New Unified Process And Quality Vision Technology Helps Improving Paper Machine Profitability

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ABSTRACT

Due to historical and technology evolutionary reasons there has been traditionally a WIS, Web Inspection System for paper defect detection, and WMS, Web Monitoring System for break and process analysis. There have been two completely different technologies, and even manufacturers have been separate corporates.

Yet, a defect is an end of a long chain of events on the paper machine and actually it should be presented always as the whole, starting from birth and ending into reel. A web break is also a chain of events, exactly like a defect, it is just a bit more unfortunate story ending into a major process and production disturbance.

Presentation will describe a new technology, where one system consisting of one uniform hardware and software, does Process (Web Break Analysis) and Quality (Web Inspection) Analysis totally integrated. Technology solution and results are presented. Also some totally new application areas, which so far have been unavailable, are presented.

Figures:

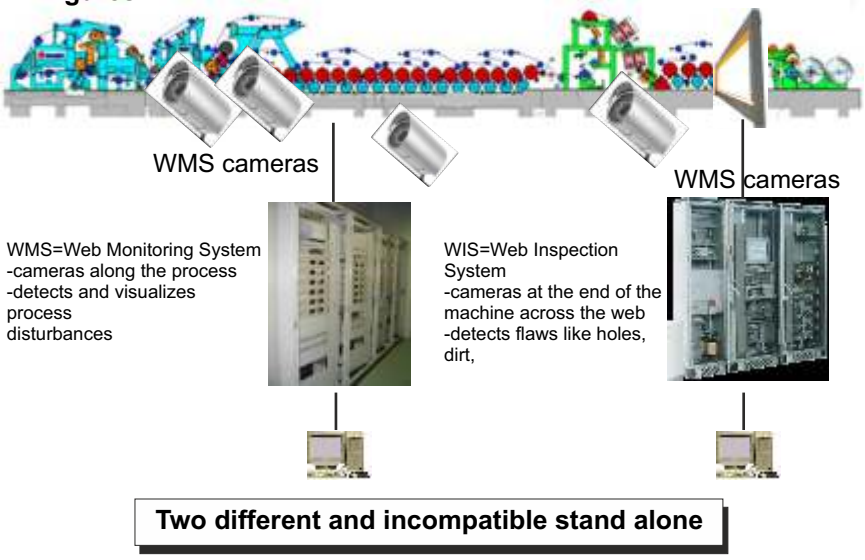
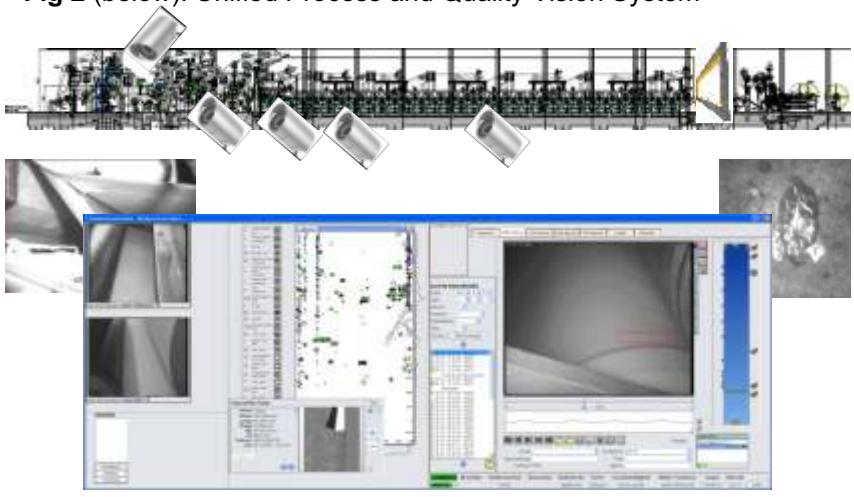


Fig 1: Current separate WIS and WMS systems on a paper machine
Fig 2 (below): Unified Process and Quality Vision System



Process and Quality Vision:
New unified Vision technology for Paper Machines

Introduction :

During the last 2 decades, Vision Technology has gradually entered the paper industry. Twenty years ago a small Finnish Company Roibox developed the first Web InspectionSystem (WIS) using line scan cameras. In WIS cameras are typically placed at the reel just before the winder, in a line across the entire web width. In the beginning it was more or less just hole detection. Over the years, this technology has experienced one major technology change around the year 2000, when true imaging was introduced and technology was mature enough.

