INTRODUCTION OF A UNIT CONTROLLER FOR "A" PAN AUTOMATION AT PONGOLA SUGAR MILL

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Abstract

During the 1989/90 season four "A" pans were automated and commissioned on the pan floor at the Pongola Sugar Mill. This paper describes the development carried out on a unit operation controller, software employed and hardware used. The implementation of the automation programme has led to improved pan exhaustions, better massecuite quality and the ability to reproduce the same boiling profile for each pan.

Introduction

Prior to the 1989/90 season all "A" pan boiling at Pongola relied on the experience and ability of the operator to boil and strike massecuites with the required consistency and quality. From experience gained from the pan control systems developed at Illovo over the past six seasons, and from the requirements of process personnel throughout the CG Smith Sugar Group, a pan control strategy was developed to run on the new generation of "Fisher Provox" control equipment (Appendix 1). The installation was completed during the month of July 1989 and refinements continued to be implemented until the end of that crushing season.

The batch pan operation is a complex discontinuous process that calls for very precise supervision, especially the temperature, brix and level control parameters. The decision as to which control techniques to use within the system is dependent on a number of factors, each of which was designed to give maximum efficiency and optimal control.

The control philosophy, design and layout of the software were set up with the following operational requirements in mind:

- Ease of use by the pan boilers
- A common menu for all the pans
- Total flexibility within the batch sequence
- Eight grades (Profiles) to provide a flexible boiling operation for each pan
- Future cutover, discharge and pan scheduling.

Control Hardware

The CG Smith Sugar Group have standardised on the "Fisher-Provox" range of control systems. One of these systems is the "Univox" Unit Operation Controller, which incorporates the best of traditional loop controllers while being able to effect very powerful batch control operations. The "Univox" system used in the development of the pan control strategy has the capability of handling eight unit points, (i.e. eight pans) each with 24 batch master programmes and all controls related to the pan floor. The control system can be simply described as a stand alone multi-tasking computer, that simultaneously addresses all inputs and outputs within up to 16 card files (card files house all cards that interface with the plant). The control system comprises two 32 bit processors dedicated to supporting a database of some 320 points.

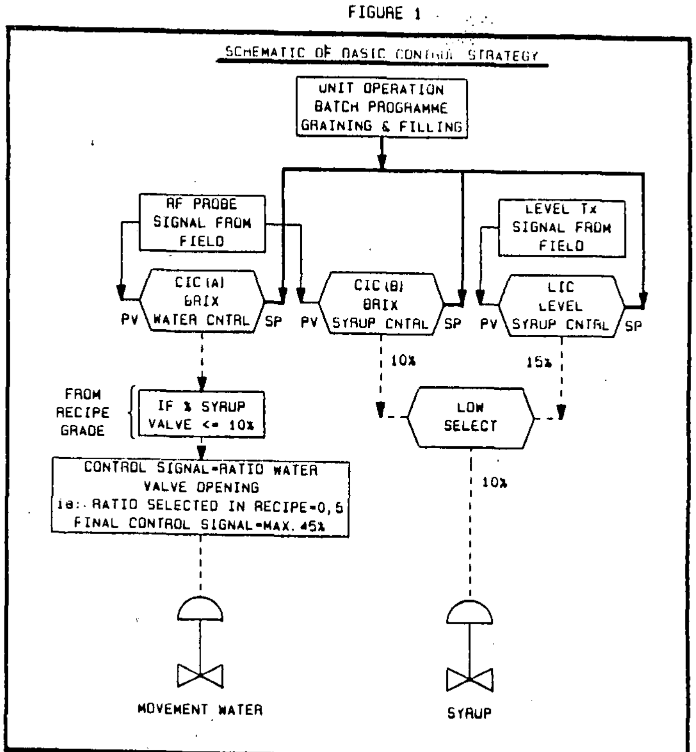
One major advantage of a unit operation controller, which makes it ideal for use on pan control, is the unit point manager. This is a user friendly menu system which provides total flexibility in the following areas:

- Loading batch pan sequence operation
- Holding the operation at a predetermined phase or step
- Restarting an operation after holding a step
- Starting an operation at any selected phase.

