Proceedings of The South African Sugar Technologists' Association — June 1987

PERSONAL COMPUTERS AS DATA LOGGERS IN THE SOUTH AFRICA SUGAR INDUSTRY

By A. WIENESE, K. J. SCHAFFLER AND L. BACHAN

Sugar Milling Research Institute

Abstract

The low cost of the personal computer (PC) has made it the ideal vehicle for monitoring processes in factories and laboratories. Software developed at the Sugar Milling Research Institute (SMRI) has resulted in two PC systems that are capable of simultaneously receiving a number of signals, monitoring these graphically in real time and of storing the data for subsequent analysis. A ten-channel IBM-based data logger has been used to determine the relationship between different milling parameters. A five-channel Apple-based system is currently operating on a pilot vacuum pan to optimise boiling performance. A single channel analogue-to-digital (A/D) system is used to profile raw sugar colorants separated by gel chromatography.

Introduction

The low cost of personal computers has led to a flood of applications in both the laboratory and the sugar factory. In many cases the PC has taken over from larger computers for the calculation of statistics, record-keeping and accounting.

These applications, although important, are not new and may be of lesser interest to the chemist and engineer. The genuinely new field of increasing application is that of monitoring, controlling and recording process events. The PC, when used as a data logger (DL), has a number of advantages over an analogue recording system. Some of the advantages are:

- The raw data can be converted into meaningful data. For example, thermocouple outputs can be converted into boiling point elevation measurements or heat transfer coefficients automatically using built-in formulae. Numerous pressure or conductivity measurements can be averaged and a full statistical report on process fluctuations presented to the technician.
- Using a multi-channel interface board, several inputs can be monitored simultaneously. Although all the inputs are stored, the user can select which channels should be displayed in real time.
- Older scientific instruments (pH-meters, spectrophotometers, Chromatographs) with no computer-based storage capabilities can easily be tied to the DL for data storage.
- Adding additional inputs to the DL is inexpensive. For example, if only 5 of the available 16 channels are in use further channels can be monitored for very little additional cost.
- Due to the mass production of the PC, costs have plummeted. Multi-channel PC-based DL's are now cheaper than their analogue counterparts.

The growth of data logging and control applications is not only due to the cost factor but also to the easy manner in which the PC can be programmed. The chemist or engineer with little or no formal training in software development can now, with only a fair knowledge of a higher programming language, produce software for monitoring experiments or process variables. Generating software in-house has been criticised by some as a "re-invention-of-the-wheel" syndrome. However, it can be the ideal approach as the end-user is closest to the application and is therefore best placed to analyse and design software that will fulfil the project's requirements.

Experimental

Two DL systems (based on either the IBM or Apple II computers) are in current use at the SMRI. The two systems although very similar do have certain software differences. The IBM system is more versatile and has a faster sampling rate. As the IBM PC has become the standard, the description of DL features described below is centred around this system.

Hardware. The system's hardware consists of the necessary signal conditioners, A/D convertor, PC and graphics printer or plotter.

Signal conditioning: The A/D interface accepts a standard 0–9 volts input signal. Most instruments and transducers therefore need some sort of signal conditioning such as attenuation or amplification. The input signal's maximum response should be conditioned to produce a voltage as close to 9V as possible in order to produce maximum resolution. A number of examples of circuits used in the pilot vacuum pan are shown in Appendix 1.

A/D Conversion: A low-cost (R450) 16-channel A/D (with single D/A output) board was used for both PC-systems. The interface card uses the successive approximation method to convert analogue signals into digital data with an average conversion time of 60 micro-seconds. The resolution of the convertor is 12-bit (0.25%) which is high enough to ensure accurate measurements of the incoming signals.

