PROCESS AUDITS – RUNNING PLANTS AT MAXIMUM EFFICIENCY

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ABSTRACT

Poor profitability and shortage of funds are discouraging capital investment in the Australian pulp and paper industry; instead there is a focus on cost reduction. However, experience suggests that most plants are running at below optimum efficiency and often have artificial bottlenecks which are limiting capacity.

Careful comparison of the differences between the actual operation of a mill and the originally intended operating parameters, and of the stated reasons for these deviations will often reveal minor changes in procedures and low-cost modifications that can make significant improvements to profitability.

This paper describes how such deviations arise and the procedure by which they can be identified and corrected.

INTRODUCTION

In the current economic climate there is a general reluctance to make large capital investments in new production facilities or even in major upgrades. However, there is still a significant focus on reducing operating costs. All too often this is achieved by cost-cutting measures and by minor upgrades of pieces of equipment.

An alternative which is all too infrequently considered, but which will often result in a much higher return on investment, is conducting process audits. The objective here is to compare the actual operation of the plant with its original design intent and on the basis of identifying the reasons for these differences to improve its performance.

Technical visitors to a plant will usually find a large number of practices which deviate from the official way that the plant is to be operated. If these visitors were involved with the original design or operation of the plant, they will find even more deviations from what was originally intended.

During a hypothetical plant commissioning phase, machine A has a mysterious gremlin.

The start-up engineers tweak the associated flow rates, pressures, and temperatures to get some product out of the front door- at this stage it is output, not efficiency that matters. The process stabilises but the original gremlin remains lurking in the background noise.

The 'start-up cowboys' are replaced with real engineers, and new and enthusiastic operating staff.

The overall plant performance is gradually squeezed up the start-up curve.

Plant reporting and the operating budget become fixed, and process centrelines are established, BUT, all of these incorporate allowances for the original malignant and undetected gremlin.

There is an old American adage that when you are up to your ears in alligators, you tend to lose sight of the original intention to drain the swamp.

Figure 1 These are not logs floating to your timberyard

We believe that it is essential to carry out a broad brush process audit on a regular basis.

This means going back to the original process design model and asking?

- *Is the plant operating as intended?*
- *Are the planned outputs, efficiencies, and production rates being achieved, or even bettered.*
- *Is there perhaps, better technology available that could be considered?*

Examination of administrative procedures will usually uncover similar deviations for official practice. The reasons for these deviations and the corrective actions are very similar to those for process plants, but fall outside of the scope of this paper.

ANALYSING THE DEVIATIONS

A process audit will begin by comparing actual operation of the plant with both the current written operating procedure and usually with the original design parameters. This last point is particularly important if this is the first time the plant has been audited, as operating procedures can develop to become means of enshrining inefficient practice.

Actual operating parameters can be found both from current instrument readings and trends, and also from records – it is important to pick up deviations which are not continuous but which occur relatively frequently. This study will also indicate which parameters and variables are unstable or erratic during operation.

Once the deviations have been identified, the next stage is to determine why written procedures have been abandoned. This will usually start with discussions with operators and supervisors, plus some investigation of documentation (which may or may not exist).

Many types of explanation will be identified, many of which will be variations of the following:

- Problems were encountered during commissioning while feed conditions to the unit deviated from design. Operating conditions were altered to accommodate this. Feed conditions have now returned to what was originally intended, but the revised operating conditions have been retained. Sometimes it is claimed that it had been proved during commissioning that the design operating conditions did not work.

  This is particularly common with filters and similar equipment. During commissioning the feed was either colder or more heavily contaminated than design and required more wash water. The additional water is no longer necessary, but is still applied. This does not create any problems in the filter, but may produce a bottle-neck in equipment processing the increased volume of filtrate.

- There is no record of why the change was made, but things work this way so there is no perceived reason to change it back to design.
- Altering certain set points makes operation easier. This is commonly found in plants where it is easier to operate equipment in a less stressed or less efficient manner.

  A common example of this is gross overdosing of some reagent to avoid problems when there are excursions in feed conditions. Unless the reagent is very expensive this will tend to go unnoticed and it may become lore that such high dosing is necessary. It is not uncommon for there to be routine laboratory testing of the feed and a recommended dose rate (including a safety margin) given for the next day. In the plant this recommended rate is routinely doubled (or worse).

