In-mill examples show how such problems as sheet breaks, coupling problems, and machine drive instability can sometimes be reduced with more in-depth analysis

Online Torque Monitoring System Reveals Unexpected Causes of Machine Problems

FEATURE

BY AL LANKFORD

Maintenance

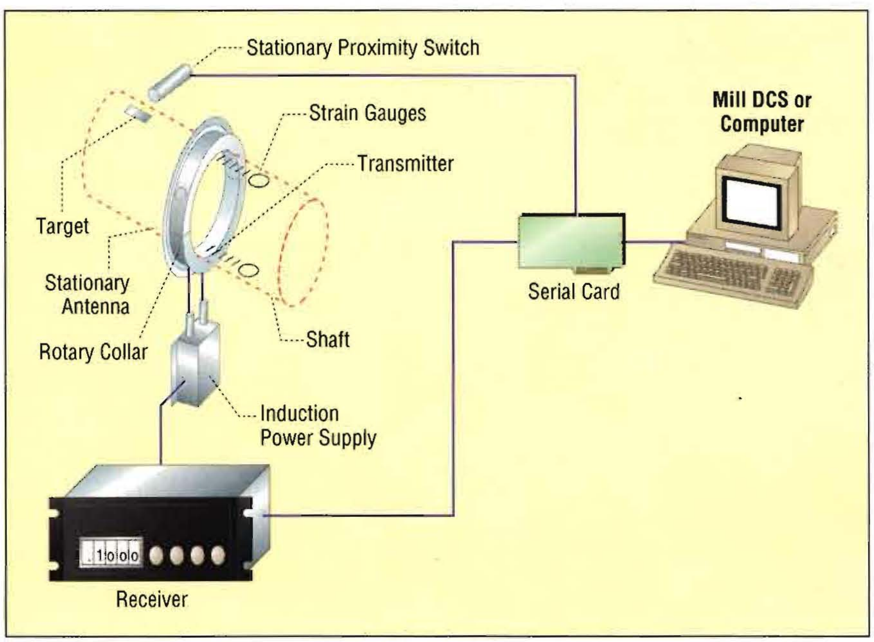
IN 1996, A DIAGNOSTIC TOOL called DriveVision was introduced for measuring and recording torque, speed, and horsepower on rotating shafts. The technology has been utilized on every section of the paper machine, including lineshafts, wire turning rolls, couch rolls, press sections, dryer sections, calenders, and reels.

The results received by using this diagnostic tool have revealed some very interesting phenomena relative to the way paper machines are functioning in the field. This article details results from four installations.

The diagnostics of the technology (Figure 1) involve strain gauging of a shaft to measure the strain in the shaft (which is proportional to the torque being transmitted). A split collar mounted to the shaft houses an antennae and radio transmitter to which the strain gauges are connected. The strain gauges and radio transmitter are powered by an inductive power supply, which also serves as the stationary antennae and signal receiving unit.

In operation, the change in voltage across the strain gauge bridge (due to the strain in the shaft caused by torque transmission) produces an electrical signal that is broadcast by the radio transmitter to the stationary antennae in the inductive power supply. The signal is processed by the receiver and is transmitted—in analog or digital form—to a portable personal computer, a mill PC, or a paper machine distributed control system (DCS).

FIGURE 1: *Schematic of a typical torque monitoring system for paper machine use.*



Taking advantage of the engineering relationships between torque and stress, as well as stress and strain, the software performs the calculations to display the transmitted torque in numerical or graph form. Shaft RPM is also measured and displayed and, from shaft RPM and torque, the horsepower can be calculated and graphed.

The most common uses of the technology have been in the dryer sections of paper machines. The problems investigated include frequent sheet breaks, premature component wear, component breakage, and flooding.

