Mill Optimisation Programs

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SUMMARY

Mill Optimisation Programs (MOP) are a structured approach, which can assist mills to improve the returns from any existing physical assets. This paper describes; the methodology, the benefits, and concludes with several case studies that illustrate the technique.

A MOP achieves the best rate of return of any alternative approach to mill investment because it delivers capacity increases by focusing on the issues that are acting to prevent stable production. The goal is to avoid / minimise capital expenditure. Existing equipment and sizing is maintained. The target is to improve cost performance by addressing the reasons for operating variations.

A MOP has five key steps: team formation; baseline analysis; benchmarking; project definition; implementation, monitoring and feedback. In the MOP approach, technical and business intellect is substituted for capital and equipment. Baseline analysis provides the current performance, variation of key production and process elements, and provides the data for cause and effect analysis. A MOP looks at both external and internal benchmarking with the latter being particularly important because every mill has its own unique character. Projects are defined from the study, and the implementation of these is subject to ongoing monitoring and review.

The MOP methodology is not revolutionary but it is good business and this is the key. It involves a business review and is not an equipment approach. The fundamentals are: avoiding capital cost; focusing on the drive to reduce operating costs; and focusing on the drive to improve control and productivity.

CAPITAL INVESTORS LACK CONFIDENCE

The pulp and paper industry has one of the highest capital needs of any industry, but at the same time the expenditure has failed to achieve a good return for investors. So currently the industry needs to focus on optimising existing plant. Our Mill Optimisation Program (MOP) has been developed and proven over several years with different major pulp and paper clients specifically to assist with this aim.

Worldwide, market demand for many of the forest industry products has been stagnant in recent years. At the same time there has been downward pressure on commodity pricing, particularly as new low cost producers enter the industry and the Asian countries develop their own industry.

Pulp and paper is well recognised to be a very capital-intensive sector. For example, over the last 20 years the US pulp and paper sector has trended an average of 12% for capital investment over sales. More importantly this has been growing at a compounded rate of 2.6% per annum. This compares with 7% capital investment / sales and growth at 1.6% per annum for the entire US manufacturing sector.

The use of capital in the pulp and paper industry has also been less than effective when compared to other industries.

Pulp and paper is a commodity market and product prices are cyclical. To maximise investment returns the goal is to time new capital spending to take advantage of the peaks in the product price cycle. The historical track record for plant expansions over the last 20 years was, however, poor. Less than 25% occurred within 1 year of the optimum time. Over 60% started up at the worst possible time.

This poor performance has made new investors wary and skeptical of the stated returns for the capital investment that is required to add new plant capacity. There is, in fact, a reluctance to invest in the pulp and paper industry.

Mills are therefore striving hard to enhance return on capital and shareholder value. The current trend is to optimise existing plant rather than to add new capacity. This is particularly true for older mills, particularly where they are not competitive as regards their operating costs.

Our Mill Optimisation Program (MOP) is a structured approach, which can assist with this endeavour. It is aimed at realising the opportunities for enhanced returns from existing physical assets. We have been performing these for over ten years in commodity market areas (Tissue, Newsprint, Linerboard and Market Pulp) and results have been significant.

Table 1 : Potential MOP benefits

Factor	Increment
Production Efficiency Gain	2 - 7 points
Production Gain	10 - 20%
Operating Cost Reduction	5 - 20 %
Quality (Newsprint)	6 fold
Cost, US$ / incremental tonne	100 - 400
IRR Average	35%

HOW DOES A MOP DIFFER?

A MOP study is very different from the traditional debottlenecking review. The key differences are as follows;

Traditional Debottlenecking

- Equipment driven approach.
- Capacity expansion occurs by increasing equipment sizes or adding new equipment.
- Operating variations are not addressed.

MOP Approach

- Existing equipment and sizing is maintained.
- Capacity expansion occurs through production stabilisation.
- The target is to improve cost performance by addressing the reasons for operating variations.

In essence, a MOP study looks at production output variations to understand the relationships between inputs, equipment, and process control systems. The goal of the MOP study is to reduce cost per ton of product, but the focus is process variations. We do this because production is the most measured and documented parameter in a plant.

