Preparing for commissioning

McKinley Mill, USA. Photo: Dennis Shore

This paper, by GEOFF COVEY[1], DENNIS SHORE[2], REG HARVEY[3], GERKE FABER[4] was presented at the 65th Appita Annual Conference and Exhibition, Rotorua, April 2011.

ABSTRACT

Many projects go well until they enter the commissioning phase and then even comparatively minor problems can cause a disproportionate amount of trouble and delay.

The commissioning stage of the project is the time when delay is most expensive because the plant is paid for but is not yet producing an income. It is also the time when there is the most attention on the project and impatience from above can cause rash decisions to be made in an attempt to minimise the delay.

If the commissioning experience is analysed after the event (which rarely happens) the reasons for the difficulties can usually be traced back to inadequate preparation for commissioning.

This paper will cite various real-life problems that the authors have encountered and show how these might have been avoided, or at least reduced in severity by proper preparation. In every case, it is not simply a matter of 'being wise after the event'. With proper planning measures could have been in place to address the problem when it arose.

The case studies will also include some for which proper planning in advance did result in avoidance of delays. These cases are often harder to identify because the problems that did not arise or which were solved promptly are simply not noticed or not documented by anyone. This can create difficulties in the next project because the measures which solved problems that did not cause much disruption can readily be omitted.

INTRODUCTION

Successful commissioning of new or substantially modified plant does not happen automatically. It requires appropriate design and preparation. The sorts of measures required for successful commissioning will generally also be useful for routine start-ups of the plant in the future, so there are also long-term benefits in proper preparation for commissioning.

When considering the costs of poor commissioning, most emphasis is usually on lost production time. Although this is important, and easy to quantify, it is generally relatively unimportant compared with the costs associated with damage to equipment and on-going inefficient operation.

Attempts to accelerate commissioning of a plant that was not properly designed with adequate provisions for commissioning can cause considerable damage due to hydraulic hammer, improper warm up resulting in shortened material life of refractories etc. and failure to run in or bed in rotary equipment. Even a fairly well managed commissioning period can be the equivalent of several years of normal operation in terms of equipment life. This often leads to compounding of losses, because the damage caused by attempting to avoid production loss early on results in the need for a premature shut (often one which is unplanned) to repair it. Consequently overall the production loss is greater than if more time had been taken over the initial commissioning.

Example 1 – lime kiln bricks

The purpose of a lime kiln is to make pulp, and there is a tendency to fail to give proper consideration to the needs of ancillary equipment.

A mill had a single lime kiln which required at least partial rebricking every year (whereas a well-run mill should be able to operate for 10 years without major attention to the brickwork). Good practice dictates that new brickwork should be gently cured over a 30-50 hour period.

Mill production prided itself with getting lime mud back onto the kiln within eight hours of the end of repairs. This met the KPI of minimising this year's shut, but resulted in another lengthy shut the next year.

Ongoing inefficient operation is often very hard to identify and to control. It is often the most expensive cost of poor commissioning because it adds to operating costs indefinitely. Commonly difficulties are encountered during start-up because the

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[1]Chairman,
[2]General Manager,
[3]Process Manager
[4]Engineering Manager
Covey Consulting Pty Ltd, 660 High Street, Kew East, Victoria, 3102, Australia.

equipment cannot be operated according to design mode early on (e.g. equipment that will normally receive a hot feed initially has a cold feed because of low throughput of plant upstream). Non-standard means of operation are then devised to overcome these temporary problems (e.g. increased wash water or reagent usage). Once the plant is running it then becomes accepted that it has to be operated in this new, sub-optimum, manner ("We proved the standard procedure does not work during commissioning"). The efficiency loss may well propagate through other portions of the plant (e.g. excessive wash water results in overload of a downstream evaporator or thickener) and future efforts are directed towards fixing the symptom rather than the cause.

Such problems can be minimised by proper planning, design and provision of resources.

PLANNING AND DESIGN

Example 2 The wrong sort of planning

A pulp mill was commissioning a 'first-of-its-kind' chemical recovery to replace a very old system.

