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Refinery Pan Automation - An Experience in Middle East

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ABSTRACT

Automation of process for increased productivity is normally the primary reason for many companies craving a competitive advantage. It can also reduce human error and thus improve quality. Other reasons to automate include the presence of a hazardous working environment and the high cost of human labor. Automation is the use of control systems such as numerical control, programmable logic control, and other control systems to control industrial machinery and processes, reducing the need for human intervention. Automation at pan station is very important as far as sugar size and quality is concerned. Also in case of sugar refinery handling with high purity material, it becomes more essential due to its sensitivity with exhaustion and purity control. In this paper views regarding refinery pan automation and experience at Yemen sugar refinery in gulf country is discussed.

Keywords : Refinery pan, brix, level sensor, exhaustion and purity control, high purity material.

INTRODUCTION

The automation of the batch pan operation tenders huge potential of plant performance improvement into multiple directions especially high purity refinery pans. The pans being the largest vapour consumers in a sugar plant have significant influence on the steam economy of the plant and desired sugar quality. The sugar crystallization performance in a pan is the most important step to control the sugar quality. Whatever the crystal quality comes out from the pans, can't be enhanced in the successive processes. The crystal quality and uniformity from the pans have also significant impact on the centrifugal performance. Therefore, pan station is an area which requires special attention to improve the overall plant performance.

The manual pan operation consists of several limitations and operational draw backs such as:

Lack of important parameter measurement

No set point for the seeding

No pre set point for the seed quantity

No calculation for the feeding for the pan filling

In many factories pan operators as per their experience take the above decisions which sometimes do not match the requirement. For manual batch pan operation, usually 2 – 5 t water per strike are required which leads typically to an additional exhaust steam demand of 2 to 16% on cane for the raw house pans and if refinery is there, additional steam consumption is required. Good crystal quality, pan capacity enhancement, smoother operation and low water/steam consumption can be achieved with modern pan automation systems. In general, it is possible to operate batch pans with no water addition

This paper deals with the application of efficient automation /instrumentation system, suited to present day need of achieving maximum steam economy and uniform grain size of refined sugar with minimum co-efficient of variation (CV), desired mean aperture

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(MA) by employing proper instrumentation with genuine sensors. Proper selection of automation system helps in optimizing the system parameters, which in turn help to run the respective stations efficiently.

MATERIALS AND METHOD

The capacity of the refinery was 2000 TPD refined sugar. For refined pan boiling, there was the practice of common seeding method for R1 to R4 massecuite.

For all vacuum pans there were 2 modes of operation: *Full manual:* The operator can control all logic and analog valves manually. The program is in stand-by. *Full automatic:* The vacuum pans are operated by the program as per the sequences determined in auto mode.

There were 3 ways of controlling the elements:

Manual (MAN), Automatic (AUT) and Cascade (CAS)

Manual (MAN): The operator directly controls the outlet of the control loop (out). The PID algorithm does not run.

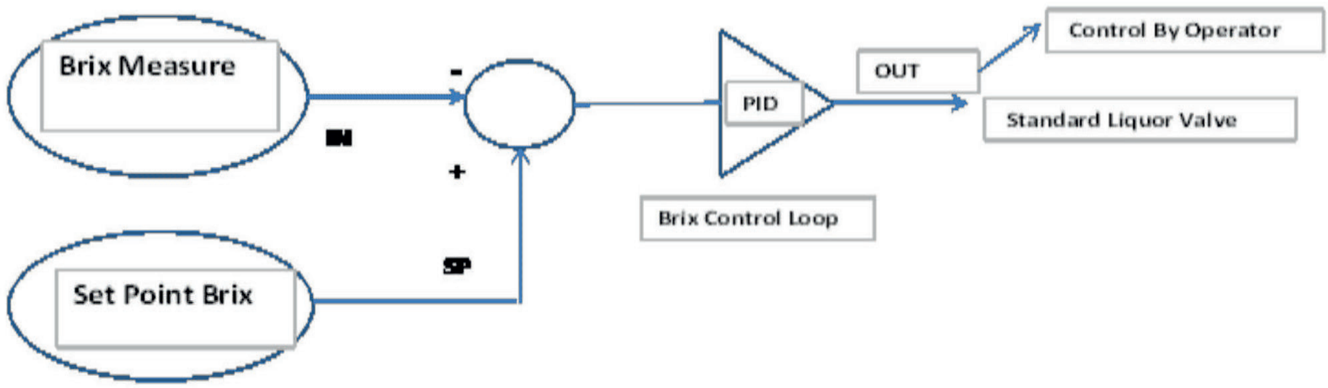

Figure 1 : Command for manual operation

Auto (AUT): The operator controls the set point of the regulator (SP). The PID algorithm runs and makes sure the set point is followed.