In 1993 a Finnish Company Hildeco invented the Web Monitoring Systems (WMS), or the Web Break Analysis Systems (WBA). In WMS systems matrix cameras are located in critical locations of the paper machine, typically outside of the web and in the front and back sides of the machine. Cameras are connected into storage units for continuous film storing. When a break occurs, films are searched for possible break reasons. In the beginning, WMS systems were just a stack of video recorders with computer controlled play-back possibilities. Since 1996 these systems have been fully digital. Today's systems are rather mature and the main differences are in

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the area of signal processing and the camera's /light's cleaning and packaging.

Figure 1 presents the current situation.

Yet, a break and defect are only two different results of one and same process disturbance somewhere in the machine. Defect is the less dangerous result. If a process disturbance could be detected and analyzed automatically for every important web defect, there would be a whole new source of information about disturbances. Disturbances typically generate hundreds of defects before they are becoming so serious, that a break is resulted. Disturbances should be presented as a series of images collected from all locations in the PM, where break cameras are installed. If this information is available operators could do corrective actions and remove the disturbances before they develop into breaks. Same time the number of defects can be reduced.

New Technology:

In the past, there was no proper technology available and so the unification of WIS and WMS was practically impossible. In recent years, some mainstream developments have brought up new technologies, which will offer new and interesting capabilities:

-security technology; automatic control of airports, railway stations etc. have exploded the image analysis mathematics developments, also better picture quality requirements have sped up camera developments

- Digi-TV, DVD and Digicameras, and mobile phones have forced high capacity processor development, specifically for image analysis and handling
- Digicameras have driven camera technology development into a new speed and resolution
- Fiber optics are a commonly accepted Internet communication technology
- LED illumination is rapidly developing and is already a good choice for short light pulses as needed to stop a fast moving web
- DOT NET is the new main software environment used in Internet

All this available new technology offers a real opportunity for unified machine vision in paper machines. Viconsys was established to create this new technology. Viconsys is a new company with extensive experience in WIS and WMS systems development, marketing and deliveries. Beginning in 2005, Viconsys started with a strong financing support and extremely short development cycle to develop the first unified technology. Currently almost 200 systems are sold and delivered and the unified technology has become paper industry's number one choice.

Heart of the system is the ultra high capacity Image Analysis Processor. It is specifically designed for paper machines and it produces an unbelievable 1,4 Tera-Flops processing speed, about 300 times the Pentium capacity. It will support any needed stream of pictures and provides complete Image Analysis in real time with the latest innovations of mathematics for every image. This analysis includes disturbance detection and sequence building, formation analysis, classification, defect detection, specific analysis of machine elements and measurable variables like edges, widths, flutter etc. It will also allow further development of analysis mathematics for several years to come. Each processor is intelligent and communicates in a 1 GB LAN. Camera images are received through fiber optics with 10 bit grey level accuracy.

There is a variety of application matched cameras for optimum capture of images along the process. The most important cameras are digital megapixel cameras with adjustable frame and line rate, frame rates up to 1000 fps. These cameras allow a lossless capture of a high speed web at any required resolution. They will cover the high resolution demand for defects and also any narrow machine space or applications, where high speed is needed.

For high resolution defect images, the web is typically illuminated with a light beam in transmissive or reflection illumination. LED's are used like stroboscopic lights; the LED's are switched on for 5-10 Microseconds depending on application. This short exposure time allows a smear free and crystal clear image of the web. LED power exceeds any current WIS light sources; there is about 5KW LED energy per meter in CD during every flash. This also allows good penetration through heaviest board and pulp sheets. (Fig.3)

Combination of new digital matrix cameras and short and strong LED flash lights will create a new level of image quality as shown in Figures 7 and 8.

Fig.3: LED light beam for a 9m wide web

Fig4: High angle reflection and transmission illumination on a board machine

Digital matrix cameras and LED flash lights are so fast, that they allow web to be illuminated from several directions and for direction an image is taken. This way a totally new capability is created for multiple board machines. Typically with Viconsys System there is one camera beam and 3 lights beams: one for transmission illumination, one for high angle reflection and one for low angle reflection. First image is taken in transmissive illumination. Then in high angle reflection and finally low angle reflection. Comparing results of all 3 independent illumination images of one and same piece of board Viconsys system can define, if the defect is in the middle layer, surface or is it an indent. Fig. 4 displays one multidirectional detection system on a boxboard machine.

