WAN-IFRA REPORT

EXTEND THE LIFE OF YOUR PRESS

CONDITION MONITORING OF PRINTING PRESSES

WORLD PRINTERS FORUM REPORT
MAY 2019

Foreword

Manfred Werfel

WAN-IFRA

What is the best time to replace a defective part of a printing press? It is best to replace a faulty or damaged machine part exactly one day before it finally fails.

But how can this time be determined? Because this seems almost impossible, many users replace critical parts on a fixed schedule. But that can be too early and cause unnecessary costs. Others replace faulty modules only after they have caused damage already. This is usually too late and increases the damage unnecessarily or even leads to a complete breakdown of the machine.

There should therefore be a way to establish a proactive maintenance system that avoids the disadvantages of a too early or too late replacement. But many parts of a complex production line are not accessible or cannot be viewed without dismantling the machine. So is it better to replace them regularly according to a maintenance schedule?

Fortunately, there are technical possibilities for using modern analysis methods and sensors to actually look into the machine (and listen inside of it) without disassembling it. We present the most important methods in this report: vibration analysis, ultrasonic analysis and thermographic image analysis.

The availability of such analysis methods and their costs today are in an area that also enables their use in small and medium-sized newspaper printing plants. In addition, printers do not necessarily have to purchase those tools themselves, as they can be used by external experts as part of a consulting project.

My Indian colleagues have gained a great deal of practical experience in dealing with such analysis systems in recent years and I am pleased that they are sharing their experience with all other newspaper printers in this report.

Condition monitoring of production equipment helps publishers and printers operate their systems more efficiently and minimise costs and effort. Ultimately, it extends the life of presses and mailroom equipment.

In this sense, I hope that this report will fall on fertile ground.

Manfred Werfel
WAN-IFRA
Frankfurt am Main, May 2019

IMPRINT

EXTEND THE LIFE OF YOUR PRESS
CONDITION MONITORING OF PRINTING PRESSES

PUBLISHED BY:

WAN-IFRA SOUTH ASIA
54, K B Dasan Road, 3rd Floor, SIET Admin Building
Teynampet, Chennai, Tamil Nadu – 600 018, India

PUBLISHING DATE:

May 2019

CEO:

Vincent Peyrègne

COO:

Thomas Jacob

MANAGING DIRECTOR SOUTH ASIA:

Magdoom Mohamed

DIRECTOR OF INSIGHTS:

Dean Roper

AUTHORS:

Jaiganesh Muniasamy
Hans Jörg Maurer

EDITORIAL ASSISTANCE:

Dean Roper, Magdoom Mohamed, Susan Philip

CONTACT INFO:

Jaiganesh.m@wan-ifra.org

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Chapter 1

About the World Printers Forum

The World Printers Forum (WPF) promotes the printed newspaper. Its mission is to serve WAN-IFRA members in promoting and sustaining the printed newspaper business and technology through collaborative research and development, global exchange of experience, creating new standards, implementing environmental guidelines, developing new strategies and fostering innovations.

It addresses all print-related questions. Its objective is to encourage innovation and productivity as well as product development that can be instrumental to publishers seeking to exploit future-oriented news media products.

WPF aims to be the central point of the international news media print community, including publishers, printers, materials suppliers, and equipment manufacturers for the print production value chain, from prepress to press to product finishing and delivery.

The World Printers Forum organises:

- International exchange
- Research and innovation
- Standardisation of processes and materials

WPF is the print community within the World Association of Newspapers and News Publishers (WAN-IFRA). It advises WAN-IFRA on all aspects of the printed newspaper. Newspaper production is defined as the business of production planning, prepress data handling and processing, and press and mailroom operations, including related topics in terms of management and technical implementation.

WPF is open to all WAN-IFRA members who are interested in the future of the newspaper printing business and print-related areas. It also partners with other organisations working toward the same objectives.

The World Printers Forum promotes:

- Improving productivity and profitability
- Sustainability
- Benchmarking
- The power of print

WPF's objectives are:

- Exploring customer expectations in communication with publishers and customers
- Strategy development for the newspaper printing business, including new and emerging business models
- International exchange of experience regarding business optimisation and innovation in product development, marketing, sales and technology

WPF achieves its objectives by organising:

- Temporary and permanent working groups
- Research projects, reports and guidelines
- Standardisation and certification projects in technology and business processes
- Benchmarking projects
- An annual international conference

Other WPF activities include:

- Advising WAN-IFRA regarding production-related events
- Maintaining a blog for discussion, working group interaction and community engagement
- Promotion of "unique selling propositions" of print in an increasingly digital media environment

To join the network, go to **www.wan-ifra.org/wpf**

After the Board Meeting on 12 October 2018 at F.A.Z., Berlin, participants visited the Brandenburg Gate. From left to right: Max Garrido, Josef Konrad Schießl, Herbert Kaiser, Michael Hirthammer, Jaiganesh Muniasamy, Rainer Kirschke, Sally Pirri, Alena Kluge, Thomas Isaksen, Manfred Werfel, Sanat Hazra, Magdoom Mohamed, Andreas Gierth, and Prabhu Natrajan.

World Printers Forum Board Members

Board members represent different regions like North America, Asia, the Nordic, Central and South-Eastern European Countries.

Members of the WPF Board in alphabetic order are:

- Chair: **Herbert Kaiser**, Koenig & Bauer Digital & Webfed AG & Co. KG, Würzburg, Germany
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- **Mujo Selimović**, Publisher “Oslobodjenje”, Sarajevo, Bosnia and Herzegovina

Chapter 2 Executive Summary

Any manufacturing facility should ideally achieve the intended productivity with optimum material and energy consumption. This, to a major extent, depends on the ability of the machinery used for manufacturing to run without any breakdown. A good strategy to maintain the machinery can make this easy. In the case of newspaper printing presses, preventive maintenance is widely in practice, which helps keep the machines almost completely free from breakdowns. Despite that, there are several factors and scenarios which require condition monitoring in the newspaper printing industry.

Modern newspaper companies around the world use various ways to ensure high efficiency of their printing machines. **Condition monitoring**, a widely practiced method, helps to achieve this with relatively less effort. The two major ongoing changes in the newspaper printing business - narrowing profit margins and downsizing of the engineering workforce - are likely to create a great demand for **condition monitoring** in the near future.

WAN-IFRA embarked on a **Mechanical Audit of Printing Presses** project in 2016, and publishers and printers in India and South Asia took an overwhelming interest in it. The project aimed to analyse the critical parts of a printing press for their condition, the nature and severity of any existing anomalies and possible root causes of faults, and also to make recommendations either to avoid failure or improve the condition of the machine by acting proactively. Such analyses are possible by employing three basic condition monitoring techniques, namely, **Vibration Analysis, Ultrasound Analysis and Thermography Analysis**.

Vibration Analysis gives a frequency spectrum wherein different fault frequencies are identifiable, and this helps to determine various fault sources. It also indicates the severity of the problem.

Ultrasound Analysis helps to identify problems such as inadequate greasing, contaminants in grease, raceway problems in a bearing, compressed air leaks and vacuum leaks, to name a few.