Valve Control Strategy

The level and the (B) brix controller outputs go through a low selector as shown in Figure 1 - where the lower of the two signals is used to control the syrup valve.

FIGURE 1



CIC (A) - BRIX INDICATING CONTROLLER (WATER VALVE)
CIC (B) - BRIX INDICATING CONTROLLER (SYRUP VALVE)
LIC - LEVEL INDICATING CONTROLLER
PV - PROCESS VARIABLE (RF PROBE AND DIFFERENTIAL PRESSURE LEVEL TRANSMITTER
SP - SET POINT (ADJUSTED BY THE PROGRAMME)

FIGURE 1

In addition a programme tracks the output of the low selector. When the low selector output is equal to the per cent value set within the recipe grade (viz. % syrup valve open before adding water) the (A) brix controller is set to supervisory mode, and the control action begins to take place on the movement water valve.

The programme ramps up the level and brix set-points over a range of sixteen pre-determined co-ordinates.

Recipe configuration

The system has been designed to be highly flexible and to this end each pan has been provided with a unique recipe (named after the pan) which consists of eight grades (boiling profiles).

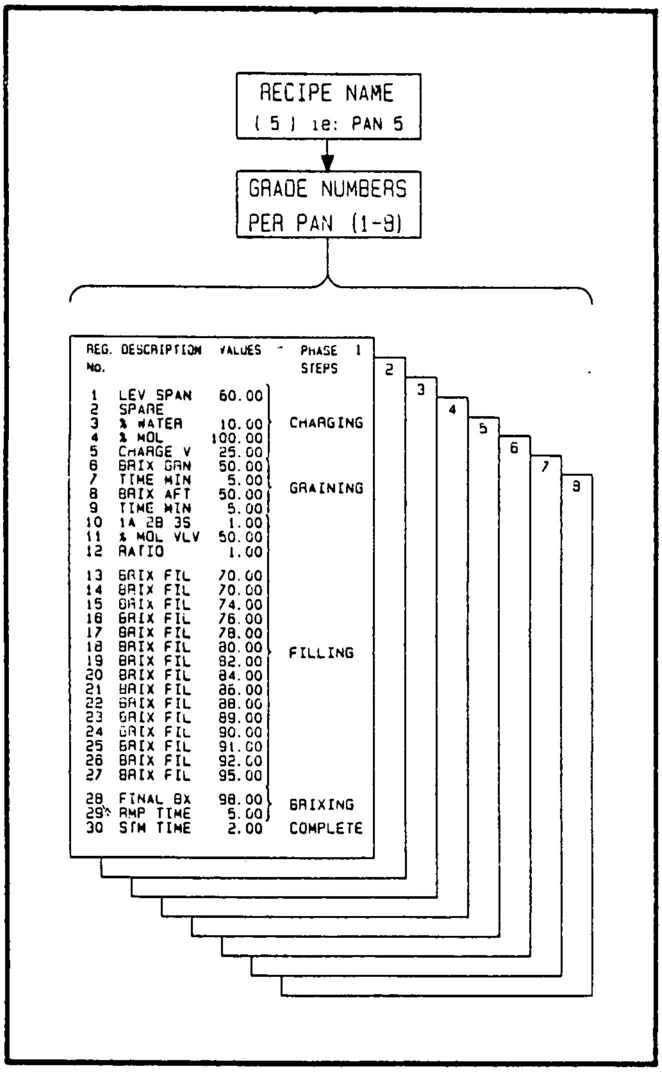


FIGURE 2

It is here in the recipe that all the parameters which are necessary to effect a successful and reproducible batch operation are set up by process management (Figure 2). The parameters that can be changed even while the pan is in operation, are:

- Pan volumes can be reduced or increased
- Feed products such as syrup A and B molasses can be changed at any phase
- Brix set-points, both on filling and prior to striking
- Any of the time periods can be varied.