- The official procedure is inconvenient and there is normally no check on whether it has been followed. Therefore there is an advantage in not using the official method. This situation is not commonly encountered in continuous operation and will not always be discovered in a standard process audit (unless the terms of the audit are to include such procedures).

  However, it is often encountered in batch and occasional activities; some common examples of this type of deviation include:

- Safety precautions – time can be saved by not properly isolating the plant, obtaining safety clothing, completing documentation.

  Fortunately, this is less common than it was a few years ago.

- Maintenance procedures – taking short cuts in isolation procedures and in actually undertaking maintenance.

  A plant with a lot of pressure equipment had a large number of bursting disc failures in some areas. We found that the failures often occurred shortly after a bursting disc had been replaced. Further investigation showed that the official maintenance procedure was greatly simplified from the manufacturer's instructions in that it did not require correct placement of the disc or appropriate bolt tensioning procedures

- Batch processes and start-up procedures – this is a fairly common case where time and effort is saved in hurrying processes to get back on line quickly at the expense of damaging equipment.
  - *Instead of curing refractory properly after lime kiln repairs, one mill would heat the kiln as fast as possible in order to be back in production within 12 hours of repairs being completed. Needless to say the repaired refractory did not last long.*
  - *In a particular process it was necessary to continuously add a small dose of reagent to an intermediate tank to control an impurity and a dosing system was provided for this. When starting from cold with a fresh charge of raw material upstream of this stage it was necessary to add much larger quantities of reagent for several hours. This was done by manually tipping in bags of reagent.*

    The approved procedure was to add 2 bags every 5 minutes (to a tank with a residence time of 10 minutes). The operators found it easier to add 8 bags every 20 minutes and rest in between. The reagent was used at the same rate, and no one would have known the difference apart from the problems caused downstream by the fluctuating impurity levels.

- The change was introduced at a time when maximum throughput was essential and some loss of efficiency was acceptable to give higher production. Normal conditions have now been restored, but the changed procedure remains, even though it is now reducing overall profit. It is probable that the plant is easier to operate under these less efficient conditions. (The converse of a change to improve efficiency at expense of throughput is also encountered, but less often).

  An example of being stuck in a low throughput mode:
  We were asked to participate in a project to achieve a 25% increase the throughput of a process producing a side-product. The plant had operated for many years at low throughput when demand for the side-product was low, but it was now becoming a major component of the profitability of the plant. Known constrictions had been removed and capacity was now close to the nameplate level.
  On investigation we found that there were still several important instances where the plant was operating far from design. One such deviation was a main, known bottleneck which, if operated to design, would have spare capacity – there was no reason for not operating it to design except for habits.

A partial audit of the plant found that 15% more throughput could be achieved without capital expenditure. Of this 15%, two-thirds would still be available after the capital equipment had been installed for the 25% increase upgrade (i.e. the upgrade would in fact give a 35% increase for the same budget.

- A piece of equipment has become a bottle-neck, so the load has been reduced there and the rest of the system has been adjusted to accommodate this. Once identified, this type of problem is comparatively easy to fix. There is a choice of spending money (usually a relatively small amount) to buy a new pump or similar or to accept the loss of efficiency. A relatively simple cost analysis will usually reveal which approach is best. In some cases there is an alternative solution of altering the flow to accommodate the bottleneck while not impairing the functions of the rest of the system.
- The plant will not operate the way it was designed. This requires investigation, if this has not already been done properly.
- The feed or product requirements have changed and this is how the plant must now operate to accommodate this change. Experience shows that this was often really only a transition problem, and the plant could now revert to efficient operation

Despite the different reasons for deviations, they are all deviations from best performance and the next stage is to investigate whether the reasons for the change are valid and whether the design settings should be restored. This can only be done by consideration of the plant's performance parameters and often by undertaking some tests.

If a reasonable process model exists it is desirable to use it to predict the probable consequences of a deviation from and restoration of standard operation. A particular benefit of this analysis is to discover 'knock-on' effects in other parts of the process. These will often be where the real cost of the deviation is borne.

An upgraded pulp mill was experiencing difficulties in washing the pulp to specification. It therefore increased wash water flow with an increased, but acceptable cost.

