VACUUM PAN BOILING BY PLC LINKED TO A SUPERVISORY CONTROL SYSTEM

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Abstract

During the early part of 1989 a decision was taken to replace the obsolete microprocessor based vacuum pan boiling controller with more modern equipment. A PLC linked to a supervisory control was chosen after consideration was given to many other process control systems. The new system was installed in August/September 1989 and offers distinct advantages over the old system. Point trending, better PID control and alarming all assist with supplying vital information to the Pan Boilers and Production Departments. This has contributed significantly towards optimising the pan boiling control. All this information is to be fed back to the LAN in order to provide plant wide information to authorised users.

Introduction

A microprocessor to control vacuum pan boilings was first installed at Amatikulu in 1978. The system proved to be unreliable due to inferior component specification and construction. The programme was also very difficult to modify or debug on site and often an outside expert had to be called in to assist with these problems. The supplier of the system also lost interest, and consequently no spares were available and back-up service became non-existent.

The system, when it was operational, achieved good boiling results but offered the pan boiler no dynamic information such as levels or conductivity values. The system also had no facilities for historical trending or storing of data. The pan boiler was thus essentially blind as to what the computer was attempting to control.

The system did provide the facility of printing and altering recipe parameters (set-points) and boiling types. A major disadvantage of the system was that one specific recipe was common to all pans and could not be altered individually to suit each pan.

It was decided to install equipment which would overcome these drawbacks and at the same time present the pan boiler with more dynamic information such as graphics, trends and alarms. These functions would assist in producing better boilings because historical control data could now be analysed, interpreted and fine-tuned.

Two groups of process control system were evaluated, namely:

Distributed control systems

Programmable Logic Controllers (PLC) coupled to a supervisory Personal Computer (PC) based system.

General Selection criteria for the equipment

The system had to be an industry standard and not a custom made package.

- Reliable and well engineered
- Adequate product support base in Natal with sufficient technical back-up
- Robust to survive in our mill industrial environment
- Spares and back-up to be readily available at short notice
- Good communication facilities to enable networking and the creation of a real-time management information centre. (Coupled to the local area network - LAN)
- Expandable to cater for complete pan floor automation, (e.g. cut-over valves, pan discharge doors, steaming out etc.)

Technical requirements of the system

- The system had to possess control functions, e.g. PID control, interlocking, lead-lag, averaging, square root extraction, adding, subtracting, dividing, multiplying, timers and counters.
- Remote Input/Output facilities to eliminate long cable runs to and from field equipment
- Expandability from a small system into a large system
- Easily programmable by technicians at the mill
- Offer easy interface between the process operations personnel and the system
- Compatibility with the existing installed instrumentation
- A supervisory system which would easily interface with the selected PLC equipment.

After much consideration was given to both distributed control systems and numerous PLC systems, it was decided to opt for a PLC linked to a PC-based supervisory control system.

Decision justification

The reasons for opting for a PLC/PC System were as follows:

- The PLC could be programmed easily by mill staff. It also proved very easy for fault finding and installation
- The mill staff were already familiar with the PLC concept
- It does not require highly trained professional people to maintain the system
- The PLC concept is modular and well structured on the hardware side and facilitates easy expansion
- The combined PLC and supervisory computer system offer definite cost advantages over other distributed systems
- The "Personal Computer" is already being used at the mill for administration purposes
- The size of each of the mill areas favours the smaller supervisory control system (pan floor, factory, boilers and mills)
- The LAN communications system is already well advanced and makes interfacing easier.

Table 1 shows a condensed comparison between systems based on a fixed I/O count for all eight pans. The more important specifications which had to be complied with were as follows:

- Environmental - withstand temperatures of up to 60°C
  - withstand humidities of 95% non-condensing
- Electrical supply - 220 V AC ± 10%
  - Frequency of 50 Hz ± 3%.
- Maximum standardisation of I/O modules

- Advanced process communications for LAN interface
- Full documentation to allow servicing, configuration and troubleshooting
- Spares available "ex stock"
- System to provide management reports and also to have a "friendly" interface with the operator in the form of a custom keyboard and colour VDU
- Be able to produce hard copies of trends, historical trends and alarms.