The thermographic Image analysis helps to identify anomalies in electrical parts, cabinets, connectors etc. Also, this could help identify the problems in small motor drives, problems in ink roller nip contacts and reel stand brakes. Generally, an infrared picture has very wide applications, but the depth of analysis is limited.

Based on the data and findings in these projects, this report throws some light on the common anomalies noticed in printing presses – the kind of anomalies and possible reasons for deterioration, the parts that are prone to damage, electrical issues associated with these anomalies, and other issues in the maintenance of printing presses.

In a printing press, blanket and plate cylinders, oscillators, main drives, powerline gears, ink-train rollers and cylinders in the folder are considered critical parts due to their functionality, and the failure of any of these may halt the press operation from between a couple of minutes to several hours, depending on the nature of the failure. Also, print quality depends on a perfectly running machine and good machine settings. Wrong settings lead to increased ink and water usage, energy losses and early wear. Hence, the inspection layout was plotted on these identified parts and the report highlights the problems associated with them.

Due to the location and functionality of these parts, they may generate different fault signatures and the fault source varies for different anomalies. Simple statistical analyses were made, based on the data available, to give a picture of the frequency of different anomalies, nature of the anomalies, and possible sources of the anomalies.

Based on the results derived from data analysis, it was observed that **blanket cylinders** are beset with many problems. As much as 43% of the total number of blanket cylinders inspected had one fault or the other. Blanket cylinders operate under high pressure and interact with paper and ink. In many cases, they are connected to the prime-mover. For blanket cylinders, fault signals are observed through the bearings which support the cylinders at the ends. These signals may warn of a problem with the bearing and housing, problems with the gear mesh, manufacturing defects in the cylinder itself, or problems in the blanket holder.

Plate cylinders were observed to have many anomalies. As much as 34.38% of them showed up with one problem or other. Functionality-wise, a plate cylinder is similar to a blanket cylinder – it interacts with ink rollers, fount rollers and the blanket cylinder. In both the cases, wrong pressure settings could lead to early wear and tear of bearings. Associated problems are almost like those that affect the blanket cylinder.

Oscillators, important for proper ink transfer, are third on the problematic list, 30% of them being found to have issues. The common anomalies observed in the oscillators were rubbing of the shaft in the sleeve, improper greasing, bearing problems and gear-train problems.

The report also provides some analyses on ink roller train, problems in folder cylinders, drives, reel stands and infeed units and the superstructure.

The last chapters of this report comprise exclusive interviews with two publishers – one from India and another from Sri Lanka – who use **condition monitoring** of their printing presses. They provide insights into the problems and the strategies to run the press smoothly.

In a nutshell, this report can be used as a basic guide to understand **condition monitoring in presses** and also to gain an overview of problems associated with critical parts of a printing machine.

Chapter 3 Introduction

The last two decades have seen the development of sophisticated rotary printing presses, which have made it possible to print high volumes of newspapers in a relatively short time. Worldwide, publishers have invested in these machines and established several printing centres based on their customer reach.

Late in the last decade, after the recession, countries in the West faced a downtrend in circulation and advertisement due to the strong emergence of digital and social media. In this situation, a printing press designed only to manufacture newspapers brought up issues like under-utilisation of machine capacity, low work-to-manpower ratio, increased production costs etc., which resulted in lack of control over production KPIs.

This gave a clear message that, to meet current circulation trends, it was necessary to cut down costs and downsize the engineering workforce by deploying optimised maintenance strategy. Also, it was evident that new investment in machines may not bring back the ROI within the stipulated time. It was observed that at times, new business models could demand retrofits to meet new market demands.

Whatever the case, existing printing machines remain an important asset and should be maintained well. The mechanical parts in a machine can last for several years with good housekeeping, proper maintenance, and operation within the safe loading conditions specified by manufacturers. Nevertheless, beyond a certain time in length of service, for example when parts reach the endurance limit of the working cycle, the mechanical parts start to lose efficiency. Damage caused by material failures, handling misuse or damage through disruption of the printing process – e.g. choked oil flow, ink mess-up, plate crash and paper roll up in blankets – may initiate failure at an early stage and timely detection of these will help prevent failure and reduce the cascading effect on other parts of the machine.

Monitoring the condition of the machine at specific intervals is one option available to keep it running efficiently with minimal breakdowns. Publishers in Western countries employ **condition monitoring** widely, as it helps them catch problems at the nascent stage so that they can be attended to before they become aggravated. By doing so, a sudden, costly failure can be avoided, safety is assured, and it is possible to keep pre-planned inventory.

The following chapters set out the approach of the project, the working model and techniques used, analyses of results, and interviews with two leading publishers in the region.

Chapter 4

Methodology and approach

Diagnosis Model

Newspaper printing presses can be classified under the umbrella term “rotating machinery” – machines which have rotating parts – as they have cylinders and rollers to allow the newsprint web to move through various sections of a printing machine. Newspaper printing presses are operated within a narrow window of time, and so it is crucial that they function without any breakdown during this period.

Today, advancements in reliability engineering have resulted in the invention of several inspection techniques for maintaining the reliability of machines. Plenty of such techniques are available for monitoring the condition of a machine, permitting analyses to various extents. For several years now, vibration analysis is the primary method of inspection to determine the condition of rolling elements in machines.

To run an inspection without dismantling the machine assembly to study the behaviour while the machine is in operation, it is necessary to use technologies to see behind the wall and at the same time not enter dangerous zones. Every part has its own character and fault signature. Therefore, different technologies are needed to get a deep knowledge about the condition of each of the parts. We used Ultrasound and Thermographic Imaging as well as Vibration Analysis, in our approach.

Vibration Analysis

The dynamicity of a machine makes vibration unavoidable, but it can be kept under control by means of various methods such as dampers in the form of rubbers, cast iron and alloys which exhibit such characteristics. In a printing press, there are hundreds of cylinders and rollers, which rotate alone or against each other while printing the newspaper.

The machine vibrates when in operation due to the movement of rolling elements in the bearings, rotation of gears and clutches, bumping of blanket and plate cylinders against each other, movement of oscillators and many other factors. The casting structures where the cylinder shafts are housed are designed to act as vibration dampers – this means they absorb/mitigate the spread of vibration energy. When a new machine is installed and approved for production, the manufacturers ensure that the magnitudes are within the designed values. However, after some years of operation there may be several instances and fatigue, which break threshold limits, and eventually the vibration signals become very strong and have deteriorating effects.

As mentioned earlier, the source of vibrations could be in any part – bearings, gears, clutches, belt drives, cylinders, and so on. Also, improper handling, mounting and damage during operation contribute to early machine problems. The time signal recorded usually contains a lot of information, more than what we need. Therefore, time signals are filtered for a certain frequency spectrum to identify common fault frequencies within the given bandwidth. The frequency may contain information on the source of the problem, while the amplitude contains information on the severity of the problem.

If the amplitude of a vibration signal grows over time, that means the problem is growing in severity. No single value can define the threshold level. Several factors, including the type of mounting, nature of production process, load under which it operates, influence the amplitude.

ISO 10816-3 guidelines: *Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts. Only to know basic guidelines for analysing the vibration signals.*

Any of the following anomalies, individually or together, could be identified as the reason for vibration. (This is not an exhaustive list.)

