Vision technology applications for paper, paperboard, tissue and pulp industry

Seppo Toivonen
Papertech Inc.
Business Manager, Europe
Moisionkatu 16
08100 Lohja
Finland

Abstract

Papertech Inc., Canada has taken full advantage of the new high resolution and high speed cameras to develop automated new Web Quality (Web Inspection) and Process Monitoring (Web Monitoring) applications for paper, paperboard, tissue and pulp industry. The usage of new digital cameras and the powerful LED illuminations in the applications form a solid base to understand the reasons and sources of the web defects and solving reasons for the web breaks.

Different applications have been developed for paper, paperboard, tissue and tissue converting machines. Web defects maps and individual defects are synchronized through the entire production process: from the base paper/tissue machine to the unwinding of the web (winder, rewinder, off machine coating, converting lines). At the same time the Web Inspection cameras are fully synchronized also with the Web Monitoring cameras allowing the operators identify the defect sources. A special Web Inspection Application has been developed for pulp dryers to count the number of dirt spots in the web.

A short application case study will be given for the above listed applications with the future trends.

Currently used technology and future trends

The current technology and application for paper and board machines and coaters have been discussed in detail in presentations and articles (1) and (2) by Kari Hilden, Papertech Inc.

This article will focus mainly on the newest developments, applications and trends.

How to get the full benefit of the invested equipment and software

Web Monitoring WMS (often called as well Event Capturing or Web Break Analysis) and Web Inspection WIS (often called as well Quality Monitoring) systems have become an inherent part of the papermaking concerning the paper and board machines and today same also applies for tissue machines.
For the new paper and board machine projects the WIS systems have been mechanically engineered into the paper machine jointly with paper machine supplier since early 1990's - this is not still true for the new tissue machines even if the importance of these system is equally high as for the paper machines.
For tissue machines the web stabilizers prevent often a full visibility of the web for the WIS cameras and therefore compromises need to be made.

For the existing paper, board and tissue machines it is often very difficult to find space for the conventional camera and light beam designs or so called O-beams.
Therefore, new designs have been developed for the WIS cameras and lights. The WIS cameras and lights can now be installed in the same housing as the WMS cameras and lights. This allows the cameras and lights to installed in very limited machine direction space and still have the full functionality of the WIS features. The dimensions of the cameras houses are kept very small having only the digital camera and the optical lens in the camera house. All digital signal processing of the WMS and WIS functions are performed in the system cabinet by the standard commercially available capture servers where to the camera digital GigE standard video signals are wired.
A typical camera house design is shown in the Figure 1.

Figure 1: Camera house design – only the digital camera and optical lens inside the house

Performance - how to get the full benefit of the new Full HD cameras

The WMS cameras that were used from early 1990's till 2007 were in most cases PAL standard bases analog cameras having a resolution of 625 lines and a 50 Hz refresh rate. There are still a lot of these analog camera WMS and WIS systems in operation on paper machines.
Quite a few of these cameras with the legacy camera systems have a 1/500 1/s or even a 1/200 s shutter speeds due to the poor illumination (lights) resulting in a very poor image quality:
Example

- shutter speed 1/200 s
- paper machine is running 1200 m/min = 20 000 mm/s
- web transfer distance as the shutter is open
    - 20 000 mm/s *1/200 s = 100 mm

Thus the paper moves 100 mm as an image is taken and causes a blurred image. Therefore, no details of the web can be seen.

The modern WMS and WIS systems use Full HD cameras allowing 2048*1048 pixels for the image size.
For a wire section (fourdrinier) application where the camera view in the machine direction is some 2000 mm the pixel resolution becomes around 2,0 mm. The needed shutter speed is then

- machine speed 1200 m/min = 20 000 mm/s
- needed Machine direction resolution = 2,0 mm
- needed shutter speed
    - 2 mm / (20 000 mm/s) = 1/10 000 s

The shutter speed of 1/10000 s cannot be practically achieved with one single LED light but two LED lights per camera need to be applied (especially true for wide machines like 7 – 8 m).
For a press section application where both the camera and the light are fairly close to the web only one LED light per camera is needed.

The new Digital cameras can trigger the LED lights to be on only as the camera is taking an image. With high shutter speed the camera shutter is open a very small time and thus the LED light is consuming very little power. The average power of used by the LED light is only 10% of the peak power of the light thus the temperature of LED light protective glass remains very low and does not burn the surrounding dust/dirt on the glass surface.

