Video surveillance troubleshooting at LSPI

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ABSTRACT: One of the first steps in improving paper machine runnability is to pinpoint where breaks are occurring. Determining the exact location of a web break is becoming more difficult as machine speeds increase. A video surveillance system consisting of a synchronizing system, a video imaging system, and a computer-controlled recording and playback system has been beneficial in determining web break locations on Lake Superior Paper Industries' (LSPI's) PM No. 1. It has also given valuable insight into probable causes of many breaks.

KEYWORDS: Monitors, television, troubleshooting, web breaks.

Shortly after the start-up of LSPI's Duluth, MN, mill in 1987, it became clear that a paper machine break detection system would be useful. Pinpointing the location of a break would be the first step in determining what caused the break and, if a cause could be determined, methods to prevent it from recurring could be developed.

The initial system consisted of a standard VHS home video camera and a tripod. While this system was crude compared to today's, it did prove to be a useful troubleshooting tool. The next step in the project was to permanently mount cameras on the front and back of the paper machine's fourth press. This again proved useful and resulted in reducing downtime about 2 hours per month. Based upon the success of the two permanently mounted cameras, the basic system as it exists today was designed, installed, and patented [1].

Video surveillance system equipment

The video surveillance system is comprised of three subsystems [2]: the synchronizing system, the video imaging system, and the recording and playback system. **Figure 1** shows a layout of the control console that houses all of the equipment except the cameras. **Figure 2** is an electrical schematic of the system.

Synchronizing system

The synchronizing, or "sync," system is comprised of a genlock sync generator and a distribution amplifier. The generator produces the "black level" that is needed for the cameras and video splitters to be genlocked together. The distribution amplifier distributes the signal to the genlockable devices in the system.

Every video image that is seen or recorded is comprised of a series of horizontal lines. The sync pulse signals the cameras to begin each new line of video image. The number of horizontal lines per image depends on the resolution of the cameras, recorders, and monitors in use. **Figure 3** illustrates one horizontal line of video image, showing the black level and related sync pulse. The full-scale range of video signal is 0.3–1.0 volts. The black level, representing the darkest video image transmitted, is set at 0.3 volts, and the brightest image transmitted is at 1.0 volts (i.e., 0.3 volts = black and 1.0 volts = white). The horizontal blanking is comprised of a front porch, the sync pulse, and the back porch. The blanking signals the end of each line of video information and prepares the system to start the next line.

Each of the cameras can accept an external sync source, rather than

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[1] Dittmann, R., Bundschuh, W., and Petersen, S., U.S. pat. 5,239,376 (Aug. 24, 1993).

[2] Petersen, S. B., *A Video Surveillance System for the LSPI #1 Paper Machine,* Operation Guide, Lake Superior Paper Industries, Duluth, MN, 1993.

using the internal syncs of each separate camera. Since each piece of equipment in the system receives the same sync pulse, the cameras can be linked on split screens. If the cameras were not linked by a common sync, the split screen would not be possible; one of the split images would “roll” while the other one would remain constant.