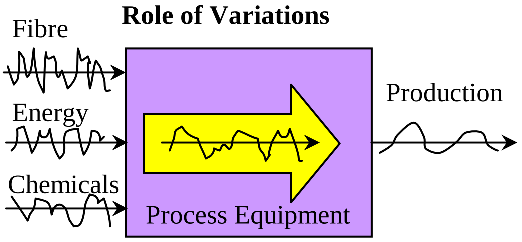

Figure 1 : Impact of Variations

In understanding these relationships we can make low cost, but high return modifications to input streams that will reduce production output variations.

Our experience is that reducing production variations by 1% can lower operating costs in commodity product grades by 1.1 - 1.5%. Moreover, because this cost reduction is across the entire production base the economic benefit is larger than that which can be achieved through traditional debottlenecking, which only provides incremental tonnage increases.

CASE STUDY

A MOP study was undertaken for a plant that was digester limited. The 20-year-old digester was operating at 20% over design capacity.

Conventional wisdom held that the problems arose from operating the plant over capacity, and that a major equipment uprate was needed. Traditional debottlenecking defined a solution of adding a new live bottom pressurised chip bin, and installing a second digester vessel. The total capital cost was estimated at US$ 19 million.

Our MOP analysis demonstrated that production could be increased by an extra 20% if input variations in wood age, chip packing density, and chip quality could be minimised. Using neural analysis and discrete modelling we were able to;

- Optimise chipper performance to increase packing density by 20% and reduce fines by 50%,
- Reduce wood age variation to the digester by 50%.

The results improved production - 70% reduction in knots with 18% reduction in active alkali (AA) consumption.

APPLICABILITY OF THE MOP TECHNIQUE

It is important to understand that the MOP technique is not a cure-all. Nor can it be applied in all plants. It is, however, very effective in existing mills that meet the following criteria.

- All commodity grade products where cost control dominates margin potential.
- Old plant, where incremental component technology and production control systems can have large impacts.
- Older multi-machine, multi-product plants where true operating costs and efficiencies are unknown.

MOP APPROACH

A MOP is made up of the following key elements:

1. Team formation.
2. Baseline analysis.
3. Benchmarking.
4. Project definition.
5. Implementation, monitoring and feedback.

Team formation

As with all successful endeavours, the establishment of an appropriate team is the first important step. A typical MOP team will have 6 - 8 members.

The team organisation for a successful MOP should draw on the strengths of both the mill organisation and the resources of an external technical specialist.

No one knows the mill, its products, problems, equipment, data sources, and organisation better than the mill staff. Combining this with external technical specialists enhances the team strength. The latter should have; relevant technical expertise, MOP knowledge, experience of other mills / sites, and benchmarking data on similar mills.

Baseline Analysis

The MOP team must collect, analyse, and review production and process data for a defined baseline period. A six (6) month time interval is recommended. It should be chosen in consultation with the mill team to be as representative of "normal" plant operation, and as close to the present day as possible.

Baseline analysis provides the current performance, variation of key production and process elements, and provides the data for cause and effect analysis.

We have found that plotting duration curves of baseline data is an effective tool in helping to focus on opportunities for process optimisation.

A duration curve is a plot of the daily production data, which has been sorted such that the maximum level is plotted at day 0, progressively through to the minimum level at day 180 for a six month interval. Figure 2 illustrates a duration curve for the paper machine.

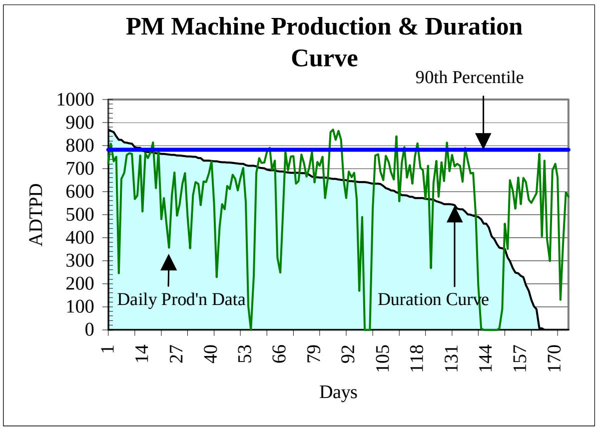

Figure 2 :

A sharp fall in the duration curve (below the 90th percentile limit) indicates an opportunity for optimisation. A flat curve indicates good performance.

