Strategic Maintenance Management in State of the Art Paper Machines

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ABSTRACT

The pulp and paper industry is under severe pressure to improve the return on capital employed. Our strategic approach to maintenance is helping to achieve this goal by maximising the machine uptime.

Maximising the efficiency and availability of a plant and equipment in the most effective manner requires a shift from traditional maintenance approach like reactive and functional, to a proactive maintenance that is fully integrated into overall plant activity.

Up keeping the high Speed Paper Machines at TNPL is possible by the implementation and execution of strategic maintenance practices. The Maintenance departments in TNPL have well documented, executed & measured strategies with meticulously planned practices to establish highest standards in maintenance.

Beginning with the general concepts and world class standards in Maintenance, this paper highlights the various strategies practiced in TNPL such as Planning and scheduling, Root cause failure analysis, Continual improvement, Technological up gradation and Value engineering. The uses of strategic enablers - Information technology and Knowledge management, to achieve the maintenance target are also deliberated. This paper concludes with the future trends and challenges to maintenance management to up keep the modern high speed paper machines.

INTRODUCTION

Plant maintenance according to German Standard DIN 31051 comprises 'all measures for maintaining and restoring the target condition as well as determining and assessing the actual condition of the technical equipment in a system.

Maintenance strategies fall into these five basic categories:

- Reactive , Planned , Preventive , Proactive & Reliability

Studies of Mr. Sue Steele, Vice President, Maintenance Reliability and Technology Services, BE&K's Reliability Solutions Group, USA are shown as a chart in figure 1.

Studies have shown that with hardly a work order planned in advance, the reactive type of maintenance results in 20% overtime for maintenance staff, equipment availability averaging only 70%, and a maintenance budget as a percentage of Replacement Asset Value (RAV) ranging from 3.2 to 4%.

Planned maintenance offers an improvement in the statistics, but not as much as might be expected. Work orders are planned in about half the maintenance jobs, but the strategy still averages 12% overtime, 80% equipment availability, and a maintenance budget as percentage of RAV of 2.8 to 3.5%.

Switching to preventive and proactive maintenance strategies begins to offer a significant return on investment. In a preventive program, with some consideration of what caused problems in the past, equipment availability can be raised to about 90% with work orders planned about 70% of the time. Overtime drops to 10% and the maintenance budget as a percentage of RAV drops slightly from 2.5 to 3%.

A proactive program is based on significant study of the causes of previous problems. Some 80% of equipment failures come under serious scrutiny and work orders are planned in some 85% of jobs. The other 15% are

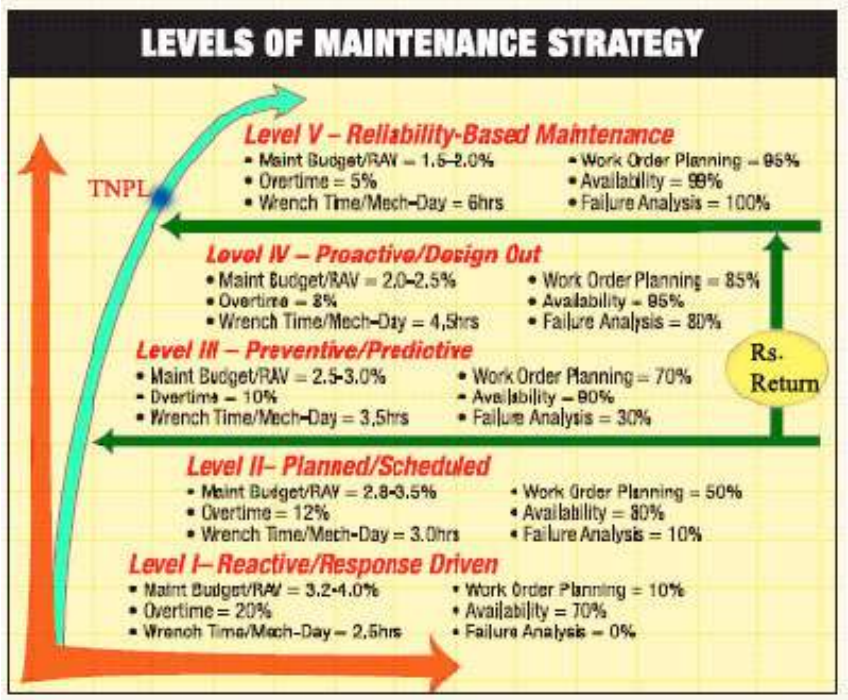

Figure 1

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consciously allowed to be reactive because their influence on the business is acceptably low. The overtime workload drops to 8% of total maintenance time and the maintenance budget as percentage of RAV drops to 2 to 2.5%.