Pan Control Logics

The batch pan programme comprises the following phases:

- Graining/Charging
- Filling
- Brixing
- Complete
- Shutdown

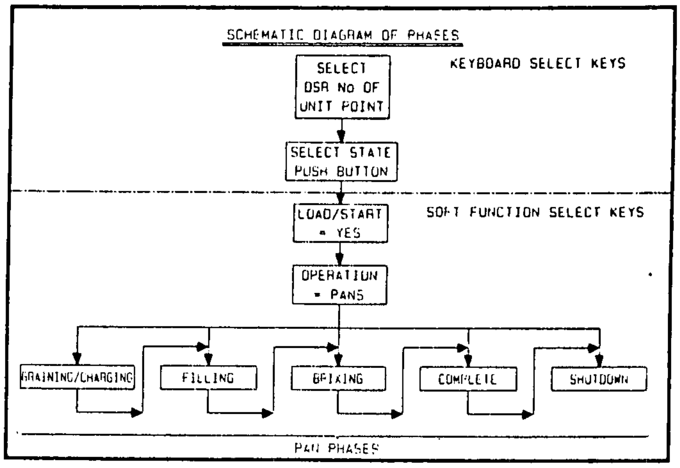


FIGURE 3

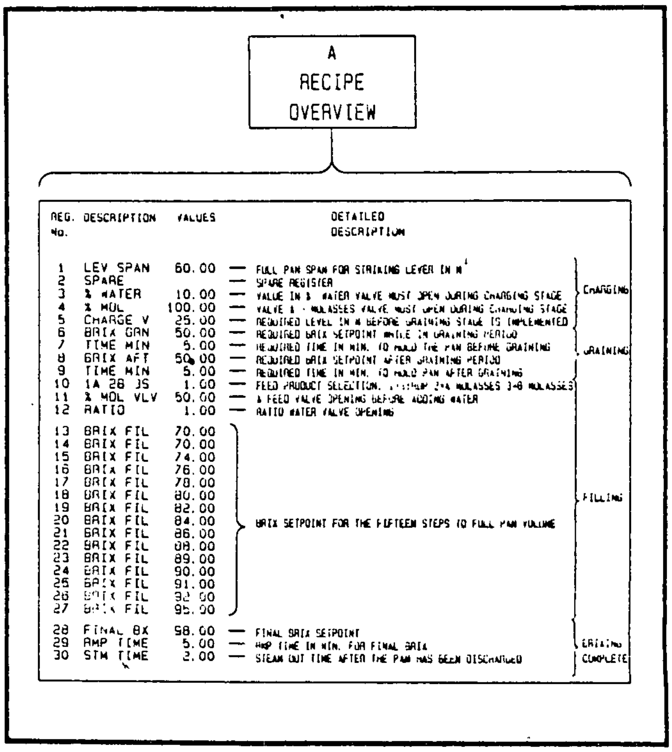
- GRAINING/CHARGING (Registers 1 to 5)
- Vacuum Raising

The vacuum is raised in the pan by setting the absolute pressure controller to automatic mode which causes the injection water valve to open.

- CHARGING PHASE When the vacuum has reached a preset pressure of -40 kPa the charging process starts. The syrup valve is opened to the per cent value for the grade selected and the pan fills to the required charge level. A number of adjustable parameters are available to control this part of the operation (Figure 4).

It should be noted that this operation can also be used to charge the pan with either a magma or seed. In such a case the parameters shown in Figure 4 would be set to meet these requirements.

- GRAINING PHASE (Registers 6 to 9) Once the level has reached the required charge level the massecuite is then concentrated to a pre-determined brix. The level would



RECIPE COMPRISES OF 1-30 FLOATING POINT REGISTERS GLOBAL TO THE CONTROL SYSTEM DATA BASE.

FIGURE 4

normally drop as the concentration takes place, but the level controller will compensate for this by adding more of the charging medium into the pan.

The graining period is crucial to the whole operation and the charge in the pan is brought to pre-set conditions in terms of temperature and brix. After the slurry has been introduced into the pan a consolidation period is initiated and the pan is held on water until this is complete. If magma or seed product is used as a footing, this phase can be bypassed by setting the values in that phase to zero, as shown in Figure 4.

