Defining the Category and Benefits of Total Machine Health Monitoring

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ABSTRACT

Paper Machine Condition Monitoring Systems has taken a revolutionary step forward with the advent of new and powerful monitoring & advisory systems. This paper reviews the traditional monitoring methods and requirements as well as those for this new generation monitoring and advisory systems.

INTRODUCTION

Traditionally, the mechanical health of paper machines have been monitored using periodic checks of bearings or felts using everything from hand held data collection tools to a well-trained ear. They are typically a periodic measurement, taking data every couple of weeks. In contrast, continuous monitoring systems have become very popular and with good reason. They continuously look at the process where a portable system or a single man can only take data periodically. However, they have been crippled by being used only by highly trained engineers or by limiting their scope of monitoring to select few applications. The modern condition monitoring system defines a complete new category of system by implementing total machine health monitoring including bearing, felt, and quality management. The new system goes beyond the need to have an expert at the other end of a phone line or computer screen. Using a library of proven solutions, it provides expert advice to the operator immediately and in a user-friendly fashion while still providing the depth of information an engineer desires.

Perhaps the most impressive use of the advisor technology is the integration of digital sheet break cameras. Cameras are placed strategically throughout the paper machine where most breaks occur or the process is most susceptible to breaks. These cameras continuously take videos of the sheet, buffering video until a sheet break occurs. At that time, short video clips are automatically made of the break. The most impressive thing is that the system synchronizes the clips to the process so that an operator immediately sees the process flaw causing the break. Once this is identified, the advisor function of the system gives the operator suggestions on how to eliminate the flaw in the process and prevent future breaks. The value to the paper maker is immediate. If only one break per day can be prevented, then 20 to 30 minutes more production per day over a one year period adds to tremendous savings.

MONITORING TARGETS

For total machine health monitoring, you must target many areas of the paper process. Traditionally, hand-held or on-line monitoring systems have focused on vibration in the press section and the bearings in the dryer section. In fact, these are very important points to be monitored. The press section of the paper machine represents the highest load and the greatest mass in the paper process. Because of these loads, bearings and mechanical components in the press rolls are prime targets for catastrophic failures. The

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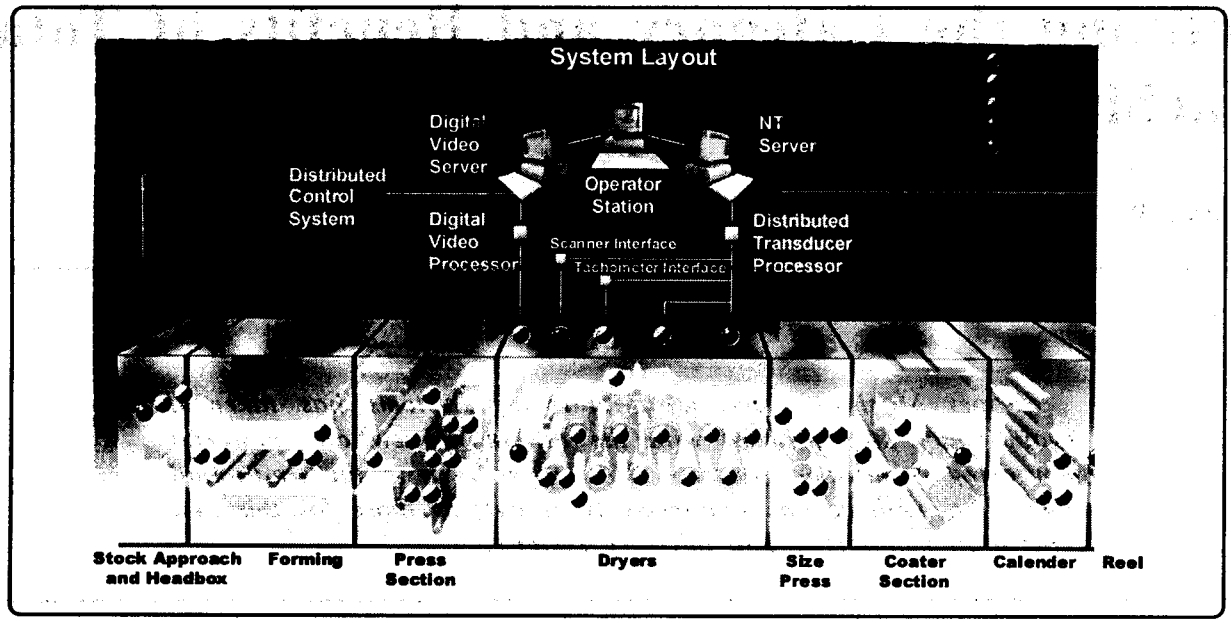