Table 1
Comparison of different pan control systems

Supplier	A	B	C	D
Type of System	**Distributed Control System**	**Distributed Control System**	**PLC + Supervisory System**	**PLC + Supervisory System**
Delivery time	20 weeks	12 weeks	12 weeks	6 weeks
Price (R)	189 965	122 724	105 227	95 066
Max. No of digital I/O Points	420		2 048	2 048
Max. No of Analogue I/O Points	64	± 100 Loops	224	224

Equipment

In May 1989 a Modicon PLC together with a supervisory package known as AFE (IC2X) was ordered. Both came from the same supplier, which was felt to be beneficial if subsequent faults were to be resolved.

The PLC is a 984-680 processor which provides 16K of memory, 2K of registers, 2048 discrete Inputs/Outputs, 224 analogue Inputs/Outputs and facilities for 31 remote I/O racks. It was decided to standardise on 24 V DC throughout for the discrete inputs and outputs. The programming language is termed "Ladder Logic" and is widely used in many types of PLC.

The AFE (IC2X) hardware consists of an integrated circuit board which plugs directly into an AT compatible PC, and software is provided on three floppy discs for set-up commands. The monitor is a 19 inch EGA and included is a programmable operator keyboard. The connection between the PC and the PLC is a standard RS 232 connection and the Modicon protocol is simply selected in the AFE (IC2X) set-up procedure. A report printer and colour printer are also connected to the PC. A 40 MByte hard disk and 1,2 MByte floppy disk drive are installed in the PC for archiving data and trends.

During July 1989 the old microprocessor developed a serious fault and could not be repaired with available expertise. It was decided to abandon all efforts to get the unit repaired and rather concentrate on the installation of the new system to all eight pans. The interface wiring was tackled by the local instrument personnel, and simultaneously, software programming was also done 'in-house'. After a week, the first pan was ready for testing. Numerous software bugs were soon eliminated and, within a fortnight, all boil type programmes were running successfully. The first pan was a seeding pan (B & C seed) capable of also boiling massecuites (A, B & C). The other pans were then tackled one by one, and software programming effort was much reduced as it was merely a process of duplication.

The PLC programme was designed to accept each set-point in a separate register, which is used in the PLC for conductivity set-point, absolute pressure set-point, timers and counters.

The Amatikulu pans have eight conductivity level probes on the side of the pan and these levels were plotted against conductivity values to obtain the boiling profile. Ramp functions were incorporated for conductivity and absolute pressure.

Each pan uses approximately 1K of memory in the PLC and 175 registers for set-points, timers and counters. Three PID blocks are used for movement water control, molasses control and vacuum control. Input and Output count is as follows:

11 Digital Inputs	—	8 level signals, 1 start push button 1 manual push button 1 disable push button
14 Digital Outputs	—	8 level indications 1 manual indication 1 start indication 1 disable indication 1 computer indication 1 strike ready indication 1 seed valve
3 Analogue Outputs	—	Water valve fMolasses valve fInjection water valve