1. Imbalance
2. Misalignment
3. Looseness of mechanical parts
4. Bearing anomalies
5. Problems in the gear box
6. Problems in belt drives

Bearing faults

Vibrations due to bearing problems are calculable. They can be overlooked to certain limits in the initial stage. They are denoted by unique terminology.

Here are some indicators that help to interpret measurements:

BPFO: **B**all **P**ass **F**requency **O**uter race

BPFI: **B**all **Pa**ss **F**requency **I**nner race

BSF: **B**all **S**pin **F**requency

FTF: **F**undamental **T**rain **F**requency (Frequency of cage rotation)

RPM: **R**evolutions **P**er **M**inute (Base frequency)

Ball Pass Frequency

The frequency corresponding to the rate at which balls or rollers in a bearing pass a point or location on the inner or outer race is referred to as BPFI or BPFO. The inner race and outer race ball pass frequencies are different from each other and are dependent on the geometry of the bearing and the rotation speed of the bearing. Due to the complex motion of bearing elements, these frequencies can't be regarded as harmonics of the base frequency and are difficult to predict exactly due to variations in bearing geometry, contact angle, and load. Nevertheless, mathematical equations available to calculate these frequencies provide all the data available. Generally, the bearing manufacturer's data sheet provides the information needed to calculate these frequencies. Again, the source of ball pass frequencies and the patterns may vary depending upon bearing conditions (BC) and are noted in the spectra of machine vibration.

General Indicators

The following interpretations are based on ISO standards. As ISO always gives maximum allowance, action should be taken at the earliest stage considering safety, quality and reliability, rather than waiting till the values reach ISO specifications. If a signal or level doubles from the initial value or from previous measurement, and/or if the trend shows the growth in that direction, measurements should be taken. Increase the frequency of inspections if it moves toward failure or arrange a replacement if there are any associated safety issues. The time to act may also be arranged after study by RBM (Risk-Based Management).

Here's a tip

It is recommended that a user with no previous experience in interpreting the results use the ISO 10816-3 standard, which is an indicator of derivations and could be used as an entry point to deeper analysis by applying some basic technical knowledge. The simple rule is to set the bar for vibrations lower than the standard, rather than allowing for higher vibrations.

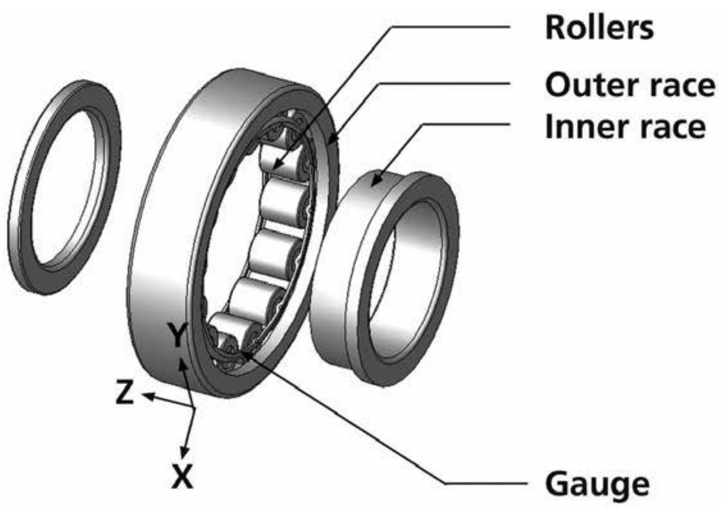
Levels and meanings

Vibration is a back-and-forth mechanical motion like an oscillating pendulum; it creates a sinusoidal wave pattern. The maximum range is referred to as amplitude, while the number of cycles per second is referred to as frequency. The frequency varies with the speed of the motion and this is defined as velocity. The standard normally measures vibration in velocity in mm/s RMS (Root Mean Squared). This measurement gives a good understanding of the amount of "breakdown energy" it contains and how much wear and fatigue it will cause in the machine or on the structure being measured. It is important to measure the movement in all three directions and advanced measuring instruments can read all the axes at one go. Nevertheless, single axis measuring equipment also produces accurate results. They just take longer to cover the inspections.

ISO 10816-3 classifies the machines based on the mounting – whether it is flexible or rigid mounted. The type of mounting of the machine determines the stiff-body resonance and how it reacts to the base speed of the machine. For instance, a machine supported by rubber or springs often has resonance at low running speeds – in other words the machine starts vibrating heavily at certain low RPM. When these machines are close to stopping, and the RPM nears zero, they vibrate heavily and stop. Such machines are considered to be "flexi-

Extraction from ISO 10816-3

Unit	Group 1 & 3		Group 2 & 4	
mm/s	Rigid	Flexible	Rigid	Flexible
0–1,4				
1.4–2.3				
2.3–2.8				
2.8–3.5				
3.5–4.5				
4.5–7.1				
7.1–11				
11 <				



Roller Bearing - Exploded view

Quelle: Web

ble mounted". At higher speeds they operate smoothly.

Generally, the resonance can easily be found when a flexible mounted machine is running up or down on its speed pattern. At resonance the vibration has a local maximum level. Modern machines have designed resonance maximum values at high RPM. They have flexible bearing-supports and foundations. They can be treated as flexible even when not mounted on rubber or springs but exhibit the same characteristics. It is understandable that the ISO

Here's a tip

The thumb rule is that resonance is not desirable in machines because it creates adverse effects. Therefore, a resonant condition in principle is not allowed, or at least should be avoided within the band of operating speeds.

10816-3 standard allows for slightly higher limits for flexible mounting as compared to rigid mounting.

A great advantage of proper vibration measurements and the use of vibration standards is that the data to judge the future maintenance cost is available very reliably at the very first step itself. If one finds levels above 3 mm/s RMS, can be sure that the machine will need increased maintenance. The specific actions

Here's a tip

As always, when relying on schematic judgements like this, make sure to use common sense when applying the recommendations. The specific vibration frequency pattern that a particular machine produces will depend on the location of the transducer and other properties of the machine.

that may be needed and their cost of course depend on the design and nature of the problem exhibited.

The next logical step is to apply filtering of the transducer signal (Time Signal) to determine the frequency behind the vibration and thus identify the mechanical fault. Use the Analysis Function (Fast Fourier Transform) to find the source of the vibrations. Two machine parts joined together should have the same vibration level on both sides of the joint. Bolts fixed in concrete foundations should have the same vibration level as the concrete if they are not loose.

The following classification is part of the old standard ISO 2372 class – large machines on flexible foundations – with some common findings added. This simplified list can be used as a first consideration when you approach both a newly commissioned machine and one, which has been in operation for some years.

Remember, it is good to consider the level of preventive maintenance procedure and housekeeping being practiced while investigating the reason for any machine that vibrates above 3 mm/s RMS.