Though many regard these statistics as the best they can achieve, incorporating a reliability program takes maintenance savings to the next level. With 95% of all maintenance planned in advance, equipment is available 99% of the time. The overtime budget drops to 5%, with maintenance technicians working 6 of their 8 hours per shift. The maintenance budget as a percentage of RAV dwindles to 1.5 to 2%.

Information Technology, Technologic - -al up gradation, Continual improvement practices and Value Engineering are some of the strategic enablers that are instrumental in the implementation of the advanced strategic maintenance strategies.

Where does TNPL stand?

Table 1 gives details of mechanical maintenance downtime of Paper Machines over the past 5 years. It clearly shows that there is a downtrend in maintenance down time over the past five years and the machine availability has always been above 99%. TNPL work culture has always been at its best with the average wrench time/mech-day being above 6 hours at all times. No failure, affecting the reliability of paper machine, is left without analyzing. Table 2 which gives the Overtime details indicates that TNPL is marching towards achieving the benchmark of the best maintenance practices in the world.

STRATEGIC MAINTENANCE MANAGEMENT

A strategic maintenance management plan involves process re-engineering and increased resource effectiveness in the following ways:

- Removing all maintenance tasks that serve no purpose or are not cost effective.
- Eliminating duplication of effort where different groups are performing the same PM to the same equipment.
- Moving to a condition based maintenance philosophy for tasks that are intrusive or require an overhaul.
- Adding maintenance tasks to manage economically preventable failure modes that have historically been run to failure (breakdown maintenance).
- Spreading the workload between the maintenance trades and operators.

Operating on a Profit Center Concept, in TNPL, the Paper Machine Operation and Maintenance teams join forces and accept the production targets and quality requirements from the production floor up. Maintenance department is now also responsible for working with the Paper Machine Production Team to ensure that the entire team takes a proactive, rather than a reactive approach. Continual improvement plan provides more reliable equipment & systems through effective, proactive engineering and maintenance, predictive maintenance technologies and maintenance planning efficiency. Some features of the strategic maintenance management practices in TNPL are described here.

PLANNING & SCHEDULING

Prudent planning and optimisation of maintenance management is aimed squarely at enhancing company's overall strategic competitiveness. The clear objective is to improve the reliability of the equipment and runnability as they relate to uptime, quality and productivity.

At TNPL, Measuring instruments like SPM meter, Vibration measuring meters, SEE pen, Thermo pen, high accuracy Surface Roughness measuring meter, Surface Hardness testing instrument for rubber & metal and Stroboscope have proven handy in carrying predictive maintenance in paper machine. The focus has also been widened to fine tune other areas like planning and scheduling, Strategic maintenance concepts, Continuous improvement strategies, Cost reduction & quality improvement techniques.

Planning and scheduling is a vital part in any type of plant maintenance, be it the traditional methods like Run-to-failure, preventive, condition-based maintenance or the contemporary pro-active or strategic maintenance technique. Emphasis is laid upon these areas to effectively use the time available during shutdowns. Jobs to be attended are pooled in from various

Table 1

Mechanical Downtime (% of available hours)

Year	PM/c#1	PM/c#2	Average
2002-03	0.71	0.71	**0.71**
2003-04	0.86	0.29	**0.58**
2004-05	0.35	0.51	**0.44**
2005-06	0.71	0.11	**0.41**
2006-07	0.45	0.21	**0.33**

Table 2

Over Time (% of available Man hours)