Computer: The manipulation, storage and subsequent retrieval of the data is done by the PC. Both IBM and Apple computers are used for this purpose. The minimum requirements for both PC's are at least 64K of random access memory, 2 floppy disk drives and a graphics screen. The software written for the IBM PC is based on the Hercules Graphics card. The Apple computer was fitted with an 80-column text card to facilitate the calibration process. One of the advantages of using a PC-based DL system is the elimination of reams of chart paper since the data is displayed on the screen and stored on disk. However, a hard copy of the data is sometimes required and therefore a graphics printer is needed. Both IBM and Apple systems have a "screen dumping" facility to obtain a hard copy either during data acquisition or when the system is off-line. The Apple system can also utilise a Hewlett Packard 7475A graphics plotter for high quality plots (see Figure 1).

Software. Most of the IBM-based software was written in compiled Basic. "Graphix", a commercial package was used in conjunction with the Hercules card for plotting the data. The DL programme consists of three parts. The first is general set up, followed by calibration and span adjustment. The final part is acquiring, displaying and storing the data on diskette. Each of these sections is discussed below.

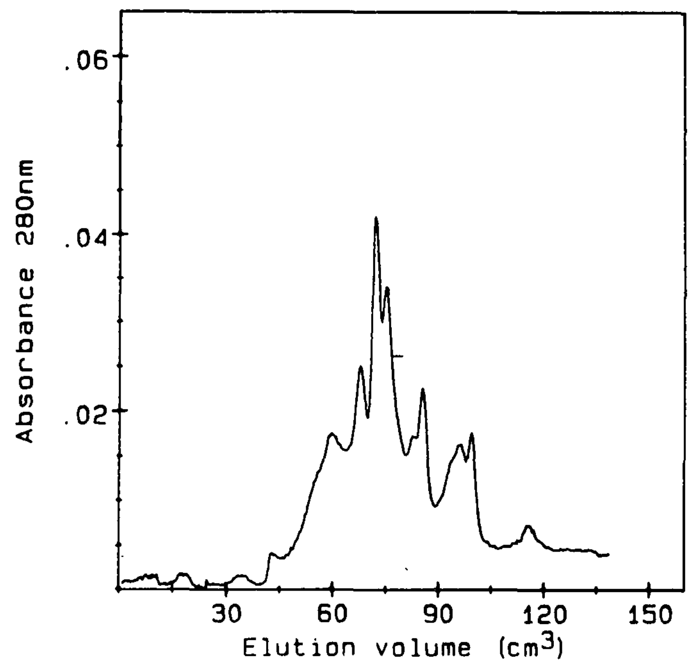

FIGURE 1 Separation of colorants in refinery Feed Liquor on Fractogel HW 40 (S) using the data logger and HP 7475 plotter.

General Set up: The general information that is initially required is the name of the run or experiment, the number of signals to be read, the sampling rate and the duration of the run. Although the A/D convertor can accommodate up to 16 channels, software restrictions have reduced this to 10 channels (5 for the Apple). The sampling rate is in multiples of 1 second. If the requested sampling rate exceeds the actual rate then the maximum speed is selected. Sampling rate obviously depends on the number of channels read and is less than 1 second for a single channel and is approximately 5 seconds for 10 channels. Although the duration of the run is set, the technician can terminate the programme at any time. The only limitation to the duration of the test is the available disk storage space. A normal double-sided, double-density floppy disk with a capacity of 360 Kb is capable of storing 90,000 data points. Reading 6 channels at an average time interval of 2 seconds will allow the user a run time of well over 8 hours.

Calibration: This part of the programme allows the technician to zero and adjust the span of each input channel. An example of a typical screen dump of the calibration table is shown in Figure 2.