Readings above 7 mm/s RMS should not be ignored since very few machines can operate under these conditions. Ignoring a sign of failure impacts the surrounded bearings and elements. Therefore, timely action is crucial. A background study and extraction of relevant information are essential to ensure that the equipment will

Here are standard vibration levels for group 2 category

Standard Vibration Level Machine Condition	Machine Condition
Up to 2.8 mm/sec	Normal
2.8 to 7.1 mm/sec	Marginal
Above 7.1 mm/sec	Critical

Speed	Effects	What to do
0–3 mm/s	■ Small vibrations ■ None or very small bearing wear ■ Rather low noise level	■ Keep under observation.
3–7 mm/s	■ Noticeable vibration levels often concentrated at some specific part as well as direction of the machine. ■ Noticeable bearing wear ■ Seal problems occur in pumps, gear boxes etc. ■ Increased noise level	■ Try to investigate and identify the reason. ■ Plan action during the next regular stop. ■ Keep the machine under observation and measure at smaller time intervals than before to detect any deterioration trend. ■ Compare vibrations to other operating variables.
7–18 mm/s	■ Large vibrations ■ Bearings turning hot ■ Bearing wear-out necessitating frequent replacements ■ Seals wearing out ■ Leakage of all kinds is evident ■ Cracks develop in welding joints and concrete foundations ■ Screws and bolts are loosening ■ High noise level	■ Plan action at the earliest as your investments are wearing down quickly. ■ Do your best to identify the reason.
18 mm/s and above	■ Very large vibrations ■ High noise levels	■ This is detrimental to the safe operation of the machine. No known machine will withstand this level without internal or external damage. ■ Stop operation if technically or economically possible, considering the plant stop cost. Reduce any further running time to an absolute minimum.

withstand long-term operation with such high vibrations without increased wear and tear.

Resonance is a common but little understood problem in modern machinery. Resonance occurs when the natural frequency of a system coincides with the exciting frequency. If any natural excitation (alternating force) in the machine has the same, or nearly the same, frequency as a resonance frequency, the vibration will be amplified in that part, and a much higher level of vibration will occur. The resonance amplifies the mechanical force and thus generates a high vibration in that direction. Resonance makes the machine unnecessarily sensitive to mechanical forces.

One common resonance frequency is the critical speed of a shaft, which depends on the rigidity and mass of the shaft, but resonance exists in all machine parts as well as in supporting beams and concrete floors. Examples of natural excitation forces are imbalance at the running speed, misalignment on mainly twice the speed, gear mesh forces etc.

To identify the presence of a resonance, the vibration levels should be measured in three perpendicular directions at the bearings. If one reading is at least three times higher than those in the other directions, one should consider resonance a possibility. It is possible to locate the resonance peak while the speed of the machine is changing. The resonance frequency is located at that RPM where the vibration has a local maximum.

Appropriate action against resonance will vary vastly depending on its location, operating conditions etc. It will normally require much experience to alter the situation. One reason is that any modification will affect the basic mechanical design of the machine and the competence of a machine designer will be required for proper justification.

However, we recommend that you do not hesitate to undertake the required modifications since changing the resonance frequency is normally cheaper than the cost of repairs that will be incurred if a machine is allowed to

Here's a tip

The basic rule is that the resonance of any part in the machine should not coincide with any natural impulse in the machine.

Here's a tip

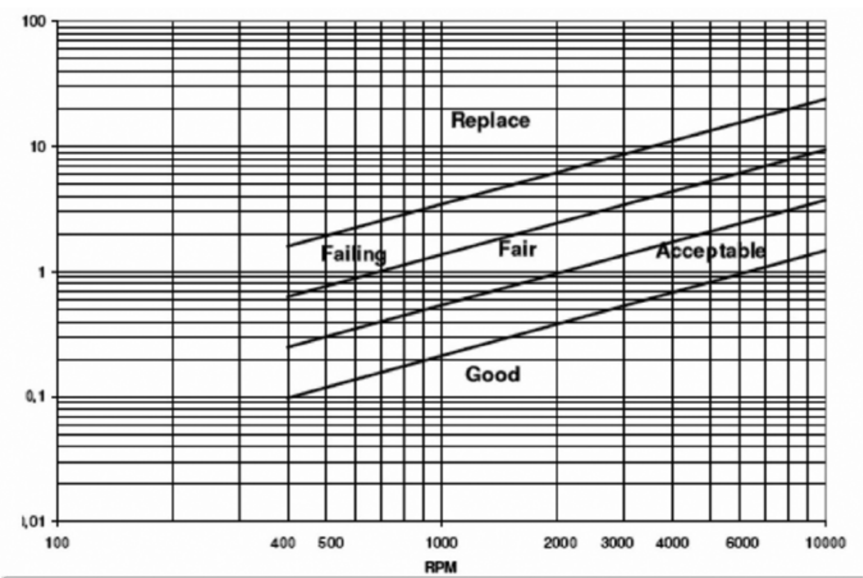
A temporary and sometimes permanent solution to a resonance problem is to change the shaft speed of the machine. Observe the regular production speed, and keep your resonance speed away from this, maybe at higher speeds of the press.

Recommended bearing conditions

Bearing condition value with the unit “g” RMS

Find the machine speed. Follow this line up to the judgment lines and read the value on the left axis.

NOTE: The diagram is only a guide to interpret the bearing condition value. If vibrations produced by other causes (e.g. flow surge, gear mesh) are within the selected frequency range, it can give a high bearing condition value without the bearing being damaged. A high bearing condition value can also result if the bearing is poorly lubricated or overloaded (e.g. by misalignment, or large belt forces). Compare this value with the envelope value and the bearing temperature. If all are high or pointing upwards in the trend analysis, you might have a bearing problem.



‘g’ force Vs RPM

operate for the long term under the influence of resonance.

Ultrasound Analysis

Ultrasound is not used as a primary inspection technique in press condition monitoring. Nevertheless, it has the capability to detect anomalies, which may not be possible through vibration analysis in bearings and oscillators. There are two ways to collect the time signal – air borne, and structure borne. These can be analysed to detect defects. The structure borne method was generally used in our inspection of printing presses though it is not restricted to this method, and it depends what to be inspected.

ISO 29821:2018 or previous versions provide the guidelines for diagnostics and condition monitoring using ultrasound. Frequencies above 20 kHz, high-frequency sound waves, beyond human audible range, tend to lose the energy quickly, and therefore it is possible to find the source of sound accurately. The acoustic score is a subjective evaluation of a measured signal. The measured data are evaluated for this purpose along with noise measured in decibel (dB). Spectral analyser (Fast Fourier Transform) can be used to locate the problem. Signals may not have unique values but denote faults, which are impossible to designate mathematically.

Ultrasound monitoring of bearing wear

Ultrasonic monitoring of bearings is one of the most reliable methods for detecting incipient bearing failure and conditions such as lack of lubrication. The ultrasonic warning appears prior to a rise in temperature or an increase in high frequency vibration levels.

Ultrasonic inspection of bearings is useful in recognising:

- The beginning of fatigue failure
- Brinelling of bearing surfaces
- Flooding of lubricant
- Lack of lubricant
- Scratching of oscillators
- Air/vacuum leaks

In ball bearings raceway problems develop due to fatigue, contaminants and higher loads. This will produce irregular surfaces, called pitting, which will cause an increase in the emission of ultrasonic sound waves. An indication of bearing failure is noted by an increase in amplitude of a monitored ultrasonic frequency over the original (baseline) reading.

