HARDY PROCESS SOLUTIONS
Measurement ▪ Automation ▪ Productivity

Application Note

Material Feed Management by Rate

Increased Productivity

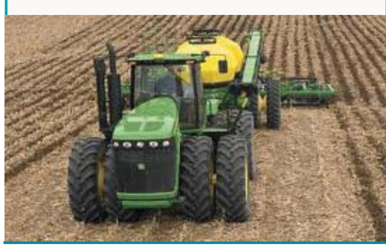
Who is this application note for?

Process Control Engineers, Automation Engineers, Systems Integrators, OEM's or anyone who intends to design, install, commission, support, purchase or offer process weighing solutions for the purpose of manufacturing or processing product.

What is discussed?

Material feed management by rate. It does not really matter what material you are working with, weighing provides accurate and repeatable material feed management result. In this application note we will address the following questions and topics:

- What is a Material Feed by rate and weight?
- What is Material Feed Rate Management?
- Why is good Material Feed Management essential to production?
- Where are the challenges?
- What measurement & control techniques are used to address these challenges?
- When should I use these techniques?
- How do Hardy's material feed rate management solutions deploy these techniques?
- Types of material feeds
- Other useful facts about feed by rate



WHAT IS A MATERIAL FEED?

During a material feed, raw material or finished product is moved from one location to another. Material feeds are used to execute and control the movement of many types of raw or finished products: liquids; slurries; powders; granules; solids; even gasses. Material feed management is used in Continuous or Batch, and Dispensing manufacturing operations.

In Dispensing rate control of a raw material or finished product takes place MULTIPLE times during a production run.

In Batch operations MULTIPLE feeds of different raw materials and quantities take place in EACH batch that is completed during a production run. Feeding these products simultaneously into a common hopper or vessel with the same feed duration could act as a mixing operation.

WHAT IS MATERIAL FEED RATE MANAGEMENT?

Managing the feed usually includes at least 5 stages in a material feed:

1. Ensuring the right conditions are met to start the feed
2. Starting the feed
3. Measuring and comparing the Rate of Change to the rate set point during the feed
4. Controlling the feeder speed to maintain the rate setpoint
5. Automatically refilling when the refill set point is reached
6. Reporting feed data (target rates, gross weight, feed total weight, etc.)

WHY IS GOOD MATERIAL FEED MANAGEMENT ESSENTIAL TO PRODUCTION?

Good material feed management has a positive impact on productivity. Here are some of the ways good material feed management impacts production:

1. Reduces raw material waste (less cost)
2. Reduces mixing times (ratio control on blending)
3. Increases quality (more effective product mixes)
4. Reduces reworks of finished product (less cost)
5. Reduces finished product loss (less give away)
6. Reduces customer dissatisfaction (fewer complaints of poor product)

WHERE ARE THE CHALLENGES?

There are at least 3 challenges that need to be considered to successfully managing a material feed.

a) In the real world process conditions do not stay constant from one feed to the next feed product -

flow rates vary due to: levels in vessels; material consistency; flow; environmental conditions; characteristics of materials, pump or feeder conditions etc.

b) Secondly, communication timing (data transfer update rates) between a distributed field instrument and a PLC or DCS is usually not very deterministic – the time between one read cycle and the next read cycle can vary for many reasons. For example: because of variations in: the length of time it takes to send, update or collect data from buffers; the number of programming loops that have to be processed in one program cycle can change from one cycle to the next. There are timing problems whether data is being used to compare real time weight against a rate set point OR whether an output is being used to control a valve, motor, conveyor or vibratory feeder.

c)Lastly, during Loss-In-Weight feeds we have refill cycles to consider. That is how we manage feeds while we are in the middle of a feed and an alarm warns us that we need to refill the feed hopper. Maintaining material totals and the target flow rate during refill is a must.

One other point to note is that the higher the feed rate, the more likely a process change will affect the outcome of the feed result, even if the change is a percent in feed rate or a few milliseconds communications delay, an error will be introduced if the feed control is not set up to take care of it. This usually results in an impact on quality by over or underfeeding feeding raw materials or finished product.

WHAT MEASUREMENT & CONTROL TECHNIQUES CAN I USE TO ADDRESS THESE CHALLENGES?

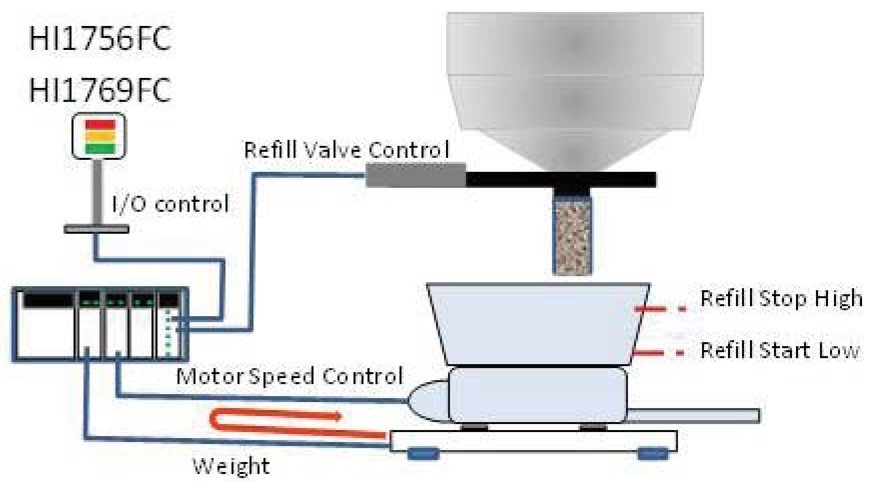
Following are 9 techniques that can be deployed to address and solve the above challenges:

1. Stabilize the flow rate – {this technique addresses challenge (a) above} Using this technique is usually only possible in liquid or slurry applications. Such as in color kitchens for example. Color Kitchens are used to mix up batches of different dyes for fabrics. In this case each of the raw material vessels are pressurized to a constant pressure to negate the effect of gravity and maintain a constant flow rate no matter what the level (height) of the liquid is in the vessel. The controller is sent a rate set point and after that as long as the pressure remains constant it never has to change. Unfortunately this is a very costly solution, and one has said that only applies to some materials.

2. Move the set point comparison as close to the process and measured weight as possible {this technique addresses challenge (b) above} – A deterministic set point comparator (speed and repeatability) plays a big part in controlling a successful material feed result. Moving the rate set point comparison out of the PLC or DSC into a dedicated scale instrument enables the opportunity for a more deterministic comparison that is closer to the process. Remember milliseconds or microseconds = pounds, kgs, grams, or ozs of material. The higher the flow rate the higher the potential error.

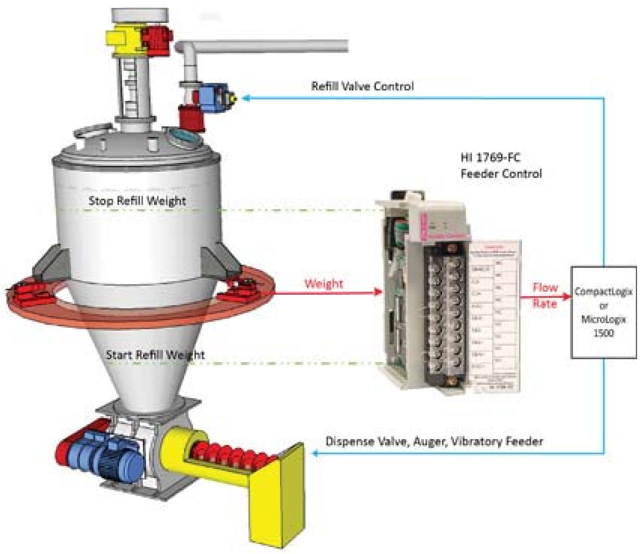
3. Use historical data from the current feed rate and control the flow rate close to the rate set point {this technique addresses challenge (a) above} - This is called "adaptive multi-speed feed control". Until recent times this has been the most common method of addressing the problems. The process flow rate is constrained by gravimetric force, so that any overall change in flow rate is reduced to a minute amount, thus reducing potential error in the feed. The set point rate values are sent to the controller and then the rate of flow is adjusted using the differential from the current rate to adjust itself to the best value. The problem here has always been the cost to install extra vessels, isolating the system on a scale, valves and/or pump speed controllers to maintain control. Secondly there is a cost to manufacturing operations as well, because during product run controlling the feed rate affects and lengthens the batch cycle time. This increases operational line efficiencies on every shift, every day, every week, every quarter and every year. It all adds up.

4. Adapt for the flow variation in real time during every feed {this technique addresses challenge (a) above} - This method is called "rate control". Firstly an algorithm is used to capture the current Rate of Change (ROC) the value based on the current flow, and a second algorithm is used to predict the change needed to the current feed based on real time flow rate changes monitored during the feed. Depending on how smart the algorithms used are, less severe multi-speed feed control might be able to be used (speeding up feed



times). And in some cases, a higher feed rate can be used to deliver exceptionally accurate feed results and at the same time deliver optimized material feed and batch cycle times.

5. Move the field instrument into the PLC chassis {this technique addresses challenge (b) above} – This technique takes care of the simplifying or shortening the "communication chain" that the data has to travel to be sent to, or read from the PLC or DCS. This technique increases determinism and helps to simplify integration time.



6. Use the field instrument for total control and share data. I/O and control with the PLC using communications.

7. Use a controller that has self calculating set point outputs {this technique addresses challenge (b) above} – This techniques offers the fastest method for delivering the control signal to the actual motor or valve, PLC or DSC input. Again increasing determinism and simplifying integration time.

8. Providing a unique opportunity to share resources and automate your system to any level required. Use extra I/O already in the PLC or DCS backplane.

9. Use a controller that has built-in automatic or manual refill cycle management {this technique addresses challenge (c) above} – This technique offers the best method of managing this problem at the local controller or PLC plug in module level.

WHEN SHOULD I USE THESE TECHNIQUES?