TEST DATE : 11-18-1986　　NUMBER SAMPLES : 8141
STARTING TIME : 12:59:40　　FINISHING TIME : 16:58:59

	NAMES	UNITS	CH	X1-VAL	Y1-VAL	X2-VAL	Y2-VAL	X-VAL	Y-VAL
1	TORML	kNm	1	-0.01	0.00	2.74	2000.00	0.89	966.64
2	SPDML	rpm	5	1.00	0.00	4.00	2000.00	2.89	942.62
3	PRSML	kPa	4	1.00	0.00	5.00	3000.00	3.19	1641.09
4	LFTGS	mm	2	1.32	0.00	7.37	50.00	1.69	3.07
5	LFTPS	mm	3	1.35	0.00	6.09	50.00	1.37	0.23
6	TORPF	kNm	0	0.20	0.00	3.61	2000.00	1.02	482.02
7	SPDPF	rpm	6	1.00	0.00	5.00	2000.00	2.81	906.56

FIGURE 2 Graphics dump of the calibration table for milling variables during bagasse dewatering (see text for details)

In the example in Figure 2, 7 channels were monitored. The name and units of each channel are entered into columns 1 and 2. The channel number on the A/D board is then entered into column 3 for each input signal. Columns 4 to 7 are used to calibrate each channel. Columns 4 and 6 are the digital values obtained from the A/D card for calibration points 1 and 2, whilst the corresponding real values, expressed in user units for these two calibration points, are entered into columns 5 and 7. At the same time these columns are used to indicate the minimum and maximum values required for the graphical display of the incoming data. Columns 8 and 9 are not accessible to the operator but are updated continuously and display the actual readings from the A/D card in digital as well as user-defined units. Before ending this part of the programme, the calibration table is stored on diskette; this is necessary if incoming data is to be studied at some later date.

Real time data acquisition: An example of the real time display of milling variables during the investigation of a dewatering mill is illustrated in Figure 3.

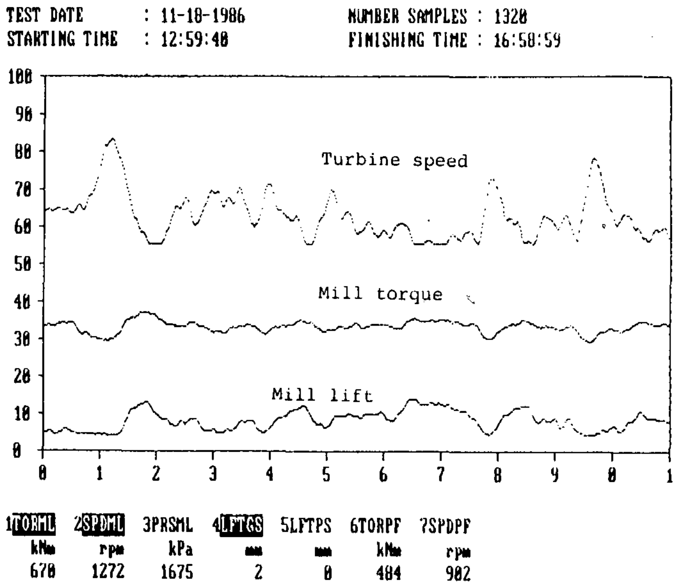

FIGURE 3 Graphics dump of real time monitoring of mill variables during bagasse dewatering. Seven channels were monitored, only three of these were plotted in real time.

The legend on top of the graph indicates the date, starting time, current time and current number of data points sampled. The last three rows of the graphics screen are used to display the names of each input signal, together with the units in which each is expressed and the current numerical value in these user-defined units. The 10 special function keys on the IBM are configured as on/off switches to allow for the display of any combination of graphs. This selection of graphs for display is an on-line facility that can be changed at any time. Signals that are not displayed are also stored on diskette for subsequent viewing or analysis. Random noise is often superimposed on the signal being monitored. Noise rejection is handled by a moving average algorithm. This smoothing feature can be toggled on and off.

Applications

The DL systems described above have been successfully used by the SMRI for the following research projects:-

Colour transfer during sugar boiling in a pilot vacuum pan

The main objective of this project is to study the effect of syrup quality on the transfer of selected impurities during boiling of A-massecuites[1]. The following instrumentation was fitted to the SMRI batch pan:-

- a conventional 2 electrode conductivity probe
- two semiconductor sensors for measuring massecuite temperature and boiling water at the same pressure (boiling point elevation)
- a stirrer torque device
- a pressure transducer.