- FILLING PHASE (Registers 10 to 27) This process sequentially feeds the pan either with syrup or water, and in the case of low grade pans, "A" or "B" molasses, in accordance with the selected ratio of water to per cent opening of the product feed valve, and allows the crystals to grow under tightly controlled conditions (per cent brix deviation). The required brix set-points are assigned to the filling volumes of the pan and are selected via the recipe and grades (Figure 4). The filling set-points are calculated as the difference between the pan charge and the strike volume, divided into 15 equal steps.

In addition there is a facility that will automatically change the feed product into the pan at any one of the 15 steps previously mentioned. This is essential on the low grade pans as it allows Process personnel to determine the purity of the final strike product.

- BRIXING PHASE (Registers 28 to 29) The previous phase has brought the massecuite up to a final stage where the pan is ready to strike or cut to another vessel. The final required product brix is attained by the addition of correction water only and by ramping the brix set-point over a desired time period to that brix pre-determined in the grade (See Figure 4).
- COMPLETE PHASE (Register 30) After the previous phases have been completed the operation then passes into this phase after operator acceptance has been initiated.

The absolute pressure controller output is set to the closed position and the vacuum breaker valve is automatically opened. When the pressure in the pan reaches -2kPaG the vacuum breaker valve will close and the discharge or cut-over valve can be manually opened. The level in the pan is monitored using both the level transmitter and the Radio Frequency probe outputs, in order to ensure that the pan is totally empty.

In the case of the level transmitter the output must reach 0,5 M3 and for the radio frequency probe the output must be 100%, after which the steam-out valve will open and remain so until a pre-determined time period has elapsed.

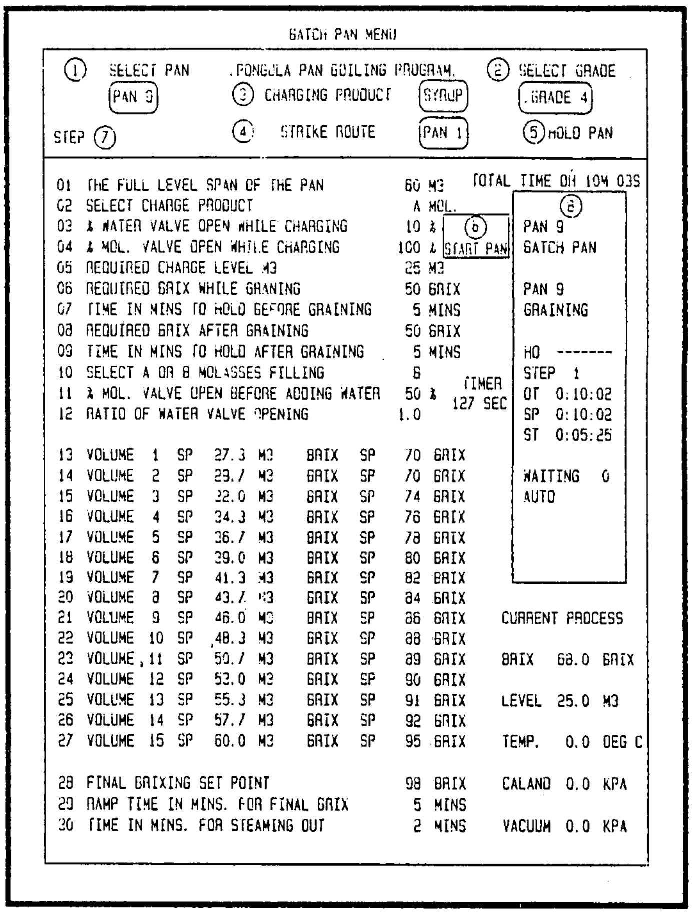
- SHUTDOWN PHASE This phase is normally activated when an emergency pan stop is required. In this case all valve settings will be set to zero (closed) and all control point modes used by the unit operation controller will be set to a manual status.

