Symposium on Instrumentation in the Sugar Industry, Problems and Application*

Instrument Maintenance in the Sugar Factory—Hal L. Memmott and Park Gaugh[1]

Introduction

The increase in the use of instruments and controls in the modern sugar factory has necessitated a corresponding increase in instrument maintenance. An over-all yearly program of sound instrument maintenance becomes increasingly important. During operating periods, a program of preventive maintenance should be supplemented with an over-all inspection, cleaning and repairing program during intercampaign. More efficient plant operation can result from a planned instrument program, noting trouble spots during campaign and using the intercampaign time for improved instrument application.

Methods

Prior to the time the factory starts slicing beets, each instrument should be thoroughly cleaned and inspected. The cleaning involves freeing all air passages and moving parts. Oil and sludge residue are particularly troublesome in air relays and baffle units. Because most instruments use air and direct the air through small parts, passages, and nozzles, not enough emphasis can be placed upon clean air. Every effort possible should be made to ensure a clean dry air supply. Oil, water, or dirt in the air can easily cause the malfunction of an instrument. The instruments should have a separate air supply system with a special compressor. The supply air to the compressor should come from a clean source, preferably from outside the factory. The compressor should be located in a cool place and must be kept in the best of condition to insure that no oil gets into the air. Special high-grade compressor oil should be used at all times.

Thorough cleaning of the instruments is also beneficial in that all parts of the instrument may be inspected at that time for wear and damage. In particular, the condition of diaphragms, bellows assemblies, connecting linkages and nozzles can be observed and worn or damaged parts replaced when necessary. Tests for proper function of instrument components should be made

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by simulating operating conditions. Correcting any instrument faults at this time will result in a smoother factory start-up when campaign arrives.

The instrument normally measures thru its primary measuring element or unit and these should be checked for calibration. Thermal systems should be checked against a reliable mercury thermometer. Thermocouples should be calibrated using a reliable potentiometer. The thermal element capillaries are easily damaged by arc welding, rough handling, kinking or excessive vibration. Providing some kind of protection for these capillaries can help, but the system should always be calibrated. The bulb sometimes becomes insulated with dirt or scale causing an error in the reading, so these should be properly cleaned. Even if a thermal system is properly calibrated, errors can result from improper immersion depth, liquid level, temperature stratifying, bulb location or the misapplication of the thermal system. These problems will probably be observed during campaign, but they should be corrected—possibly during intercampaign. The solutions to these problems are obvious once the problems are recognized. For example, stratifying can be overcome by agitation, either mechanical, or in the case of smaller tanks just a tangential entry of the supply stream.

A dead-weight tester may be used to check and calibrate pressure systems to ensure their accuracy. Air purges will reduce corrosion from vapors where such is a problem with units measuring pressure. Bubble tubes have as the receiver a pressure measuring unit so these systems should be calibrated in a like manner to pressure systems. The greatest problems with bubble tubes are leaks and blocked air passages, so generally all tubing and capillaries should be inspected for kinks, and flattened or damaged areas. Using one-inch pipe or copper pipe for bubble tubes will reduce errors and troubles caused by solid material build-up and also reduce channeling in heavy syrups. Raising a bubble tube a few inches from the bottom of a tank such as raw juice tank or pulp water tank may prevent bubble tube errors. Bubble tube operation in heavy slurries can be helped by using two concentric tubes with a small water purge running into the outer tube. In this case the outer tube or pipe should be 1½-inch or 2-inch pipe. Bubble tubes in some locations such as the concentrating pans or tail-end evaporators can be given a hot water purge simply by drilling and installing a small water line in the high and low pressure bubble tubes at an elevation above the normal juice level. This will melt out troublesome sugar or salt build-up that is the source of errors in these level readings.

The importance of the control section of the instrument cannot be overlooked and so the control unit must be properly aligned and adjusted. A few tests of the responses--proportional response, reset rate, and proportional derivative—can verify their proper operation.

Perhaps most of the time required for instrument maintenance is actually spent on actuating motor and valve overhaul. Pneumatic motor operated valves all need cleaning and usually the packing gland needs repacking. Here too, the cleaning is almost second in importance to a thorough inspection for wear, loose valve seats and rough stems. At least part of the repacking of glands during campaign can be overcome by the careful selection of the proper packing. One type of packing that has been particularly successful for valves operating in heavy syrups is Garlock #5733 Teflon braid packing. The proper lubricant can reduce stem wear and also increase packing life. For example, for valves in hot juices and syrups, the use of Rockwell-Nordstrom lubricant #555 gives excellent results.

Chattering causes excessive wear on valves and operators and results in a high maintenance cost. Of course, the best way to get away from chattering is by the proper planning and designing ahead of time so that the correct valve is used in a line of the correct size. If a chattering valve is already in service and cannot be replaced with the correct valve, a hydraulic snubber just ahead of the pneumatic operator will stop the chattering in most cases. However, this method cannot be used to cure troubles caused by misapplication and poor installation of control valves.