Year	PM/c#1	PM/c#2	Average
2002-03	8.12	7.18	**7.65**
2003-04	5.50	5.05	**5.28**
2004-05	6.39	6.13	**6.26**
2005-06	5.19	5.31	**5.25**
2006-07	6.20	5.46	**5.83**

check lists, pending jobs register, production job list, condition monitoring reports and from various ISO schedules. Problems can also be logged into the On Line Integrated System by the production team, which can be scrutinized and carried over to the list of jobs to be attended. In the next stage all jobs are studied in depth and prioritization of the jobs is done. Meticulous planning is done to utilise the resources in the best possible manner and separate job orders are generated for each technician. Scheduling activities begin with the procurement of materials well in advance of the shutdowns. On an average about 12-16 hours are being spent on the planning and scheduling activities for a paper machine shutdown of 24 hours by using all the above inputs. This has made it possible for completing almost 90-100 jobs involving about 100 people in various levels during the available shut down hours.

ROOT CAUSE FAILURE ANALYSIS

Today, repetitive failures in the Paper machine Profit center are unacceptable, because they indicate the presence of one or several of the root causes such as: a basic change in design, change in material of construction, wrong installation and change in operation parameters. With a proactive approach in paper machine maintenance, the emphasis is on root cause of critical failures.

Case History: A typical example is the Suction Couch roll bearing (23160 CC-W33) failure in PM#1. Figure 2 shows the extent of damage that occurred to the couch roll back bearing.

Problem faced : The average life of the bearing was only about 240 running days and upon inspection the bearing found damaged.

Cause Analysis : A root cause analysis of this repetitive failure pattern was taken up. All possible causes were listed and put into detailed cause and effect study. Finally the major reasons for this failure were identified as (I) the run-out of the back head in the bearing seating area and (ii) true-ness of the bearings seating area with reference to the head mounting face.

Corrective measures done : A deviation of 260 microns was noticed in the perpendicularity of the bearing seating area with respect to the head mounting face. This deviation was corrected, by means of metal spraying and re-machining, in the year 2004.

Results achieved : There has not been a failure till date. Table 3 lists the details of bearing life and effect of Root cause failure analysis

Table3

Effective life of Couch Roll Back Bearing in PM#1

Bearing Installed	Bearing Changed	No.of Days in operation	Bearing condition
09-02-99	12-04-00	193	Damaged
07-07-00	21-01-02	317	Damaged
05-08-02	21-01-04	220	Damaged

Root Cause analysis done during Jan'04 to May'04

Reconditioning and correction during May'04

No.of days roll put into service after correcting the back head:

From	To	No.of Days	Bearing condition
06-05-04	20-10-04	164	Good
13-06-05	09-12-05	176	Good
06-04-06	till date	443	Good

Total no. of days without failure: 783 (and still in operation)

Figure 2

CONTINUAL IMPROVEMENT

A sound maintenance management strategy should therefore be considered a valuable business tool used to assess equipment capability, and the continuous improvement efforts of asset performance. Maintenance is no more considered to be cost centre. With the help of operator feedback and statistical records, reports from the shift maintenance technicians, various problems are identified, analysed and corrected.

The various efforts being taken towards the continual improvement plan are

- Mill performance audit was done on the 20 year old Paper machine # 1. The study was done in 2005 with special emphasis on corrosion, vibration and runnability. Recommendations of this study are under implementation.
- Installation of offline shell cleaning system for wet end suction rolls of paper machines to replace the 20 year old practice of manual drill cleaning of plugged holes. Figure 3 shows the cleaning system in operation.
- The roll grinding machine was relocated on a swimming foundation and being renovated with CNC controls to improve the accuracy of grinding to meet the precision grinding requirements of Shoe press rolls.
- Lubrication schedules and standards are well established for all equipments and off-line filtration units are installed in all lubrication and hydraulic systems.
- Automatic self-cleaning filters for

Figure 3

Knife change frequency in cutters

Year-->	2002	2003	2004	2005	2006
Material-->	HCHCr Knives	Carbide tipped knives			
Cutter 1	23	5	5	5	3
Cutter 2	12	5	5	4	2

high-pressure wire and felt cleaning showers are installed to have an effective fabric cleaning.