Batch Pan Menu

The batch pan menu that is used to initiate all the required operations has been designed to be as flexible as possible. In order to use this menu, illustrated in Figure 5, all that is required of the operator is that he understand the function of the 8 DSR numbers (Direct Screen Reference numbers), shown as circled.

A brief description of each function is given in Figure 5.

When DSR 8 (Figure 5) is initiated, the pan will automatically fill to the desired charge level and pass through the required phases until the strike volume has been reached. An operator attention request alarm will be sent out to the field to inform the operator that the pan is ready for striking or cutting.

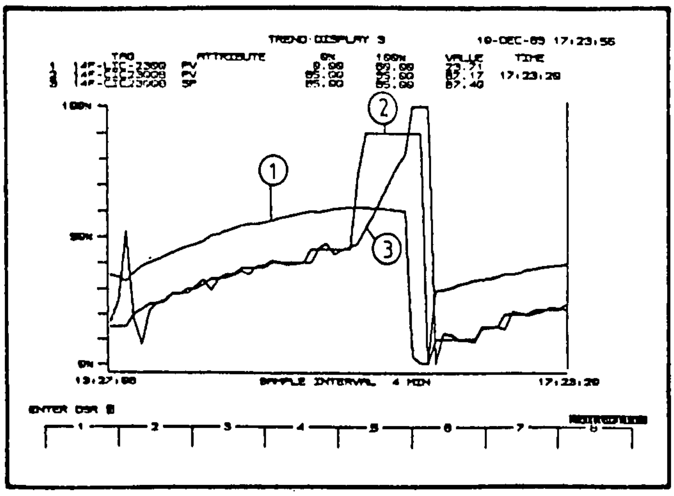


DSR 1 - SELECT WHICH PAN TO START.
DSR 2 - SELECT WHICH GRADE OR BOILING PROFILE HAS TO BE FOLLOWED.
DSR 3 - SELECT PRODUCTS TO CHARGE THE PAN.
DSR 4 - THIS IS AN OPTIONAL FUNCTION THAT HAS BEEN PROVIDED FOR THE FINAL ROUTE SELECTION OF THE PRODUCT ONCE THE OPERATION IS COMPLETED.
DSR 5 - ALLOWS THE OPERATOR TO HOLD THE PAN ON WATER AT ANY STAGE OF THE BATCHING SEQUENCE.
DSR 6 - SELECTION OF THIS UNIT POINT ALLOWS THE OPERATOR TO INITIATE THE PAN BOILING SEQUENCE.
DSR 8 - THIS IS SIMILAR TO DSR 6 BUT WILL ALLOW THE OPERATOR TO CHANGE TO ANY OTHER PHASE AT ANY TIME.
DSR - DIRECT SCREEN REFERENCE NUMBER. ALLOWS THE OPERATOR TO ACCESS A POINT TO INITIATE ITS FUNCTION i.e. STOPPING STARTING A MOTOR, CHANGING A CONTROL POINT FROM AUTO TO MANUAL MODE ect.

FIGURE 5

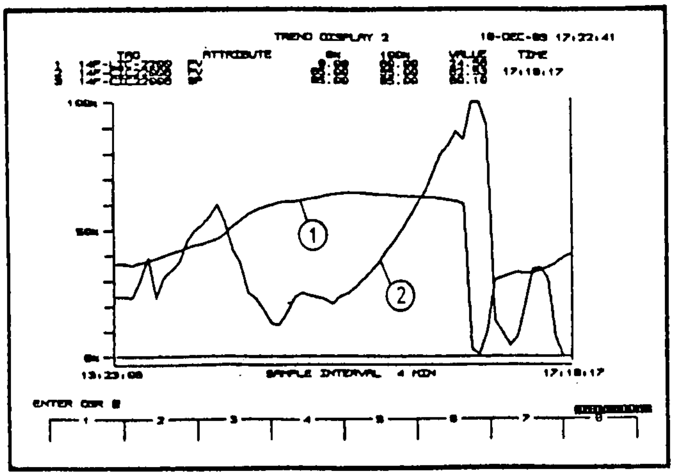
Results

The results that were attained during the closing part of the season indicate that there are benefits to be gained from pan automation. It is clear from studying the two pan boiling profiles shown in figures 6 and 7 that automatic control is far superior to manual control. (Brix and level curves match ideal pan boiling techniques).