Mill staff members know their plant intimately, but often this knowledge is scattered and compartmentalized. So during the baseline analysis period, the MOP team holds structured interviews with mill staff. A major benefit from the MOP is realised by doing this, in that it provides a platform for extracting and organising the baseline data from the breadth and depth of the mill. A mill information system such as MOPS or PI makes data manipulation easier. However, using log sheet data and traditional mill statistics achieves the same results.

Representatives from the different functions and levels involved with a unit operation are interviewed. This facilitates team building and participation. It is a cost-effective way of gathering information, and generates a wide range of brainstorming ideas.

Benchmarking

Benchmarking is the comparison of similar operations. Two types of benchmarking are used in a MOP - external and internal.

- External benchmarking compares how the process units in a mill are performing relative to other similar plants. The problem is that no two facilities are identical. Mills have different; equipment, ages, sizes, process configurations etc. So external benchmarking is best considered to be the tool that focuses everyone on the areas of greatest potential gain.

- Internal benchmarking is therefore used to overcome the limitations of external benchmarking. The mills own production data becomes the benchmark. This is done by taking the 90th percentile as the capacity potential of the process unit under study. (Refer to the duration curve – Figure 3). Internal benchmarking is the mills own data and is therefore beyond question. It also provides the basis for a range of "why" questions. "Why could we operate at this level here and not here?"

Methodology

Using the benchmarking as a guide to areas of deviation from the norm, the next step is to delve into the plan in some detail. This entails again using the mill's own data to interpret areas of concern.

Instabilities often caused units to run away from their optimum in a "safe" region. The root causes are typically process control issues such as poorly tuned loops, control valve sizing, etc.

Bottlenecks are limitations in mechanical or electrical equipment that physically prevents higher production. Often an impellor change, motor uprate or speed change can open the bottleneck.

Problem area other than the above are the last category to identify. These may be procedure, maintenance practices, grade sequence changes or manning issues that create non-optimum operating conditions.

Project definition

The next step in the MOP process is to develop the projects needed to optimise the process. These are developed from a cost and economic evaluation standpoint. It must be noted that projects, which arise from a MOP study, are defined as small capital expenditures that are needed to debottleneck the mill. Typically there is "no free lunch" ie : projects need some spending to optimise conditions rather than just a good idea.

The projects are sorted and prioritised into three categories.

- Procedural changes
- Process changes
- Capital projects

A MOP will give highest priority to the capital projects, which have upstream, or prevention components. For example;

- Prevention of off grade production higher than reclamation.
- Wood quality higher than paper quality.

All projects are estimated, scheduled and agreed by the MOP team and Mill Management.

Implementation, monitoring and feedback
The final step in the MOP process is to implement the projects and to then measure the results in an orderly fashion.

Up until this stage, the external technical specialists will have provided 70% of the total effort. For the implementation phase and follow-up work, the mill participants take the project lead and undertake the majority of effort.

Our experience is that 6 - 12 monthly follow-up review and feedback continues to generate ongoing benefits from a MOP.

CAPITAL REQUIREMENTS AND RETURNS

Based on our experience, gathered whilst executing MOPs for more than 10 years, Figure 3 compares the effectiveness of MOPs with other forms of capital investment.

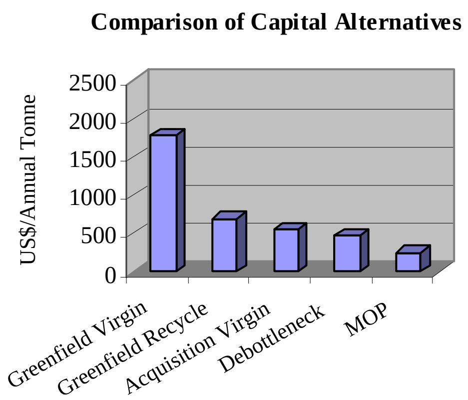

Figure 3 :

Internal Rates of Return (based on H.A.Simons experience)

- MOP 30 to 50% IRR
- Debottleneck 20 to 25% IRR
- Acquisition Virgin 4 to 8% IRR
- Greenfield Recycle 8 to 10% IRR
- Greenfield Virgin -5 to 3% IRR

THE MOP NEEDS A DIFFERENT APPROACH

In the MOP approach, intellect and business knowledge are substituted for capital and equipment. The different approach needs different tools, and different people.