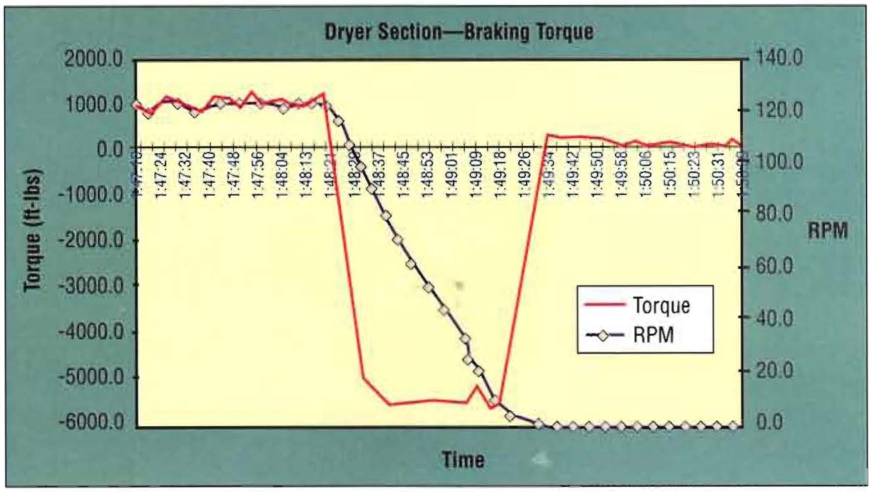
The torque loads in dryer sections tested to date have been significantly higher than what is predicted utilizing the standard TAPPI calculations. It has also been observed that the torque load in a dryer section can increase by as much as 40% due to flooding of a single dryer.

The higher than expected torque readings can have multiple causes. Common torque-consuming situations include sleeved bearings on the dryers, condensate buildup, high felt pressures, and worn bearings. Additionally, aggressive acceleration and deceleration rates can create high torque demands that can adversely affect equipment performance and life (Figure 2).

SHEET BREAK PROBLEMS. At a Southeastern linerboard mill, one of the paper machines had been experiencing an excessively high number of sheet breaks in the dryer sections. The problem had been especially severe when attempting to change machine speed during ramp ups or grade changes. The situation was all the more frustrating because the paper machine had recently undergone a major rebuild to increase production.

After investigations and brainstorming sessions, mill personnel concluded that the problem could be caused by condensate buildup in the dryers. The torque monitoring system was installed

FIGURE 2: *Aggressive acceleration and deceleration rates can create high torque demands that adversely affect equipment performance.*



in three of the four dryer sections to test this theory.

The paper machine trims at 240 in., operates at up to 2,400 fpm, and is turbine driven through a lineshaft and cone pulley arrangement. The information from torque measurement showed that the three dryer sections experience significant torque oscillations immediately preceding a sheet break (Figure 3).

Comparing data from the three sections, the torque oscillations occurred simultaneously in all three sections. Since it is highly unlikely that all three sections experienced condensate loading at exactly the same moment, this was eliminated as a cause (in these

FIGURE 3: *In one case study, torque measurement showed that all three dryer sections experienced oscillations immediately preceding a sheet break.*