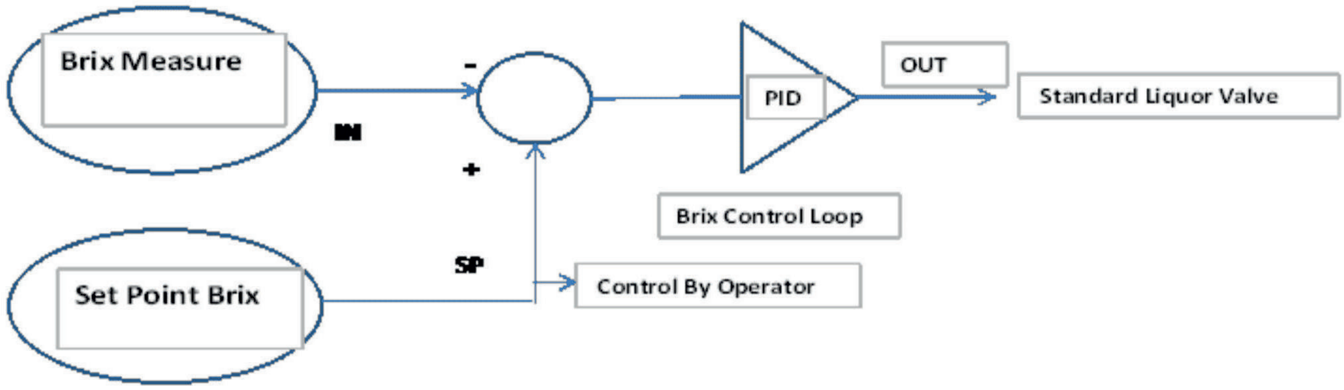

Figure 2 : Command for auto operation

Cascade (CAS)

The set points of the regulator (SP) are controlled:

- Either by the result of a calculation block
- Or by the outlet (OUT) of another regulator

The operator cannot actuate this regulator. The PID algorithm runs and makes sure the calculated instructions are followed.

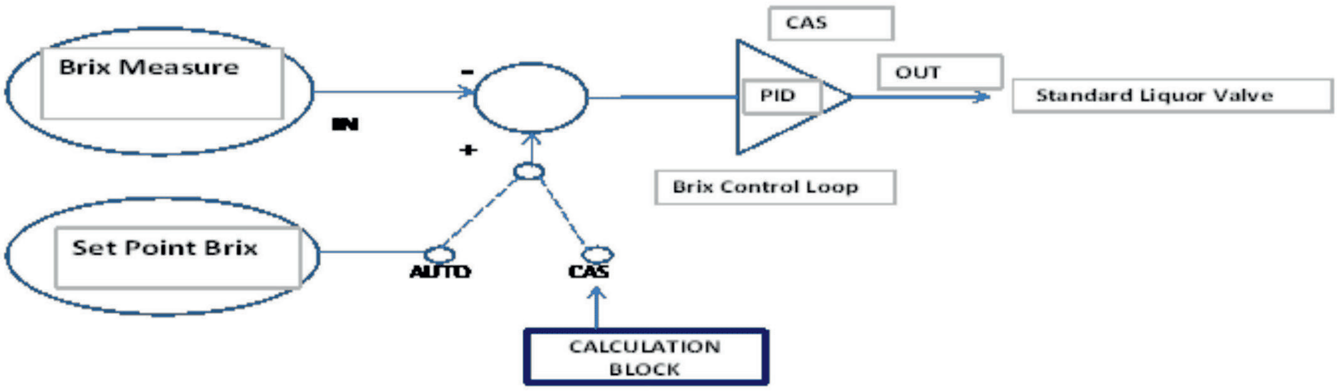

Figure 3 : Command for cascade mode

Functional description of the sequence:

Load stand by: This phase is the stand-by phase. At the end of a process of batch pan, the sequence returns to it. In case of the operator push the "stop" button available at any moment of the process, the sequence return to it. The "start" button selected by the operator starts the batch sequence.