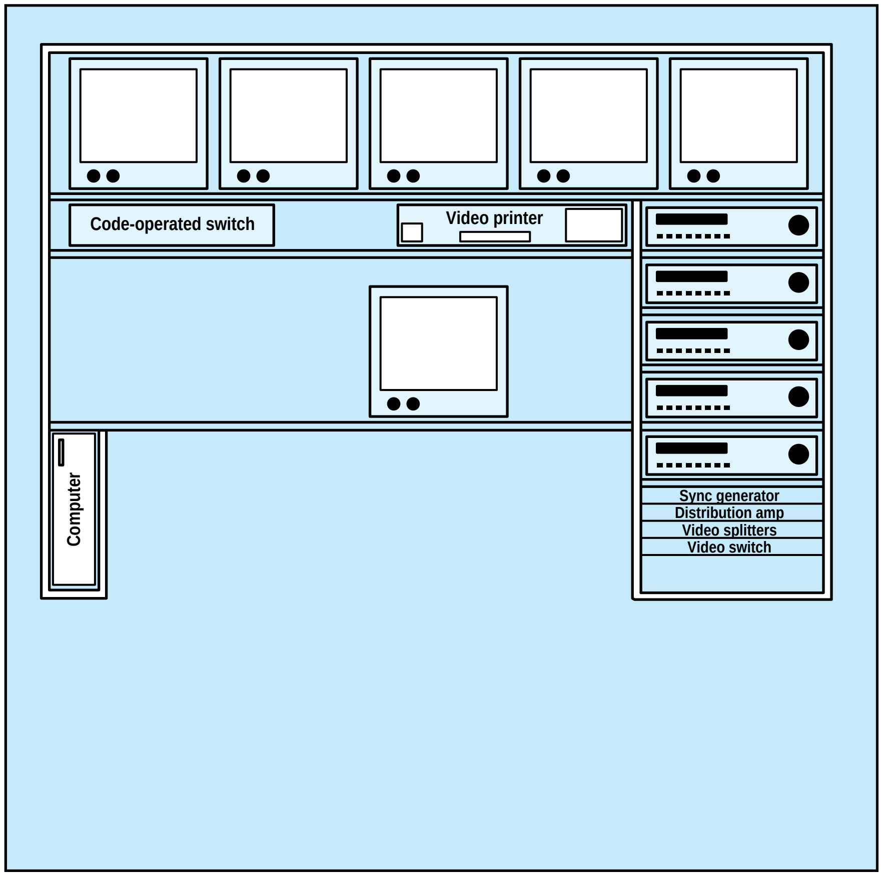
Video imaging system

The imaging system consists of the cameras, the video splitter, the video monitors, the video printer, the video switch, and the code-operated switch. The cameras function much like a standard video camera, but there are some significant differences. The Panasonic Model WV-BL604 cameras have a variable shutter speed (1/250–1/1000 seconds), 500 lines of resolution, and automatic iris control. Each is capable of accepting an external sync pulse, thereby allowing pairs of cameras to be viewed on split screens. Each camera is linked to the rest of the system via a highway network (**Fig. 4**).

Many of the cameras are located in hostile environments. Temperatures in excess of 130°F and humidities to 100% are common. **Figure 5** shows a machine diagram and possible camera locations. Most cameras are in pairs (front and back) at each location. To combat the hostile environment, each camera is enclosed in an air-cooled housing. Dry instrument air is fed into the housing via a vortex tube, resulting in a dry 70°F environment. The air also pressurizes the housing to prevent water entry. The housings also help keep the camera lenses clean. In wet locations, such as the back side of the press section, air knives and automotive headlight wipers are used to clean the outer lens. **Figure 6** shows a camera housing and the lens-wiping mechanism.

Each pair of cameras is fed into a video splitter. The splitter allows the two images to be merged on a single monitor that is split horizontally or vertically. This split image is recorded by one VCR. The monitors that are used for real-time display and videotape review are standard Sony 12-in. black-and-white units with 700 lines of resolution. The images displayed on the monitor are recorded by the VCRs.