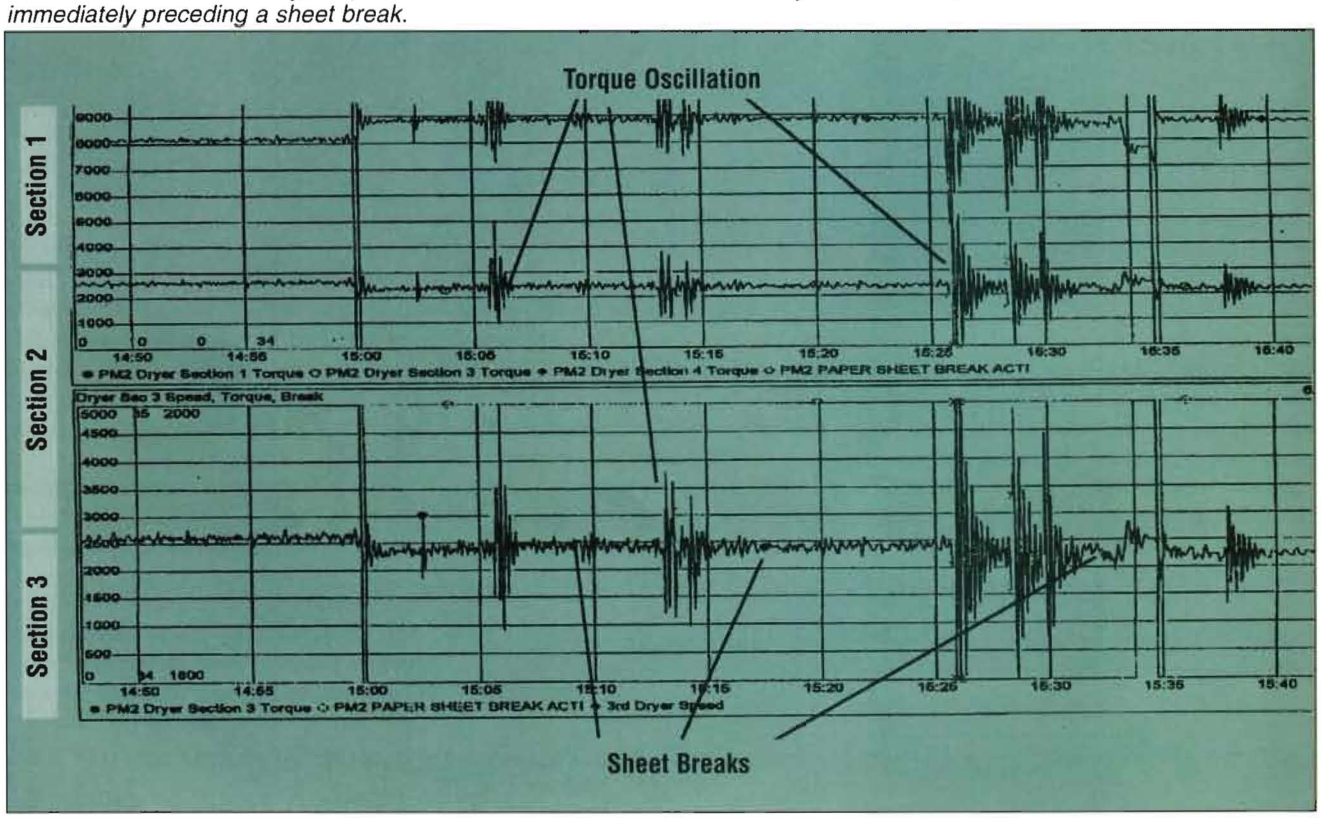
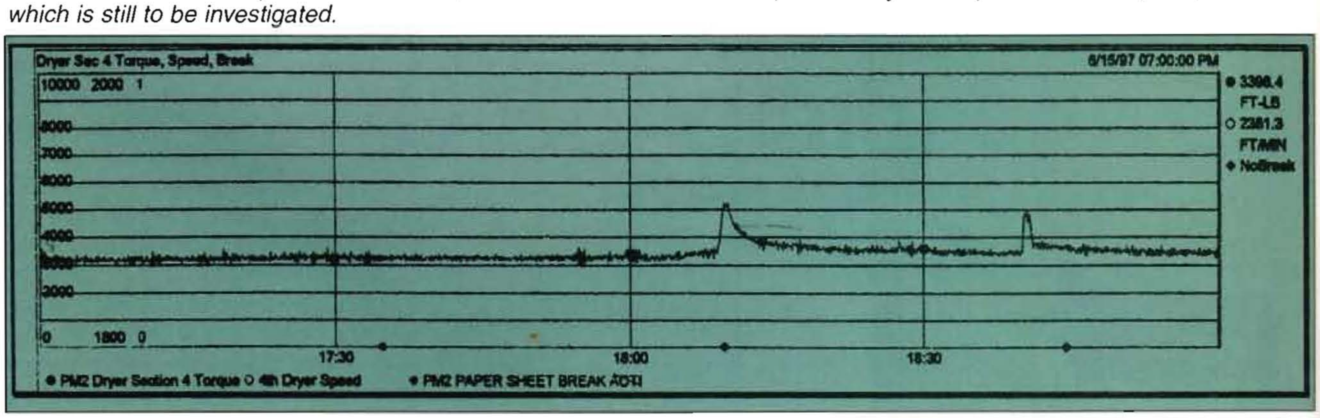


FIGURE 4: *Based on torque measurements, this machine continues to experience cyclic torque oscillation spikes, which is still to be investigated.*



instances). With the exception of the sheet, the lineshaft is the only process component common to all three sections, and the problem-solving activities began to focus there.