An example of a good image using two LED lights on the wire section is shown in the Figure 2.

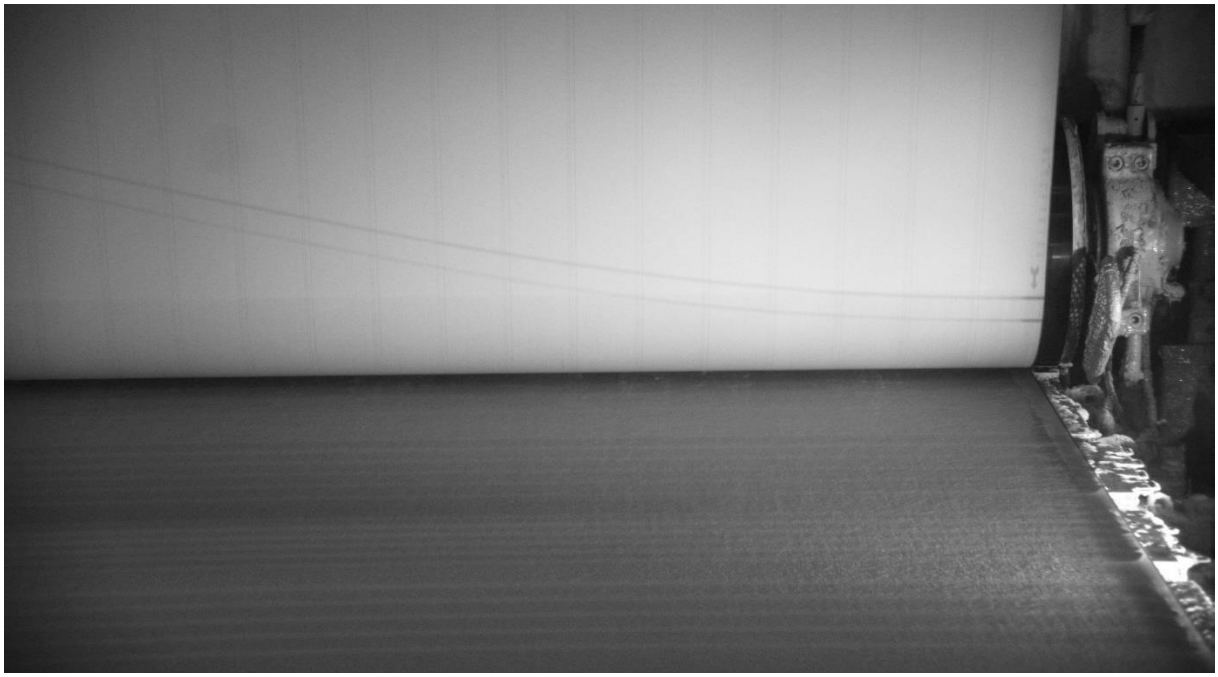

Figure 2: Web moving 1200 m/min – Full HD camera with two LED lights for half the web

Reliability - how to maintain the good image quality on 24/7 basis

To maintain the good quality of the videos and the images the camera lenses and the light protective glass need to be kept clean. Too often the image quality is destroyed with poor protective technology.

In a very dirty environment the camera lens needs to kept clean. A special pin hole technics can be used where air is flowing through the camera house and coming out from a small “pin hole” opening at the camera end surface. See the Figure 3.