A detailed plan was prepared for the expected progress for every half-hour of operation from when the first liquor was fired to when the new unit was running at full capacity and the old system was shut-down and de-manned (less than 48 hours later).

No provision was made for any equipment not performing according to expectations or any problems whatsoever. Unsurprisingly, the plan was wrong within the first hour and a prolonged and difficult commissioning followed.

Long before the ineffectual plan was devised, problems had been introduced in the design phase:

- Pilot plant data results were disregarded in preference for operating according to how things were done in a familiar but unrelated plant.
- Untested materials handling equipment.
- No provision made to modify equipment easily if required.

The whole approach indicated an inappropriate mindset for successful commissioning. The approach should have included: an expectation of and planning for problems; equipment with excess capacity in areas where performance cannot be adequately predicted in advance; and plenty of spare parts and scope for modification.

DESIGNING FOR COMMISSIONING

In many plants there is some consideration of start-up difficulties in the form of a few extra lines carrying process water or fresh steam for use during start-up in place of process fluids. Usually this approach is inadequate and proper design requires a consideration of what might happen and what problems may be encountered. Effective design will consider how plant operation is different during start-up from normal operation.

Example 3 The plate evaporator

A mill installed a new set of multiple-effect, falling film, dimple plate evaporators. Figure 1 shows a schematic of the device. Such plates are very fragile and easily damaged by water-hammer. Steam is introduced to a plenum at the bottom of the plates and the plenum also serves to collect condensate. If the condensate level becomes too high, it will submerge the steam inlet and severe hammer will result. Conversely, if level is lost, there is no flow to the condensate pump and damage can occur quite quickly.

During steady operation these conditions are not a problem, but during start-up the condensate level can fluctuate wildly. The system supplied had very shallow, low volume condensate plenums and level gauges that had a very small operating range. In start-up condensate flows were erratic and the shallow nature of the trough meant that they were frequently out of range. The short span of the level indicators meant that most of the time all that the operator could identify was that condensate was too high or too low and the control system effectively became 'bang-bang'. This problem was happening with six interconnected stages simultaneously.

The manufacturer's solution was to re-interpret the operating instructions to mean that water hammer was acceptable during start-up, but better avoided during normal operation.

The result? – The system never performed to specification and after several years of operation it was found that several of the plates had been cracked during commissioning (difficulty of inspection delayed the discovery until the unit performance had deteriorated severely). The plant had been damaged before it was put in operation and expensive repairs were required.

Proper design could have prevented this. Just two minor modifications would have been required: a deeper plenum to permit level fluctuations without water hammer; and a second level indicator with a wider range (but less precision) to permit tracking of levels during start-up.

The vendor had sold many such units previously, and it is hard to understand why they had not modified the design.