An ultrasonic system based on detection and analysis of modulations of bearing resonance frequencies can provide subtle detection capability, whereas conventional methods are incapable of detecting such special anomalies. As a ball passes over a pit or fault in the race surface, it produces an impact. A structural resonance of one of the bearing components vibrates or "rings" by this repetitive impact. The sound produced is observed as an increase in amplitude in the monitored ultrasonic frequencies of the bearing. The sound quality of these changes can also be heard through headphones.

Brinelling of bearing surfaces will produce a similar increase in amplitude due to the flattening process as the balls get out of round. These flat spots also produce a repetitive ringing that is detected as an increase in amplitude of monitored frequencies. Further study on brinelling will help to detect the anomalies accurately.

A good bearing makes a rushing or hissing noise. Crackling or rough sounds indicate a bearing in the failure stage. In certain cases, a damaged ball makes a clicking sound whereas a high intensity, uniform rough sound may indicate a damaged race or uniform ball damage. Loud rushing sounds similar to the rushing sound of a good bearing, only slightly rougher, can indicate lack of lubrication. Short duration increases in the sound level with "rough" or "scratchy" components indicate a rolling element hitting a "flat" spot and sliding on the bearing surfaces rather than rotating.

If any of these conditions are detected, more frequent examinations should be scheduled. Data should be collected to note, and trend the decibel rise. In addition, the bearing sound should be analysed using spectral analysis software (FFT) or by connecting the ultrasound instrument to a vibration analyser.

There are other inspections possible using ultrasound; for example, air leakages can be detected, as well as faults in Variable Frequency Drives (VFDs) and electric sparks. Compressed air is the most expensive energy used in machines and leakages are easy to repair. Therefore, inspections offer high return on investment (ROI).

Thermographic Analysis

Thermography

At normal or room temperature, all objects emit infrared energy. A thermal camera shows the emitted heat radiation of a component as an infrared image. The colour and value scale on the right side are equal to the colour inside the thermographic image. In the Iron Colour Mode, high temperatures are bright and low temperatures are dark. The range of the scale is adapted to the temperatures of the object.

The temperature of the surface is not the real temperature. Emissivity of surface greatly influences the image. High emissivity objects appear hotter in the IR image than low emissivity objects of the same temperature. The thermal image is also influenced by reflection, environment temperature, humidity, distance and transmission. All these properties must be recognised during the analysis. The quality of a thermographic reading belongs also to resolution, lenses and sensor capability. For example, the distance to an object and the resolution of the Focal Plane Array (FPA – sensor array) limit the accuracy of the reading.

Modus Operandi

Criteria

Class of danger is based on the difference of the calculated temperature at nominal load (mostly 70 °C) and its difference compared to the actual temperature. For the assessment of individual temperature increase on cables and clamps and/or terminals, the excess temperature (difference between the environment temperature and temperature of the tested object) is additionally classified under three categories:

Class of Danger (according to VDE Certification Institute GmbH)	
Class 0 or 1	delta T = 0–10 K: No danger but conspicuous
Class 2	delta T = 11–20 K: Worth observation
Class ≥ 3	delta T ≥ 21 K: Defect detection; removal of error
Class -X	Additional class for errors, which are not possible to classify under standard rules

Class of Risk	
Class 0	No risk, but conspicuous
Class 1	Temperature may increase with higher current
Class 2	Defect may surface
Class 3	Defect exists and must be repaired
Class > 3	Critical status

Measurement in mechanical equipment

Criteria

At mechanical locations, there are no absolute parameters to describe a fault. The criteria depend on the material in use, working loads and usage. Production conditions, age and environment are also factors. Insulation and equipment safety measures as well as equipment “packaging” can distort the measuring phase of analysis because they “slow down” heat radiation. Only the temperature of the surface can be detected. However, conclusions can be drawn regarding the temperatures generated from behind these shielding components. In most cases it is possible to achieve reference recordings facilitating the use of similar equipment with the same design and working conditions. Differences of more than 10 °C (23 °F) in the same location, same load and on identical components are a sign of a fault and require further investigation.

Another condition to be aware of is the temperature in a gear box or gear cabinet. Readings greater than 80 °C (176 °F) are dangerous because such temperatures can have a disastrous effect on the lubrication. Information on lubrication specifications is helpful in making a full analysis.

Here’s a tip

The expected temperature is the temperature calculated by the actual load.

Class of Risk	
Class 0	No risk, but conspicuous or reference measuring
Class 1	Temperature difference regarding the load
Class 2	Conspicuous, but actually not risky
Class 3	Defect may arise
Class > 3	Critical status

General repair recommendations

General recommendations for electrical findings

The following recommendations can be used for thermal defects:

- Check load of power line and machine.
- Compare the dimensions of the cables with the circuit diagram.
- Increase the distance between elements for air circulation.
- Clean the clamps and if necessary, fit them with a torque.
- Change or repair immediately objects falling under Class 3.
- Enable air circulation.

General recommendations for mechanical findings

- Verify that proper lubrication maintenance cycles – i.e. greasing and oil filtration – have been done.
- Verify that proper lubricants are used.
- Verify that manufacturers' specifications for mechanical loads are being adhered to.
- Verify compliance with proper clamping, fastener torques, and fastener specifications.
- Remove and replace identified failed components to minimise damage to neighbouring components.
- Identify improper (beyond design) use of equipment i.e. severe cocking or mating of nipping barrels (early bearing failure).
- Check bearings for breaks using a strong magnet at the open housing and gear in machinery using central oil distribution check filters and tanks.
- Do a visual inspection of the bearings and touch the bearings with small soft wooden sticks.

Chapter 5

Our Findings

From the projects carried out in South Asia, we have analysed a huge set of data under different headings and derived some statistical figures based on that. Analyses are given under two main headings – Printing Tower and Folder. Under Printing Tower, Blanket and Plate Cylinders, Oscillators, Main Drives, Gear Boxes are covered. In Folder, Knife Cylinder, Folding Cylinder, Collecting/Jaw Cylinder, Main Drives and Gear Box analyses are provided. These analyses are made for indicative purposes and to throw light on some of the problems occurring widely in all the machines inspected.

Printing Tower

Blanket and Plate Cylinders

Plate and blanket cylinders are very important parts of a printing machine. Generally, they are heavy and supported by bearings at the ends and connected to a powerline at the gear side.

In our inspection and analysis of various printing presses, we arrived at figures, which show that the cylinders have the most anomalies. As far as cylinders are concerned, readings were taken from bearing housing using both vibration and ultrasound. Based on the source of anomalies, they were grouped and accounted for under the respective cylinders. Not all the anomalies denote a highly critical issue; the problems range from early stage of an anomaly to severe ones. The table below presents some statistics:

Description	Plate Cylinder	Blanket Cylinder
Total no. of cylinders inspected	320	320
Total no. of cylinders with anomalies	110	137
% of cylinders with anomalies	34.38 %	42.81 %

Some of the most commonly observed critical faults are given below:

1. Shaft condition
2. Lubrication inadequate
3. Bearing conditions and impacts
4. Looseness
5. Plate bump

Recommendations: Check plate and blanket mounting locks to avoid plate and blanket removal while running; avoid web breaks and roll up; use right grease and right quantity at right intervals; conduct regular pressure setting check between plate to blanket and blanket to blanket cylinders; check for gear problems in the gear mesh frequency that affect bearings; ensure proper handling of bearings and cylinders during repairs and service.