1. Control desk



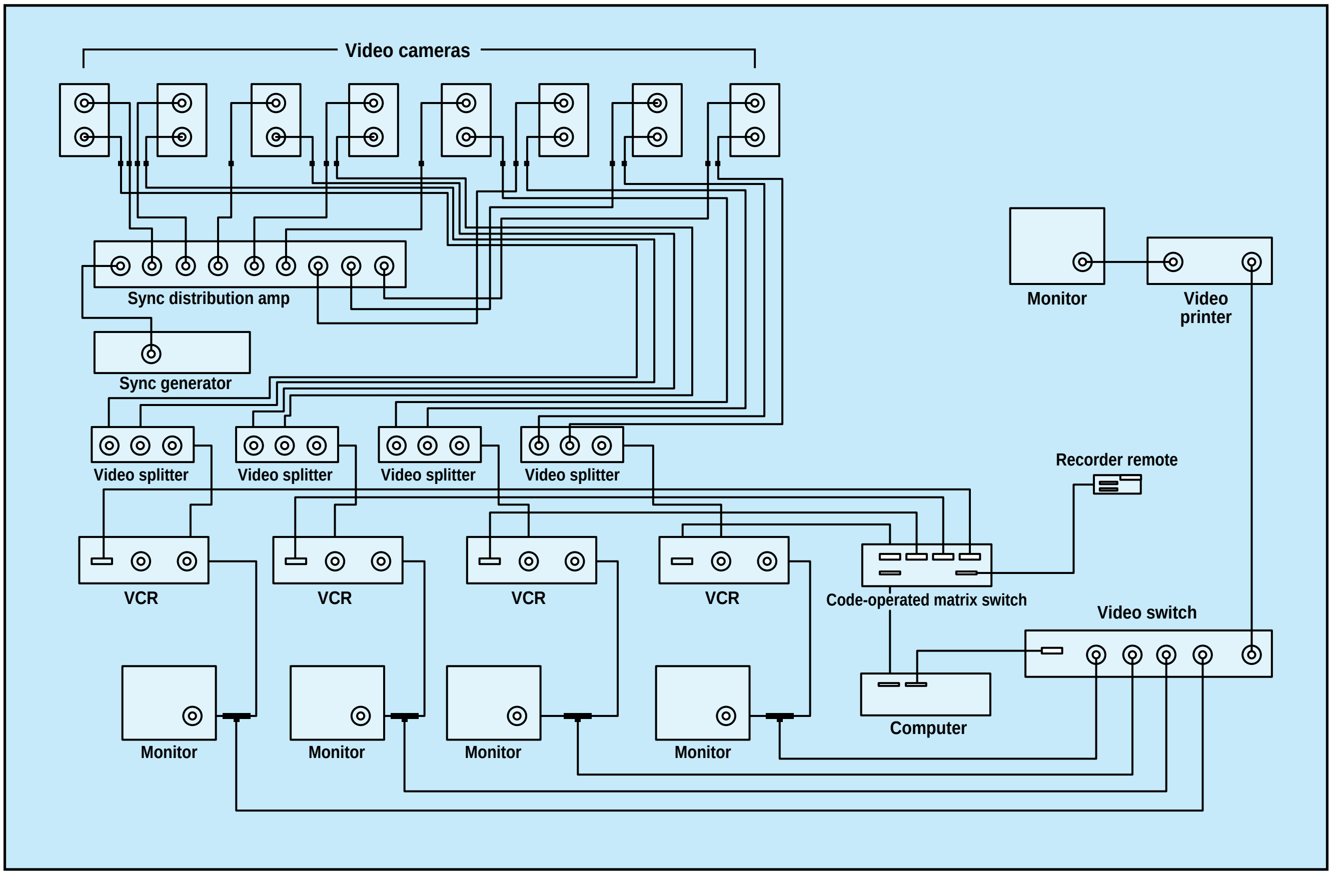
The video printer allows the operators to print a 3 x 5-in. black-and-white hard copy of any video image recorded; the current printer is a Hitachi VY-150A. An operator can select and print an image from any of the VCRs. Hard copies of each break are saved for future reference.

The last two components of the video imaging system are the video switch and the code-operated switch (COS). The video switch, which serves as the interface between the monitors and the video printer, is controlled directly by the personal computer (PC). The COS is the interface between the computer, the VCRs, and the VCR remote. The various control signals from the PC and the remote are distributed to the appropriate VCR(s) through the COS.

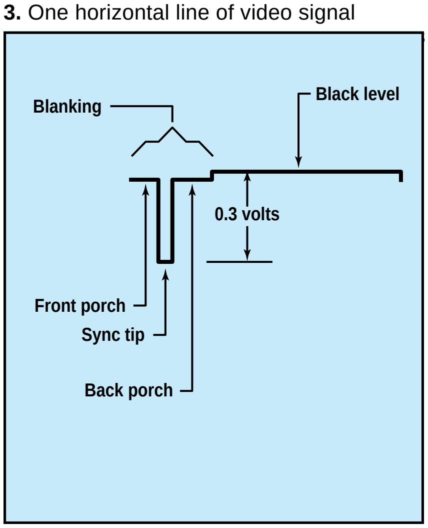
Recording and playback system

The recording system is comprised of the VCRs and the personal computer. The VCRs are similar to a standard home unit in that they record the images onto a VHS-format tape, but these VCRs are more specialized. The system VCRs are Panasonic Model AG-6750A units with 340 lines of resolution; they record and play back in fields. A home VCR records and plays back in frames only; each frame is made up of two fields. As a result, twice as many images can be recorded in a given amount of time with the Panasonic units. At 1311 m/min (4300 ft/min), a field is recorded every 34 cm (13.4 in.).