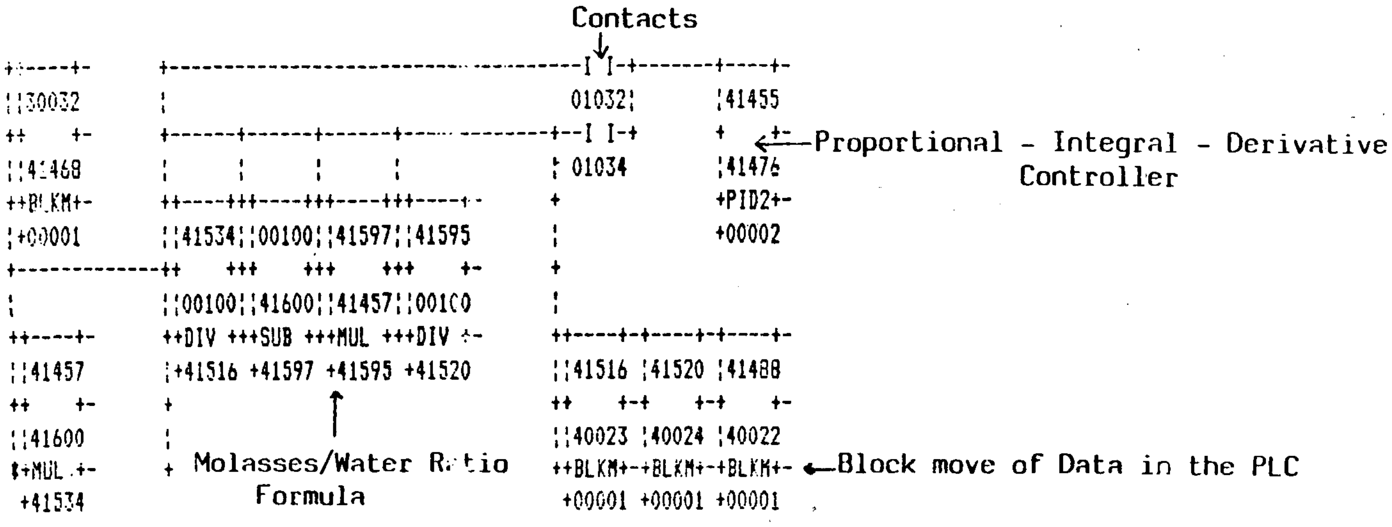

FIGURE 1 A PLC Network (Ladder Logic) showing some of the functions used.

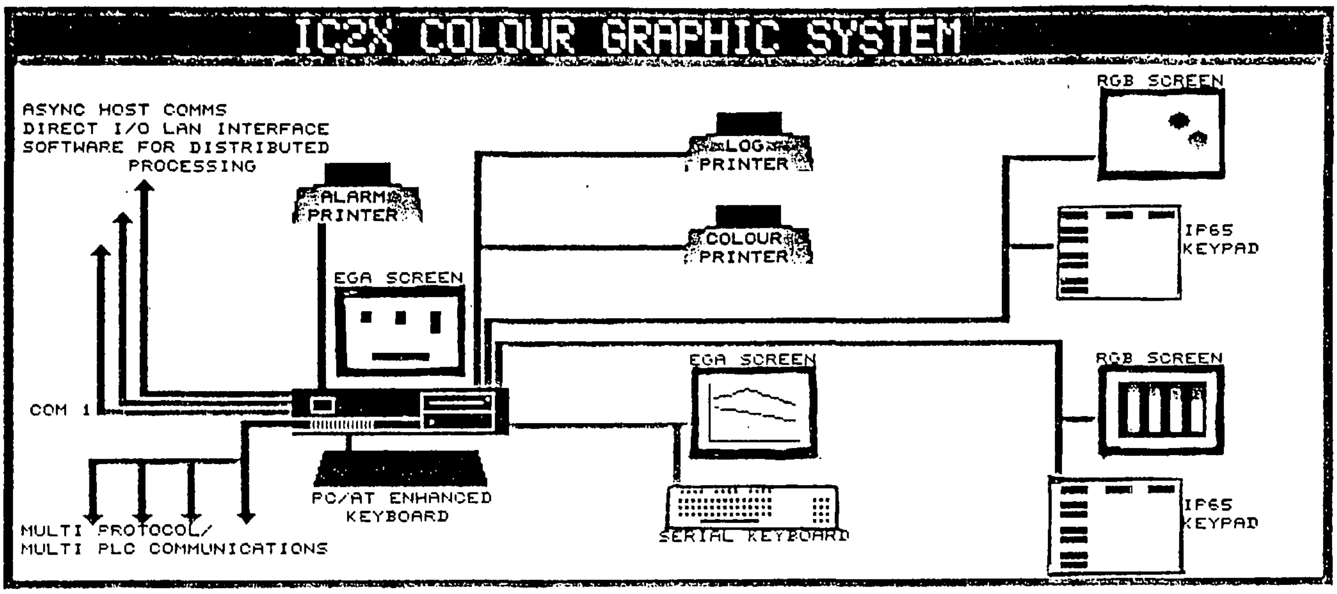

FIGURE 2 A typical AFE (IC2X) System layout.