Oscillators

Oscillators are important for smoothing ink throughout the roller to avoid ink accumulation in different ink-key columns. Also, it has contact with at least two rubber rollers. Oscillators have a very complex system of movement achieved by means of different gears and gear trains. It is important to note that oscillators are directly connected to powerlines in the gear side of the machine and the oscillator shafts slide inside a bush. Therefore, any problem associated with oscillators not only affects quality but also the power consumption.

From our analyses, we found that oscillators are the most neglected parts in printing towers. Here are some statistics:

Description	Oscillators
Total no. of oscillators inspected	960
Total no. of oscillators with anomalies	292
% of oscillators with anomalies	30.42 %

Recommendations: Shaft wear and bearing problems were observed as a major source of trouble, so it is important to conduct better maintenance, replace the housings/couplings as necessary at the right time and ensure that the seals are in place to prevent ink misting from entering the shafts. These good practices will help prevent early failure.

Roller Train (Ink and Fount Rollers)

For consistent quality, ink and fount distribution are very important. All the rollers must be set at the optimum pressure for this. Our inspection showed that roller trains had the next highest problems in printing towers. Rubber rollers must exhibit good characteristics for proper ink transfer when they are kept at optimum pressure. High tack of ink, high/uneven nip pressure, improper cleaning of rollers, scaling/fouling and high rubber hardness were notable reasons for increased temperature.

The following table shows statistics of roller train issues:

Description	Roller Train
Total no. of roller trains inspected	320
Total no. of roller trains with anomalies	52
% of roller trains with anomalies	16.25 %

Recommendations: Regularly check the pressure settings and quality of rubber rollers in all aspects; check the mounting brackets and pressure setting mechanisms; ensure proper washing of rollers after production; see that dried ink is removed from rollers; remove scaling/fouling; check hardness. These are key to keeping roller trains running without any trouble.

Gear box

The gear box refers to the gears in the powerline on the gear side. Whether it is a shaftless machine or shafted, power to rotate the cylinders is transferred through these gears.

Therefore, proper maintenance, mounting, proper cooling systems etc., are essential for smooth operation. Imbalance, misalignment, overload, improper cooling etc., are some reasons for early failure of gears. Some of these lead to early wear-out or uneven wear. They also cause machines to develop more backlash and differential tooth loads.

Even though it is difficult to take measurements at the gears, readings taken through plate and blanket cylinders and oscillators may indicate the presence of gear mesh frequency. And in some cases gear mesh frequency is measurable at the shaft end-bearing of a main drive (motor).

The table below provides statistics:

Description	Gear Box
Total no. of gear boxes inspected	160
Total no. of gear boxes with anomalies	25
% of gear boxes with anomalies	15.63 %

Recommendations: The first step in protecting gears would be to carry out oil analysis at regular intervals. The schedule can be fixed based on the production capacity of the plant. A ballpark figure would be 700–1000 hours. Oil analysis reports help to track the trend of wear in gear systems, details about oil quality and presence of metal particles, which may come from bearings. Either gear oil suppliers or third-party companies can help in doing this.

Main Drives

Any problem in a main drive directly affects power consumption. Generally, all other parts are driven by main motors. Since the motor deals with both electrical and mechanical energy, different technologies are available to perform a complete inspection.

The scope of our inspection was primarily confined to mechanical performance. Bearing conditions at shaft and cooling fan-end, proper cooling of motor case etc., were taken into consideration. However, it is possible to carry out other inspections like, Motor Current Signature Analysis (MCSA) and Variable Frequency Drives (VFD) analysis, to give a complete picture of the system. Our findings and statistics are given below:

Description	Main Drives
Total no. of main drives inspected	80
Total no. of main drives with anomalies	27
% of main drives with anomalies	33.75 %

Recommendation: Properly cleaning of cooling fins, checking proper water flow for water cooled motors, careful remounting if the motor has been removed for maintenance/repairs and leaving enough space around the motors for cool air to circulate are some points to be taken care of to avoid failures.

Folder

The folder is a highly critical unit of a printing press because any serious breakdown in it brings the whole press to a halt, since often, no standby is available for this unit. Therefore, companies do perform proper preventive maintenance activities with regard to the folder.

The first fold, cutting and second fold happen in this unit. In the process of cutting, the cutting blades act against rubber padding and this creates a lot of stress in the main cylinder bearings and in gear trains.

Knife Cylinder

The Knife Cylinder has two sets of knives, which cut the newspaper against a rubber beading. Improper setting of knife heights creates a lot of stress in gears, bearings and the load pattern in drives.

Folding Cylinder

The Folding Cylinder, located between the Knife Cylinder and Collecting Cylinder, is operated with cam followers for the movement of tuck blades. Knife cutting patterns create stress in the Folding Cylinder as well.

Apart from this, improperly adjusted tuck blades and cams elevate the temperature locally. However, this may be a negligible problem. Primary importance is given to bearings and statistics based on anomalies in the bearings.

Collecting Cylinder

The Collecting Cylinder collects the newspaper from the Folding Cylinder and drops it in the delivery wheel. Here again, it comes with a set of cam followers to open and close the jaws. Improper adjustment creates stress in the cams and generates heat. Again, this may be a negligible problem.

Our focus was on cylinder bearings. Interestingly, it was observed that Collecting Cylinders had more problems than the others. From the table further down, it can be seen that almost 50 % of the Collecting Cylinders inspected were found to have problems.

Main Drive and Gear Box

Improper support for main drives, varying load patterns, stress in bearings, improper cooling etc., affect the performance of the drives. Only one drive out of 10 was found with some problem.