2. Electrical schematic



3. One horizontal line of video signal



The VCRs are linked to two computer systems, the 386-based PC for basic control functions such as playback, stop, rewind, and eject, and the paper machine's distributed control system (DCS). When the paper machine's DCS receives a sheet break signal from the break detection eyes, the specified VCR displays a visual alarm on its monitor. Each VCR's monitor also displays the date and time. This time is synchronized with the paper machine DCS once daily.

The personal computer is a 386-based unit with a 120-MB hard drive. A custom Basic program provides a series of menus through which an operator can manually or automatically control one or all of the VCRs. A recorder remote can also be activated through the PC to control one VCR at a time. The remote is equipped with a shuttle wheel for single-field advancement. When recording in the automatic mode, the PC waits for the VCR to receive and display the sheet break alarm generated by the DCS. When the alarm is received, the VCR records for 15 seconds, stops, and rewinds for 30 seconds and then waits for an operator to review or restart the tapes. Each tape is also automatically rewound when its end is reached. If a break occurs during this rewind, it is not recorded,. The tapes typically last about 1 week before the recorded quality deteriorates.

System uses and benefits

The surveillance system plays a key role in troubleshooting breaks and reducing paper machine downtime. The major use of the system is the investigation of operational breaks, and the video system generally allows the operating team to determine exactly where a break has occurred. This determination plays a key role in the cleanup during the break. The area around the break location is cleaned of any deposits that may have contributed to the break and is inspected for visible damage, such as a felt hole. Repeated similar breaks also indicate when press section doctor blades may be failing. **Figures 7–17** are examples of typical breaks and the type of evidence that the video system records.

Figure 7 is a view of the bottom side of the pickup felt near the back edge. The figure shows the sheet dropping off the felt as it travels into the first press nip. Knowing where the sheet break occurred, the operating team washed the forming section well before attempting to rethread.

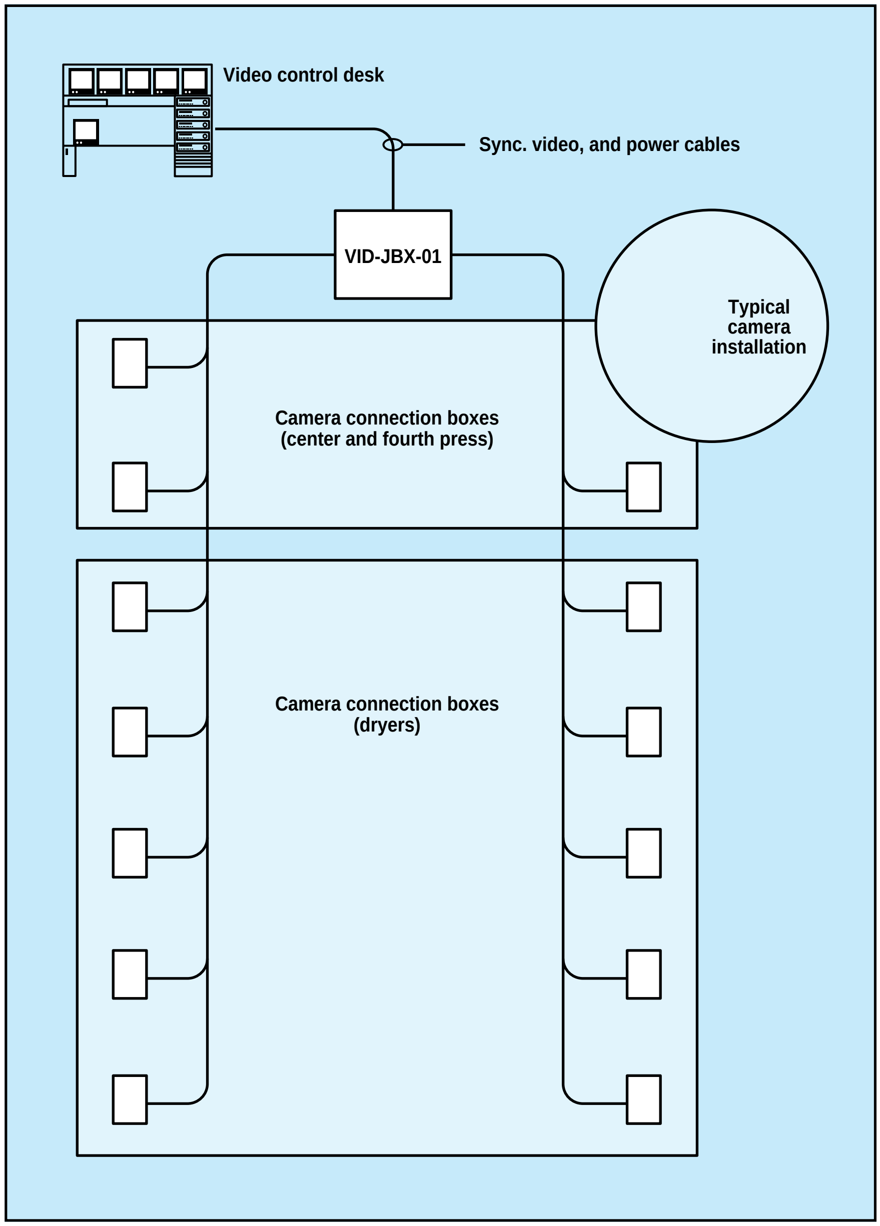
Breaks that are caused by inadequate cleanups are also captured with the video system. Figures 8–11 are from the drive side fourth press camera. In Fig. 8, a piece of broke that was not removed during a prior break's cleanup is seen traveling with the first dryer felt. The piece of broke is thrown off the felt and floats down (Figs. 9 and 10) until it contacts the paper in the transfer between the fourth press and first dryer section, causing a break (Fig. 11).