- For the first time an Online inside cleaning showers for suction rolls are being installed to avoid suction roll jamming and enhance roll-changing frequency.
- Standards are set for alignment. Normally alignments are done only with dial gauges and to an accuracy specified by the manufacturer. However for the machine drives and vacuum pump drives and its gearboxes it is done by computerised laser alignment systems.
- With the increased machine running speeds, the balancing standards have been revised from G2.5 to G1 for all rolls in paper machine.
- Procurement and usage of latest tools and tackles, towards easy and precise maintenance practices. Eg: Laser alignment kits, Oil contamination analysis kit, Hydraulic torque wrenches, Hydraulic jaw pullers, Hydraulic nut runners etc.

TECHNOLOGICAL UPGRADATION

Technology is an important strategic resource like any other resources such as manpower, materials etc. Technology up gradations are done for carrying out incremental improvements on the equipments / methods and up scaling. It is done where technology acquisition cost is prohibitive and sufficient skills/expertise are available in-house to undertake indigenous development.

Examples of technology up gradation & absorption in TNPL are as follows:

- Change of regular bearings to newer designs. Eg. CARB bearings are installed in Dryer cylinders and Stainless steel bearings are used in Wet end tail cutter
- Replacements of Vent grooved Stainless steel cover with cost effective Composite/Poly urethane cover for Controlled crown roll in paper machine press bottom nip
- Replacements of HCHCr fly and bed knives to Carbide tipped knives.
- Removal of dissolved water from the hydraulic oils by Oil purifiers
- Installation of Side entry split mechanical seal for Slush Pulpers
- Replacement of DC drives with AC drives in Sheet cutters
- Replacement of UHMHDPE sealing strips to Rubber graphite sealing strips in the wet suction rolls.
- Upgrading the oil seal with labyrinth ring and bearing isolators in vacuum pump gearboxes,
- Use of Synthetic lubricants for high speed, high temperature and also wet end bearings.

TNPL Experience:

High Carbon High chromium Steel knives were used in 3 sheet cutters and they were replaced with the carbide tipped knives. The performance and life cycle extension was excellent and long lasting. This was a major breakthrough in our Finishing House maintenance as we could improve machine availability and reduced maintenance. It was also later extended to the slitter knives and the results are very encouraging.

This concept was later extended to the 50 TPD and 100TPD cut pack sheeters and the life of knives has increased many folds. Technology however comes with a price. The limitations of carbide tipped knives are

a) It is very sensitive to impact load. The knife has to be ensured for straightness and any bend has to be removed before every installation.

b) The initial procurement costs are high.

VALUE ENGINEERING

Value Engineering is an extremely powerful methodology for cost reduction and value improvement. It is more in the term of worth and utility rather than cost and quality. It is more comprehensive and the improvement in value is attained without sacrificing quality, reliability, maintainability, availability, etc.

A few of the various cost reduction and quality improvement benefits by means of our efforts are listed below:

- Regrinding and reuse of sparingly used Carbon fiber doctor blade removed from the Shoe Press - Nipco P roll. Around 400 doctor blades were reused on the Calendar rolls resulting in savings

of around Rs.20 lakhs

- Indigenisation of various imported spares worth several crores of rupees such as retension shoe blades, speed flow roll bearing assemblies, suction roll bearing housings, refiner segments for new generation conical refiners, gear internals and Main Vacuum pumps.
- Re-engineering of pumps and fans such as Secondary cleaner supply pump, HP shower pumps, dryer hood exhaust fans.
- Energy conservation projects implementation like

- Stock pumps like Broke tower pump, Machine chest pump were run with AC motors and flow control was through control valves. As frequent operation of control valves were an energy loss, VFDs were installed and controls done through them.
- Replacement of V- belts to Flat belts with an eye on energy conservation and less maintenance.
- Standardization of materials such as couplings, v-belts, bearings, lubricants, filtration elements etc.

STRATEGIC ENABLERS TO MAINTENANCE MANAGEMENT.

STRATEGIC ENABLERS that helped us in implementing the above maintenance strategies much more effectively are discussed below:

INFORMATION TECHNOLOGY IN MAINTENANCE MANAGEMENT

Information technologies (IT) can be referred to all computer systems and networks, plant automation system such as distributed control systems, design drawing database etc.