1 - PROCESS VARIABLE OF LEVEL CONTROLLER
2 - SET POINT OF BRIX CONTROLLER
3 - PROCESS VARIABLE OF BRIX CONTROLLER

FIGURE 6 Auto control



1 - LEVEL CURVE
2 - BRIX CURVE

FIGURE 7 Manual control

The R.F. (Radio Frequency) probe as a measure of the concentration proved to be both an accurate and reliable means of brix measurement for the high purity boilings. (See Table 2). Further details of the principle of operation are given by Radford *et al.*[1].

Analyses carried out over a wide range of pan brixes show that there is a strong correlation between R.F. and Laboratory brix. Tests were carried out on the pan products prior to automation and again after the pan boilers had become familiar with the system. Results are given in Table 1.

Although there was a slight increase in the pan boiling times there was also a corresponding increase in the pan exhaustion and brix of the massecuite at strike.

Conclusions

Although there have been a number of significant improvements with the introduction of pan automation the development work on the Unit Operations Controller has not reached its final stage. It is expected that in the coming season the boiling times will be reduced and provision has been made to install the necessary hardware to automate the strike and cut-over systems.

Although the R.F. probe has proved satisfactory for the high grade massecuites, the industry is still faced with having to use conductivity measurement on the low grade products. Development work will be carried out during this coming season on an hydrostatic measurement system, that it is hoped will provide continuous readings of both pan product density and level.

REFERENCES

1. Radford, DJ, Tayfield, DJ and Cox, MGS (1988). Further developments in automated white pan boiling using radio frequency control. *Proc S Afr Sug Technol Ass*: 60 pp 94–102.

Table 1

R F Probe versus Lab. Brix

	Linear)	Coeff 1	Std. Error	F	r	t cal.	t (0,90)	Signif
R F vs Lab	43,05	0,52	0,93	230	0,84	15,2	,67	

Table 2

Pan Data

	Automatic		Manual					
	Mean	Std. Dev.	Mean	Std. Dev.	Mean Diff.	t cal.	t (0,9)	Signif
Syrup Brix	60,79	1,72	59,80	2,76	0,99	1,47	1,67	–
Mct. Pty.	84,76	0,56	85,51	0,63	−0,75	4,78	1,67	+
Mct. Brix	91,85	0,64	91,05	0,80	0,80	3,68	1,67	+
Pan Exhaust	69,36	2,44	67,96	3,02	1,40	1,70	1,67	+
Pan Time (hrs)	2,24	0,56	2,11	0,59	0,13	4,29	1,67	+
A-Mct Exhau.	62,89	1,54	63,60	2,34	−0,71	1,21	1,67	–
A-Mol. Pty.	67,35	1,16	68,21	0,94	−0,86	2,71	1,67	+

APPENDIX

INPUT/OUTPUTS DEFINITION

The inputs and outputs that were used on each pan, are as follows, see sketch below:

Analogue inputs

Pan level, absolute pressure, massecuite temperature and calandria pressure.

Analogue outputs

Syrup feed, movement water and condenser injection water.