first recommendation for any continuous monitoring system is to have it installed in the press section. Additional monitoring is preferred in the headbox and the moving components in the wet end. Additional monitoring has also been done in the drainage flows from the dryers as well as oil feed systems to bearings.

Just as important as monitoring for catastrophic failure, it has become the trend to monitor how mechanical flaws are effecting the end quality of the sheet. The condition monitoring system allows the operator to monitor the quality of the sheet being produced through the scanning quality control system. Once a high speed, repeating condition occurs, the system matches the frequency of the condition to the machine component with the corresponding frequency. This pinpoints the source of the abnormal quality condition. To a paper mill striving toward continuously improving product quality, this tool is invaluable.

Placement of digital sheet break cameras begins with the locations historically troubled by sheet breaks. A mill chooses to locate as many cameras as economically feasible. Typically the first location include the first press section, under the first dryer cans, the size press, and the calender stack or the real. With dedicated processors per camera, the system can easily be expanded as new trouble spots are identified.

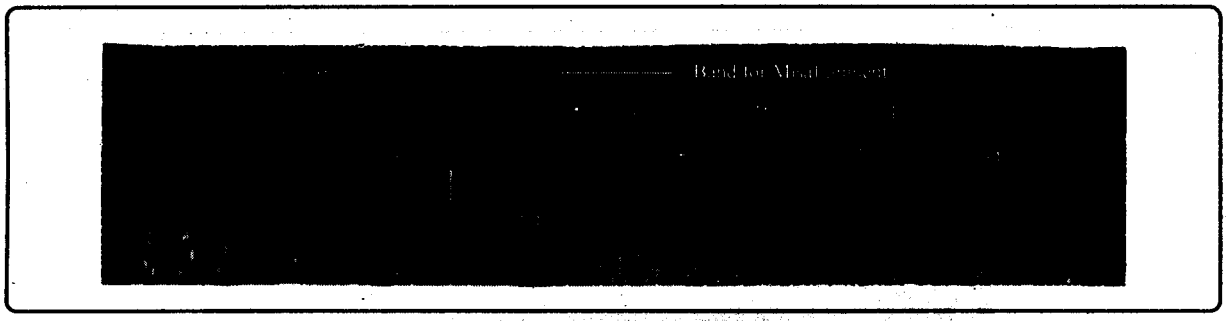
Cameras also allow the paper maker to be mobile. Mobile cameras can be used to monitor hard to reach locations or be moved from trouble spot to trouble spot around the paper machine.

PROPER INSTRUMENTATION

The success of any continuous monitoring system begins and ends with the quality of the sensors that are placed on the machine. The system uses accelerometers for detection of vibration. These sensors can be mounted in a radial or axial position relative to the center of the roll and bearing. The placement of the sensor is determined by the direction of the load. In the press section, where most of the load is in the radial direction, accelerometers are mounted in the radial direction. This will help identify conditions such as felt barring, rolls bouncing or rolls out of shape. If a mill specifically wants to look at the health of the press bearing, sensors can be monted in the axial direction as well. High signal levels from the press load can drown out the bearing signature. Although the condition monitoring system can still detect the signature, it is preferred to have an accelerometer dedicated to monitoring the bearing to insure a strong bearing signal.

