SUSTAINED GROWTH WITH MAINTENANCE BEST PRACTICES AND RE-ENGINEERING EFFORTS IN TNPL


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Abstract :

With development and advancement in machinery, the maintenance techniques had also undergone changes. Today we can rarely hear the term Breakdown Maintenance amongst maintenance engineers in a plant. Even the decision makers have come to understand that maintenance is no more an expense, but is as well a component that can affect the bottom line in a great way. This has therefore necessitated maintenance team to move towards best practices in every part of maintenance activity. Maintenance engineers are in a position to re-engineer the equipment or its maintenance activity to ensure positive impact on the bottom line. In this paper, the various best practices followed by TNPL is discussed with focus on re-engineering concepts.

Key words: *Maintenance techniques, Best practices, Continual Improvement, Re-engineering*

Introduction

Maintenance has grown in number and complexity over the three generations. In the First Generation, namely Breakdown maintenance, an equipment was left to fail and maintenance was done to fix it. With increased emphasis on equipment availability, the concept of Preventive maintenance gave birth. This ensures that equipment is maintained irrespective of its condition after a specified period. In recent days there are innumerous maintenance techniques and diagnostic tools, which have led to the Predictive style of maintenance. Any maintenance activity will travel through various processes like Work flow control, Maintenance plan, Diagnosis techniques etc. Besides these, Knowledge management, Continuous improvement etc. act as facilitators for any maintenance activity to become a best practice. In spite of all these efforts, due to design flaws, changing operating conditions or ageing of an equipment, it becomes necessary to carry out re-engineering in order to maintain the equipment better and extend the life of the same.

TNPL has pride in having many of the best practices available in a Pulp and Paper Industry without sparing any opportunity for re-engineering. The details in the following discussion will establish this fact with lucidness.

Best Practices in TNPL

In TNPL, all processes in a maintenance activity discussed above are given atmost attention to ensure high equipment availability and reliability. TNPL has the experience of following the best practices in all areas of maintenance, of which following are a few:

1. Diagnosis and Monitoring of Bearings

The key aspect of any maintenance programme is diagnosis and monitoring. Various tools are available for diagnosis and monitoring of key parameters. Bearings form the heart of any rotating equipment and in TNPL monitoring the condition of bearings are done using SPM and Vibration techniques. Monitoring reports are analysed and action taken accordingly, which has helped TNPL in preventing breakdown to a large extent.

Examples of best practices in Diagnosis and monitoring of Bearings:

- Providing bearing condition monitoring sensors for most of the points in Paper Machine 1 and 2 and critical points in Deinking Plant. A typical setup of the bearing condition monitoring meters and a sample bearing failure analysis is shown in Fig.1.
- Implementing online bearing condition monitoring for critical locations in Paper Machine 3
- Providing vibration monitoring sensors for heavy equipment like Refiners in Paper Machines and Dispersers in Deinking Plant.

2. Sustaining the health of Lubrication and Hydraulic systems

With advancement in Paper Machine designs, the importance of Lubrication and Hydraulics has grown at a greater pace. Today no Paper Machine is found without systems like Centralised Lubrication System, Hydraulic

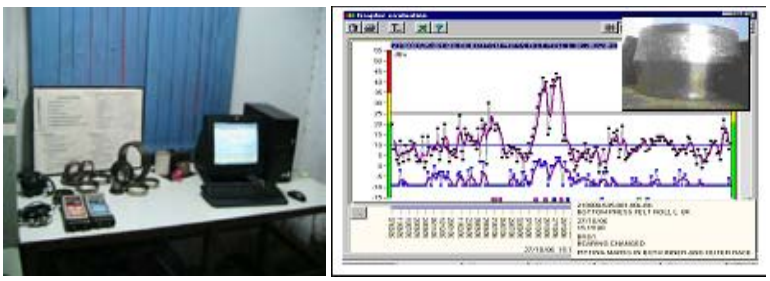


Fig1 : Bearing condition monitoring and Damage

Systems for operation of roll movements and showers. The entire operation of such systems rely on the quality of oil that is being used. Eventhough initial filling is done with good quality of oil, it becomes a challenge to maintain the quality of oil, as foreign matter like water, dirt etc. find their way into the lubrication and hydraulic system. TNPL has been successful in overcoming issues relating to quality of oil by implementing a series of best practices. Following is a list of measures taken in this regard:

- Testing of hydraulic and lubrication oils in various powerpacks, in a periodic manner, to evaluate the oil cleanliness level in lubrication and hydraulic systems. Test kit and sample patch test results are shown in Fig.2.