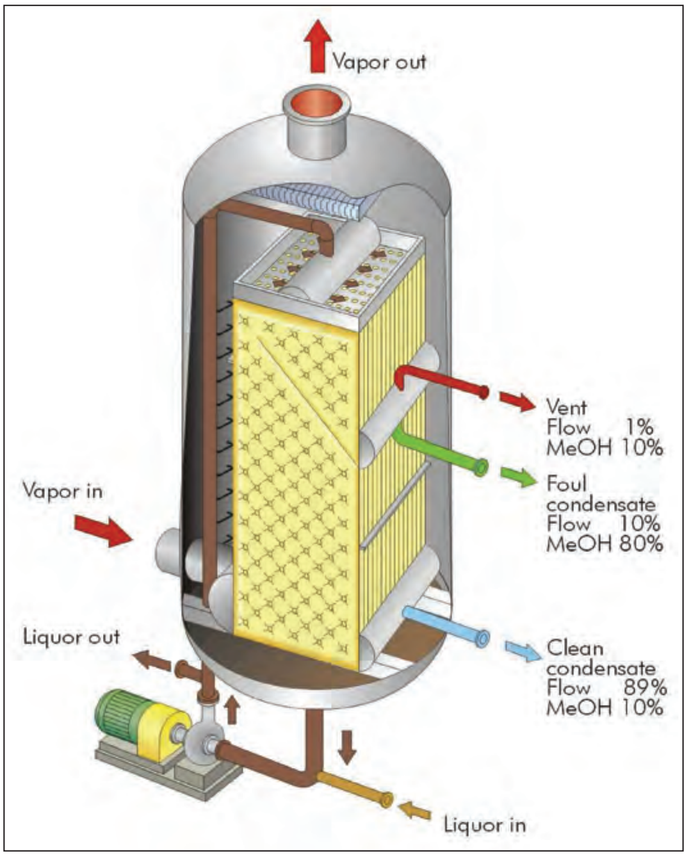

Fig. 1 – Schematic of dimple plate evaporator

Example 4 Getting it right

In the same mill that experienced the evaporator problem there was also a slaker-causticiser system. The green liquor system ahead of this was well insulated and it was recognised that at times it would be necessary to cool the green liquor to prevent boiling in the slaker. Therefore a water cooled green liquor heat exchanger was installed.

It was also recognised that during commissioning and start-up, the green liquor would be cold and it would be difficult to establish reaction in the slaker. Therefore, provision was made to use steam instead of water in the green liquor heat exchanger.

OPERATING INSTRUCTIONS

Good operating instructions are critical to a good start up and to efficient operation. They can also be of great assistance in completing the design of the plant.

A first draft of the operating instructions should be prepared as soon as the flowsheet becomes reasonably firm and then the instructions should be updated in a critical manner at regular intervals. When preparing the instructions it is important to consider at each stage: What is to be achieved? How is this to be achieved? What might stop this happening? What might go wrong and what could be done about the problem? Are all necessary precursors complete?

If done properly, this process will identify where extra valves, lines etc are required (at a stage where their provision does not cause undue difficulties). It will also help identify what other resources might be required. Table 1 lists some examples of conditions needing to be controlled to reduce the danger of blockage occurring in a vessel

Not every possibility identified in the example in Table 1 will require accommodating measures. Some will be deemed sufficiently unlikely and difficult to counter that a 'hope for the best' approach will be more appropriate. But even here, foreknowledge does allow care to be taken in watching for problems developing and at least recognising in the time allowed for commissioning that there could be lengthy and expensive delays if worst scenarios develop.

TABLE 1
Conditions to be controlled to reduce danger of blocking in a vessel

Is it practical to add further controls to minimise the risk of blockage?
Are there means (physical access, manpower and cranes) to remove the blockage.
Can the vessel be readily isolated and made safe?
Is there a need to have somewhere safe to transfer the material forming the blockage (e.g. is it hazardous, or is it necessary to drain a large quantity of liquid from the vessel which must be stored)?
Does the vessel contain packing or absorbent for which there must be facilities for cleaning or spare material available?
Etc...

BEING READY

It is almost impossible to commission a plant successfully if it is not ready or construction and/or maintenance work has not been done properly. It is far too common to try to make up for lost time during construction by starting commissioning before plant work is sufficiently complete and by reducing the time made available for commissioning. This begs the question 'If construction was so difficult, why should commissioning be easy?'

This attitude also leads to the philosophy of 'sort it out once the plant is running'. This is usually by far the most expensive way of solving problems, and the most likely to result in incomplete solutions.

There is more to being ready for commissioning than having the plant complete. It is also necessary to have adequate resources available to tackle any problems that might reasonably be encountered.

Getting the right people

If people working around the project are not really interested in the outcome, commissioning will be difficult. Normally this is not a problem, but for some projects which do not increase production (e.g. environmental and energy saving) it may be difficult to get total commitment. Production people may also lack interest if they have been excluded from the project, and without their help things will be difficult.

The quality and attitude of the operators makes an enormous difference to start up. In some plants poor industrial relations, operator training, operator attitude and/or operator ability will be the biggest problem working against a smooth start-up. Even 'little' things like moving promptly from one step to the next. If the operators don't care ('we get paid whether we work or not') start-up will be difficult.

