Automation of Vacuum Pans and Filters

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ABSTRACT

Automation of vacuum pans and filters can be justified through improved operation and labor savings.

Converting from 100% manual control, with its finely divided areas of responsibility, to instrument operation from a panel with periodic overall inspection, required careful planning. Information previously available through widely scattered temperature, pressure, and flow indicators and recorders was incorporated in the central control panel. Where feasible, the instruments themselves were placed in the control panel.

Control features, size, and information desired were the criteria of instrument selection.

Personnel considerations centered around new areas of responsibility, re-training, job re-evaluation, and absorbing those displaced.

Instrument maintenance costs have run about $2,000 per year. The net savings, before taxes, resulted in a three-year payout.

Approximately four years ago at Morton Salt Company's Rittman, Ohio, Plant, a project was approved for automating the vacuum pans. This paper outlines the thinking, planning, and execution of the project.

At first glance, it appeared that the labor savings and improved yields would justify the automation of the vacuum pans and filters. Preliminary estimates indicated an expenditure of $30,000 to $40,000 would be required. Prior to automation, the crew consisted of four men per shift to evaporate, de-water, and dry. An investigation showed that one man could be eliminated from this group with adequate pan control and possibly another at some future date with better filtering and drying control. The savings realized by eliminating one man per shift, or a total of four, was in the neighborhood of $16,000 per year. Better yields could be realized through longer runs between boilouts because of improved level regulation and a more systematic method of removing salt from the pans. At Morton Salt Company, according to a rule of thumb, a capital investment should pay for itself in three years or less, neglecting depreciation and taxes.

Physically, the equipment in the pan house and filter area is as follows:

There are two sets of evaporators located in a common pan building that usually produce two different grades of salt.

One set of triple effect calandria pans: 18, 20, and 22 feet in diameter respectively.

One set of 12 foot diameter triple effect calandria pans; plus the usual supporting equipment; a vacuum pump on the large set, steam jet air ejectors on the small ones, injection water pumps, barometric condensers, salt slurry pumps, etc.

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The filters, located in a separate room adjacent to the pan building, are top feed, 6 x 7 foot stainless steel (fabricated) and 6 x 4 foot ni-resist with Elliott exhausters for vacuum. The dryers, which are now eliminated, were the vibrating, perforated, deck type using fin heaters with forced air fans.

Before using automatic controls, salt removal was manually controlled, using DeZurik valves. The amount each valve was opened depended on the salt suspension. The percent of salt suspension is determined by reading the milliliters of settled salt in a 1,000 milliliter graduate sample taken bi-hourly by the pan engineer. The samples are obtained from 3/4 inch lines flowing continuously from the body of each pan to the salt slurry tank located on the ground floor of the pan building. It is the operating procedure to hold about 10% salt suspension in the pans.

The operating personnel included the following:

A pan operator, working on the second floor, regulating brine level, steam flow, and responsible for overall operation.

A pan engineer, having a third class license, working on the ground floor, handling the salt removal, auxiliaries, condensate quality, filling and dumping the pans, etc., and under the direction of the pan operator.

A filter operator, responsible for the operation of the filters and dryers under the direction of the pan operator.

A filter helper, assisting the filter operator and checking dryer operation.

The instrumentation available to these men before the project was undertaken consisted of steam flow meters (recording the steam flow to each set of pans), thermometers on the belt and body of each pan and the injection water in and out of the condenser, vacuum or pressure gauges on the belt of each effect and the barometric condensers, vacuum recorders and temperature recorders covering the same points indicated above. The filter operator had a continuous record of the production tonnage; indication of filter vacuum as well as the air temperature to and salt temperature away from the filter. On the ground floor, the quality of condensate was monitored from the first effects and second effects with separate conductivity cells tied into an electrical balance type recorder controller. If the salinity of the condensate exceeds a pre-determined point, air driven valves open allowing the water to dump to the sewer. A red light and horn warn the operator when this occurs. In addition, the pan operator maintained an hourly log on which he noted the temperature, pressure or vacuum of each belt and body, the barometer reading, and the steam flow for each set of pans. He also logged the salt suspension readings taken from each effect bi-hourly by the pan engineer, and the salt tonnage figure daily.

With regard to the selection of instruments, it is of utmost importance that you consider the information that guides your operator now and tailor your new controls and indicators accordingly. If not, you may design the system -- and a good one -- commensurate with what information YOU think is necessary to run a set of pans and not in line with what your people have grown accustomed to. Your operators are apprehensive enough about the changes without imposing an additional burden on them.

The operating personnel in this case were in the habit of reading both temperature and vacuum so it was important that this information be incorporated in the panel board.

The panel board is mounted on the ground floor of the vacuum pan building as a control center for pan operation. It was attempted to incorporate in the panel the necessary controllers and indicators so that the pan engineer would have 100% control of the pans, plus monitoring of critical points in the rest of the system. With the above in mind, the following control points were selected:

First, steam pressure on the belt of the first effect.

Second, brine level control on each effect.

Third, salt slurry removal control on each pan leg.

Points to monitor, using scale indicators:

First, vapor temperature on the belt and brine temperature on the body of each effect.

Second, water temperature in and out of the barometric condenser.

Third, the absolute pressure on each barometric condenser.

Points to monitor with signal light indicators:

First, an alarm annunciator system on critical pump motors and drives.

Second, condensate level on the belt of each effect.

