COMPUTER SUPERVISION OF PROCESS PLANT - A USER REPORT

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INTRODUCTION

Shell has been using computers for supervision of process plant since the late "60s. Since for the large scale plants that typify refinery operation, computer monitoring and supervision can give improvements in operation that result in substantial benefits.

The system developed, called PROSS (Process Operating and Supervisory System) has been installed on a large number of plants throughout the Shell Group. At Shell Haven Refinery a system has been in use on the Crude Distiller for six years. This paper reports on experience gained on this system and is a user rather than developer view.

BACKGROUND

A11 too often computers are just applied to problems without any clear idea of what is to be achieved. So in this section the problems associated with manual data collection and plant supervision are considered. In particular with respect to the requirements for a computer based system.

The first problem is how to improve the quality and availability of information about plant performance. On a traditional plant most readings, apart from temperatures, come as a value from 0-10 and no correction on flows is made for changes in density. This means that even something as simple as a mass balance requires considerable effort if an accuracy of better than 5% is to be achieved. Also, the time taken to produce information about plant operation means that it is outdated by the time it becomes available. Thus a system that is able to provide accurate and immediate information about the plants performance is the first priority. You cannot make a sensible change in operation if you do not know what your current operation is.

The second problem is how to improve plant operation by both making products closer to the specification, and operating the unit at minimum cost. The basic choice to achieve this is between a system of closed loop control or supervision. At Shell the overriding view is that it can be counter productive to introduce systems that are not transparent to the operator. If it is not clear to the operator why certain action has been taken then the operator does not know whether the action taken is correct or not and does not know whether he should intervene. (This is considered a potential problem with multivariable control for example.) An alternative is to computerise or computer assist the actions that operators take, and thus free them to take higher level decisions. This led to the decision to introduce a supervisory system.

It was decided to develop the system initially for Crude Distillation Units., since they were identified as being particularly complex. Here as many as ten products are produced and plant conditions need to be adjusted depending on the mode, i.e. the crude oil being processed and the product package required. Changes in mode might typically occur every five days. In practice the operators change conditions after looking up the mode in their "Black Books". Thus a supervision system based on these modes was developed.

SYSTEM DETAILS

The information requirements of the system are met by having a variety of levels of average value corrected and in engineering units. The base value is the two minute average calculated from several spot values. All instruments linked into the PROSS system have a two minute value. The next level of information is the one hour average. Here a rolling one hour average is calculated from the two minute averages and the average for each hour stored for a twenty four hour period. The one hour average is only applied to important process variables because of the storage and calculation requirements. Finally, twenty four hour values are calculated by integrating the two minute values from midnight to midnight.

In addition to the conversion of values to engineering units, it is also possible to produce calculated variables from the basic values.

A reporting system was provided that gave a range of report types. These include: VDU reports that give a summary of operating conditions for various plant areas, timed twenty four hour lineprinter reports used for accounting; and plant log reports based on one hour values, used to assess the technological performance of the unit.

Process supervision is achieved by setting targets for certain process variables which may have deviation limits set. Should a plant value exceed the limits an alarm light flashes on a graphic plant mimic in that section. A set of targets for a particular mode of operation may be saved in the system for subsequent recall or modification.

In addition to the reporting system, and mode supervision system, a man/machine interface is required in order to inform the operator of events and to permit the operator to access information. This interface consists of a console with three VDU's and three keyboards. The most used keyboard is the fixed function keyboard which gives access to plant information as either single values, or plant reports. The next keyboard is for mode supervision. This has a key for each section of the plant which lights when a limit is exceeded on the plant area. It is used to acknowledge alarms, to obtain information about the points in alarm, and to obtain summary reports about the particular plant areas. Finally, there is a TTY keyboard for access to some of the more complicated functions of the system.

OPERATOR AND MANAGEMENT REACTION

The initial reaction of operators to PROSS was one of suspicion. They were concerned that the computer was going to take over their jobs. Overcoming this understandable resistance took some three to six months. It was important to assure them that PROSS was there to help them do a better job, rather than do their job for them, and that it showed how important their job was when it was considered worth providing a computer to help them. After this first stage the operators divided more or less into two groups; a minority who rejected the system in favour of the old ways; and the majority whose curiosity overcome their fears and became very skilled at using the system. Not surprisingly the older operators tended to be in the first category, and the younger operators in the second. Another problem encountered was that supervisors did not become familiar with the systems so easily, because they had less reason to use it. Also, they did not wish to display their ignorance to operators and so did not experiment as much.

Interestingly, we recently introduced a Foxboro Spectrum system on our Crude Distillation Unit and one of our other plants. On the Crude Distiller the system was well received. On the other plant, they had no previous experience of computer based systems. Here it met with similar resistance to PROSS when it was first introduced.