Discrete outputs

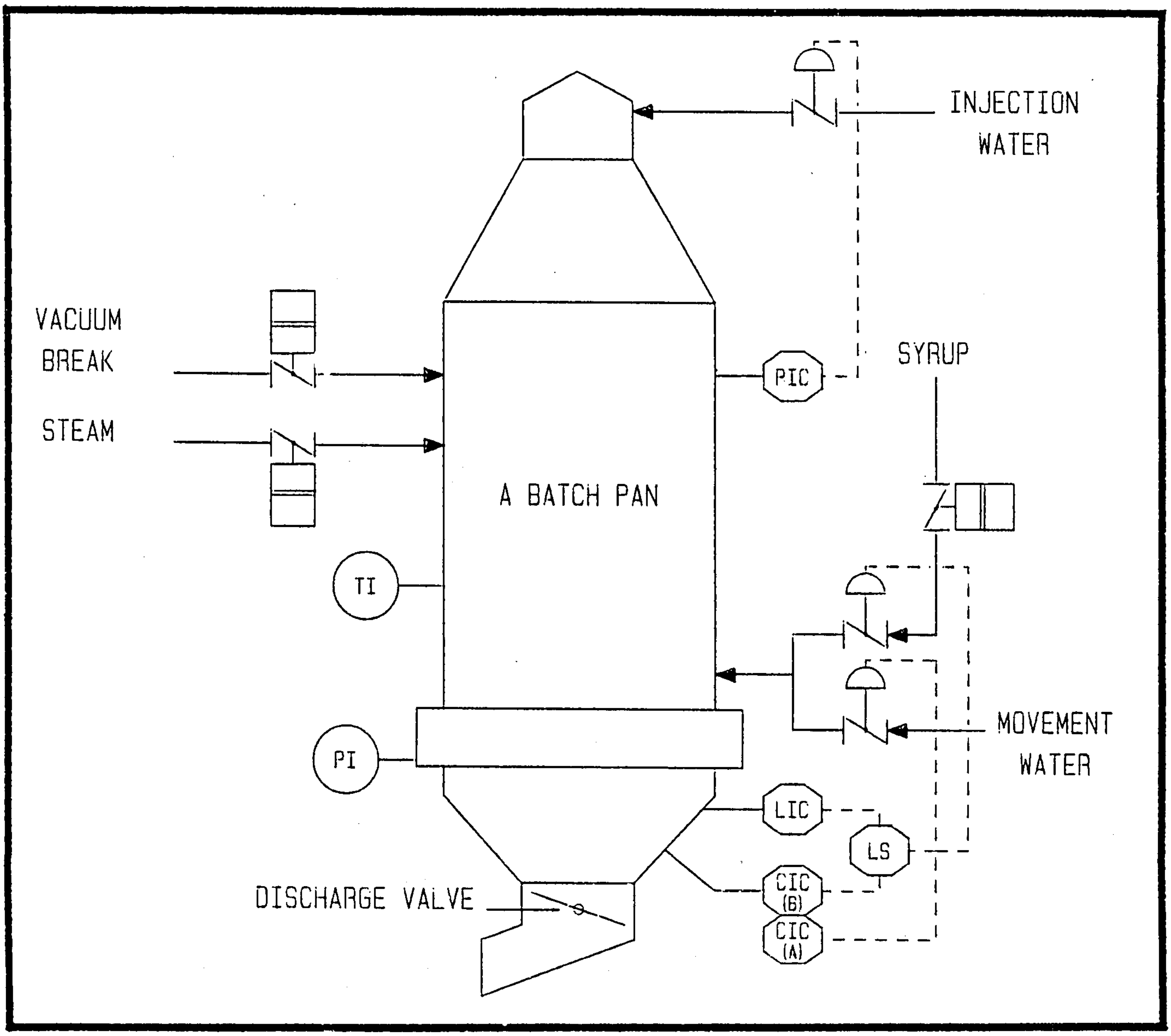
Pan steam out valve, seed valve, vacuum breaker and future discharge, feed and cutover selection valves.

PID control loops

The following control algorithms are associated with the following absolute pressure, brix A (water valve), brix B (syrup valve) and level.

Field instrumentation

Radio frequency probe for brix measurement, differential pressure for level, calandria pressure, absolute pressure for vacuum and massecuite temperature.



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CIC (B) - BRIX INDICATING CONTROLLER (SYRUP VALVE)
LIC - LEVEL INDICATING CONTROLLER (SYRUP VALVE)
LS - LOW SELECTOR
PI - PRESSURE INDICATOR (CALENDRIA PRESSURE)
PIC - PRESSURE INDICATING CONTROLLER (ABSOLUTE PRESSURE)
TI - TEMPERATURE INDICATOR (MASSECUITE TEMPERATURE)