Figure 12 is from a camera in the press section. The paper is seen leaving the center granite roll and passing under the No. 1 paper pass roll. The apparent bubble/hole was observed on several other breaks that occurred over a one-week period. In an attempt to solve this recurring break, a trial was performed, which consisted of throwing small lumps of dewatered stock into the machine at various locations. When thrown into an area at the top wire, this material re-created the break (Fig. 13). A modification of the washup procedure eliminated this type of break. The results of this and similar trials proved beneficial in troubleshooting other breaks as well.

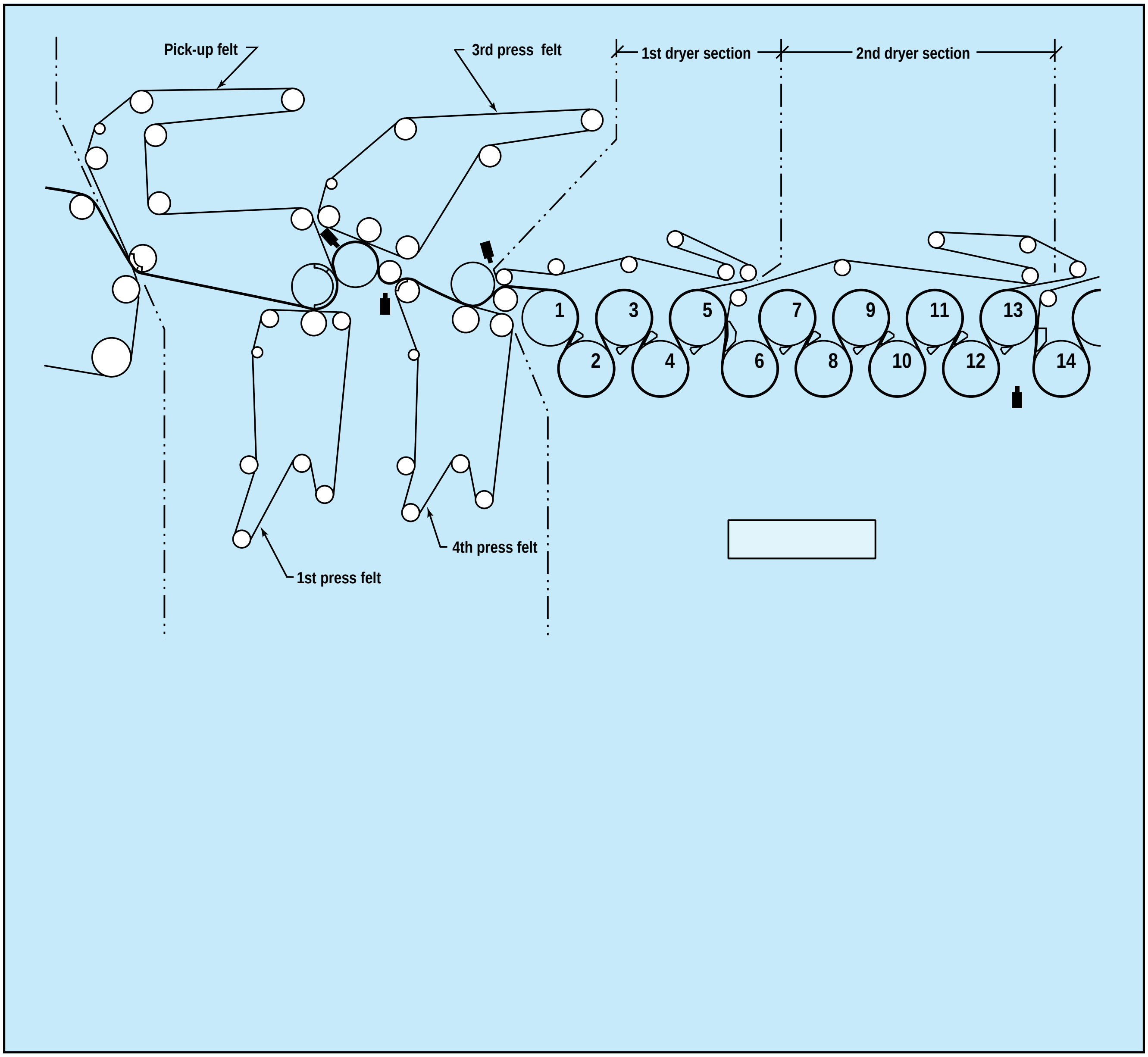
Sheet defects that caused breaks similar to that shown in Fig. 14 were also re-created. This figure shows the paper on the drive side of the center granite roll between the second and third press nips. A small white spot can be seen about 46 cm (18 in.) in from the sheet edge. This spot caused a break in the dryer section. Figure 15 is the re-created break caused by throwing stock onto the center granite roll after the doctor blades. Again a small white spot can be seen approximately 61 cm (24 in.) in from the sheet edge. This spot became the bubble shown in Fig. 16 and the break seen in Fig. 17. Figure 16 shows the lower side