Pressure transducers are used to monitor pressure in the headbox. Optical and mechanical tachometers are used to monitor speed in the various sections of the paper machine for reference. Recently, many new mills have used the system to monitor drainage flows from felts and huge boxes as well as oil flows for bearing cooling.

In order to monitor the quality of the sheet, analog signals are taken directly from the scanning heads of the quality control system. This can be done with any brand or model of scanning system. Although



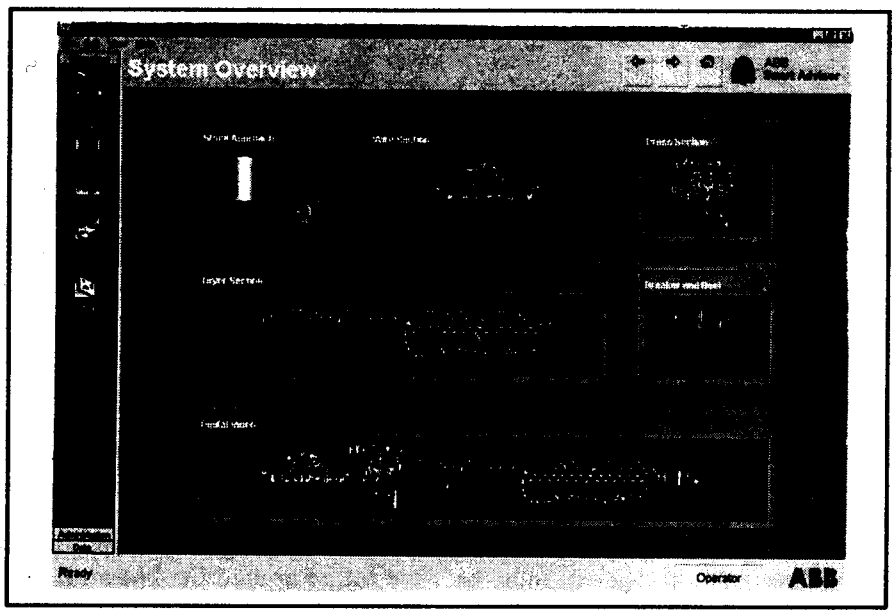
most systems choose only monitor basis weight and caliper, signals for moisture, ash, gloss, and more can be monitored as well. Raw voltage signals are taken directly from the sensor without filtering. One of the benefits of this method is that variation in the signal can been seen with a much higher frequency than in the host QCS where calculating profiles and communicating high volumes of information must be considered.

SIGNAL PROCESSING

Signals are processed using Fourier Analysis to break raw wave forms into power spectrums. Different types of faults will appear as peaks in the spectral plot of the spectrum at specific frequencies. Traditionally, these spectrums have been read by experts or trained engineers. These engineers would report back to the machine or maintenance management on a potential problem and a job order issued to resolve the issue. Hours or days could pass before the information is passed on or acted upon. The beauty of this system is that the every operator can see the information immediately and in a form he/she can readily use.

Time Synchronous Averaging isolates the signature components of the felt and the press section. It identifies the root source of dynamic variations in the incoming signals. Within the spectral plot, bands are set up around the known frequencies. In the press section for instance, these bands relate to barring, filling, compaction, etc. By knowing the speed and the diameter of the roll, bands can also be set to see roll irregularities.

Detecting internal faults in a bearing is extremely difficult. The condition monitoring system uses a process called High Frequency enveloping to filter out low frequency vibration in order to detect small, high frequency impacts generated by a damaged bearing. Examples of this kind of damage include inner race and bearing cage defects. High Frequency Enveloping isolates on known signature frequencies of the bearing and filters out other signals. It then monitors this frequency and its harmonics to display a picture of



what happening in the interiors of the bearing. The benefit of this technique is realized when problems with bearings are identified at a critical stage and fixed before causing unscheduled downtime.

