Control in Carbonation

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The primary aim in the control of first carbonation is to maintain the alkalinity of the carbonated juice uniformly at the optimum value. The customary control system consists of a pair of electrodes in the effluent, a pH recorder-controller and a control valve in the kiln gas line. When the pH of the effluent differs from a preset value, the controller transmits a signal to the kiln gas valve and adjusts the gas flow to return the effluent pH to the setpoint. This type of control is commonly referred to as feedback control because an error signal is fed back to the controlled variable. Disregarding the relatively low variations in the buffering capacity of the raw juice, the deviations of the pH from the control point are primarily due to changes in the flow rate of milk of lime or, in Steffen houses, of saccharate milk.

By its very nature, feedback control cannot prevent process upsets; it can only restore the process after an upset has occurred. The time required for restoration depends to some degree on the magnitude of the upset. When the saccharate flow rate changes frequently, the pH of the effluent may oscillate above and below the control point for extended periods, because with feedback control, corrective changes of the controlled variable are not instantaneous.

Obviously, if the flow rate of kiln gas could be changed instantaneously to the proper value, when a change in the flow rate of saccharate occurs, pH deviations from the control point would be eliminated. The instrumental requirements for such a control system become evident when we regard the carbonation process as a continuous acid-base titration. When the composition and flow rates of kiln gas and saccharate milk are held constant, the pH of the carbonated juice will remain essentially constant because the ratio of acid/base flow is constant. Conversely, to maintain a constant pH, it is necessary to maintain a constant ratio of kiln gas/saccharate milk flow rates.

Based on these considerations, a carbonation control system was developed and installed at the Woodland, California factory

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of Spreckels Sugar Company. The control principle involved here is primarily feedforward control, wherein the kiln gas flow rate is maintained proportionately to the saccharate flow rate. The heart of this system is a ratio relay which maintains the desired ratio of the two reagent streams. The ratio is continuously variable over the range of 0:1 to 2:1. The response of the relay to input changes is shown on the graph (Figure 1).

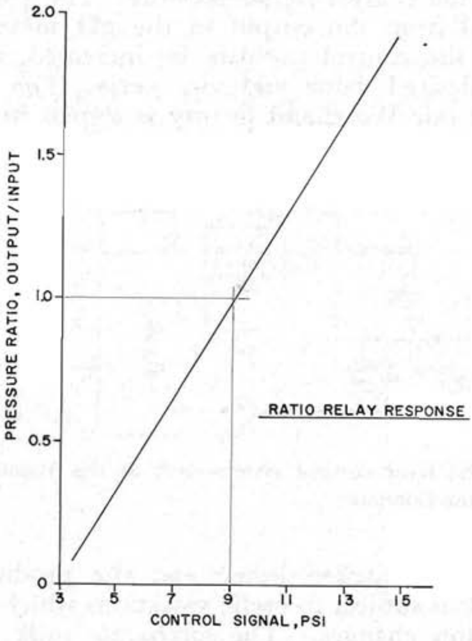

Figure 1.—The ratio of relay response to input changes.

Since our control system is pneumatic, relay functions are shown here in units of air pressure. The output pressure from the relay is a function of the input pressure and the control signal pressure. With a control signal of 9 psi, for example, the ratio of output/input pressures is unity. Thus, if the input pressure is 10 psi, the output pressure is also 10 psi. When the control signal pressure is increased to 12 psi, while the input pressure remains at 10 psi, the output pressure from the relay increases to 15 psi. Conversely, when the control pressure is reduced to 6 psi, the output pressure drops to 5 psi. Thus, the ratio of output/input pressure is set by the control signal pressure.

With a control pressure of 6 psi, for example, the ratio is 0.5. An input pressure of 8 psi will thus produce an output pressure of 4 psi; an input pressure of 10 psi produces an output pressure of 5 psi, etc.

When the relay is connected into the carbonation control system, in a manner where the input pressure represents the flow rate of saccharate milk to the carbonator, then the output pressure can be utilized to control the flow of kiln gas. The alkalinity of the carbonated juice can then be controlled by adjustment of the control signal pressure. The control pressure can be derived from the output of the pH meter. It is only necessary that the control pressure be increased, when the pH is above the desired value and vice versa. The basic control system used at our Woodland factory is shown in Figure 2.

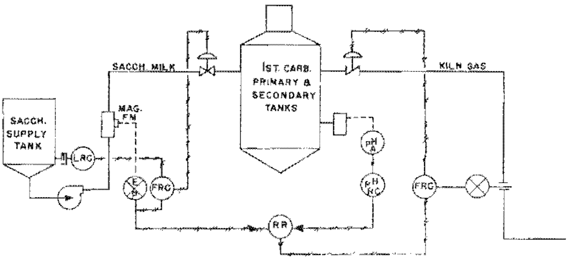

Figure 2.—The basic control system used at the Woodland factory of the Spreckles Sugar Company.

Woodland is a Steffen house and the production rate of saccharate milk is subject to cyclic variations which are the result of periodic filter changes. The saccharate milk supply tank—at the left of the drawing—acts as a buffer tank to smooth out the flow of saccharate to the carbonation system. Saccharate milk temperature and density are controlled automatically.

The saccharate supply tank has a level sensing device and a level recording controller (LRC). The output from the level controller is connected to the saccharate flow recorder-controller (FRC), in cascade. Thus, the saccharate flow rate follows the tank level; when the level increases, the flow rate also increases, and vice versa. The saccharate flow rate is sensed by a magnetic flowmeter; its electric output is converted into a pressure signal by the transducer (EP). This pressure is proportional to the flow rate.

The pressure signal is fed to the ratio relay (RR) as the relay input pressure. As shown earlier, the relay output pressure is always proportional to the input pressure. The output pressure is cascaded into the kiln gas flow recorder controller (FRC) and thereby maintains a gas flow rate which is proportional to the flow rate of saccharate milk. A change in the flow rate of saccharate milk thus produces instantaneously a proportional change in the flow rate of kiln gas, and the alkalinity of the carbonated juice remains essentially constant.

The ratio of kiln gas/saccharate milk flow rates is controlled by the output pressure from the pH recorder-controller. The alkalinity of the carbonated juice can thus be controlled by adjustment of the setpoint of the pH controller.

The system described here is a combination of feedforward and feedback control. Process upsets due to changes in the flow rate of saccharate milk are eliminated by the feedforward control function. Feedback control from the pH meter stabilizes the process and maintains the selected pH value. Campaign tests have shown that control of carbonation juice alkalinity with the new control system is far superior to that achieved with the original feedback control. Installation of the new system in other Spreckels factories is nearly completed.

The system is by no means limited to Steffen houses. In straight houses, an additional ratio relay can be profitably employed to keep milk of lime flow proportional to raw juice flow, thus maintaining a constant percent CaO. The balance of the system then remains substantially as shown. When changes occur in raw juice flow, simultaneous changes in milk of lime and kiln gas flow assure constant percent CaO and constant carbonation juice alkalinity. The carbonation control at the Chandler factory of Spreckels Sugar Company, a straight house, employs a system of this type.