Fig 2 : Oil Patch Testing kit and result

- Adopting suitable oil purification measures, online and offline to ensure proper quality of oil. This is achieved using Centrifuges, Electrostatic Oil Purifiers and Vaccum Separators.
- Replacing Shell and Tube Heat Exchanger with Plate Type Heat Exchanger, which are more efficient, reliable and relatively maintenance free

Fig 3 : Heat Exchangers (Shell & Tube and Plate Type)

3. Root Cause Failure Analysis

As the demand for equipment availability is gaining importance day-by-day, the concept of Root Cause Failure Analysis is gaining importance. Today, repetitive failures in the Paper Machine is not permitted and any such failure is subjected to Root Cause Failure Analysis.

A typical example of such an analysis is the success story of Suction Couch roll bearing (23160 CC-W33) failure in PM#1. Figure 4 shows the extent of damage that occurred to the couch roll back bearing.

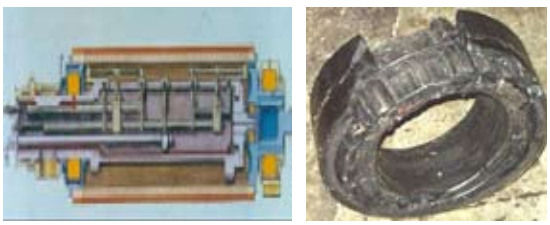


Fig 4: Couch Roll and Damaged Bearing

Problem faced : The average life of the bearing was only about 240 running days prior to 2004. Each time the bearing was removed, a significant damage was noticed and the bearing had to be changed.

Analysis : A root cause analysis was done, for about 5 months during 2004, to get rid of this repetitive failure. A detailed cause and effect study was done for all possible causes and 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: Ever since this correction was done in the bearing seating area, failure of bearing as encountered earlier was never witnessed. The average bearing life has increased to over 1000 days.

4. Audits of Systems and Machines:

Paper machine audits are essential to the papermaking process, as they give valuable information to increase efficiencies, minimize fiber loss and improve sheet quality. Understanding this, TNPL does audits of individual systems and also the entire machine as and when required. Some of the major audits done and actions taken based on them are as below:

- Audit of deculator cleaning system in PM1 was done during 2003 to improve dirt removal efficiency in approach flow sytem and ensure air free stock to headbox. Significant improvement in cleanliness was observed after implementing the short term recommendations. The long term recommendation of changing the design of cleaners was later implemented when Paper Machine was shut for Life Cycle Extension project .
- The structural strength of wet end of PM1 including Headbox was subjected to audit during July 2006 and it was found that the structures in Press part were not strong enough due to corrosion. This initiated the Life Extension Project, wherein the entire Press structures were replaced along with modern dilution headbox.
- An audit of Dryer section in 2009 helped us in determing the safe operating speed of Dryer section
- The latest in this list is the audit of vacuum systems in both machines PM1 and PM2 during January 2017. Fig 5 shows the details of measuring pionts duirng this audit. The audit results would become the basis on which upgradation to blowers in place of water ring vaccum pumps will be decided upon.

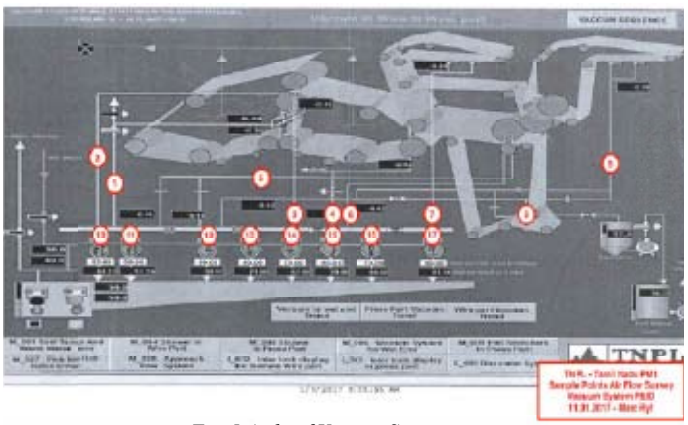


Fig .5 Audit of Vacuum System

5. Continual Improvement:

TNPL believes to adopt the Best Available Technology (BAT), to ensure that maintenance practices are improved day by day. TNPL has adopted BAT in areas

like material handling, EOT crane maintenance, Roll grinding etc.

Some of the continual improvements done with focus on best practices are:

- Realignment of Roll Grinding machine to ensure the grinding accuracy.