Online Integrated Information System (OIIS) at TNPL

TNPL recognized in 1995, that a computerised maintenance management system is necessary for planned maintenance and reduction of downtime. Initially TNPL managed to develop custom made programs by NIIT, Pro 32 software by SPM, to store, retrieve and analyse data for Bearing health monitoring, Spare part procurement, Equipment downtime and Overtime data analysis.

In this age of continual change, TNPL faced with further maintenance requirements. Maintenance technology advanced as well, with the advent of client/server (CS) applications with secured database & graphical interfaces with greater flexibility than previously possible. TNPL therefore engaged CMC in 2002 to put in place an On line integrated system (OIIS). This system is developed using the Oracle database with developer 2000.

The hallmarks of this implementation are:

- This system integrates all modules like production, maintenance, materials management, human resource development.
- The maintenance module has proved to be a success in effective management of spares apart from being a useful tool in maintenance planning and scheduling.
- This maintenance system has become a daily tool for improving work processes.
- It has become the primary application used by the purchasing, stores and accounts departments.
- Mill wide we use this as the spare parts inventory catalogue.
- Department heads use this to view up-to-the minute production data, approve/deny purchase requisitions.
- Emphasis on preventive and predictive maintenance has played a critical role in improving maintenance efficiency. Our OIIS system is integral to these improvements.

The salient features of the Maintenance module in the OIIS system benefiting Paper Machine Maintenance are:

- Maintenance of various master tables like Equipment master, Area code master, Problem code master, Activity code master, component master, equipment component assembly master.
- Maintaining complete equipment history with manpower and material consumption details.
- Generating schedules for routine, preventive and shutdown maintenance.
- Recording the details of MIN's generated and spare parts received into the Paper Machine Inventory.
- Recording of details of Indents generated for spare parts requirements.
- Down time analysis of paper machines and report generation.

Other IT Applications

Apart from the OIIS, there are other dedicated systems and controls which contribute, in a big way, to the maintenance system in paper machines. Some of them are:

- In order to monitor the bearings, failure of which causes most of the breakdowns in paper machines, TNPL has gone for SPM technique. As many as 1400 bearings in both the paper machines are being monitored on a scheduled basis. Data loading and analysis is done on a separate system using dedicated software.
- Drawings of necessary spare parts are developed in-house using AutoCAD 2002 and preserved in the Data Warehouse. Around 100 drawings every year are developed and continually updated for reference and spares procurement. Reverse Engineering concepts are used to incorporate specifications relevant to the spare part manufacturing.
- Alarm indicators, safety interlocks, tripping set points are inbuilt for the critical parameters in the DCS of the paper machines. These have helped the maintenance crew in the up keeping of hydraulic and lubrication systems.
- Customised data maintenance and report generation for ISO 9001, ISO 14001, ISO18001 using Microsoft Windows

KNOWLEDGE MANAGEMENT

Knowledge management refers to strategies and structures for maximizing the return on intellectual and information resources. Because intellectual capital resides both in tacit form (human education, experience and expertise) and explicit form (documents and data), KM depends on both cultural and technological processes of creation, collection, sharing, recombination and reuse. The goal is to create new value by improving the efficiency and effectiveness of individual and collaborative knowledge work while increasing innovation and sharpening decision making.

Knowledge Management (KM) role is

to connect knowledge owners with the knowledge seekers. The knowledge of one is transferred to the mind of the other, so that a new decision can be made or situation can be handled. KM provides a means to capture and store passing knowledge and broker it to the appropriate individuals.

Knowledge Management (KM) is a technique to effectively capture, store and network the incidents, cause and effects. It comprises the following:

- Construction (compilation/ collection) of knowledge generated within the organization (and from external sources) into a Knowledge Repository (KR)
- Organise the knowledge so constructed in the organization in such a way that is easily accessible to all those in the organization, who need it, on time.
- A management system that maintains the KR up to date and relevant.
- A set of tools, including computer systems that facilitates case of accessing the KR as well as building and maintaining it.