The key to processing sheet break images is synchronization. Having sheet break video is useless unless the operator can get nearly instant access to the sheet video. The main benefit is gained if he can see the cause of the break. By synchronizing video from all cameras to the exact same place on the sheet at the time of the break, the operator can not only see the break happen but what the cause of the break. This dramatically decreases the time needed to solve the problem and prevent another break.

ARCHITECTURE

The current release of the condition monitoring system runs from a Windows™ NT operator station. The NT graphics allow the operator to look at a very simple display of a specific paper machine section turning from green to yellow or red, signifying different alarm conditions. With a simple mouse click, the operator is presented with all the monitored conditions of that machine section, including the section creating the alarm. With a link to the existing quality control system or distributed control system, data can also be presented to the operator with reference to the operating conditons at the time of the alarm condition such as machine speed, rush/drag, or nip load, etc.

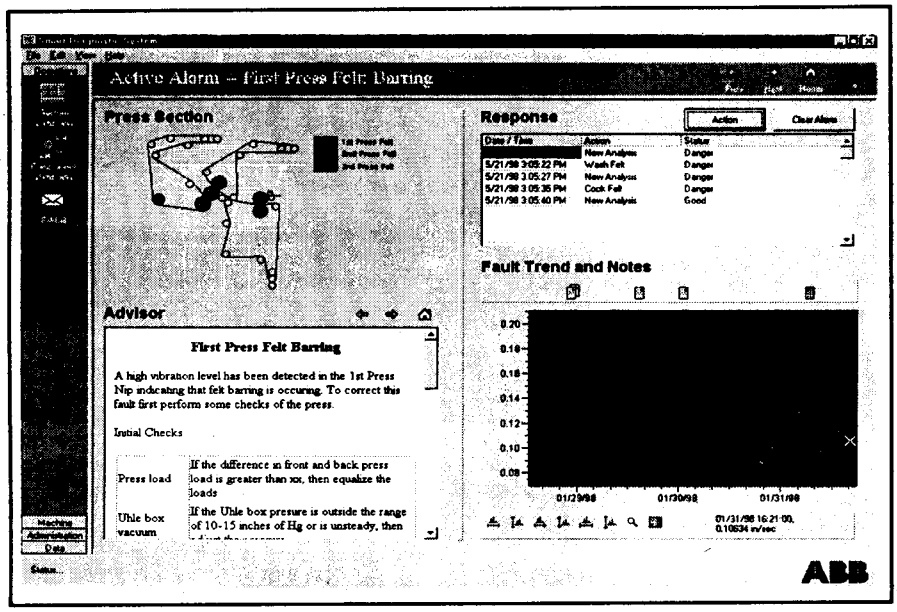
At this point, there would traditionally be a meeting to discuss probable causes and ways to fix the problem. With one mouse click, the condition monitoring system tells the operator in his/her language what to do to eliminate the problem. This advice could be to wash the felt, or sour the wire, or change the bearing, or many other recommendations. This advice comes without the time consuming delay of waiting for an expert over the phone, or waiting until additional mill personnel arrive on site. the benefit of this is immediate when machine conditions can be immediately instead of waiting hours for help at a very expensive rate.

One additional benefit of working within a network environment is that information about machine health can be electronically mailed from one user to another. It can also be sent to an expert for his/her opinion with the click of a mouse. this immediately increases the technical expertise available to the operator and brings visibility into the process to a previously unknown level.

As machine health monitoring grows and becomes a pillar in every paper mill, the technology will continue to grow. The advantage of using NT technology as an interface is that it can be easily expanded to take advantage of the constantly improving technology. It can also be done in a very cost-effective manner.

BENEFITS

The benefits of this system are immense. They



generally fall into four major categories - Felt Management, Roll Management, Bearing Management, and Quality Management.