It is perhaps interesting to note that management attitudes towards PROSS have mirrored those of the operators. Management have been divided into believers and non believers. However, recently the system had to come off-line to be overhauled whilst the unit was running. This soon made clear the significant contribution PROSS was making to the running of the unit, and there was a clamour to have the system on-line again as soon as possible.

OPERATING EXPERIENCE - THE REPORTING SYSTEM

The most significant improvements that PROSS has brought have come from having measured values corrected and calculated in engineering units. Also, calculated variables all-owed such simple things as yields to be instantly available. Together these opened up a new window on the plant because the simple and mundane calculations were taken care of which enabled the process engineer to gain a far more precise view of how the plant was working.

The different time based averages have come to have distinctive uses as experience with the system has developed. The two minute average is most useful as an indicator of the dynamics of the process. Since control is not involved, and process time constants are long, a two minute average is quite adequate. Indeed it is preferable to a value which bounces about every second due to signal noise, as has been found with commercial computer based control systems.

The one hour averages have found their place in assessing plant performance against laboratory results. In practice, the material produced at any instant is affected by the operation of the unit over a period of time due to the hold up of the process, particularly accumulation vessels. Consequently the one hour average has proved most reliable in reconciling plant operating conditions with measured product qualities. This also means that the one hour average is preferred when test runs are performed.

The twenty four hour values are used for oil accounting purposes and for the checking of flow meters. An accurate mass balance is necessary in assessing plant performance. Since even rundown flows are measured by orifice plate meters, confirming the accuracy is important. The method used is to check the integrated twenty four hour value against tank dips. Having ensured that the flows are accurate, they can then be used for accounting purposes to provide daily information on plant yields and energy consumption.

Originally PROSS was intended as a stand alone system and the output for accounting purposes was a series of line printer reports produced on a daily basis. This information had to be fed manually into the refinery accounting system. It was not long before attempts were made to feed the data in automatically. The technical problems were not great since the option chosen was to write the relevant reports onto a magnetic tape, put it in the internal mail, and then read it onto the mainframe computer. Unfortunately, a simple mistake was made in assuming the figures produced by PROSS were always correct. This soon produced a major problem because information which had previously passed through many peoples hands, who checked it for accuracy, was now being put into the accounting system without any checking at all. The solution to this problem was to have the figures verified by the shift supervisor who was given an opportunity to make any necessary corrections before transmission to the accounting system. The effect of this simple change was to dramatically improve the quality of information and reduce the effort required in reconciling operating data.

When PROSS was first installed, considerable effort was put into producing graphic displays and reports. The idea being to make the information easier to understand. It was with some surprise then that it was found that these reports were very rarely used by operators. After talking to operators it became clear that the way that they saw the plant was not the same as the way a process engineer saw the plant, Whilst a process engineer thinks of a plant as a flow scheme which is embodied in pieces of equipment, the operator thinks directly of the piece of equipment, so when you talk about controller PIC152 he thinks of a measurement element six floor down on the north side of the column, and a control valve just behind the compressor on the gas line. Another disadvantage is that because of the space taken up by the graphic, relatively little information can be displayed at once. By far the most popular form of display with the operators was simply the tag number, value and target for the instruments in a particular plant area, arranged in such a manner as to get the maximum amount of information on one screen.

This principal of only providing the essential information required has found a general application. When the system was first installed about six daily reports were produced on various aspects of plant operation, all neatly layed out with tables and headings. It was found that because there were six reports, nobody looked at any of them.

Eventually, all the information was concentrated onto one daily report, ruthlessly eliminating any information for which a clear need could not be established. The new daily report covers just one sheet, but covers is the right description because there is no wasted space at all. On the other hand this report is carefully examined by a number of people who are interested in the Crude Distillers performance.

OPERATING EXPERIENCE - PROCESS SUPERVISION

Just as the early mistake with information for displays and reports was to over do it, so too with the supervision system. The temptation was to set too many targets and to set limits for too many of those targets. The result was that there were always alarm lights up, indeed usually the alarm lights for most of the plant sections were up. Thus, because the operators had no chance of complying with most of the targets, they ignored all of them. The secret again lay in only setting limits on process variables of extreme importance. On distillation columns, for example, that means that the pressure and top and bottom temperature have limits set, but not the reflux ratio, reboil rate and feed temperature.

In contrast to this, when setting limits about targets, it has been found that it is better to set them tight rather than loose. The rational behind this is that the limits are intended to give an early warning when the plant is upset so that prompt action can be taken. If the limits are set too wide on a variable, then the unit becomes upset before action is taken and as a result the adjustments required are greater. On the other hand limits must not be set so tight that it is not possible to run steadily for prolonged periods without exceeding the limits.

Another lesson that had to be learnt is that when an alarm light comes up either the plant is out of trim, or the target is wrong. Initially it is very often the latter. This can be a humbling experience, but also very educational, because it is by getting targets wrong that the temperature quality relationships are discovered. Thus the discipline which using a mode supervision system imposes results in an improved understanding of how the plant works.