In addition, it was planned to incorporate into the panel some of the receiver recorders that were in operation at the time this project came into being. These included two eight-point electronic temperature recorders measuring the brine and vapor temperatures from the body and belt of each effect respectively plus the temperature of the injection water in and out of the barometric condenser, and two steam flow integrator recorders. The measurement of condensate salinity and the operator's log are maintained as before.

After several different layouts, a panel 80 inches high by 112 inches wide and 20 inches deep was selected. Foxboro was selected as the instrument supplier and the builder of the panel.

The following controllers, transmitters, and operators were selected:

Steam Flow: An indicating pneumatic receiver controller, a pressure indicating transmitter, and a diaphragm motor operated butterfly valve.

Brine Level: An indicating pneumatic receiver controller, a differential pressure measuring device as a transmitter with a zero to 30 inch range, a diaphragm motor operated Saunders type valve, (air to open with an Everdure bronze body). Working off the stem of the valve was a relay type valve positioner.

Salt Removal: A manually set timer device which indirectly controlled a pinch type rubber body air-operated valve on the slurry line from each pan. The timer operates on a one minute cycle. The operator can set the percent of valve time open on the dial of the timer for each pan. The setting is adjusted according to the bi-hourly salt suspension samples taken by the pan engineer on the ground floor.

Temperature Indication: Dual pneumatic receiver indicators with red and green scales side by side; one unit for each effect, showing the vapor temperature of belt and the brine temperature in the body, and one showing the water temperature in and out of the barometric condenser.

Absolute Pressure: Absolute pressure gauges with catchalls were specified.

Production tonnage is transmitted from each weightometer by means of a position indicating transmitter to a two-pen pneumatic receiver recorder. This recorder enables the ground floor operator to see the amount of salt produced by each set of pans.

All air signals are transmitted between 3 and 15 psi. A 24 plug-in relay unit motor alarm annunciator with bullseye lights monitors critical motor drives. This unit has test and acknowledgment push buttons as well as a howler (horn).

Capacity actuated electronic relay units with "fail-safe" devices are used to monitor the condensate level in the belt of each pan. A bull's-eye light signal indicates high level. These are the controls and indicators incorporated into the panel along with the recorders mentioned earlier as being used at the time the project went forward.

Sometimes, it is the supporting equipment that makes or breaks a project of this nature. This one was no exception. Clean air is paramount to good instrument operation. Air lines must be properly sloped and adequately trapped. Each transmitter has its own air filter and trap with a blow down connection.

Proper functioning of the level control had much to do with the success of the instrumentation. Trouble-free purging with condensate of the DP cell connections made the arrangement successful. A small portion of the condensate to the boiler room hot well tank is bled continuously into a tank from which it is pumped through the purge system by a double-acting proportioning pump. Purge meters at each connection control the rate of flow.

Copper tubing, 1/4 inch x 0.030 inch, in five and seven tube flats, sheathed with polyethylene for atmospheric corrosion protection was used in the air transmission system. Aluminum carrying trays were purchased to support the tubing. With the panel shipped complete with controls, indicators, tubing connections in place and labeled, little time was required to hook it into the system. The total time for the complete installation was about ten weeks.

Shortly after the completion of the instrumentation of the vacuum pans, filter drying was started and the deck dryers eliminated. At this time, air operated pinch valves were installed on the slurry feed to the filters. These valves are remotely operated by manually turning an air regulator valve. Electronic temperature recorder controllers, using iron-constantan thermocouples, were purchased for the monitoring of the salt temperature. This temperature is an indication of the degree of dryness of the filter discharge. If the salt temperature falls below a pre-set point, the second screw conveyor handling the salt will reverse -- causing the salt to be re-slurried. As a further protection, the screw conveyor (immediately beneath the filter), the filter, the exhauster, and a solenoid valve to the air operated slurry valve feeding the filter are interlocked so that a failure in one piece will stop that equipment "up stream" or dependent on it.

With respect to personnel changes, training sessions were held, during which the changes in responsibilities were reviewed and discussed. It was desired to gradually shift the overall responsibility from the pan operators to the pan engineers operating from the panel. Those formerly called pan operators are now called "rovers" and assigned a specific inspection route. To make certain the route was followed, ten key stations were installed and each shift rover was given a watchman's clock and instructed to make six rounds per shift. The training of the ground floor engineers continues. Each one of these men is to learn and work the rover's job. It is the plan to reduce the overall crew to two men per shift: a pan engineer and rover. This last reduction is possible because of the simplification and instrumentation of our filtering and drying operations.

Instrument maintenance has been running about $2,000 per year for labor and material. The maintenance is under the responsibility of the electrical foreman. Just recently, an apprentice has started familiarizing himself with the instrument upkeep and repairs. Later on, this trainee will be enrolled in an instrument maintenance course.

Before closing, some of the mistakes made on this project should be enumerated. Benefiting from the great white light of hindsight, the following suggestions are made.

Specify an instrument air compressor; an air compressor off the shelf will give oily air problems.

Check into the necessity of automatic reset, rate time and proportional action on your controllers. The steam controls selected had automatic reset and proportional action but, on the level control, rate time would have been helpful along with the proportional action specified. This decision depends on conditions; for some, it might be desirable to have all three on some controllers.

Use tube bundles or singles, not flats; they are too hard to handle.

Install mercury relays for interposing relays on the alarm annunciator system and end the troubles from dust.

In conclusion, the total investment in the automatic control of the vacuum pans and filters came to approximately $35,000, of which $5,500 was for labor and $29,500 for materials. As a result of this installation, we have saved approximately $14,000 per year, before deducting taxes and depreciation. The system functions well, and has done much to smooth out the operation of the pans and filters.