Upon investigation, it was uncovered that the pneumatic controller for the turbine governor had not been tuned correctly. Consequently, whenever a speed change was attempted, the governor "hunted," which resulted in varying turbine output. This caused oscillations of the paper machine drive torque which showed up on the torque monitor. These oscillations were severe enough to cause sheet breaks.

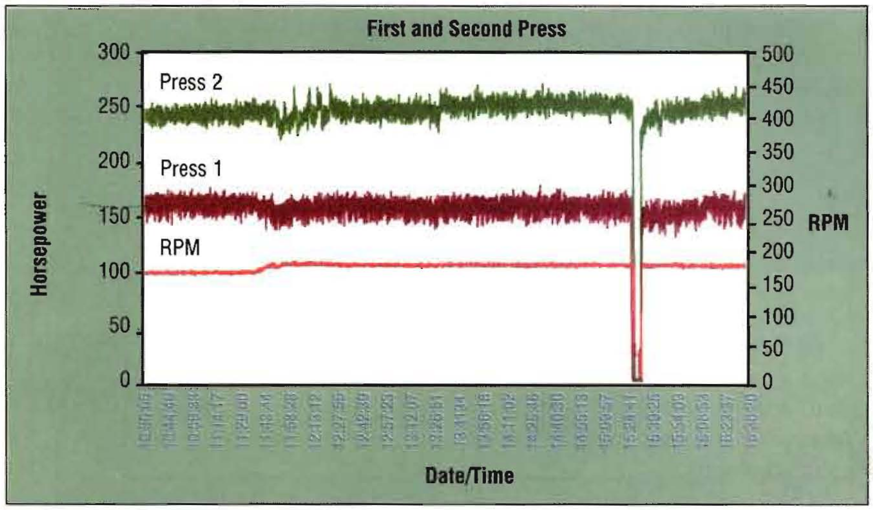
Since this discovery, the governor controller has been properly tuned, and sheet breaks during speed changes have been reduced to normal levels. However, there is still a higher than normal number of sheet breaks in the dryer sections during normal operating conditions. As Figure 4 shows, the machine is still experiencing cyclic torque oscillation spikes every 3 to 30 minutes. The cause of this is still being investigated but it is thought that problems with the condensate system—resulting in temporary water buildup in the dryers—could be a factor. Additionally, changes in steam value and/or turbine output could be possible causes.

COUPLING BREAKAGE. A 174-in. trim, 1,100 fpm corrugating medium machine at a Midwestern mill was having problems with wear and breakage of the shaft couplings in the first press. Interestingly, the second press had the same configuration and drive as the first press but did not experience the same problems with coupling breakage. The torque monitor system was installed on the in-drive shafts of the first and second press rolls to see if there were differences in the torque levels of the two that would account for the problems.

Upon measurement, and contrary to what was expected, the torque level in the second press was 66% higher than the first press (Figure 5). However, that level did not exceed the capacity rating of the coupling. The question, then, was what could be causing the first press coupling breakage?

The first and second press share a common fabric. The measurements shown in Figure 5 indicate the second press torque may be pulling the first press, creating an overdrive condition at the coupling. In this situation, the first press drive motor was holding the first press roll back against the drive from the second press, which is transmitted through the shared fabric. Although the torque level on the first press in-drive shaft was not excessive, the overdrive can produce conditions detrimental to coupling life.

FIGURE 5: *On this machine, second press torque is higher than the first press, indicating that the second press may be pulling the first press.*