Less Vacuum Creation: This step enables creation of vacuum in the pan and checking of its vacuum tightness. Less vacuum valve opens in this step.

Raising the Vacuum: This phase enables the control of the pan and checks for vacuum loss. The less vacuum valve remains open.

Charging of pan

This step is designed to charge the vacuum pan with fine liquor from the storage tank until the calandria is covered. The standard liquor valve opens. Liquor control valve is opened by the brix control loop in order to charge faster. The less vacuum valve remains open. If the filling level of pan is reached as per set point and the "concentration disable" button is selected, the system remains in same step.

Stand-by before concentration: The pan is put in stand-by under vacuum in case of problems in the process. If the filling level of pan is reached as per set point and the "concentration enable" button is selected, the system changes over to "step 6: high vacuum".

High Vacuum: This phase determines the desired absolute pressure to be maintained in the vacuum pan during concentration. The vacuum of the pan must be as high as possible to shorten the duration of concentration.

- Less vacuum valve is closed and high vacuum valve opened.
- Stirrer is started.
- Vacuum is achieved as per set point.

Concentration : This phase is designed to concentrate the liquor added to the vacuum pan. In this step liquor was concentrated until a first brix threshold with full steam flow on the calandria. Vapour from the steam transformer was injected in the steam side of the calandria. The condensate flows from all the pans are collected in the condensate tank. The sugar vapours were sent to the air cooled condenser where they are condensed.

- Steam valve is opened according to SP given.
- As we concentrate, the level of the vacuum pan decreases. Standard liquor must be added as per level SP.

When the brix reached to set point, the message "please prepare a new seeding" was displayed. The operator has to prepare a new seeding solution and put it into the small tank. Once done, he acknowledges by pushing on the local push button. If the desired brix is reached and the new seeding is ready, the sequence changes over "step 8: final concentration".

Final Concentration: This phase is designed to concentrate the liquor added to the vacuum pan until a super saturation-coefficient value suitable for seeding is reached.

- The stirrer keeps on running.
- When the level is lower than set point, liquor valve opens.
- Once the level is higher than set point, liquor valve closes.

When the brix reaches the desired value, the sequence changes over to the "step 9: seeding".

Seeding : If the "automatic seeding" button is selected, when the brix reaches the desired value and the R-seed distribution system is ready, the sequence changes over to the "automatic seeding". This phase is designed to form the grains required to obtain the wanted crystal size and uniformity at the end of the crystallization process.

- The calculated set point is assigned to the brix control loop
- The stirrer keeps on running.
- Liquor valve is opened as per brix and level.

Manual seeding

This phase is designed to make a manual seeding if the automatic seeding is not available (default of pump, lack of R-seed massecuite, etc.). The operator takes a prepared solution in the lab which he injects manually in the pan. Once done, the operator confirms in the DCS via the "manual seeding ok" button.

When the seeding valve is opened and once the timer has elapsed, the sequence changes over to the "crystals formation" step.

Crystal formation: This phase was designed to create more grains and make the size of all grains uniform before starting the crystallization phase.

- The set point is assigned to the brix control loop which controls the liquor control valve.
- The stirrer keeps on running.
- The seeding valve is closed.
- Steam valve is opened as per set point.

  Then it is switched over to next step-11 "Crystallization"

Crystallization: This phase is designed to raise the crystals, growing the grains of sugar that have already formed without allowing any new sugar crystals to appear. The operator chooses by selecting the appropriate button the "advanced final tightening", the "normal final tightening" or the "delayed final tightening".

- The calculated set point is assigned to the steam control loop which controls the steam control valve.
- The pressure control loop on regulates the pressure according its set point.
- The calculated set point is assigned to the brix control loop which controls the liquor control valve.
- The set point is assigned to the power control loop which controls the liquor control valve.
- The stirrer keeps on running.

  If the operator has selected "advanced final tightening", "normal final tightening" or the "delayed final tightening"., once the level has reached its respective set point, the sequence changes over to the next step: discharge stand-by".

Discharge stand by

This phase is designed to keep the vacuum pan close to discharge conditions prior to proceed to the final tightening. This step remains active in case of problem with the massecuite receiver (not running or high level inside) or for any other reason decided by the operator. The sequence may remain in this phase by selecting the "final tightening disable" button.