These signals were all converted to 0–9V and fed into a data logging PC (Apple) via a 16-channel A/D card. During boiling all these parameters could be monitored/displayed on the graphics screen and could therefore be kept within narrow limits by the operator. Lionnet[1] concluded that the DL system was largely responsible for the standard and reproducible boilings obtained and therefore the observed changes in sugar quality could only have been due to quality of the syrup feed liquor. The pilot pan and DL system are shown in Figure 4.

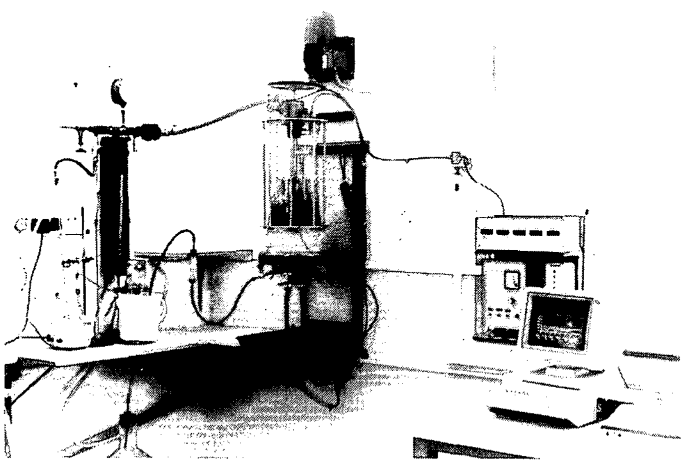

FIGURE 4 SMRI pilot pan, Signal conditioning, electronics and data logger.

Optimising bagasse dewatering mills. By using the PC-based DL system it has been possible to study any combination of related parameters such as mill lift, turbine speed, nozzle box pressure and chute pressure during bagasse dewatering. Wienese[2] has recently described the findings of this project in detail. Figure 3 shows a typical printout of the different milling variables using the IBM-based DL.

Fractionation of sugar colorants by gel-chromatography

Gel-chromatography is currently being used at the SMRI to separate colorants from raw sugar and related products. It is hoped that this fractionation procedure will provide useful information on the origin of certain colorants. The output of the ultra-violet detector, used to monitor colorants eluting from the gel-column, has been coupled to a PC-based DL. The system produces neat A4-size chromatograms. Besides replacing the conventional recorder, the system could be used to monitor up to 5 gel-columns simultaneously. An example of a typical colorant profile is shown in Figure 1.

Conclusions

Staff at the SMRI are now able to assemble their own simple, yet effective, low cost data loggers using either IBM or Apple personal computers. Software design is done in-house allowing rapid programme updates as the needs of research projects change. DL's will allow the chemist/engineer to monitor a great number of variables (eg pH, temperature, pressure, conductivity, torque, specific ion electrodes, speed and chromatographs IC outputs). In fact the scope depends upon the imagination of the user. Three recent applications of DL's at the SMRI have shown that due to the high sampling rates and large sample sizes reliable logs of analogue variables can be obtained together with all the advantages that digital computers produce.

REFERENCES

1. Lionnet, GRE (1987). Impurity transfer during A-massecuite boiling. *Proc S Afr Sug Technol Ass* (in press).
2. Wienese, A (1987). The performance of Diffuser Bagasse Dewatering Mills. *Proc S Afr Sug Technol Ass* (in press).

APPENDIX I

Signal conditioning of instrumentation of pilot pan

Variable	Probe	Conditioning
1. Massecuite temp.	Semiconductor	Instrumentational Op-amp
2. Steam temp.	Semiconductor	Instrumentational Op-amp
3. Pressure	Pressure transducer	Amplifier (3 ×)
4. Conductivity	Dual electrode at 6 K cycles	Amplifier-rectifier
5. Stirrer torque	Voltage drop proportional to armature current	opto-coupler-amplifier