The original basis of the mode supervision system was that for any mode of operation a set of target values can be determined which will always apply for that particular mode. Thus, it would be necessary to determine these targets in the first place, but after that it would just be a question of selecting the appropriate mode from the library and plugging it in. Unfortunately, it did not turn out to be so simple. When PROSS was first conceived in the late sixties most refineries ran a relatively small number of crudes. This is no longer the case. Today, in addition to crude, mixtures of condensates and residues are being processed frequently. This means that a very large number of modes are required and the chances of running the same mode are much reduced.

Another problem has been that even where the same mode has been run the targets set during a previous run are found to be incorrect for the following run. The reasons for this are not clear, though small differences in the crude composition, together with mixing of crudes with tank bottoms from previous runs are two possible explanations.

Together these factors have meant that the process engineer has spent a disproportionate amount of time in making sure that the mode in use is correct and appropriate. This has been considered sufficiently important that, just as the mode supervision system was originally envisaged as being an important aid to the operator, software has now been developed to assist the process engineer in providing good modes.

OPERATING EXPERIENCE - HARDWARE AND SOFTWARE

PROSS was originally developed in the late sixties early seventies. Unusually for such a system at that time it was written mostly in FORTRAN rather than machine code. This was a bold step and involved using what were then considered powerful mini computers. It is this decision which has undoubtedly led to the longevity of PROSS because it has allowed developments and improvements to be made relatively easily. In particular, Shell locations using PROSS have been able to develop their own ideas, and the Shell Group as a whole has then been able to benefit from them. Thus it has been a characteristic of the PROSS system software that it has developed to meet the needs of users.

This has not been the experience with hardware. Although writing most of the system in FORTRAN meant that developments to the system were relatively easy, it did not give the system portability to any great extent. Originally PROSS was developed on CDC mini computers, these became dated, and then obsolescent, and finally CDC withdrew from the mini computer market which meant a major change of hardware was required for new systems. Hewlett Packard were selected, and an enormous effort was put into converting the software. Meanwhile, some of the older systems installed on CDC equipment, including ours, were beginning to become unreliable and replacement of the hardware was necessary.

The main lesson is that whilst software systems tend to develop and grow, the hardware on which they are based decay. This means it is particularly important to develop systems so they are as machine independent as possible.

COSTS AND BENEFITS

A system of this type costs £250,000 to £500,000 for the hardware. The software costs are hidden because the system is developed for the Shell Group as a whole, but comparable software would cost at least as much again. Such a system would be capable of covering up to 1000 points on one or more plants. In addition to make good use of the system a process engineer must be dedicated almost full time to PROSS and plant support activities, as well as the necessary resources for system maintenance.

The benefits arise from more steady and consistent operation of the unit which improve distillation yields at a given quality, and also gives the confidence to operate closer to quality constraints. Typically a 50% reduction in quality giveaway has been found. Substantial energy savings have also been possible from operating columns at reduced pressures and balancing exchanger networks. For units of the scale found on an oil refinery, these benefits give a handsome return on investment.

FUTURE DEVELOPMENTS

An "All new" system has completed development and has been installed at a few locations. It has many features aimed at overcoming weaknesses of the existing system. At Shell Haven the existing system is due to be replaced in 1986 and extended to other units at the refinery. It is perhaps indicative of the improvements that have been made that the new system is written in Pascal and uses three DEC VAX 11/750's, although it nominally performs the same functions.

CONCLUSIONS

In using a process supervision system over six years a number of lessons have been learnt.

1. New technology is unlikely to be welcomed with open arms. Winning people over takes time and effort.

2. Different types of average have distinctive uses. A two minute average gives a current value without the noise associated with a single point. A one hour average is suitable for comparing laboratory or quality instrument results with plant conditions when considering changes in plant operation, whilst a twenty four hour integrated value is used for accounting purposes.

3. The information produced by the system for accounting purposes is rarely completely correct. Verification is therefore required. This is best done before information is transferred to accounting systems.

4. Graphic displays are helpful for people unfamiliar with the plant. However, relatively little information can be displayed. Conversely, tabular output gives high data concentration for those who are familiar with the plant.

5. A process supervision system is essentially an information handling and presentation system. It is very easy to present information just because it is possible. Discipline is necessary to present only the essential information.

6. Variables for supervision should be restricted to those critical for plant performance. limits for alarms should be set tightly so that action is taken promptly on a plant deviation. Targets may also be set for other unsupervised variables to give reference values.

7. Use of PROSS has imposed a discipline that has resulted in considerable knowledge being gained in plant, operation.

8. Software develops and improves with time, whilst hardware decays. This makes portability a vital element in the development of process supervision systems.

9. At least a 50% improvement in quality giveaway has been achieved for rundown streams as well as improved economy of energy usage, resulting in attractive payouts for the system.

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