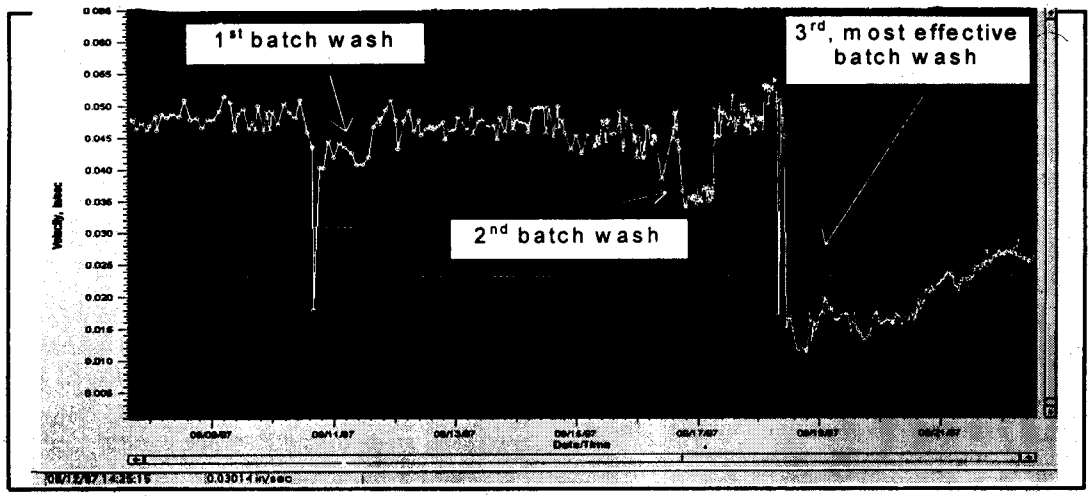
FELT MANAGEMENT

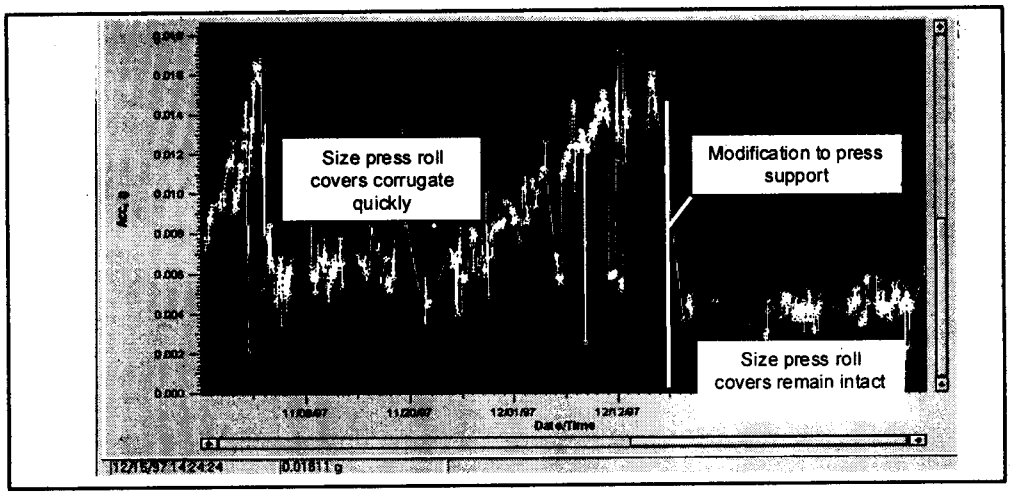
Felt life is effected by two major factors: drainage and vibration. Drainage decreases over the life of the felt as it compacts and is filled with fibers and fillers. Excess vibration is caused by uneven compaction, compression leading to barring, matting and other high frequency irregularities.

By using Time Synchronous Averaging and High Frequency Enveloping, the Condition monitoring system can identify when a felt is at the end of it's useful life. Instead of cutting off the felt because it has reached a predetermined calendar date, the felt is cut off when it has begun to effect sheet quality or is effecting the comfortable speed at which the machine can be run. Extending the felt life by 5 days per felt can save as much as $40,000 per year plus improvement in sheet quality toward the end of every felt run.