Knowledge Management initiatives in TNPL Paper Machine Maintenance

a) We have a well maintained library (figure 4) housing all the knowledge resources who crave for knowledge and for sharpening their maintenance strategies. The library hall is well maintained with manuals of the Pm/c 1, Pm/c 2 & Converting areas segregated and stored. It also houses Spare part procurement details, Equipment drawings, technical as well as non-technical printed materials and also supplier catalogues.

b) An e-library comprising a extensive collection of Compact discs (CD), with OEM visual training aids, technical presentations and data furnished by various manufacturers of bearings, v-belts, spindle tapes, timer pullies, gearboxes, filtration, lubrication and hydraulics, ISO standards, and other catalogues.

c) The Equipment History KARDEX is maintained since inception of all equipments in Pm/c 1 and in Pm/c 2. Presently it is being computerized and linked to the OIIS for enlarged viewer ship base.

d) Periodic training sessions and discussions help both in documentation and multiplying the knowledge thus leading to an effective knowledge management.

e) The in-house Structured Training programs are conducted periodically to develop knowledge, skills and attitudes, in compliance with ISO 9001:2000 standards. This training is based on the employee needs on Shaft alignment, Bearings, Vibration, Hydraulics, Pumps etc.

f) Maintenance Engineers are also trained at the reputed Maintenance schools abroad.

Figure 4

g) Successful Total Quality Management Circles at Paper Machine

- Auto set change in Winder of Pm/c # 1 to increase the winder productivity.
- Fabrication and erection of Liftoff device for Dryer 01 doctor holder loading/unloading in Pm/c # 2 resulted in increased Paper Machine uptime per occasion resulting in increase production amounting to Rs.5 lakhs per annum.
- Modification of Decurling station at 100TPD Cut-pack sheeter resulted in 3 % reduction in rejection of core end reels resulting in annual savings of Rs.6 lakhs.
- By suitable in-house modification in the UWS of the 50TPD cut-pack sheeter, a reduction in 1.72% of finishing losses due to copier conversion of 62 cms width reels. This has resulted in an annual cost savings of around 4.5 lakh rupees

Therefore KM gives significant benefit to improve our quality of service, time schedules, avert disasters, and reduce costs through early diagnostic patterns, alerts, and probable actions.

FUTURE TRENDS AND CHALLENGES

Like any other industry, the pulp and paper industry in India is also changing fast and the future is going to be full of challenges from various angles. Some of them which can be visualized now are:

- Day by day the paper industry is moving towards new technological advancements aiming at more efficient and high speed paper machines, with efficiency and production levels being the main targets. This will pose a challenge to the maintenance team as we cannot afford to have idle machines due to equipment failure, efficiencies due to poor maintenance practices, or high costs due to rework. The equipment uptime, efficiencies and maintenance costs will become more and more critical.
- The designs of future paper machines are such that the time required for fabrics changing is minimal. This imparts pressure on the maintenance team, because of limited time for maintenance activities.
- With the rapid change in the

technology, equipment and systems become obsolete at a faster pace. This will increase spare parts inventory and non-moving spares .It will be a challenge for the maintenance team to keep the inventory under control, identify the obsolete spare periodically and dispose them at the right time.

- Yet another challenge will be the depletion of experienced hands by way of retirement and attrition. It is a fact that there are very few persons who are into the core engineering field, be it mechanical, electrical or instrumentation. Therefore training and motivation need no emphasis, so that maintenance quality is increased and attrition rate is brought down.
- The cost of maintenance is always on the uptrend due to continuous escalation of spare parts and manpower cost. It will be the responsibility of the maintenance team to find out suitable alternatives at a lesser rate, so as to keep the overall maintenance costs under control.

With challenges from all directions, the maintenance team will have a difficult time ahead. But looking at the way maintenance concepts transformed all through these decades, we are sure that the challenges posed to us will be successfully driven over.

CONCLUSION

Following tangible benefits are derived by adopting the above maintenance strategies in our plant:

a) Increased availability of plant and machinery
b) Better utilisation of maintenance resources, men, material and logistics.
c) Increased and extended use of plant and machinery.
d) Availability of history of machines to enable decision making.
e) Reduction in unnecessary paper works, in essence improvement in the overall productivity and profitability of the organisation.

The above are only a start lines to improvement, and there is no finish line. “If you stop becoming better, you are not good anymore” is an old and very appropriate statement.

We have to come to an age, wherein, we have a well documented maintenance system which networks all techniques, with an emphasis on implementation and continual improvement.

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