of the No. 1 paper pass roll between the center and fourth presses, and Fig. 17 shows the transfer between the second and third dryer sections. This evidence confirmed a suspected problem that the center press doctor blades were not uniformly contacting the granite roll; they were occasionally allowing stock to leak past them.

In addition to the break investigation, the system is also used to detect mechanical equipment failures. One example concerns a drive fault in the fourth press. The fourth press consists of a granite roll and a crown control roll, both of which are driven. A "normal" break occurred and was recorded by the video sys-

4. Camera highway network



5. Camera locations—press and dryer sections



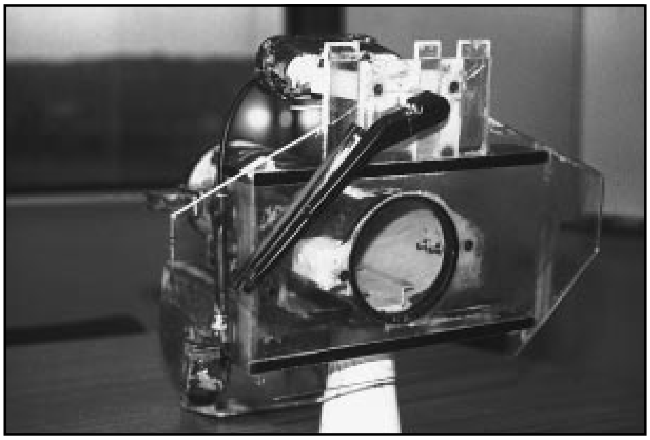
tem. The evidence indicated a loss of tension in the paper exiting this press. Since this was not common, it prompted the operating team to visually inspect the fourth press area. The inspection revealed severe vibration in the gear box for the crown control press roll. It was determined that the crown control roll's drive had failed on the run. This roll was being turned by the granite roll, thus causing the vibration in the gear box. While the video system did not pinpoint the problem, it helped direct the troubleshooting effort, thereby minimizing the downtime.