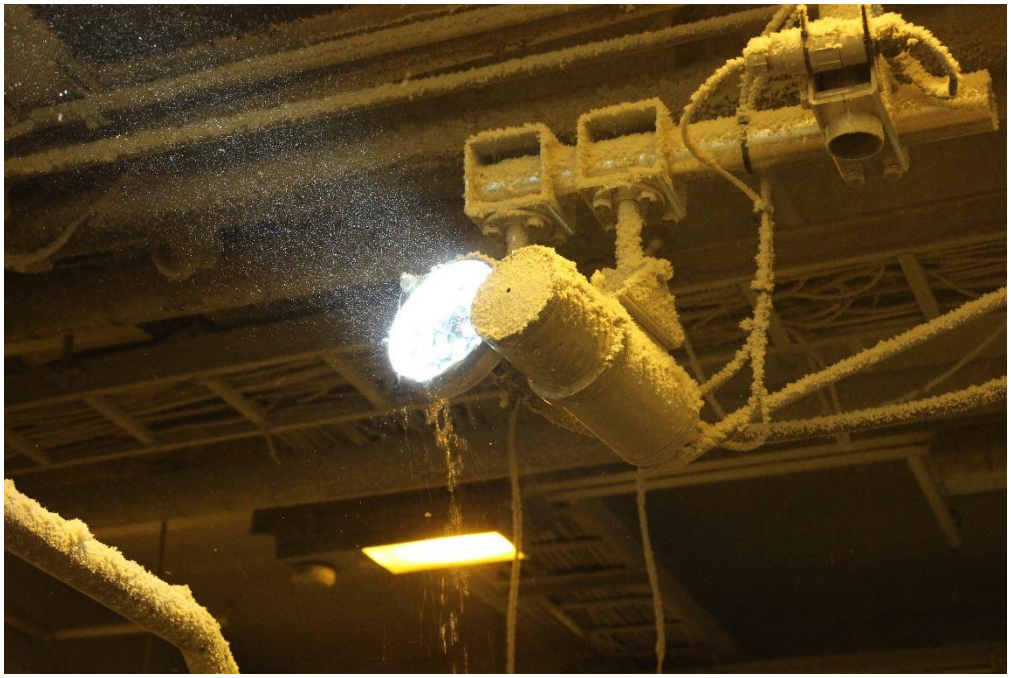

Figure 3: The pin hole with air flow prevents the dirt get into the camera optics. The LED water shower creates a water film on the LED light surface and prevents the dirt build up.

The Figure 3 also shows how a cleaning water shower nozzle create a thin water film on the LED light glass and prevents it get dirty.

The Figure 3 demonstrates how none mechanical cleaning solutions can be used to guarantee on 24/7 basis a good image quality.

Performance - how to prevent WIS false defect detection on a dirty environment

Flying dust or water particles between the web and camera cause a “false defect” to be identified by the WIS software unless these “false defects” can be filtered out by the software. “False defects” make some 97% of all defects on tissue machines WIS application unless they are not filtered away. True defects are of course travelling with the web speed and along the same Cross Direction (CD).
A matrix digital camera (like you have in your smart phone) sees a defect passing by camera usually some three to five times depending on the web speed. A CCD line camera (reading only one line of pixels at a time) does not know what is the speed of the “false defect” and whether it is travelling on the same CD position. Therefore, only matrix cameras can be used to identify or filter out “false defects”. See the Figure 4.