Closed butterfly valves have the force of the upstream pressure against the whole face of the disc. This condition can cause problems such as bent shafts, stuck valves, and leaky packing. While cleaning this type of valve, careful inspection of the valve shaft and operator stem should be made to make sure these parts are straight. If a bent stem is located it should be replaced with a larger stem to prevent further trouble. Because of the high torque required to operate these valves, every effort should be made to make sure that the valve and operator are correctly aligned.

Instrument accessories are an integral part of an instrument and these accessories also require maintenance. The supply air regulators and filters require complete cleaning and replacement of filter cartridges where necessary. Some pot metal types of regulators and filters react to the moisture in the air and this adds to the contamination of these parts. Climax Type 245 combination filter and regulator gives excellent results under adverse air conditions. The moving parts and air passages in this unit are large enough to function efficiently even in very dirty air.

This covers a part of the maintenance problems in a factory, but a few other items should be mentioned, such as spare parts, etc. An adequate supply of the inexpensive parts such as gaskets, o-rings, diaphragms, diaphragm material, small relay parts, springs, etc., for both the instruments and the accessory equipment is essential. An excellent thing to keep in mind in purchasing instruments is to buy from a company that produces all the various kinds of instruments required in the factory. The ever-changing sugar factory requires an instrument that can be changed from one job to another with the simple substitution of one or two components. This requires that the instruments have unity, be as simple as possible and be adaptable to different application. The importance of these considerations is realized when determining the number and cost of spare parts. Regardless of cost, some of the expensive components, such as sensitivity units, absolute pressure bellows, etc., must be kept on hand. The more applicable these parts are to several different instrument types the more useful a stock of parts will be at a nominal cost. Standardizing on instruments from a reputable company helps to reduce the parts stock also.

Summary

1. Clean air is necessary for successful instrument operation.
2. Planned installation and sensible application is a big factor in instrument maintenance.
3. A planned program of cleaning, inspecting and adjusting all instruments is necessary.
4. Use preventive maintenance where possible.
5. Buy instruments from a dependable manufacturer.

Cost Reduction through Instrumentation Improvement in Steam Balance, Fuel Savings and Other Material Savings—Harold C. Dyer[1]

Cost reduction through instrumentation

About fifteen years ago, I was introduced to the problems of instrumentation in the beet sugar industry as the result of an instrument failing to perform on the process it was intended to control. No one was responsible for the satisfactory operation of any instrument and no one seemed to care too much whether

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or not the instrument worked properly. At the time I became interested in the problem, I found that many of the installation failures were the result of salesmen's errors in selling instruments without knowing the process to be controlled and the apathy of the operators toward automatic controls.

During the intervening years this condition has changed considerably. Instrument salesmen today are generally engineers and have become more familiar with the problems of the beet sugar process. They are now better qualified to recommend the proper type of instrument, and some of the plant personnel have become more interested in the satisfactory operation of control systems.

I have been invited to discuss with you in this paper "Cost reduction through instrumentation, improvement in steam balance, fuel savings, and other material savings." Unfortunately, instrumentation in our industry has lagged behind other industries. We have now learned that not only can labor be saved, but often as much or more benefit can be obtained in improved operations. In the past, in many instances operators lacked confidence in instruments and were reluctant to allow instruments to function completely on their own. In other cases, instruments could not be effectively applied to existing equipment . Until the equipment could be economically replaced with a type adaptable to instrumentation, automation had to be delayed.

Improvement in steam balance

Probably the most familiar control system for this purpose being used in the sugar industry is the evaporator control with which many of you are familiar. We have a total of seven factories equipped with evaporator control systems. In most of our installations these controls are used on a quintuple-effect evaporator, in which the exhaust steam from the main generator turbine is admitted to the steam chest of the first effect where it gives up most of its heat to the thin juice, causing the juice to boil. Vapor from the boiling juice cools in the evaporator dome and is piped to the steam chest of the second effect.

This process continues to the fifth effect where the vapor is condensed in a barometric condenser. The instruments used generally for the control of this system are designed to maintain the correct juice level in each effect, maintain constant density of the thick juice, hold first and third vapors constant, thereby maintaining second vapors at a relatively constant pressure, and to keep the evaporating rate equal to the demand for evaporation. This latter function is accomplished by raising and lowering the absolute pressure of the fifth effect.

The first and third vapor pressure controller, controls the pressure of the first and third vapors by operating a butterfly valve in the exhaust steam line to the first effect and a butterfly valve located between the second and third effect in the vapor line. This controller is a double unit type; one unit controls the pressure of the first effect, and the other unit controls the pressure of the third effect.

The absolute pressure controller measures and controls the absolute pressure within the last effect by operating a valve in the water line to the barometric condenser. The control point of this instrument is pneumatically adjusted by the thin juice supply tank controller.