5 Analogue Inputs — Pan vacuum
Pan conductivity
Tail pipe temperature
Massecuite temperature
Pan level (future)

In the event of a PLC failure, the pan boiler simply switches over each valve to manual mode. This is achieved by turning a selector switch from "automatic" to "manual". This selector cuts out the signal from the PLC and the valve can be adjusted by means of a potentiometer on the local pan panel. This local panel also indicates pan levels and valve percentage openings. This is valid for both automatic and manual boiling.

Supervisory System

The AFE (IC2X) was also configured by mill personnel. The system supports 3000 digital and 1500 analogue points. Buffer points are also available to simplify addressing. Dynamic graphics displays, value trends, alarms, recipes and report writing are some of the standard features available.

The pan system is configured to display all variables concerning the pan conductivity value (bar graph and value), absolute pressure value (bar graph and value), tail-pipe temperature, computer/manual, levels and current boiling identification. All of these points are trended on a graphic page and are also stored on the hard disk for recall at any time.

The recipe is displayed with all the variables and the set point value. Some values can be altered by the pan boiler if the points are enabled. This allows, for instance, conductivity set-points to be changed but not absolute pressure set-points. These can be selected by the Production department. An example of the recipe display is shown in Figure 3.

Historical data on the hard disk can be transferred onto a Lotus spreadsheet and displayed as a graph. Scaling can also be done in the Lotus graph mode. Events are also stored on the hard disk for historical recall at a later stage.

The stem has two printers. A black and white printer is used solely to print out events and alarms as specified and also management reports at predetermined times. A colour graphics printer is used to print historical trends and any other screen dump. The printing of a screen can also be triggered at a predetermined time or by a digital status change in the PLC. An overview of a single pan control is shown in Figure 4.

The pan boiler can view each individual pan parameter on a continuous basis. Trends can be followed to ensure that

PAN 8 RECIPE

1	VACUUM SETPOINT V1	90.0	2	VACUUM SETPOINT V2	90.0
3	VACUUM SETPOINT V3	90.0	4	VACUUM SETPOINT V4	90.0
5	VACUUM SETPOINT V5	90.0	6	VACUUM SETPOINT V6	90.5
7	VACUUM SETPOINT V7	90.5	8	VACUUM SETPOINT V8	90.5
9			10		
11	GRAINING SETPNT C1	53.0	12	CONDUCT SETPNT C2	55.0
13	CONDUCT SETPNT C3	55.0	14	LEVEL 1 SETPNT C4	55.0
15	LEVEL 2 SETPNT C5	0.0	16	LEVEL 3 SETPNT C6	53.0
17	LEVEL 4 SETPNT C7	52.0	18	LEVEL 5 SETPNT C8	51.0
19	LEVEL 6 SETPNT C9	50.0	20	LEVEL 7 SETPNT C10	48.0
21	LEVEL 8 SETPNT C11	46.0	22	FINAL C SETPNT C12	45.0
23			24		
25	W/MOLS CHARGING A1	10.0	26	W/MOLS STABILISE A2	100.0
27	W/MOLS BRING T A3	40.0	28	W/MOLS LEVEL 1 A4	40.0
29	W/MOLS LEVEL 2 A5	30.0	30	W/MOLS LEVEL 3 A6	20.0
31	W/MOLS LEVEL 4 A7	2.0	32	W/MOLS LEVEL 5 A8	0.0
33	W/MOLS LEVEL 6 A9	0.0	34	W/MOLS LEVEL 7 A10	0.0
35	W/MOLS LEVEL 8 A11	0.0	36		
37			38		
39	STABILISING TIME TI	300	40	SEEDING TIME T2	25
41	ESTABL. SEED TIME T2	1500	42	THINNING TIME T4	60
43	BRING TOGETH. TIME T5	60	44	BRIXING UP TIME T6	600
45			46		
47	C3-C4 B/T RAMP TR1	40	48	C4-C5 LEVEL 1-2 TR2	40
49	C5-C6 LEVEL 2-3 TR3	40	50	C6-C7 LEVEL 3-4 TR4	39
51	C7-C8 LEVEL 4-5 TR5	39	52	C8-C9 LEVEL 5-6 TR6	38
55	C11-C12 LEVEL 8-F T9	35	56		
57			58		
59	V1-V2 RAMP TIME TR10	15	60	V2-V3 RAMP TIME TR11	15
61	V3-V4 RAMP TIME TR12	15	62	V4-V5 RAMP TIME TR13	15
63	V5-V6 RAMP TIME TR14	15	64	V6-V7 RAMP TIME TR15	15
65	V7-V8 RAMP TIME TR16	15	66		
67			68		

FIGURE 3 Typical recipe format indicating all the conductivity set-points; vacuum set-points; water/molasses ratios and times.