The quality and attitude of staff is just as important. Obviously competent and well trained staff will make start-up easier, but some other less immediately apparent characteristics can also have a big effect. Staff with any of the following characteristics will make commissioning harder:

- Pessimism –this is infectious.
- Treating operators as inferiors – generates inferior performance.
- Poor relationship with colleagues – lack of co-operation between disciplines.

You do not want just one type of person: problem solvers, finishers and recorders are all required. People who are good at design may not be good at commissioning. People who relate well with others will be a big help. People who can think on their feet and take initiative **after** thinking are very useful.

The supplier's representatives can also have a major impact on your commissioning. They know their equipment better than you do and will have seen many of the problems before. The good ones take a genuine interest in getting the plant running and integrating their equipment with the rest of the plant. Unfortunately, the bad representatives can be a big hindrance with attitudes such as:

- "Once minimum requirements are met I am off."
- "It's all problems in the equipment next to mine – sort that out, then I will start work."

Knowing the type of people you want may be easier than actually getting them.

For operators this may be difficult because industrial relations are likely to be outside of your control, but you can insist on proper training before start up (get this in the project plan and KPIs). If possible try to generate a sense of ownership and enthusiasm. This works better with some people than others and success may have more to do with the culture of the site than anything else.

For other staff you are more likely to be able to select, or at least assign duties:

- Try to keep those staff who cannot think on their feet away from roles where they are by themselves solving problems.
- Try to keep those without people skills on day shift.
- Try to keep the pessimists off the start-up team altogether

Getting the right technical representatives can be more difficult. Often it is the attitude of the supplier company that determines the attitude of their staff – better to have kept away from these people. Keep an eye on people early in the project and try to get the ones you want for commissioning. In extreme cases you may need to demand a change of personnel – this may lead to a bad relationship with the supplier, but overall you will usually be better off.

Sufficient resources

One of the most frustrating things on commissioning is discovering that there are not enough spare parts to cope with upsets during commissioning (in the days of mechanical shear pins it was common to discover that there were not enough spares to cope with a few feeder blockages). Another common problem is to find that a pump needs to be speeded up, but there are no larger sized pulleys or no motor large enough for the new duty.

Well before the plant is due to start up look carefully and pessimistically at what things might break, or might need higher speed or more power etc. Determine the availability of spare parts and make sure that you have enough of each – especially the long delivery parts. This is easier in a large facility than a small one because there is more likelihood of one spare being appropriate for multiple applications.

It is obvious that an adequate number of people will be required, but make sure that there is some slack in the system to cover people being ill or suddenly leaving the company etc.

Give very careful consideration to sampling and analysis. Make sure that there are adequate sample points (and they are not commandeered for other purposes). Try to arrange for as much analysis as possible to be done on site, and if possible around the clock (it is possible to hire analysts and equipment that will not be required once the plant is steadied for the commissioning period only). Ensure that people are trained to perform the tests properly and that there is access to people who can properly interpret the results – numbers alone are of limited value.

PRECOMMISSIONING

It is beyond the scope of this paper to go into pre-commissioning in detail. However it is **essential** that before commissioning is attempted, all equipment is clean, correctly connected and working properly.

One should never skimp on pre-commissioning. It is much less expensive to correct problems at this stage than once process fluids have been introduced to the plant:

- No need to cool, drain, flush, clean before fixing.
- Contractors and equipment are all still on site (and clearly it is their responsibility to fix it).
- The problem can be found on day shift, when people are prepared for it and resources are available to attend to it promptly.
- Equipment, sensors etc can be damaged before the plant is on line if there is inadequate pre-commissioning. Spares may not be available yet and start-up delayed, or 'run blind' until they arrive.