The density controller measures and controls the density of thick juice leaving the last effect by operating a valve in the outlet line from the thick juice pump, thus throttling the flow from the pump.

The level instruments measure and control the level of the respective bodies by operating a valve in the inlet juice line to the respective body. Measurement of level is accomplished by bleeding air into two level taps located on the bodies.

The exhaust steam pressure controller measures and controls the pressure of the exhaust steam by operating in sequence a make-up valve and a relief valve. By the use of controllers the vapor pressures can be maintained for use elsewhere in the process.

Fuel saving through boiler controls

In the operation of a boiler steam generating system there are several essential elements which must be controlled for efficient and economical operation, resulting in fuel savings. These mainly are steam pressure, rate of fuel feed, fuel-air ratio and draft. We will consider these in this order.

Steam pressure

Steam pressure is a direct indication of the load demand on the boiler. If the load increases, the pressure will drop; conversely, if the load decreases, the pressure will rise. It is necessary to keep the pressure relatively constant in the main header to have an adequate supply of steam at a given temperature available to the process equipment. Varying pressures and temperatures are often injurious to the process. For this control a master controller is used. This controller measures the steam header pressure and sends a loading impulse to the fuel feed controller to maintain a constant steam pressure.

Rate of fuel feed

In order to maintain a constant pressure in the main header, it is necessary to change the rate of fuel feed to the boiler. As the load increases, the fuel feed rate must be increased proportionately and conversely, decreased with decreasing load. For this control a fuel feed controller is used. This controller receives the loading impulse from the master and changes the fuel feed to correspond to the master loading.

Fuel-air ratio

As the fuel feed rate changes it is desirable to change the rate of air flow to the boiler proportionately. As fuel is burned, the carbon combines with the oxygen in the air, thus forming CO_2 in the flue gases. If too much air is supplied to the furnace, it dilutes the gases and the CO_2 content will be low. Also, the boiler outlet gas temperature will be excessively high. If not enough air is admitted to the furnace, then all of the fuel is not burned and we get CO_2 and CO in the outlet gases. CO is unburned fuel which is wasted out of the stack. In normal operation it is desirable to operate with a small amount of excess air. In the case of natural gas fuel, the excess air should be between 10 and 20%. This will give approximately 9 to 10% CO_2 and 3 to 5% 0_2 in the flue gases. With fuel oils and coal, these readings are higher. For this process a fuel-air ratio controller is used. This controller measures the fuel flow and changes the air flow (forced draft fan) to correspond to the rate of fuel feed, thus maintaining the desired ratio for efficient operation.

Draft

When considering draft, we think of the negative pressures in the boiler. The usual boiler is built for balanced draft and there are leaks in the setting which would allow gases to escape into the boiler room if the pressure in the boiler exceeded the pressure in the room. It is desirable to keep the furnace pressure at a point lower than the room so any leaks will be from the room into the boiler instead of in the opposite direction. For this process a draft controller is used. This controller measures the pressure in the furnace and operates the outlet damper to maintain the furnace pressure at a point slightly lower than that in the boiler room.

There are several types of systems which may be used to accomplish this control which operate pneumatically, hydraulically, or electrically.

In addition to the above controllers the following instruments are used on different functions: steam flow meters that record the load on the boiler; temperature recorder for recording the air and flue gas temperatures to assist in determining the efficiency of the boiler; CO_2 and oxygen recorders that analyze the flue gases and tell how efficiently the fuel is being burned; draft gauges that measure the pressures and drafts in the air and gas systems, and tell the condition of the boiler from the standpoint of fan operation and whether or not the boiler is becoming dirty due to soot build-up.

Other material savings

There are many types of instruments which may be used in the beet sugar industry which not only will result in reduced operating costs and material savings but also in better product control. Some of these are pH control for carbonation, sulphitation, and predefication, milk of lime control, density control of melters, humidity control for sugar storage, closed circuit T.V., and many others.

In addition to the control of the process through the use of instruments, it is possible to use automatic electrical controls at many locations. We have used many of these and have built some rather extensive push-button control panels used for automatic control of the following: limerock and coke handling, operating of the lime kiln, wash house and beet handling, beet slicers, continuous diffuser, centrifugals, bulk sugar storage and loading, and many others which time does not permit discussing at present.

I have not attempted in the time allotted for this paper to give any statistics of specific dollar savings through instrumentation but all of the above applications have made their contribution to the reduction of costs through instrumentation in the beet sugar industry.

In closing I wish to say that I feel that the application of instrumentation and automatic controls in the beet sugar industry is still in its infancy. The opportunity of applying automatic controls to this industry is unlimited, and if we in this industry expect to compete with rising production costs in the years ahead we must continue to use more and more automatic controls. I feel that the engineers are ready to design a fully automatic beet sugar factory as soon as they are given the opportunity to do so.