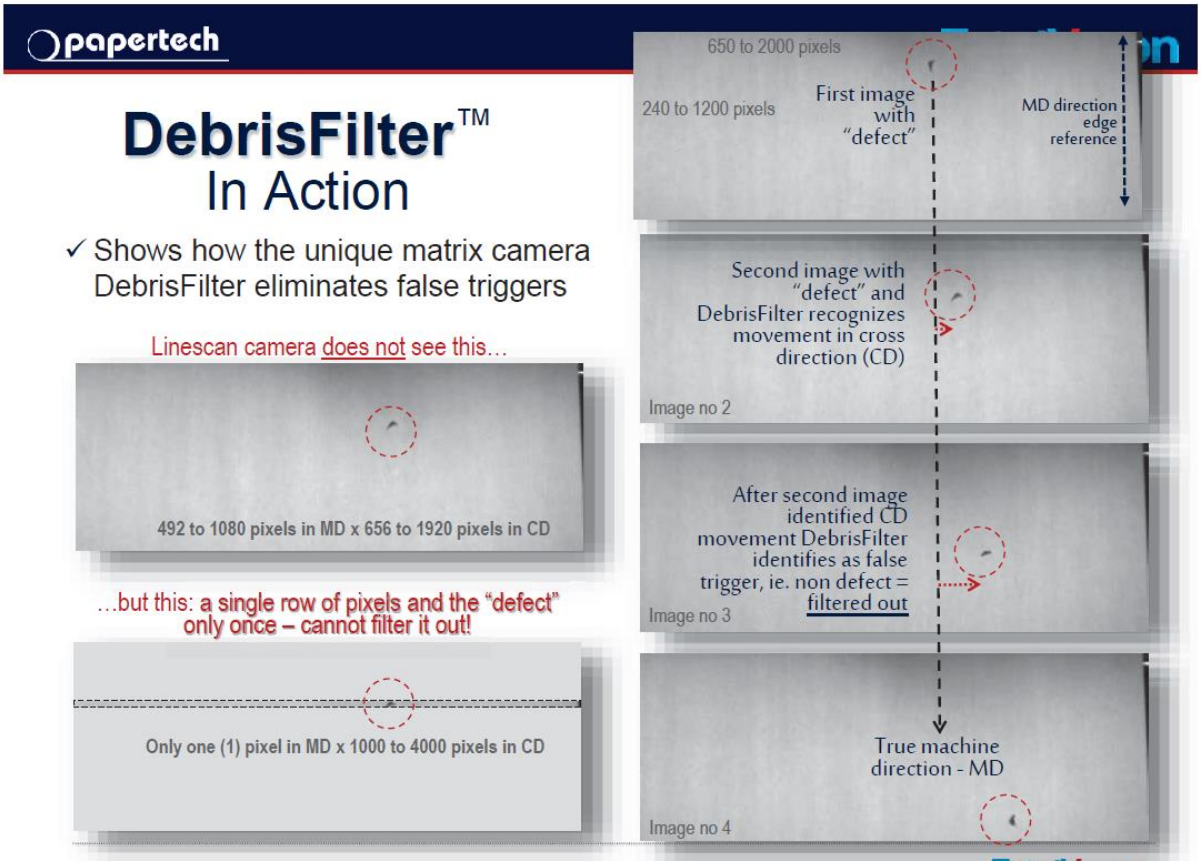

Figure 4: “False defect” filter software used with matrix cameras – images on the right

Production line WIS synchronization - solutions for several levels of needs

For each sub process of the paper production a defect identification chain can be installed by Integrated Web Inspection and Web Monitoring. The Web Inspection cameras are fully synchronized with the Web Monitoring cameras allowing the operators identify the defect sources.

On different mills and different processes, the needs to reject or to patch the defect may be varying:

- Example 1:
  - base paper machine: WIS defect map creation and marking of the web edge with machine direction kilometer code every 200m - 500 m. See the Figure 5
  - slitter winder: recreate the defect map by using a code reader. See the Figure 6.
  - rewinder: patch the holes or other defects
  - Off machine coater: read the code marks synchronize the new defects on the OMC
- Example 2:
  - tissue machine: mark the defect with a defect color marker
  - converting line: observe or read the defect marks and slow down as passing by the defects – see the Figure 7.