During this phase the brix control loop and the power control loop don't control the liquor control valve but the water control valve.

- The pressure and steam control valve are regulated according to set point.
- The liquor valve is closed in this step.
- The water control valve opening is the maximum given by the brix control loop and the power control loop.
- The stirrer keeps on running.

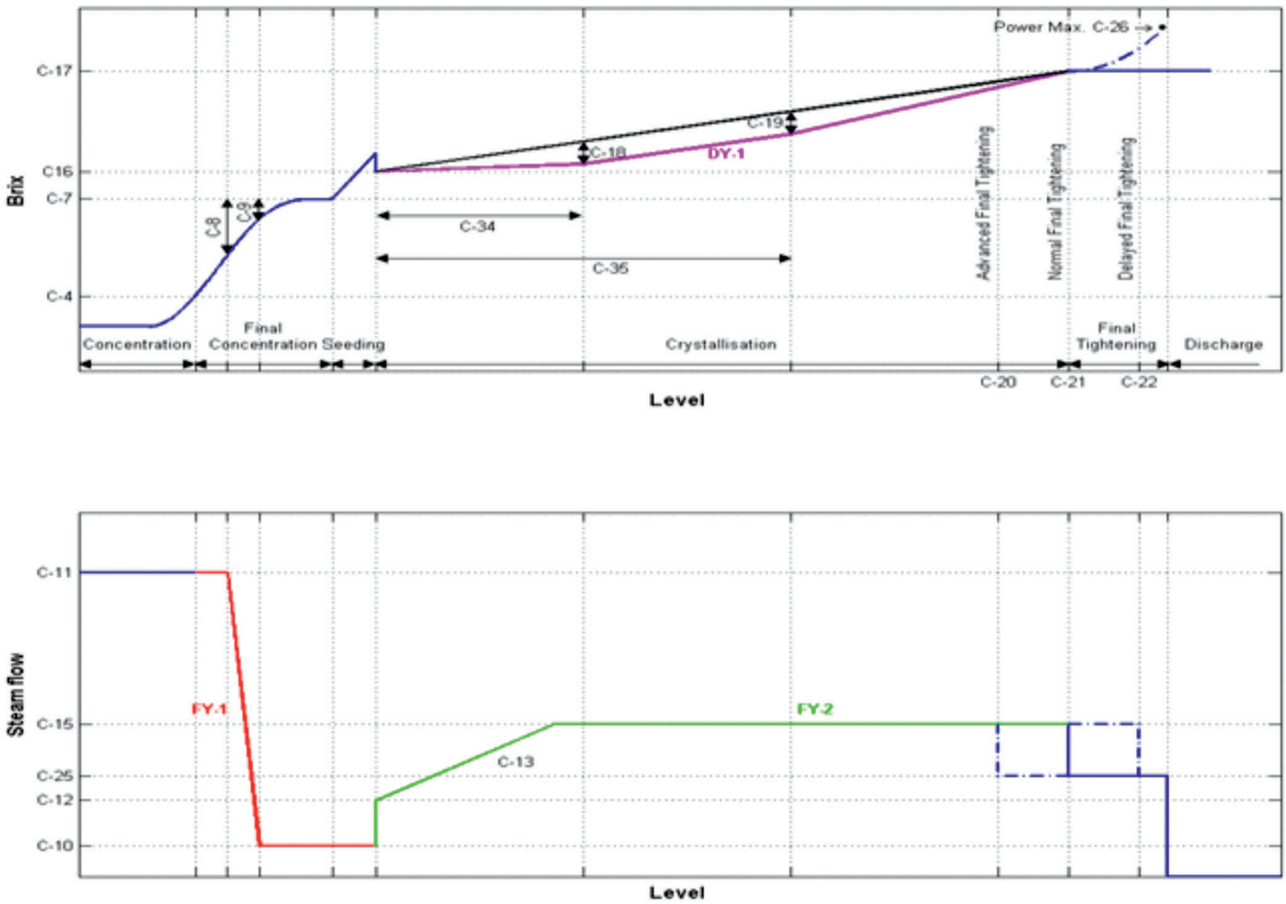

Figure 4 : . Level vs brix and steam flow

If the "enable final tightening" button is selected, the level of massecuite receiver enables the emptying of the pan, the stirrer of the massecuite is running the sequence changes over to the next step: final tightening".