The system also has several real-time uses. It can be used to monitor the sheet edge in the open press draws to determine if the sheet is flipping or folding over. Wrinkles have also been observed in the dryer section, and the operators have fixed the problem without a web break or without significant off-quality paper losses.

The next-generation system

Since its inception, the system has undergone several changes and improvements to increase its effectiveness. Cameras, camera locations, and VCRs have been changed and improved. The next step in its development will be a change to 100% digital components. A computer hard drive will be used in place of the current VCRs. This will improve the image quality in two ways. First, it will improve the image resolution by re-

6. Camera housing and lens-wiping mechanism

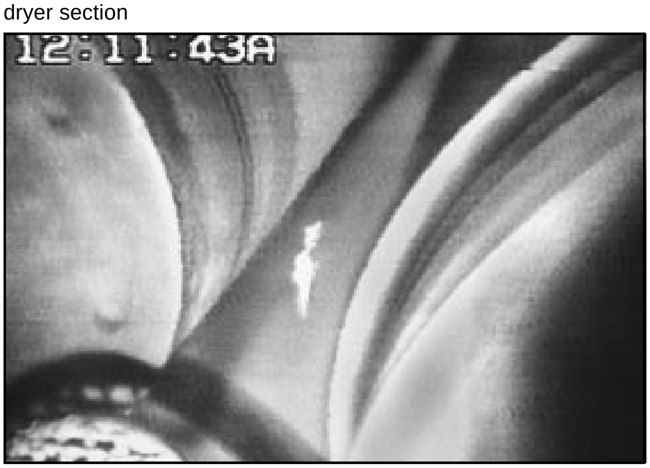


7. Bottom side of the pickup felt near the back edge

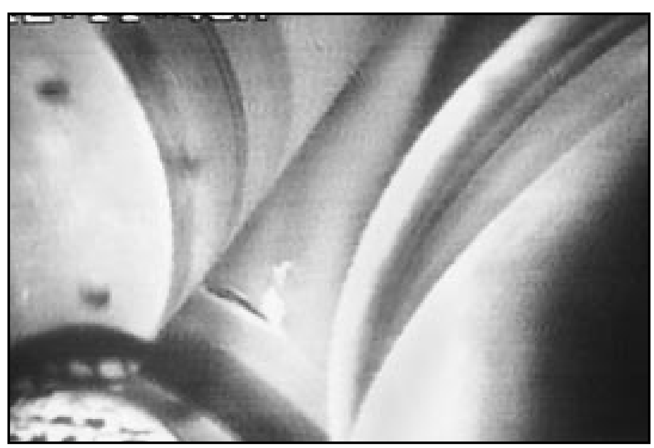
8. Piece of broke that was not removed during a prior break