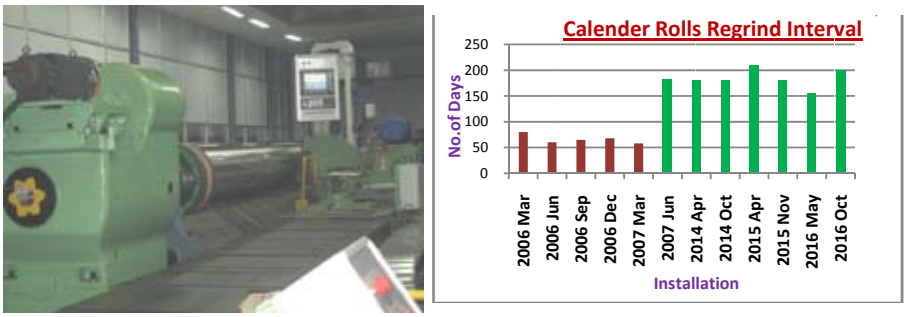


Fig 6: Roll Grinding Machine and Details of Regrind interval

- Upgrading roll grinding machine during 2007 with CNC control for achieving better roll surface finish and thereby a longer regrind interval. Since then the regrind interval has been around 180 days on an average (ref Fig.6)
- Identification of suitable grease for critical applications
- Alignement checks for EOT crane gantry rails
- Balancing Paper Machine rolls as per grade G1 to ensure smoother runs in elevated speeds
- Replacing Rotating syphons with Stationary syphons in all dryers in PM1
- Replacing wire rope slings with Nylon slings for ease of handling and maintenance
- Replacing conventional gearboxes in EOT crane LT drive mechanism with shaft mounted

.7: EOT Crane - Old Arrangement & New Arrangement

gearunits, thereby saving power and reducing downtime (Fig.7)

- Making use of various diagnostic tools for measuring critical parameters like temperature, Surface roughness, Material hardness, Material Thickness etc. Tabel 1 below explains the special instruments available and used at TNPL:

Table : 1 - List of Special Instruments

Sl.No.	Parameter to Check/Measure	Intrument
1	Bearing condition monitoring	SKF SEE PEN, SPM T2001, SPM Lenovo
2	Vibration	Rion VA 10, IRD 811
3	Gear mesh, Looseness	Unilux Miti-Lite Stroboscope
4	Shaft Alignment	Tribotech Easy laser, Fastalign
5	Temperature	SKF Thermo pen, Raytek MT4 non contact thermometer
6	Alignment	Nikon Optical Instruments
7	Water content in Oil	Pall Water Sensor
8	Material hardness	Proceq- Equotip 2 Hardness Tester
9	Surface roughness	Surtronic, Hommel T500
10	Air, vacuum leaks	CTRL 101 Ultraphonic Detector
11	Bearing mounting / dismounting	Bearing Heater, Oil pump
12	Doctor Blade aligment	Angletrol
13	Oil viscosity	Visgage
14	Roll finsh after grinding	SBA Roll Measurement Kit
15	Thickness of Pipes and vessels	Ultrasonic Thickness Guage

6. Computerised Maintenance Management System:

Computerised Maintenance Management System (CMMS) is considered to be an integral part of any maintenance system. TNPL recognised the importance of this and developed a customised program with the help of NIIT to store, retrieve and analyse data for spare part procurement, equipment downtime and overtime. By 2002 TNPL went on with a more sophisticated, yet customised system, using Oracle database and Developer 2000. This was developed by CMC and was called the 'Online Integrated Information System'.

With vast changes in this field, many standard packages were available in the market for maintenance of a plant. Now TNPL has the Oracle Asset Management System for the maintenance activities of the plant. This being a part of the standard product Orcale E-Business Suite, has links to all other modules like purchase, stores, human resource etc. This enable us to calculate the cost of maintaining an asset over its life, along with details of all maintenance activities carried out in it. A typical screen shot of this system is show in the fig.8.

Maintenance Re-Engineering:

Maintenance is never going to be the same throughout the lifetime of an equipment. As years pass by, it will become more and more difficult to maintain an equipment at its best. A time will come when maintenance of the equipment will turn to be a loss making activity. At this time maintenance engineers are left with only two options i.e., to either dispose off the equipment and go for a new one or go in for rebuilt to bring back the equipment to its near best health condition.

When such a situation arises, TNPL has been very careful in deciding the option to be followed. There are a lot of examples which shows that re-engineering is not a new concept for TNPL and has been followed for quite a long time now.