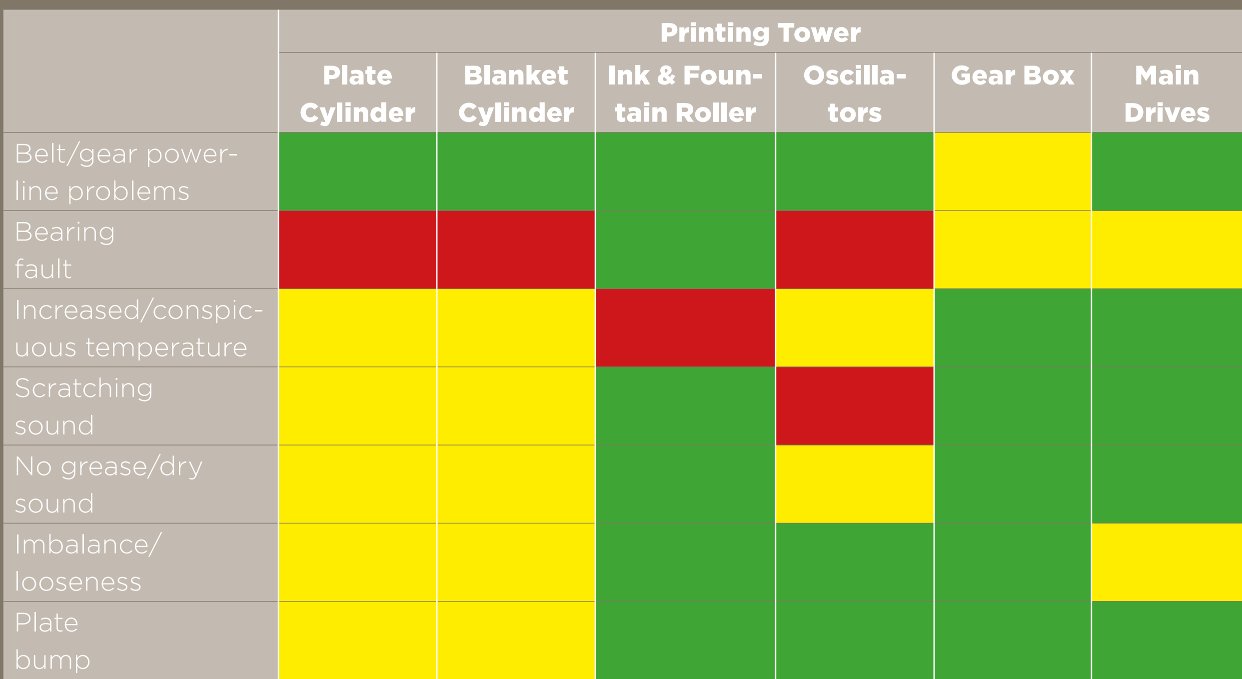
Gear box issues were difficult to analyse because readings could not be recorded on the gear side of the folder. Gear mesh frequency was observable only through the motor shaft.

However, the temperature on the gear side of all cylinder bearings could be recorded during the infrared image inspection. Oil analysis results could provide the status of the gears.

Some shaft ends could be inspected by ultrasound and a stethoscope. The main difficulty was to separate the bearing signal from the knife impact signal. Some of the observed fault numbers are given below:

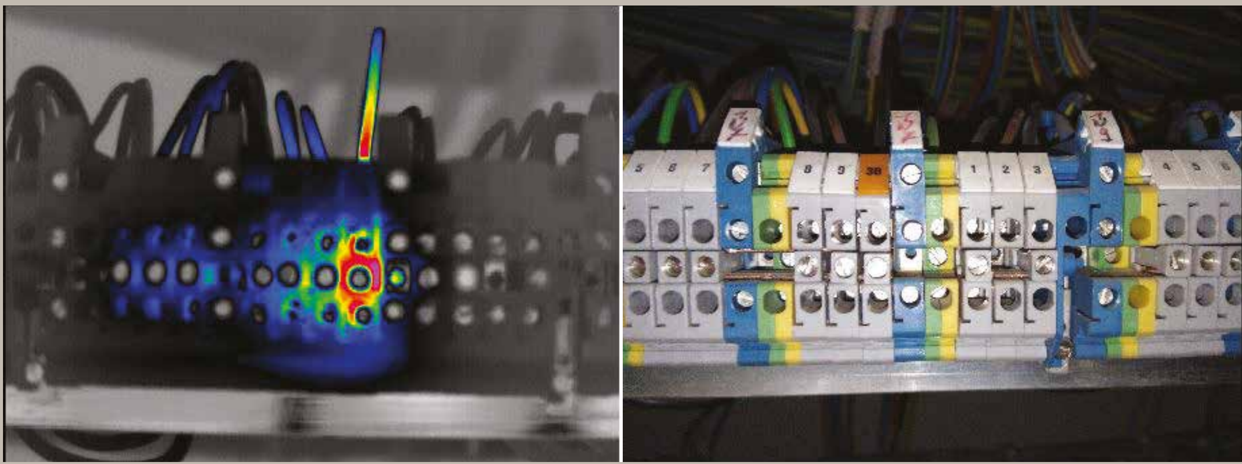
Description	Knife Cylinder	Folding Cylinder	Collecting Cylinder
Total no. of cylinders inspected	10	10	10
Total no. of cylinders with anomalies	4	1	5
% of cylinders with faults	40 %	10 %	50 %

A heat map reveals the different kind of problems, grouped for convenience, that could occur in different parts of the printing tower. The colour-coded Table below is based on their influence in printing and the number of times we found problems during inspection:



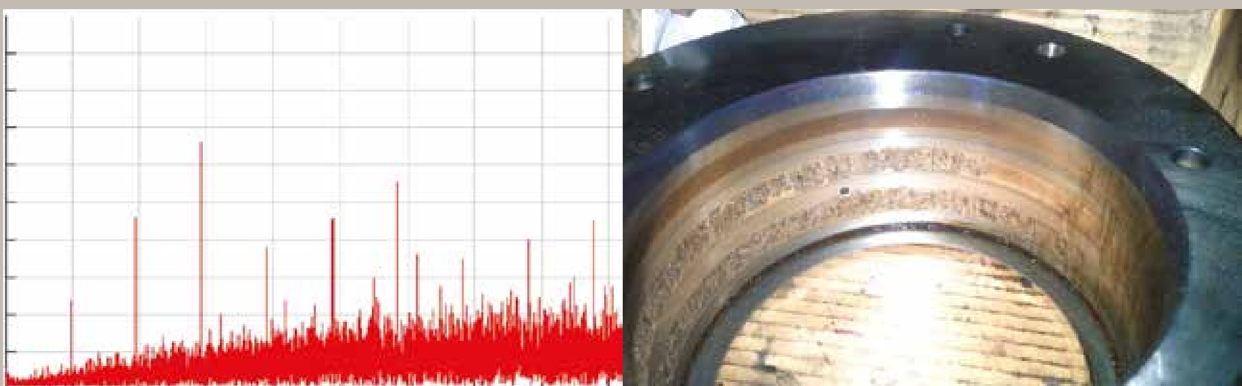
Red denotes highly critical and high occurrence rates, yellow stands for medium and green for least occurrence or no relation.

Few examples of condition monitoring applications in printing a press



Thermography: Infrared image shows the anomaly in electrical clamps

Vibration analysis: Frequency and harmonics spectrum - FFT output



Ultrasound analysis: FFT output of faulty bearing and actual condition of the outer race

Somnath Guha

VP, Production & Engineering
ABP Pvt Ltd,
Kolkata

Interview with Somnath Guha

What was your approach to the mechanical audit project? How did it align with your long-term maintenance goals?

The printing machine in a newspaper industry is the most valuable asset at least in monetary terms. In order to take full benefit of the lifecycle of the equipment or to extend it further, we need proactive maintenance, i.e. a preventive maintenance strategy for stabilising the reliability of the machine. A mechanical audit is by far the best and only way to achieve the goal.

What are the general challenges/bottlenecks you see in running a printing press, which is more than 15–20 years old?

When equipment becomes old, the major challenge would be to identify the points of potential failure and actual failure. Due to age-related issues these two points tend to come closer if they are not properly assessed. Hence condition monitoring should be done before a possible failure can become a reality.

What is the secret behind the successful maintenance of your presses?

At ABP we always believe in proactive maintenance rather than reactive strategy. It is a planned exercise, with steps like systematic inspection, detection and correction. This results in prevention of incipient failures.

How do you equip your maintenance team for this?