9. Broke is thrown off the felt

10. Broke contacts the paper between the fourth press and first dryer section

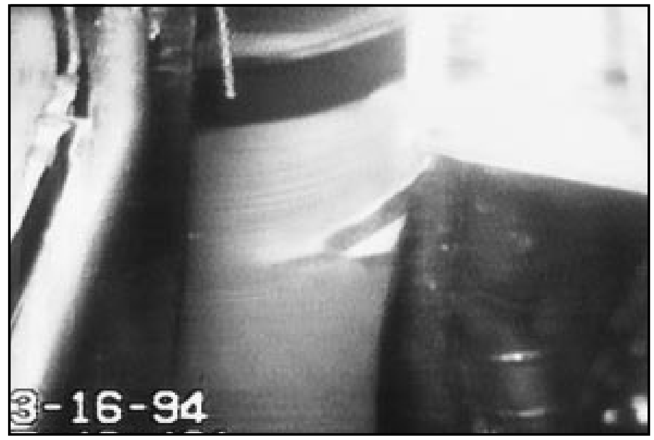


11. Broke causes paper break



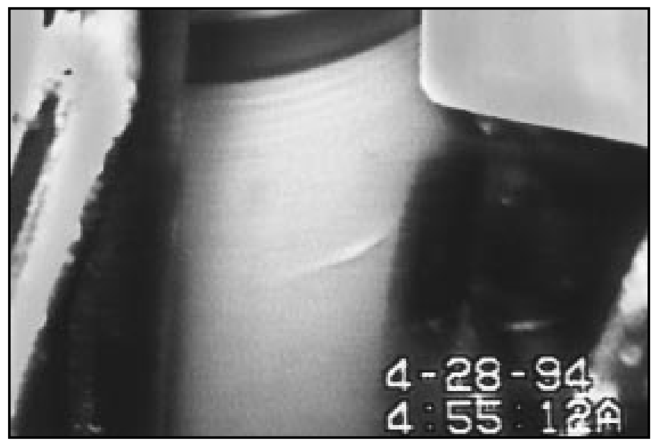
12. Paper leaving the center granite roll and passing under the No. 1 paper pass roll

13. Stock thrown in the top wire area re-creates the break

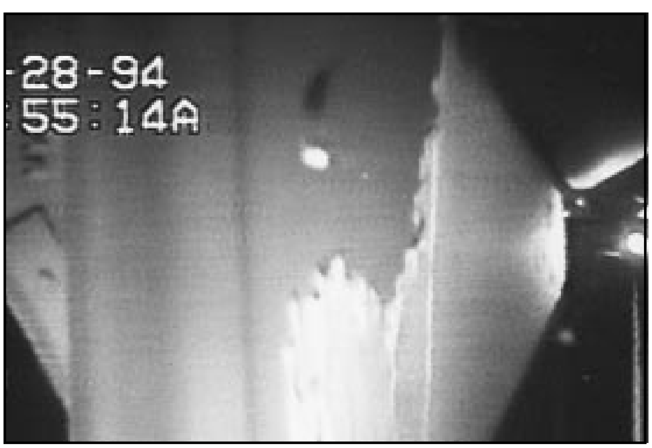


14. Paper on the drive side of the center granite roll between the second and third press nips

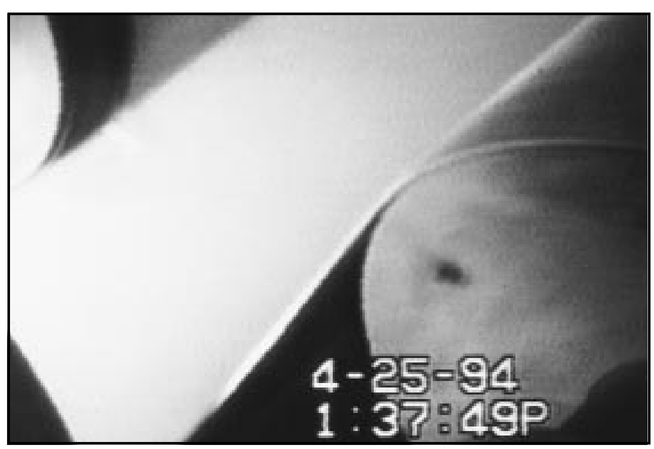
15. Re-created break caused by throwing stock onto the center granite roll after the doctor blades



16. Bubble approximately 61 cm (24 in.) from the sheet edge



17. Bubble becomes paper break



placing the current 340 lines of resolution with digital imagery that has many times the resolution. The camera, with 500 lines of resolution, will then become the limiting factor. Second, the system will be faster, since the hard drive can read and write twice as fast as the VCRs. This will result in an image every 17 cm (6.7 in.) at 1311 m/min (4300 ft/min).

Another benefit of replacing the VCRs with a hard disk is that the photo images will be in a digital format. A laser printer, which will replace the current video printer, will produce larger hard copies with better resolution at a faster rate. In digital form, the images can be accessed on any PC via the mill's computer network. Additional imaging techniques, such as object analysis for defect edge detection, will help determine on which side of the sheet a defect is located.

Cost savings

The initial justification for the system was based on saving 3 hours of downtime per month. At that time in 1991, this represented an annual savings of over US$ 400,000.00. The system met and exceeded this justification. Today, up to 80% of the paper machine breaks are recorded and evaluated with the video system.

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