The tools we use are not traditional engineering tools to be used for plant design but instead they incorporate business analysis to process performance parameters.

- Financial sensitivity models.
- Dynamic simulation models.
- Discrete human / machine interface models.

A traditional engineering design team is not suitable for a MOP study. The different approach required for a successful MOP needs a different team makeup. The skill base should include:

- Senior level operations background.
- Expertise in economic analysis.
- Senior level engineering experience.

WHY DOES THE MOP WORK?

The MOP is not rocket science but it is just good business and this is probably the key. It involves a business review and is NOT an equipment approach. In summary then, the fundamentals are:

- Avoiding capital cost.
- Focusing on the drive to reduce operating costs.
- Focusing on the drive to improve control and productivity.

CASE STUDY 1

A MOP was carried out at a linerboard mill operating with two pulping lines.

The first, older line had a continuous digester, one in-line refiner, pulp storage, hot stock refiner and then three conventional rotary drum vacuum washers for brown stock washing followed by two deshive refiners.

Line two also had a continuous digester followed by three in-line refiners, an atmospheric 2-stage diffusion washer followed by three deshive refiners.

The initial benchmarking identified higher than normal energy use.

Table 2 itemises the power input compared with normal industry practise from a range of mills used in the benchmarking. All mills in the comparison were producing pine linerboard.

Table 2 : Energy Use Benchmarking

	Energy Use in KWhr/ADt		
Refining Position	**Line 1**	**Line 2**	**Benchmark Mills**
In-line refiners	115	32	54 – 90
Hot Stock refiners	53	-	50
Deshive refiners	338	244	100 – 160
Total	**506**	**276**	**150 - 200**

Two facts that the benchmarking revealed were:

1. Total power use was higher than industry standard

2. The balance between in-line and deshive refining was different.

Power cost was high in this mill so the impact on operating cost was significant. Firstly, digester operation was examined for non-uniform cooking, flow imbalances and other factors, which would influence variability in the digester blow line output. This turned up a few differences but none that accounted for the difficulty loading the in-line refiners.

Next digester inputs were examined. White liquor variability was considered normal. Chip quality as measured by a Williams length classification also appeared to be normal. The mill did not measure chip thickness or wood density routinely. Therefore, a crude sample box was constructed to determine the over thick chip fraction (i.e. over 8mm in thickness). Immediately it became apparent that this faction was high – up to 27%.

The significance of this was that the in-line refiners could not be loaded because of the high rejects content in the blowlines. To compensate for this, the deshive refiners had to work disproportionately harder to reduce rejects. The traditional engineering approach would be to install a chip thickness screening system. The MOP approach was to closely examine the woodyard and in particular the chipper operation. By decreasing chip length you also reduce average chip thickness. Through a series of trials, chip length was reduced from 33mm average to 25mm and the over-thick chip fraction fell from 27% to 12%. This was still not ideal. A good target is less than 10% over-thick. However, fines and pins generation started to increase and overload the rotary screens so 25mm chip length was chosen as the new target. The flow on effect was a decrease in blow line rejects and over a period of 2 months overall power use was slowly decreased. The mill was also able to rebalance the power use to put more energy into the in-line refiners and back off the deshive refiner power use.

The MOP approach was low capital cost because only chipper knife settings were changed. More pins and fines were generated that were burnt in the power boiler but this was more than compensated for by the lower overall power use in refining.

CASE STUDY 2

An integrated chemi-thermomechanical (CTMP) mill was undergoing a major capital expansion project. A critical item from the end product quality aspect was the performance of the screening system whose configuration was being upgraded from primary/ secondary/ rejects (P/S/R) to stage 1 primary/ stage 2 primary/ secondary/ rejects (P1/P2/S/R).