However, this resulted in increased flow and reduced concentration of black liquor to the recovery section. The increased flow used up all the spare capacity of the evaporators, and the reduced concentration resulted in foaming and contamination of the condensate which required it to be diverted to the spill system for re-evaporation. A vicious circle developed which ultimately led to enforced reduced pulp production to avoid contravening the mill's discharge licence. (The problem was ultimately solved by improving the way that the wash water was applied, less to the diffusion washer, and adding a 'sweetening line' to allow recycle of concentrated liquor to the evaporator feed tank to keep the concentration above the foaming point).

If a mill model does not exist, it is unlikely that it is worth developing it just for the purpose of a process audit, but other benefits suggest that a modern mill should have such a model anyway.

THE RESULTS

Investigation of the reasons for the deviations from recommended practice will typically lead to one of five outcomes;

1. The change is not for any very good reason, but it is innocuous and can be allowed to continue. In our experience this situation is rare.

2. The change is not for any reason which is still valid and is harming plant performance. This will typically be the case for 25-75% of the deviations unearthed. These require immediate attention.

3. The change does reduce process efficiency/profitability, but the adverse effect is small and is outweighed by the benefits in ease of operation. In such cases it may still be worth investigating whether the improvement in operation can be achieved by some other means that has less adverse effect on efficiency.

4. The change is a desirable one. This will be most of the balance of cases. Here the 'official' procedures should be modified to reflect the improved operating method. However, this should not be the end of the consideration of the change. Unless a proper investigation was made before the change was implemented, it is still desirable to investigate whether the change has been large enough, or whether there was a better way in which the need might have been managed.

5. The reason for making a change was valid, but the actual change made was not the best one. This will occur in perhaps 5-10% of the deviations found. It can be one of the most difficult to analyse properly and to implement the better procedure.

The appropriate actions in each case are obvious, but there remains the question of how these actions are implementation and enforcement. This will be discussed briefly below.

CENTRE-LINING

At this stage of the investigation it may also be desirable to look at the issue of 'centre-lining'. If profitability and product quality are to be maximised it is not enough just to operate 'within an acceptable range' the objective should always be to operate as close to the target values of the parameters as can be managed.

Figure 2 When near enough is NOT good enough

The ethos should be that an 'operating tolerance' is the most that can be tolerated, but the objective is to be in the centre of the target.

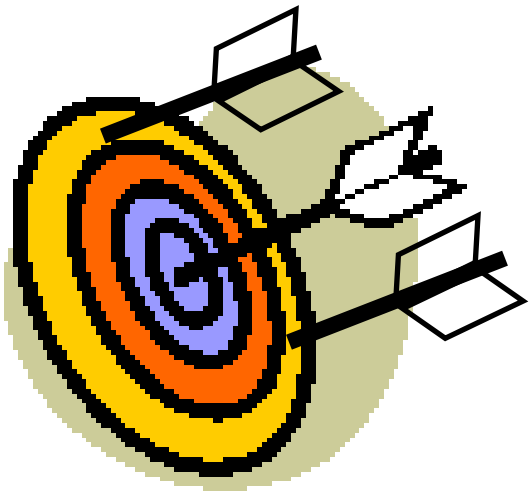

Figure 3 The arrows are all on the target, but do they all score the same?

For many or most mills this will require a major shift in culture, perhaps more so by management than by operators, as it is up to management to recognise that this will not happen by itself and that it must provide the resources to permit it to happen.

This is a very worthwhile exercise, and everyone will benefit. However, it must be recognised at the outset that the true centre-line is not necessarily where people thought it was before the exercise began.

IMPLEMENTATION AND ENFORCEMENT

It is not enough to identify changes that should be made; these changes must be put into effect. A note in the operators' instruction log is not enough. What has to be done is to cure bad habits. This requires training (often only for a very short period) to explain why the current practice is wrong, what the correct practice is to be, and why this offers advantages.

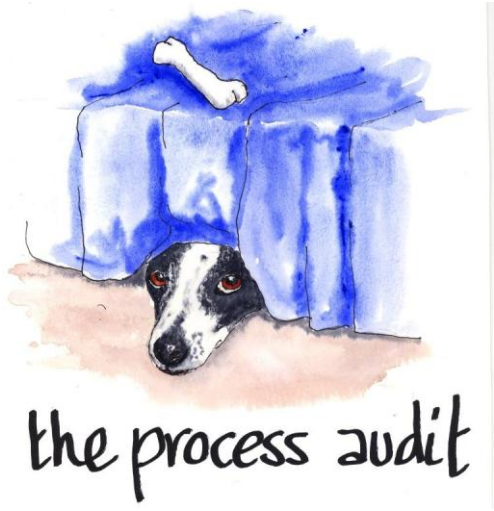

Figure 4 Not the process audit!