The absolute minimum situation before attempting to run process fluids would be to check that:

- All motors are running in the correct direction.
- All valves (manual and actuated) have been stroked.
- There has been visual inspection of all vessel interiors and large pipes for foreign objects and these have been removed.
- All lines have been flushed through thoroughly – this is to remove debris as well as to establish continuity.
- All equipment has been checked for mechanical completion.
- Spades, isolations etc. have been removed.

Example 5 – Why equipment should be inspected

- A chance decision to check inside a large clarifier found a large hunk of steel in the bottom.
- This would probably have been scraped by the rake to the outlet sludge line and blocked it.

TABLE 2 **Commissioning problems occurring despite testing**
Large underground pipe swept, rubbish bagged and bags tied – but not removed.
Thermal fluid bed heated to red temperature – can then see aluminium ladder inside.
Scaffolding foot partly blocking tank outlet – supplier blamed because his pump kept cavitating.
Door to fluid bed hot wind-box bricked up – pity they forgot to close and bolt the door!
Pipe neatly welded onto ring main – should a hole have been cut as well?
Gasket on foul gas collection line – or is it a spade?
Cut-in for new branch on line –the cut-out was found to be blocking the hot cyclone outlet.
Safety valve with relief branch plumbed into the jacket it was protecting.
Drowned cat blocking valve on potable water line

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Figure 12 shows the reduction of the dilution factor over the last year. It also shows that the calculated stock consistency from the formation zone settled between 7 and 8%. It is possibly limited by the vacuum that can be applied in the unit.

In the first few months after these changes were implemented the Batch Mill performance was inhibited by problems with screen dilution pumps. Once these were overcome the production constraint was white liquor supply. The justification for upgrading the washing was greatly reduced.

SOAP REMOVAL

Now that the output of the Pulp Mills is limited by evaporator and recovery capacity the justification for removing soap may be related to the opportunity to increase evaporator and recovery boiler capacity. Soap is also a valuable byproduct.

Foran (*3*) reports that industry surveys and studies have shown that soap is a significant scale component, particularly in soluble carbonate-sulfate scales in evaporators and concentrators. Over time it can lead to a 15% loss in heat transfer coefficient.

Besides the scaling impact soap reduces the liquor burning capacity recovery boilers. For a steam side limited boiler the given mass of soap will displace twice the equivalent mass of black liquor solids.

Both of these issues have an impact on pulping capacity. This opportunity and that of potentially selling the soap as a byproduct needs to be quantified against the capital cost of recovering the soap.

CONCLUSION AND ACKNOWLEDGEMENTS

The improved performance of the chemiwasher, restoring M4 and M2 Papermachines to full capacity, was a result of the work of many people:

- Operators and management of the BKM who needed to maintain the rates they could, observe what was happening and initiate trials and process changes.
- Defoamer suppliers who provided advice and chemicals that helped mitigate the impact of the soap in the early days and then reduced the dosing as other changes came into effect.
- Technical and laboratory personnel who had to lead and support efforts to find out what was happening to the process.
- Equipment Vendors who proposed the upgrade options supported by their International corporate knowledge, as well as linking us with industry contacts that had solved similar problems and very generously shared their experiences.
- Capital Projects engineers, including consultants, who analysed, designed, implemented and commissioned the process changes.

This paper provides an overview of the steps that were taken over the period, by all of the above, to improve the production output as a result of understanding what was happening with the soap and operation of the washer.

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- It would have been necessary to drain the clarifier to locate the problem: draining it would take several days - even if the outlet line was not blocked.
- The whole pulp mill would have been shut for some time if it had not been found. Worse if rake damaged.

One should never be complacent about inspections, line flushing etc. Table 2 lists a few examples of problems that were not discovered in time, despite testing having been undertaken.

Where possible checks should also be made to ensure that indicators, flow switches, level switches etc. are functional. Often it is not possible to check the full range of the instrument at this time, but one can at least determine whether temperature, pressure, level and flow indicators move, and that movement is in the right direction, when water goes into the plant.

CONCLUSIONS

Commissioning will almost always be a difficult time, but proper preparation can certainly improve the probability of the difficulties being manageable.