ROLL MANAGEMENT

Roll management can be an issue of safety as well as economics. Common problems are shell cracks, bearing defects, cover wear, or shaft failures. Additional issues such as roll misalignment can appear particularly on brand new paper machines. When roll problems become catastrophic failures, machines can be down for days and the possibility for personal injury is quite real. When a problem is detected is detected, the mill can pian ahead to fix





the problem during the next scheduled down rather than suffer an unscheduled down between their normal outages.

BEARING MANAGEMENT

The condition monitoring system can detect several types of impending bearing failures including cage, ball, inner and outer race defect, misalignment and looseness. Accelerometers are mounted near the bearings. Vibrations are monitored and the time waveform decomposed using the spectral analysis. In addition to standard analyses, High Frequency Enveloping is used to filter outlow frequency vibration that would be caused by other factors within the roll or dryer can. HFE detects high frequency impacts generated by a damaged bearing.

Energy from each band is plotted over time. When this energy level reaches a certain threshold, alarms are generated. The operator is then presented with the specific roll and bearing that has reached a critical status and presented with solution to fix it.

QUALITY MANAGEMENT

The Condition monitoring system can detect quality variations and irregularities beyond the normal expectations of a Scanning Measurement and Control System. More importantly, it can pinpoint the cause of variation and suggest ways for the operator to eliminate it.

Contribution Analysis references the signal variation in the quality signal to produce a percentage contribution from each mechanical component along the paper machine. This leads the system to identify the specific fault that is occurring in the component.

A good example of this would be a paper machine that is producing a sheet with high frequency caliper barring. The system identified that the source of the barring is the press roll based on the frequency of the barring matching the resonant frequency of the press roll. This frequency in the press roll is a signature of a deformed roll. The system then advises the operator to change the roll during the next down and either replace it or regrind it. Time Synchronous Averaging isolates the signature components of the felt and the press section. Within the spectral plot, bands are set up around the known frequencies that relate to barring, filling, and compaction. By knowing the speed and the diameter of the roll, bands can also be set to set roll irregularities.

SHEET BREAK REDUCTION

Reducing sheet breaks is one of the highest priorities in any mill. By having video available to see a sheet break in slow motion as well as be able to synchronize to the source of the break, the operator dramatically increases his chances of preventing another break. A 10% reduction in annual sheet break could lead to as high a $1.0 million per year savings. Even slower machines suffer when sheet breaks occur. The payback on any size machine is typically 3-6 months.

PRODUCTION INCREASES

Paper makers face very difficult decisions when tasked to increase production on a paper machine. The choices include spending a great deal of valuable capital, changing the designed product mix, or making many small steps through minor capital improvements. When capital money is always difficult to attain and the market is driving your product mix, options are

very limited. By monitoring all the critical points on a paper machine and identifying which point is limiting speed or quality the most, a per machine manager can improve his process step by step. In this manner, he/she can make small investments instead of one large one and make his gins in a predictable, manageable manner.

CONCLUSION

In order to monitor the entire health of the paper machine, one must consider the mechanical health of the machine as well as the felts in the press section, and the quality of the paper that is being produced. The Condition monitoring system monitors all of these factors. Just as importantly, the systems the operator with probable solutions. It utilizes the latest in Windows™ NT software for interface making it expandable and cost effective. In short, The Condition monitoring system gives the mill total and immediate access to the health of the paper machine. It provides them to access to an expert system without relying on an expert to analyze it. Paper makers may be content with their current felt life, receive few complaints for high-speed variations in their sheet, and be fortune enough not to experience many catastrophic failures at this time. However, they will certainly understand the benefit of this system in terms of insuring that when these situations arise, and they certainly will, the will be prepared, alerted, and advised on to a corrective path.