1. Conversion of Lubrication arrangement:

Paper Machine #1, commissioned during 1984 had centralised lubrication system for most of the bearings in Dryer section, except the rolls in the dryer screen stretcher arrangments. Needless to say, the life of oil lubrication bearings are higher than that of grease lubricated bearings for obvious reasons. TNPL waited for an opportunity to convert such grease lubricated bearings into

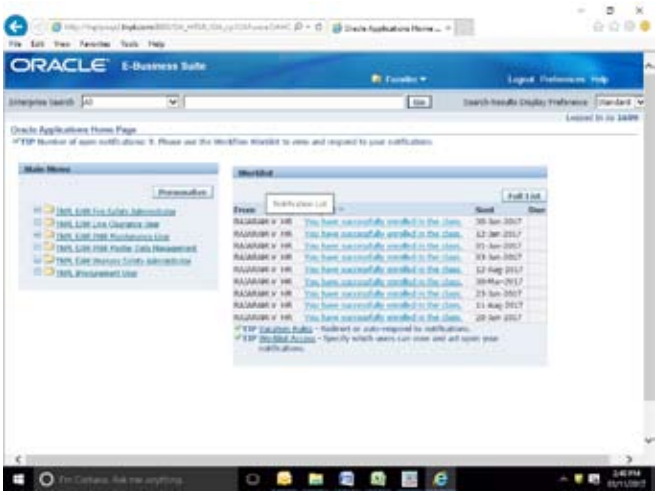


Fig. 8 : Oracle Asset Management

Fig.9 : Modified arrangement for Oil lubrication

oil lubricated ones and this was executed, taking advantage of the Paper Machine rebuild, during 2002. In this period all the 14 grease lubricated bearings were re-engineered to make them suitable for oil lubrication.

Table 1

Dryer felt roll bearings replacement and failure analysis				
Description			Bearing Location	
			Drive side	Tender side
Table 2 iod	Type of Maintenance / Lubrication	Bearing Population	14	14
1985 to 1998	Preventive / Grease	Changed as per Schedule	3	3
		Breakdown	2	1
		Total replaced	5	3
1989 to 2002	Predictive / Grease	Changed as per SPM value	27	23
		Breakdown	0	1
		Total brgs replaced	27	24
2003 to 2016	Proactive / Oil	Changed as per SPM value	4	2
		Breakdown	0	1
		Total brgs replaced	4	3

The housings were provided with suitable oil inlet and outlet provisions and oil tubings were laid. The benefits were evident from the number of bearing changes in these locations. Table 2 below describes the benefits of this re-engineering.

2. Life Cycle Extension of Paper Machine:

The Press section of Paper Machine #1, which has a Trip Nip configuration, was built with MS frames. TNPL had also gone for a rebuild in 2002 for installation of Shoe Press. With extensive use of chemicals in the wet end of Paper Machine, the MS frames were corroded very badly, which affected the machine up time quite often.

TNPL was sensible enough to audit the structural stability of the entire Paper Machine very soon and identify that the Press frames were in a bad condition. Moreover the fabrics changing process was a time consuming one and hence required long shutdowns every month. It was then that TNPL decided to take up the Life Cycle Extension Project of Paper Machine#1.

Under this project, the entire press section MS frames were replaced with SS / SS cladded frames. This also gave an opportunity to redesign the frames for easier fabric changing. Now TNPL enjoys the benefits, like stable machine structurals and easier fabric changing

Fig.10 : Press part - Before and After LCE

process leading to higher operating speeds and hence lower shut down times (Fig.10).

3. Modification of Roll Cover

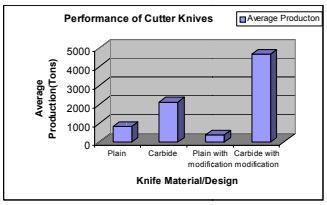
Paper Machine no.1 has a tri-nip configuration, with a crown control (CC) roll as the first nip bottom roll. This roll needed recovering of the shell as the groove depths had reduced considerably after 10 years of useful life. The roll was originally of a steel wire wound over the shell. Roll covers are generally selected based on the paper grades run on the machine. Various alternatives to the steel wire wound shell were explored. The options available for recovering were Steel wire winding, steel sleeve or composite / polyurethane material covering. For printing & writing grades run on PM#1 all three covers were suitable. It was the time when TNPL was facing issue of low bulk in the paper, which was primarily due to the raw material, bagasse. Upon evaluating all the options available for recovering, it was found that with a PU cover, the nip width and dwell time is more compared to hard nip, which thereby helps in retaining the bulk of the paper. To take advantage of this phenomenon, TNPL went ahead with PU cover in-place of Steel cover. This gave TNPL double advantage of lower cost of recoving and higher bulk in paper produced (Fig. 11).