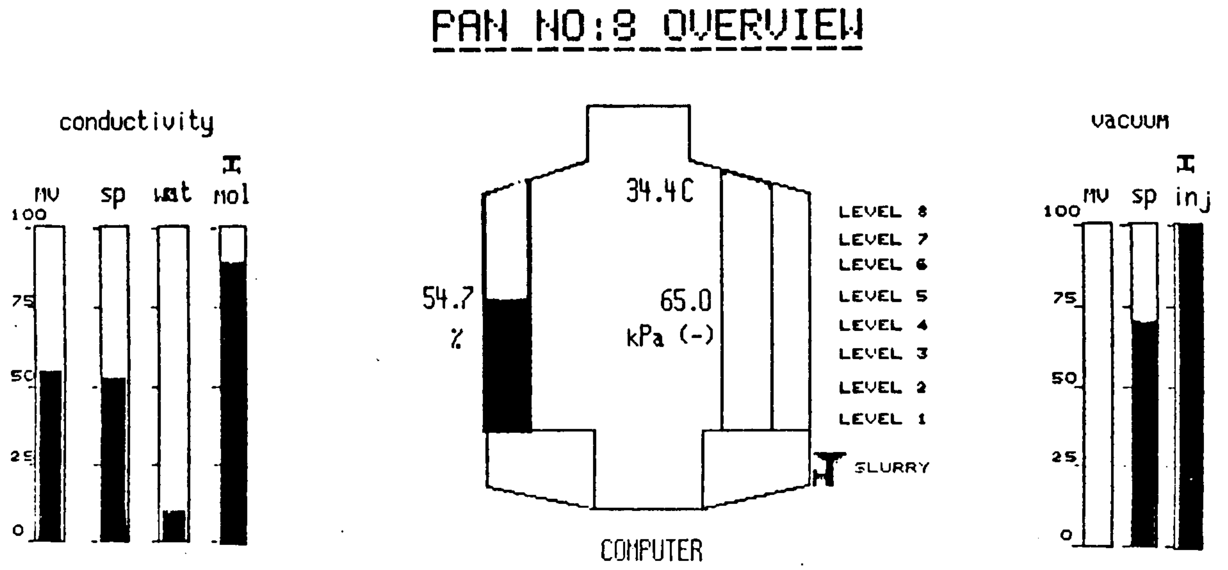

FIGURE 4 A typical overview indicating measured variables (mv), set-points (sp) and valve outputs.

the boiling is according to the specified profile. This can be done as the conductivity value is trended on the same graph as the conductivity set-point.

The conductivity set-point and vacuum set-points can be individually ramped between levels. This feature enables the step in set-point to be smoothed out between adjacent level probes.

Each pan has its own unique recipes. For example, Pan 8 B-seed can be set totally different to Pan 7 B-seed. The pan boiler selects which recipe must be down-loaded, modifies the values which are permissible to change, and then down-loads them into the PLC registers.

An overview graphic has been configured to give personnel a status view of all eight pans simultaneously.

Deviation alarms are also configured on each pan's actual conductivity value. If the actual value deviates from the set-point by a certain amount, say 3%, then an alarm will be brought up to warn the pan boiler of this irregularity. The alarm is also printed on the log printer. This allows the pan boiler to react quickly to a potential problem.

Conclusions

The PLC and Supervisory System proved very easy to configure and programme. Continuing development is proceeding with the management reports and information gathering.

The system offers the Production department all the information necessary for improving pan boiling techniques. It also forms part of a plant-wide information base which will be created at Amatikulu in the near future.