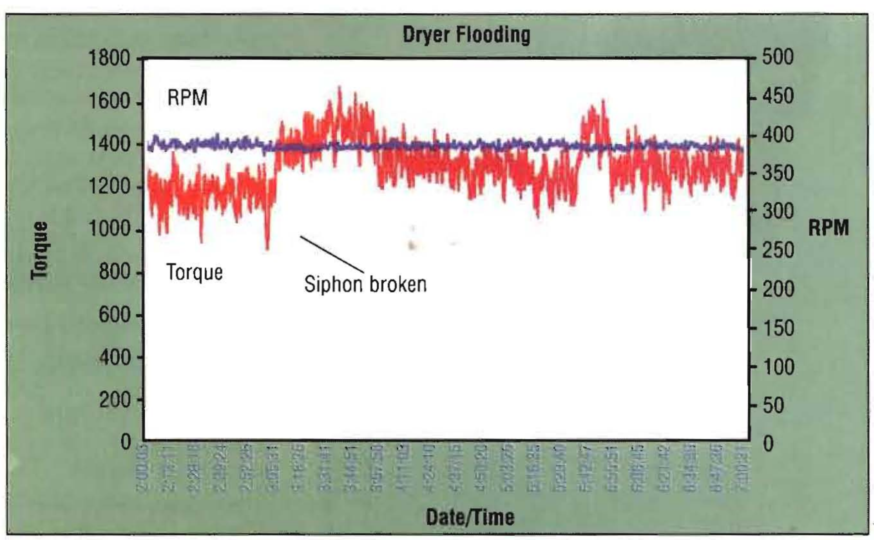


DRYER GEAR BREAKS. In this case, the torque monitor was installed on the dryer section in-drive shaft of a 170-in., 3,200 fpm linerboard machine to help determine the cause of rapid wear and excessive breakage of the nylon spur gears on the bottom dryer tier. As the paper machine speed already was at the upper end for nylon dryer gearing, any variance or out-of-tolerance condition in the drive or performance of the section could create a dynamic condition exceeding the capacity of the gear teeth. This paper machine was driven by a prime mover, lineshaft, and pulley arrangement.

Inspecting the drive train, the second gear downstream of the pinion had been removed. This created a condition in which the felt became the primary power transmission device between adjacent dryers (the sheet was the secondary device). The felt, therefore, carried 80% of the full torque required to drive the dryers downstream of the pinion in addition to its normal running load.

This power was transmitted through the felt return run from the upstream dryers and gears. Therefore, the entire drive load for this section was transmitted through one side of the pinion and its mating upstream gear. This gear mesh was then subjected to double the normal running load. Since this dis-

FIGURE 6: *Torque measurements helped one mill determine that the torque increase coincided with a siphon break and subsequent flooding of one of the dryers.*



covery, the missing gears have been replaced, the smooth transmission of power through the gear train has been restored, and gear wear and breakage have been reduced.

Interestingly, during analysis of the data, it was discovered that at 3:05:31, the torque began to climb, and by 3:45:53 had increased 40%. After that, the torque decreased slightly but remained at levels of 25% to 42% higher than previous operating levels. The mill then compared this data to the log of machine events and determined that the torque increase coincided with a siphon breakage, and subsequent flooding, of one of the dryers (Figure 6).

DRIVE INSTABILITY. At a fine paper mill, the 154-in., 1,950 fpm paper machine was having serious problems with machine and drive stability. The paper machine was driven by a steam turbine connected to a lineshaft and pulley arrangement. Steam usage at the maximum operating speeds normally was in the range of 26,000 to 28,000 lb/hour, but had begun requiring 32,000 lb/hour for the same speed. Additionally, the instability caused the machine to require *two to three days* to get back up to maximum speed after a sheet break.

The torque monitor had been installed on both sides of the turbine gearbox to determine torque loads and look for torque variances. Results to date have been that the torque loads on both sides of the turbine (wet and dry end) are within the calculated ranges. However, horsepower draw in the wet end consistently oscillates between 450 and 525 hp while the paper machine speed remains steady.

On a recent outage, the turbine was disassembled and found to have a worn thrust bearing and worn stationary and rotary vanes. The thrust bearing and rotary vanes were replaced, and the stationary vanes left as is (a replacement was not available). This has improved the situation but has not eliminated the problem entirely.

In checking the fabric change records, there seems to be a correlation between fabrics manufactured by different vendors and the drive instability. The permeability of both fabrics is specified to be identical. The torque monitor is now on the paper machine recording torque values at the wet end. It will remain on the wet side of the turbine gearbox after the next fabric change to determine if a difference exists in torque load between the two fabrics. ■

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