable logic controllers that are used in controlling many aspects of the plant's production. As PLCs become increasingly more powerful and capable, many engineers consider using a plant's PLC to perform functions usually performed by the integrator and PID controller as described in previous sections. This section will describe the various advantages and disadvantages of each approach and then offer a recommendation for which type to use.

Integrator/Controller Use - Advantages

The integrator and PID controller used for the typical weigh feeder retrofit kit or upgrade has been developed and refined over many years. The integrator/controllers on the market today are third or fourth generation digital devices that have been shaped by years of market demand and feedback. They offer the user simple interface through alphanumeric displays and keypads and allow for menu prompted set up, calibration and trouble shooting procedures.

Typically, the integrator/controller is built using modular printed circuit boards. This allows easy field trouble shooting and any necessary board replacement while keeping the necessary spare parts to a minimum. Often, one complete integrator made up of three or four printed circuit boards can be used as all of the necessary spare parts for ten operating units for many years. Also, most suppliers offer at least a one year warranty.

Integrator/Controller Use - Disadvantages

As the integrator/controller is a device dedicated to perform one very specific function, there could be an application that may require slight variations in the control of the feed rate that may not be possible with the integrator/controller by itself. Some manufacturers have the ability to inexpensively modify the integrator control algorithms, but this is not generally the case.

Another potential problems lies in the area of serial communications. As there is no standard protocol for serial communications between industrial computers, each manufacturer usually designs their software around their specific needs. This makes it cumbersome at best for users to interface their computers or PLCs with an integrator. If the plant has a computerized inventory system that needs constant information on the totals of material that have been fed, it may be necessary to use an analog interface to the integrator. For large systems, it may be worthwhile to write the necessary software to complete the interface.

PLC - Advantages

Most of the advantages in using an existing or new PLC for performing the integration and control functions normally provided by an integrator/controller lie with the end user's familiarity with the PLC and their skill level in programming the PLC to accomplish the desired functions. If the plant has a main PLC to keep track of the various processes occurring, a PLC for the weighing feeders that simply plugs in to the main PLC as a remote I/O device would be attractive. Also, most companies building PLCs have well trained, locally available service technicians or engineers to assist with any problems that may occur with the hardware.

PLC - Disadvantages

The first disadvantage to using a PLC as an integrator becomes apparent when the types of analog signals coming from the weigh feeder are analyzed. To obtain the desired resolution, the belt motion transducer signal is usually a frequency in the neighborhood of 200 to 800 Hz. Even the low end of this frequency is outside the ability of the PLC to count the pulses using a standard input module. To use a belt motion transducer of this type, the PLC would require a high speed encoder module. One of these modules would be required for each weighing feeder. It would be possible to use a much slower speed frequency input as generated by a proximity switch. This could be done at a maximum frequency of approximately 10 to 12 Hz based on a PLC scan time of 80 to 100 milliseconds. However, careful analysis would be needed to ensure that this low frequency will provide enough resolution for accurate measurement of the belt speed over its entire range of speeds.

Another problem arises when the load cells are considered. The PLC does not have a regulated power supply for providing the excitation voltage for the load cells in the 10 - 15 VDC range that they typically require. Also, typical analog input modules measure over the range of -10 to +10 VDC. This is a much higher range than the expected load cell signal of 0 to 30 millivolts. Additional external hardware could be used to overcome this problem. There are commercially available strain gage meters that provide the necessary excitation and signal conditioning. Usually, these types of devices will use a 4-20 mA signal for output corresponding to 0-100% of load capacity. This 4-20 mA signal could then be fed into a standard -20 to +20 mA input module. The resolution of this 4-20 mA signal and the resolution of the analog to digital conversion of the PLC card would need to be evaluated. If the available resolution is not fine enough, there is a possibility that the system may not be able to meet the overall system accuracy requirements.

Other problems likely to be encountered involve initial set up and calibration and the required on-going calibration. The PLC programmer could probably program the PLC with the appropriate set up and calibration values to get the system running. Would they, however, go through the trouble of writing the software for and providing the operator interface hardware required for a technician to zero the feeder on a daily basis and check the span calibration each month? If this is done, it is likely that because of the extreme cost of PLC operator interface devices, the operator interface will be in one central location. This will require technicians with walkie/talkies at the feeder and at the interface. If follow up calibrations are difficult to perform, they will never be done and the accuracy of the machine and the overall process will be suspect.

If there are problems with the weighing system, will the PLC program have functions to trouble shoot and help solve the problem? Only the programmer or well trained technicians would be able trouble shoot problems. Would it be possible to correct a problem without bringing the whole system down?

Another complex problem involves the scan time of the PLC program. Careful analysis should be done when considering the use of a PLC to perform the functions of the integrator and controller. Does the program run fast enough to process all of the required information and do a good job of controlling the feed rate? Is the PLC used for other functions that will slow this down even more? If the PLC crashes and goes down because of hardware or software problems, can the plant afford to be without the function of all of its weighing feeders?

RECOMMENDATIONS

With all the present limitations in PLC hardware and the cost and complexity of the software and operator interface, along with the problem of losing the function of all of the weighing feeders if the PLC goes down, it is best to use the very competitively priced stand alone integrator and controller. If it is necessary to interface the integrator with a PLC for data transfers, it is best to use the relatively low cost analog communications. On a large installation, it may prove feasible to use a BASIC module in the PLC and serially communicate with a network of integrators. The cost of writing the software to do this could be offset by the savings in the reduction of wire runs that would be needed for analog communication. There are integrators that can plug in to PLCs as remote I/O devices and this will further enhance the argument to use stand alone integrator/controllers.

ECONOMIC CONSIDERATIONS

This section will briefly discuss the overall expected cost of a weighing feeder retrofit kit or upgrade.

As mentioned earlier, installation costs can be minimized by a well designed weigh section that provides the installation crew with the flexibility needed for plant floor installation. Usually, a two man crew with supervision from the supplier of the upgrade kit can get a complete system installed in one day. Subsequent kits can usually be installed without supervision and be done at a rate of two kits per day.

Maintenance costs for the weighing section of the feeder are relatively low. The electronic hardware that makes up the integrator and controller is usually very reliable and lasts for many years while requiring little or no attention. Most of the maintenance costs come from maintaining the mechanical parts of the weighing feeder. This would include greasing idlers and bearings, changing gear reducer oil at the recommended service interval, etc. Another large portion of the maintenance cost comes from the cost of maintaining the calibration. Daily zero tests usually take less than 10 minutes while a monthly span test with a roller chain or with static weights should take between 30 and 60 minutes. The twice yearly material test to verify the accuracy of the span tests will be the most expensive part of the maintenance. This is usually an all day affair requiring the feeder, material, trucks and several people to do all the work.

SUMMARY

This paper discussed the consideration between purchasing a new feeder and a retrofit kit and focused on weighing feeder retrofit kits. The focus included an overview of typically required components, a discussion of application considerations and a more detailed discussion of important components. Also discussed was the question of stand alone integrator use versus the use of programmable logic controllers with a recommendation for the use of stand alone integrators given.