The overall rejects rate on mainline tonnage was being increased from 39% to 58% and the P1/P2/S/R system was to start up at full production rate and quality during an extended maintenance shutdown day. So a dynamic simulation of the upgraded screening system was carried out to verify the following:

- Higher flows within screening loop due to higher rejects rate with a view to minimising pump and piping modifications.
- Lower retention times in existing tanks due to higher rejects rate with a view to avoiding tank overflows.
- Adequacy of the control system (i.e. adequate for start-up, upsets, auto screen purging, changes in production levels, etc.).

The dynamic simulation included the following:

- Accurate tank modelling to exact dimensions, including overflow levels, etc.
- Accurate piping system modelling (diameter, length, fittings, elevations, etc.).
- Actual pump curve and motor power input.
- Control valve size and characteristics input.
- Screen characteristics input (pressure drops, thickening factors for purchased baskets, etc.).
- DCS control configuration and interlock logic input.
- Control tuning parameters input.

The pre-start-up results were:

- The control strategy allowed for auto start, auto screen purging, varying production rates, etc., with minimum fluctuations in tank levels.
- Interlock set points, time delays, etc. were correctly set up.
- Bottlenecks restricting production levels were identified.
- Equipment, tank and piping modifications were minimised for the new system configuration.
- The model dynamically simulated actual operating conditions showing, for instance, which tanks overflowed if production rate increased beyond a certain level and which controls were the most critical insofar as their incorrect loop tuning would cause process instability.

The most important result was that, for only a small fraction of the project cost expended for dynamic simulation, the mill was able to carry out a flawless start-up of the upgraded screening system.

CASE STUDY 3

An integrated mill utilizing kraft pulp and groundwood pulp to manufacture light weight coated paper required an MOP study to find non-capital methods of improving operating efficiency and product quality. A review of operating records over a six month period showed that production had stagnated at unsatisfactory levels due to high unscheduled downtime and paper quality was resulting in a high number of formal complaints and loss of future orders. In depth interviews with key mill personnel identified a number of barriers to effective management and control.

The paper mill group believed that their problems were related to poor quality pulp and ineffective maintenance procedures. The pulp mill groups did not understand what the paper machine requirements were. The maintenance and engineering groups were in a fire-fighting mode with preventative maintenance and long term planning slipping and no capital relief in sight. Staff groups such as Technical, MIS, Accounting and Personnel were focused on internal department goals and objectives. This may sound severe but variations of this theme are found in many established mills that we visit and the first step is to recognize that there is a problem.

The first step was for senior management and superintendents to develop a common set of goals and objectives for the mill and to communicate these to all employees. Re-organization was designed to integrate the various departments and to provide cohesive working units. Representatives from engineering and technical were assigned to report directly to the Paper Mill Leader for day to day assignments. Paper mill staffing was organized to provide a good balance between technical leadership and strong operating skills. Cost accountants were assigned to work with the Department Leaders to develop discrete measurable parameters and easy to read cost reports broken down into manageable areas.

Maintenance was re-organized to provide a mix of centralized and area maintenance to ensure daily operating priorities were addressed while central maintenance tackled the preventative maintenance, project work and long term planning. Technical representatives from the pulp mills were included in the Paper Mill operations and quality meetings to ensure that requirements were clearly identified. Focus was shifted from departmental orientation to customer orientation where each department identified with their customer.

In less than a year, productivity improved 10% and costs were reduced by 6% while customer complaints were cut in half. Even more important, these improvements continued due to increased employee satisfaction, which come from total involvement in the process.

CONCLUSION

- Mill Optimisation Programs can deliver improved mill returns from existing physical assets.
- Capacity increases are achieved by focusing on the issues that are conspiring to prevent stable operation.
- The MOP differentiates itself in that the focus is on optimising performance without spending capital dollars (or spending minimal capital dollars).
- Technical and business intellect is substituted for capital and equipment.
- In other words it involves a business review and is not an "equipment change" approach.
- The composition of the MOP team is a critical element. It should draw on the strengths of both the mill organisation and the resources of technical specialists with; relevant technical expertise, MOP knowledge, experience of other mills / sites, and benchmarking data on similar mills.
- Typically a MOP investment will achieve an IRR of better than 30%.

ACKNOWLEGMENTS

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