Final tightening

This step is designed to bring the massecuite to the maximum discharge brix conditions. The end of this step is determined by the power of stirrer or by the operator if needed.

- The pressure and steam control valve re regulated according to set point.
- The liquor valve is closed in this step.
- The water control valve is closed in this step.
- The stirrer keeps on running.

When the stirrer power reaches its desired value, the sequence changes over to the next step "vacuum: valve closing".

If needed, the operator may select the "advance discharge" button. The sequence changes directly over to the "vacuum: valve closing".

Vacuum: valve closing

This phase is designed to isolate the vacuum pan (on vacuum side) by giving the time to the vacuum valve to close.

- The pressure control valve is closed.
- The liquor control valve is closed.
- The stirrer keeps on running.

When the timer is elapsed and the vacuum control valve is closed, the sequence changes over to the next step: steam valve closing.

Steam valve closing

This step is designed to stop the vapour inside the calandria of vacuum pan by giving time to the steam valve to close.

- The steam control valve is closed.
- The stirrer keeps on running

When the timer is elapsed and the steam control valve is closed, the sequence changes over to the next step: vacuum breaking.

Vacuum breaking: This step is designed to raise the internal pressure of the vacuum pan to the atmospheric pressure. Pressure increase is done by injecting vapour from steam transformer.

- The stirrer is stopped.
- Steam valve is opened till it matches the pressure set point

When the pressure is higher than set point and the "discharge enable" button is selected, the sequence changes over to the next step: discharge.

When the pressure is higher than set point and the "discharge disable" button is selected, the operator message "discharge disable?" is displayed.

If the timer is elapsed meaning that there is a default in the vacuum breaking phase (vacuum leak, no steam available), the sequence changes over to the "next step: vacuum breaking default".

Vacuum breaking default

This step avoids emptying the pan while it is not at atmospheric pressure. The operator has to select the "reset" button to restart the step: vacuum breaking".

Discharge

This step is designed to fully discharge the massecuite formed during crystallization into its massecuite receiver.

- The discharge valve is opened.
- The steam wash valve is operated as per pressure set point.

When the timer is elapsed, the sequence changes over to the next step: discharge and washing.

If the level switch of the massecuite receiver is covered, the sequence changes over to the step: full massecuite receiver". If the alarm high level of the massecuite receiver is active, the sequence changes over to the step: full massecuite receiver". If the agitator of the massecuite receiver is not running, the sequence changes over to the "step: full massecuite receiver".

Full massecuite receiver:

This step is designed to wait for the level of the massecuite receiver to come back to a normal level or for the agitator to run in order to complete the emptying of the pan.

- The discharge valve is closed.
- The steam wash valve is operated as per pressure set point.

When the agitator runs, the high level switch is not covered and the high level alarm is not active, the operator may select the "reset" button. The sequence restarts the step: discharge".

Discharge and washing: This step is designed for rinsing the pan and the discharge valve to avoid problem on the opening action of the valve during the next batch of the pan.

- The wash valve is opened.
- The discharge valve remains opened.
- The steam wash valve is operated as per pressure set point.

When the timer is elapsed, the sequence changes over to the step: washing.

Washing: This step is designed for rinsing the pan and avoids any massecuite build-up inside the pan. The pan, the seeding pipe and the instruments are washed.

Discharge washing

This step is designed to fully discharge the washing water remaining in the pan. The recovered the sweet water flows to the sweet water tank.

When the timer is elapsed, the sequence changes over to the "step 1: load stand-by".

CONCLUSION

Automation in any industry is a must for achieving the consistent quality of the end product with appreciably reduced manpower. But, the implementation of automation needs higher level of investments for high level instrumentation. The payback period of the additional investment for enhanced automation depends on the size of the plant. Hence, for different phases of automation as described above; the decision is to be taken as per case to case basis. The cost implication involved for achieving different phases of automation has to be worked out carefully. In this refinery in Middle East refined sugar quality of 600-750 micron MA and less than 25 % CV is achieved and it is exporting refined sugar to all Middle East countries and Europe.

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REFERENCE

Bhojraj S.K., SISSTA Annual Convantion (2016). Review of role of automation in evaporators and continuous pan station – concepts suited to present day needs.

Tascon J.D., Latorre J.M., Rodriguez J.G., Gil N.J. (2020). Overview of Crystallization In Vacuum Pans In The Colombian Sugar Industry.