Our maintenance team is well trained from the factory itself. Involvement during installation process helps in a great way. We always try to follow the best practices across industry. Maintaining history of events in SAP based system is one of the best ways as it gives access to all the persons involved as well as works as a ready reckoner.

How did your organisation execute the findings of the mechanical audit project? What are your observations?

We went through the detailed report of ultrasound, thermographic and vibration analyses as per ISO 10816-3. Then we checked the recommendations and priority ratings of the respective components. Based on that we took immediate and appropriate action.

How did this project benefit you? What were the challenges you faced in the execution?

There were absolutely no challenges in executing the audit. The only thing we had to do was make some changes in production planning as the audit requires running of equipment at different speeds. The benefit was immense. Specifically, we got to know the health status of components, which are not accessible, be it in the folder or the printing unit. In addition to mechanical components we even got to know the health status of electrical components like motors, junction boxes, panels etc. through the thermographic analysis.

Janaka Rathnakumara

Chief Operations Officer/AGM, Wijeya Newspapers, Sri Lanka

Interview with Janaka Rathnakumara

How did the mechanical audit project help you realise your long-term maintenance goals?

WAN-IFRA always updates us and familiarises us with its new concepts and development programmes. This helps us maintain our position as Sri Lanka's number one newspaper printing plant, with most updated technologies, concepts and innovations. The comprehensive mechanical audit offered by WAN-IFRA was a great experience.

We at Wijeya Newspapers Ltd. already had long-term maintenance targets, which were included in the KPI targets of our mechanical engineering team. Before the audit we had identified existing press conditions and drawn up maintenance schedules to match the capacity of our mechanical engineering team. The team was keen to review the findings of the mechanical audit project so that the maintenance effort could be taken to the next level by proactively addressing the gaps.

Our major objective was to achieve zero breakdowns within the operational windows. To achieve that target we were already implementing a proactive maintenance programme. The mechanical audit conducted by WAN-IFRA directed our attention to areas, which we had not identified before. Some of the audit findings compelled us to look beneath the surface and do a micro-level analysis to determine the root causes of some mechanical issues. Further, it helped us diagnose the major failures in the mechanical systems, including wear-and-tear in printing machines and other supporting machines and equipment. The audit was very helpful in identifying potential failures and reworking our proactive maintenance schedules in order to conduct scheduled maintenance more efficiently.

In your facility, a few machines have been running for close to 20 years. What are the general challenges you face in maintaining them?

There are many challenges in running a printing press for a long time. The most important are high wear-and-tear due to continuous operation, high vibrations and high heat generation. On the other hand, it's not possible to retrofit new technological devices to the old machines to match new generation requirements.

How do you manage to equip them with the latest technological developments to meet your current demands?

We always keep in touch with our suppliers (OEM) and keep abreast of new technologies and developments regarding existing machines.

If we need to modify our machines to suit our requirements, we discuss the issue with our suppliers and take their ideas on board to successfully complete the task. For example, we introduced a new version of the QuadTech system to our press lines for the purpose of auto registration and cut-off control. It helped us to increase efficiency.

What is your strategy for successful maintenance of the presses?

We have developed and implemented sound housekeeping practices and maintenance management systems such as the Japanese 5S concept and TPM (Total Productive Management). In addition to that we have employed other sustainable practices of cleaner production, green productivity, lifecycle analysis, carbon footprint calculation and responsible care chemical management practice, ISO 14001-2015, ISO 50001-2011 and ISO 45001-2018. All the best practices are integrated with maintenance management, quality management and operational management practices in the organisation. Therefore, these best practices help us to keep plant efficiency and productivity at a high level all the time.

What learning and development support do you provide to pressmen and the maintenance team?

We continuously organise training and awareness programmes for our maintenance teams. This helps prevent our machines from developing mechanical, electrical and electronic issues. These sessions cover 5S, TPM, TQM (Total Quality Management) and Quality Circle Awareness on internal KPIs of maintenance teams as well as evaluation of the team performance on a monthly and annual basis.

What was your strategy to execute the findings of the mechanical audit project? What are your observations?

We made a detailed study of the mechanical audit report and took note of the gaps identified in it. After that, we started implementing the suggestions. This was done in three stages. First, we implemented immediate and no/low cost options. Then we put in place moderate cost options and finally implemented high cost involvement options. We also gave priority to high risk, then moderate risk and finally low risk issues.

How did this project benefit you? What were the challenges you faced in the execution?

The mechanical audit project proved very important in solving issues in the electrical drives in Goss press, folder drives etc. before they suffered drastic failure. Further it helped to

- Track the trend of wear-and-tear of all critical parts
- Immediately replace the severely affected parts
- Replace expensive parts within a pre-planned budget
- Run the machines with optimum energy consumption, thus avoiding having to pay for energy losses
- Improve reliability by maintaining the machines as close to their original condition as possible
- Extend the service life of the machines within minimum budget
- Reduce the deterioration of machines

The main challenges were finding the relevant service providers and spare parts, particularly at short notice.

How do you think better results can be achieved?

The major objectives of a mechanical audit are to enable preventive action before a part fails, reduce repair costs, prevent revenue loss, bring back the system to a good condition and extend the service life of machines. To achieve these objectives, we need to develop a frequency table to conduct mechanical audits with two- or three-year intervals. In this way it will be possible to identify potential issues and failures at different stages in the lifecycle of a machines and ensure good performance as well as extend the lifespan of the equipment.

Chapter 7

Conclusion

Much of the development in newspaper printing started after the introduction of four colour printing in a single tower. Today newspaper presses have become very sophisticated. With the advent of computer-to plate systems, shaftless presses and semi-automatic or fully-automatic presses, better skilled engineering workforces are being employed. This has necessitated improved maintenance strategies, development of the workforce and changes in working methods.

The problems that have been discussed in this report do not develop solely because of machine aging but have roots in other elements such as press maintenance, operation, housekeeping, handling and replacing parts etc. Preventing or solving these issues will improve the overall productivity. For instance, a small bend in a brake disc can elevate the temperature up to 2000C, which is very dangerous for a newspaper press. A short circuit or resistance heating in electric cables is simply waste of energy and could lead to a fire accident. Resonance or high vibrations can have cascading effects in other systems, affecting quality and machine structure and assembly. Vibration generally causes energy loss and minimising it will have a direct or indirect effect on the process and/or on efficiency.

Importantly, almost none of these problems discussed above are detectable in commonly used practices in most printing companies. The questions that often come up are: "Do we really need condition monitoring?" or, "Do we consider printing a downtime-critical industry to justify the use of condition monitoring when we have enough time to spare for maintenance?"

The answers to these questions are complicated and may need deeper study. However, taking a simplified view, condition monitoring not only helps reduce downtime, but also improves work practices and promotes reliability to a high degree.

In the West, condition monitoring has become an accepted part of maintenance strategy. The printing companies there have seen the benefits of this practice in running the press optimally in terms of both efficiency and longevity. First-hand accounts of those who have walked the trail show that where condition monitoring has been made a regular practice, machines have been running well for close to 30 years, with incomparable productivity and efficiency.

WAN-IFRA believes that optimised preventive maintenance practices with condition monitoring will bring immense rewards and result in major long-term benefits. It's time for newspaper printers to take a leaf out and adopt these best practices.

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