With modern control systems it is usually comparatively simple to configure alarms to display when the set point or measured value is far from the new target. This will reinforce the operator's objectives, and if suitable alarm logging exists it can also alert supervisors to cases where new objectives are regularly being neglected or not achieved.

Production staff (NOT technical staff) will also need to monitor performance regularly and to insist on the proper standards where necessary.

If centre-lining is to be adopted, this requires much more extensive training as it represents a cultural shift for most mills. Implementation and enforcement requirements are similar to those described above.

FREQUENCY, EXTENT AND PERSONNEL FOR AUDITS

The frequency with which audits should be conducted is primarily a matter of economics. If the plant has never had an audit before it is probable that a lot of corrections will be required, and if these are maintained future audits will be much less expensive to perform but will produce less benefit. Unless the organisation has the will to implement and maintain the benefits arising from the audit, there is little value in undertaking the exercise.

Typically periods of less than two years will not be cost effective, but five years is too long for good operation to be maintained between audits.

Theoretically the entire site should be audited in one co-ordinated study, as this will maximise the ability of identifying knock-on effects between different parts of the operation. Also any change in operating culture can be introduced uniformly.

In practice, such an exercise is expensive and difficult to administer. Therefore, it is better to work by sections, but each section must be large enough to be a distinct stage in the plant operation. The first time an audit is performed restricting it to one section of the plant also enables the benefits of the exercise to be seen from what amounts to a trial project.

One of the most important decisions is who should undertake the audit.

In making this decision it is essential to remember the human factor and that emotional issues are likely to be as important as purely rational ones if the outcome of the audit is to be effective.

For the process to work it is essential that people understand that this is not going to be a witch hunt and that no one will be blamed – the objective is more efficient future operation, not punishment for past oversights. The auditor has to be someone to whom the audited is able to admit that things have not been done in the best way in the past. If this trust does not exist then defensive or obscuration tactics will be employed and the benefits of the audit will be lost.

An effective audit cannot be performed by someone from the unit being audited as they would be too close to the problem and too likely to accept that any deviations are for good reasons. People from other units on the same site will usually be among the worst to pick for an audit because it will be difficult to avoid "point scoring" and "face saving" tactics. Using an auditor from a different site of the same company usually reduces, but does not eliminate these problems – much will depend on the culture of the organisation and the nature of the relationship between different operating sites.

Establishing a central group from 'head office' committed to this task looks attractive superficially, but will generally be very bad for two reasons. Firstly, there will be a high perceived threat. Secondly, most companies will have a tendency to disband or borrow from this type of group whenever there is an economic problem. This detraction will usually presented as a cost saving measure and as putting responsibility back to production sites – the

outcome will be to defeat the purpose of the exercise.

Figure 5 I'm from head office, and you should not feel threatened by this process audit

The best approach is to use an outside consultant. This minimises the territorial issues and has the advantage of using someone who is not too close to the everyday issues of the plant and who is most likely to see new issues and solutions.

As an example of what this approach can achieve is a site not in the pulp and paper industry. Covey Consulting started auditing parts of the client's operation as a loss reduction program (the client probably still does not think of the exercise as a process audit). This led to improvements in operation and the whole-hearted adoption of the principles of working to targets by the company.

Operations staff of the organisation check the operating parameters against target on a daily basis, and if it has been necessary to operate away from target, they take any necessary measures to allow production to return to target.

Over a four year period the following has been achieved:

- 50% reduction in product losses.
- 50% reduction in losses of expensive reagent.
- Production rate optimised for profit, not throughput.
- Greatly reduced downtime.

CONCLUSION

It is our experience, and that of others, that most pulp and paper mills operate away from the original design objectives, and away from the modified objectives currently in place. Investigation has shown that in many cases these deviations have adverse effects on operating costs and/or plant capacity. Even in cases where the deviations are beneficial, they are often not the best adjustments that could have been made.

Therefore most mills would benefit from a formal process audit. The adage 'old habits die hard' explains why such audits should be repeated every few years.

There are many reasons why deviations from best practice can begin, but once established they can be very difficult to identify, particularly by those most closely associated with the plant. Therefore cannot be undertaken by the staff of the mill where the plant is located, and to be most effective, audits should be conducted by someone from outside the organisation.