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Digital Blending Systems

Theory of operation

Using highly advanced mass flow instrumentation and modular control systems, blending operations have become more accurate, more economical, and more flexible. Automatic, continuous, in-line digital blending systems now control flows of liquids and solid raw materials in exact predetermined proportions – directly to intermediate processes, packaging lines, or tank trucks.

A continuous blending system consists of multiple raw material feed lines connected to a common line that contains an appropriate mixer, either an in-line static mixer or a mechanical mixer, normally needed for highsheer mixing. The raw material feed lines contain flow measurement devices, usually mass flowmeters, and a means of controlling the flow rate, such as a flow control valve or a pump driven by a variable-speed motor and drive system. If feasible, an instrument that monitors the blended product, via analytical or physical measurement, may be placed in the exit stream. A feedback loop that automatically adjusts the blend proportions might also be needed. As an alternative, the raw material streams may feed a batch blending tank, where the streams are mixed and tested for conformance to specification.

In many plants, blending has traditionally been performed through batch processing. Typically, components are added, in proper proportion, to a mixing tank. These components are usually added sequentially using a weigh scale or tank level to produce a product recipe. The product batch is sampled and analyzed to ensure product quality after the recipe has been completed and proper mixing has been ensured. In batch blending, several issues contribute to overall system inefficiency.

Control description

A master demand signal sets production rate. This is accomplished by setting the specific flow rates for the individual raw material feed streams in the correct proportions to produce a finished product with the desired composition. For each raw material, a pulse measurement signal from the pulse-generating flow transmitter is also sent to the control system. The pulse measurement signal is scaled to the desired engineering units for totalization and control. The individual component stream controller compares these pulses with the desired set-point. Any difference between measurement and set-point is detected and converted to an error signal, which is used to reposition the individual component flow control valve or feed motor speed controller to maintain the desired flow.

Advantage of digital blending

One of the most important advantages of digital blending stems from the ability of the controller to precisely match the measured quantity versus the demand signal. Since the quantity measurement and the demand can be positively equated, the digital controller itself is virtually error-free. The flow measurement devices used to generate the pulses therefore govern total system accuracy almost entirely. The more accurate the flow measuring devices, the higher the total system accuracy.

Analysis of this control technique will show that the component controller is basically a quantity controller, because it controls counts directly. Hence, the component controller continuously controls the exact quantity of each component in the blend – that is, each pulse or count can be related to a finite quantity of the product being measured.

Prior to in-line digital blending, automatic blending was accomplished by analog methods, which controlled flow rates rather than quantities. If a certain blend was desired, flow rates would be controlled over a given time period to give the correct percentages of components in the total blend. By using analog flow control, the controller must see an error in the flow rate before a control action takes place to correct the error. The amount of "error" would not be measured or totalized, therefore no correction for the error could eventually occur. By using digital control, each "quantity" of raw material is measured. If an error occurs between the desired amount and the measured amount, the control system recognizes the error and can compensate for it by slightly adjusting the quantity per unit time; or, if blending into a tank, the precise quantity of raw material can be added by adjusting the length of the run.

It is important to recognize that digital blending is "instantaneous quantity control" – and final or intermediate products can be made in exact proportions and on specification.

Types of blending systems

Two types of digital blending systems are currently available. The first is the so-called "memory system," which has the capability of storing error pulses caused by the deficient component. Assume that we have a three component system feeding a concentrate, solvent and preservative to a surge tank. If one of the component streams drops in flow rate, the other two continue to be fed into the tank. The memory control system immediately senses that one of the flows has fallen behind, and error pulses begin to be stored in the memory controller. When normal operation is restored, the control system makes up the deficiency of the blend as quickly as possible. Alarms are also available, which shut down the system if the stored error pulses become excessive. This system, therefore, has application possibilities where considerable surge capacity exists and where, because of this capacity, off-specification product can be tolerated for a short period of time.

Digital Blending Systems

Eventually, the product will be on specification, but surge capacity must be available. An application for this form of control would be the blending of component streams directly into a tank truck, where the blended product will not be used immediately, and additional agitation would occur during transportation.

The second system, the so-called "pacing system" is basically the same except for the component controller. The functions for the rest of the system are the same and, broadly speaking, so is the function of the component controller, which still equates measurement pulses to demand. The big difference in this system is, if one component slows down, all other components slow down in direct proportion.

As an example, suppose we use the example described above, the blending of a concentrate, solvent and preservative. If the solvent stream were to slow due to a clogged strainer, the solvent controller would immediately sense this slowdown and go into a pace condition. A pace signal would be sent to the master controller where the system demand rate has been set. The master would reduce the demand rate to a rate with which the solvent stream could maintain the proper proportion. To keep the proportion correct, the controller would reduce the rate of the other streams so the system continues blending on-specification product, but at a slower rate. When the problem that caused the solvent feed to slow down has been corrected, the control system would immediately and automatically increase all flows to their normal rates and continue to maintain the desired proportions. The advantage of the pacing system is readily apparent, because a steady flow rate may not be always achievable.

Benefits of digital blending systems

Improved Blending Accuracy – Tighter product specifications can be developed, eliminating giveaway of expensive components. Costly reblending, due to off-specification product, can be eliminated.

Product Uniformity – Consistent on-specification product can be made from run to run, no matter what operator or shift produces the blend.

Greater Operating Efficiency – Production time can be reduced in comparison to batch methods. This allows more production throughput with less equipment. Too often, large quantities of product are produced when batch blending is employed. This excess product must be stored. With digital blending systems, just-in-time production techniques can be used, reducing the need to store finished products.

Increased Operator Effectiveness – Operators know more about the blending operation and can track the process better with centralized control. Automating the process allows for easier operation, thus reducing operator errors.

Improved Safety – Hazardous or toxic chemicals can be handled safely in enclosed pipelines, versus mixing in tanks.

Lower Capital Expense – Blending systems take up less floor space than an equivalently sized tank blender.Pumps and pipelines can be smaller, thus reducing capital costs.

Reduced Maintenance Costs – Many mechanical devices, specifically weigh scales require frequent, routine maintenance to sustain a desired level of performance.

Digital blending system applications

Blending systems, similar to those described above, have application in virtually every area of the process industries. Typical applications include:

- Gasoline blending
- Lube oil blending
- Asphalt blending
- Paint manufacturing and mixing
- Paper stock
- Continuous and batch reactor feeds
- Fuel oil/jet fuel blending
- Plastics/colorants/ plasticizers
- Detergents/soaps
- Juice from concentrates
- High fructose corn syrup/sugar blending
- Milk and ice cream mix standardization

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