It depends on a combination of the following:

- The feed accuracy you are trying to achieve
- The feed rate you are trying to reach
- The batch cycle time or flow rate operations require
- The cost of the material you are feeding
- The number of feeds done per batch, shift, year
- The material you are feeding
- How the material is being fed
- Whether you are doing continuous or batch feeds
- The PLC and communications available

These are all questions that need to be considered and/or answered. What is worth thinking about is that the more demanding your application is, the more likely you need to use multiple techniques to optimize the material feed management operation/results.

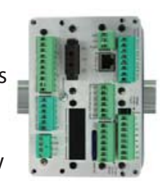
HOW DO HARDY'S MATERIAL FEED RATE SOLUTIONS DEPLOY THESE TECHNIQUES?

Hardy offers instruments that deploy various combinations of the above mentioned techniques. These instruments when coupled with Hardy's load point solutions offer differing mix of performance, capability, and cost.

Value Class Instrument (HI 4050)

• Moves the rate set point comparison closer to the PLC process providing measured weight and rate.
• Using communications in combination with other equipment to perform basic rate control.

Performance Class Instrument (HI 4060)




• Moves the field instrument into the PLC chassis via communications
• Moves the rate set point calculation and control information close to the process
• Uses historical data from the current rate and stored rate calibrations controlling the flow rate close to the set point
• Uses a controller that has control output included
• Remote control and display to monitor and control the process

Advantage Class Instrument (HI 1756FC, HI 1769FC)

• Moves the rate set point comparison as close to the process and measured weight as possible
• Uses historical data from rate calibration, actual rate changes and controls the flow rate close to the set point
• Continuously adapts for flow variations in real time.
• Moves the field instrument into the PLC chassis with plug in modules and direct backplane communications.
• Uses a controller that incorporates independent rate output control software.
• Uses a controller that has an in-built refill cycle manager, totalizer and rate condition status indicators

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TYPES OF MATERIAL FEEDS

Dispensing/Loss-of-Weight: Batch or Continuous

In Loss-In-Weight (LIW) operations the scale is installed on the vessel or container the material is being moved from. LIW feeds are used in Dispensing processes and Batch (when multiple material feeds need to be done into a single mixing vessel simultaneously) processes. Supply bins and feeders in loss-of-weight applications are supported by load points to weigh the material being dispensed into receiving containers or flows. Feeders are included on that load point or platform scales to calculate control for material as it is dispensed. Hardy sends control levels to variable discharge gates or motor controllers to control the rate-of-flow of material from the feeder (see our Rate Application Brochure) while calculating the rate of loss for the ingredient. This rate is a range of 0-100% established during the rate calibration setup. Hardy controller performs automatic refills for the supply bin or feeder when programmed weights is reached, start auxiliary operations, supply alarm, status, shutdown indicators and has a flexible configuration to fit into your application.

OTHER USEFUL FACTS ABOUT MATERIAL FEED MANAGEMENT BY RATE

Instrumentation and Control:

Hardy's instrumentation for controlled dispensing includes weight and rate controllers. They can be standalone systems, connected to host computers, or programmable logic controllers (PLCs). Total net weight can be tracked with Hardy's totalizer feature, which keeps track of the total amount of net weight dispensed. Bar graphs give a visualization of the amount being dispensed or totalized.

Accuracy:

High resolution, fast update rates, plus the adaptive capabilities offered in Hardy's controllers allow for precise rate control required in differing processes. Example: if one hundred pounds of flour is to be added to the process at a certain rate, the scale needs to be able to be read in tenth of pound increments. The scale weight feed back allows the controller to calculate the ROC and control the rate of material entering the bag. Hardy controllers also have the ability to adapt for material bulk density changes. A user-selectable preact can stop the filling process earlier in order to compensate for the in-flight material, so it doesn't over shoot the final desired weight. The flexible configuration allows you to match the controller to the application.

Speed:

Filling is increased using the motor speed control capabilities of Hardy's controllers. The rate is controlled using PID technology and continuous monitoring of the rate to insure the material fed is meeting the require flow rate. The ability to vary the rate as a ratio of another flow allows the process speed to vary as required.

Alarms/Tolerance Checks:

Various alarms are monitored continuously and can be set to notify operators. For example, if the controller energizes the feeder and no rate of change is detected within a preset amount of time an alarm is set. If the feeder supply level shows a low amount of material, a refill is requested. If that refill fails and reaches a low-low weight in the hopper, the feeder stops and an alarm will signal. There is capability to notify upstream and down stream processes that will be affected with the stoppage of the feeder. Alarms are also set to notify the operator if the material falls over or under pre-defined rate tolerance ranges. The filling process can be configured to stop when an alarm goes off, continue at a preset rate, or continue as is. If a disturbance to the scale is detected a limit is set to the amount of correction is applied. This setting also allows for correction for product bulk density changes.

Would you like to improve your Material Feed Management?

To find out more about our solutions or to ask for a quote, please contact Hardy at **1-800-821-5831** or visit **www.hardysolutions.com**