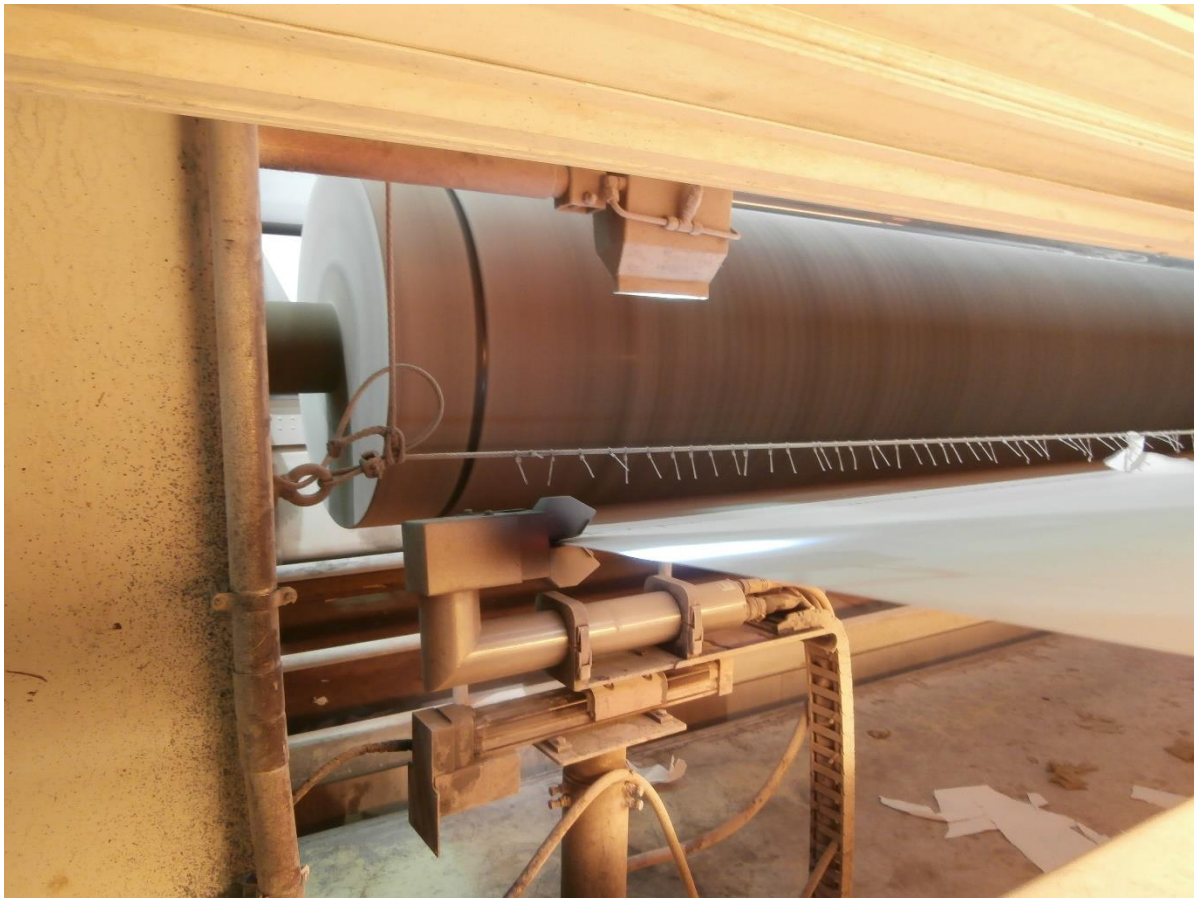

Figure 5: A code marker and a code reader for code verification at edge of the base paper machine

Figure 6: A kilometer code marked at the edge of the jumbo roll at unwinding (top) and the code reader

Figure 7 : A defect color marked at the end of the jumbo roll

Usually on paper and board machine the web is marked with a kilometer code at the edge of the paper. The code is read on the following process (like a slitter winder) and a new defect map is created for the entire jumbo roll and even for the small customer rolls. These smalls rolls can then be unwound either at rewinder for patching or at sheeter were the rejects gates can be opened as the known defects are unwinding. Especially for high priced grades - like folded box board - the automatic rejecting at the sheeter will save a lot of production. Only the defected web area is removed instead of rejecting the entire small roll.

For tissue applications the web is marked at the edge usually with 1 – 3 colors. Each color is indicating a certain defect type like a hole or an edge crack. The operators see clearly at the unwinding the diameter areas where the defects are residing and can reduce the web speed to avoid web breaks.

The automatic patching and/or rejecting only the defected web areas will save a lot production and prevent shipping bad quality paper to the customers.

Special application – Reel turn up monitoring

Reel turn up is an event that can cause a lot of web breaks. Many different mechanical and process solutions have been introduced by paper machine or paper machine component suppliers. What is common for all these applications is that very fast camera technology is needed to “freeze” the real turn up moment in order to fine tune or make a diagnosis how well it functions. Figure 8 shows an application where the web is cut with two high pressure water jets and clue is applied on the remaining strip.

Figure 8: Monitoring of the reel turn up system with ultra-fast digital camera

Web Inspection – Matrix or CCD line cameras?

Both matrix and CCD line cameras have been developed under the past years for high resolution and fast speed applications. The matrix cameras are used both for Web Monitoring and Web Inspection purposes. The CCD line cameras are used mainly for Web Inspection purposes only. A normal resolution today for a matrix camera is Full HD resolution with 2048*1088 pixels. A typical CCD line camera also has 2048 pixels resolution with a line scan rate 80 kHz or greater.

Matrix cameras have a special application area where they perform clearly better than the CCD line cameras. Web Inspection with matrix cameras and “False Defect Filter” software can be used to filter out false defects like dust particles as discussed earlier in this article.

CCD-line cameras have an advantage over the matrix cameras for certain Web Inspection low angle reflection geometry applications like measuring the defects on the paper that is winding over a paper turning roll with a small diameter.

Experienced Web Inspection suppliers use today both matrix and CCD line cameras to fulfill all application requirements in paper and tissue making processes.

Summary

The functionality between a Web Monitoring and Web Inspection system is not any more black&white. The cameras inside the Web Monitoring camera houses can perform Web Inspection functions like edge crack monitoring. The two systems today are fully integrated and synchronized and help the papermaker both to improve the paper quality and at the same time to detect the root sources for the defects.

References

1. Hilden, Kari K., *“Improving paper making and coating efficiency with web inspection cameras”, TAPPI Papercon 2011, Covington, Kentucky, USA*

2. Hilden, Kari K., *“Improving Coater Runnability with Web Inspection and Web Monitoring cameras”, TAPPI, Papercon 2014, Nashville, Tennessee, USA*