Fig.11: PM1 CC roll

4. Modification of Knives in Cutters:

- The knives of conventional cutters were with High Carbon High Chromium material. With increased ash levels in paper produced, the wear out of knives was very high. TNPL then looked out for the Best Available Technology and found way back in 2003 that Carbide Tipped knives were the best alternative available. Soon, the knives were changed from HCHCr steel to Carbide Tipped knives. The benefits were visible immediately after this. The average knife changes had come down from 23 knives / year to just around 5 knives/ year.
- Another example of re-engineering was in Cut Pack lines. In A4 sheeters rough cutting in sheets demanded frequent knife changes, even though the cutting knife edges were carbide tipped.

In order to tackle this rough-cut issue, re-engineering of knife angles were necessary. Accordingly various knife angles were tried. Finally the top knife angle was raised from 19' to 24' and the bottom knife angle changed from 16' to 21'. Soon after, a significant performance improvement was witnessed, by way of increased production. Fig.12 shows the re-engineering effort and benefits.



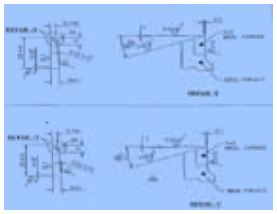


Fig. 12 : Modification of cutter knives and performance details

5. Re-engineering for ease of maintenance

Maintenance activity of an equipment is often done to perfection only when it is done in the work shop rather than at site. Maintenance at site becomes further more difficult when the location and working space is not sufficient. TNPL had faced such an issue in the Speed flow starch system that had 4 nos. of Vibrating screens, which were located in an area that was not conducive for maintenance. This often led to flaws in maintenance activity and hence frequent failure. Moreover Speed flow rolls were getting damaged frequently, due to dry run that happens before starch could be pumped from +0 mtr. floor to the roll surface in +7 mtr.

TNPL decided to re-engineer the entire system and accordingly relocated the vibrating screens to a new place, which was very convenient to work in (Fig.13). Also the pipe line routing and valve location were modified to ensure quicker pumping of starch to the rolls and hence avoid dry run damages. The results were in line with the expectations

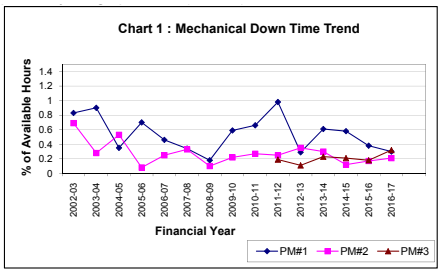
Fig. 13: Old location and New location of Vibrating Screens

and now maintenance activity in this area has come down drastically.

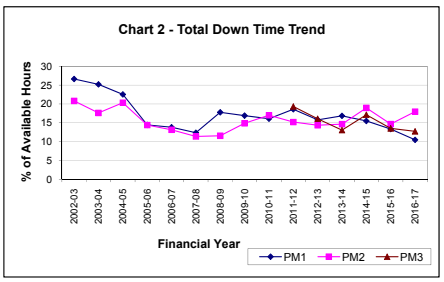
Results of Best Practices and Re-engineering

Having seen the various best practices adopted and re-engineering efforts in TNPL, it is time to see if they have produced better results in performance and productivity. TNPL considers Machine availability, Breakdowns and Maintenance cost as the major maintenance metrics that can tell about the effectiveness of maintenance.

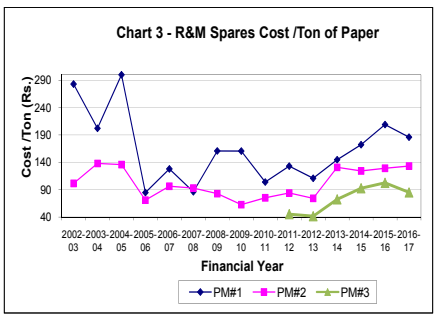
Mechanical breakdowns of paper machine have come down over the years as depicted by the graph below (Chart 1):



Besides mechanical downtime, the total machine availability is always being maintained at a high level with reduced total downtime, as depicted in the graph below (Chart 2):



Maintenance cost per ton of production over the years seems to be fairly stable in spite of increasing cost of maintenance spares and tools (Chart 3). This itself proves that the practices being adopted in TNPL are amongst the best in the industry.



Conclusion:

The examples discussed show that efforts taken in following best practices of maintenance will definitely help in better performance of a mill in the long run. But sustaining at this level is the key in ensuring consistent performance of the mill. With rapidly changing maintenance techniques and practices, the maintenance team in any mill has to be ready to accept and absorb the maintenance best practices along with necessary re-engineering, where ever necessary.

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