Fig. 5: A typical operator interface. On right hand display defect map and latest defect, a slime hole. On left hand display the disturbance sequence is created automatically and last image on the sequence is the slime hole as seen at the WIS

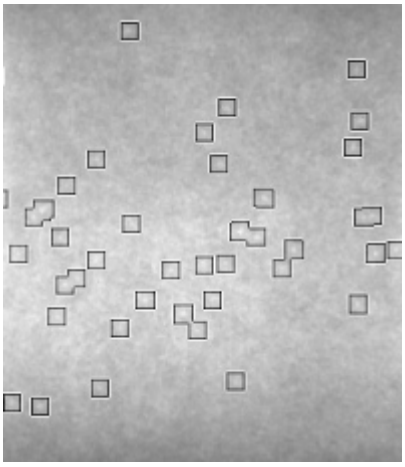

Fig. 6: Image Analysis detects water droplets on boxboards top layer. Droplets are no stronger than voids in formation, but they have stronger boarders, which is detected by image analysis

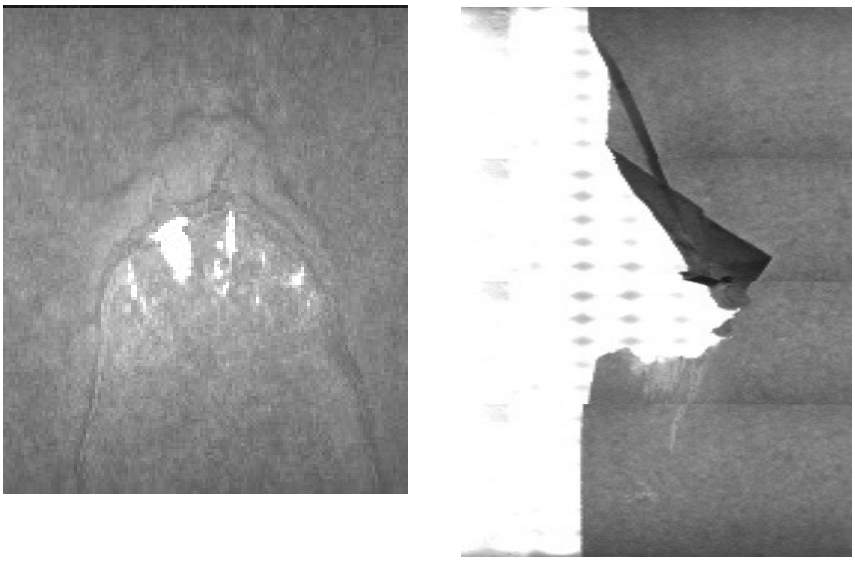

Fig 7: Typical quality of defects on a fine paper machine at 1500 mpm

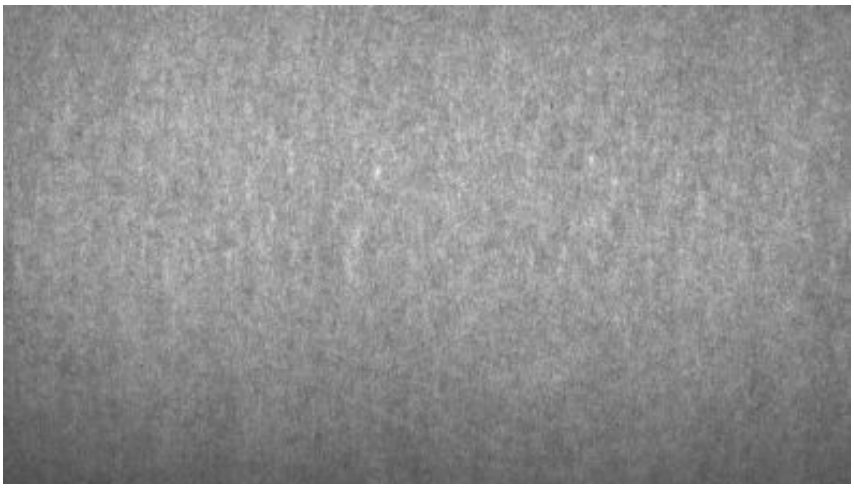

Fig. 8: Formation image on 1600 mpm newsprint machine

LED flash light technology is also applied for Process Cameras (Break cameras). Strong LED light is built into one and same housing with camera and necessary processing power and cleaning system. This is doable first time, because LED's do not generate heat and thus they can be built into one and same housing with cameras. Digital fiber optical cable connects cameras into Image Analysis processors and there are no junction boxes needed. Image quality is so good, that first time in the industry even the imprints of felt joints can be visualized. Figure 9 shows

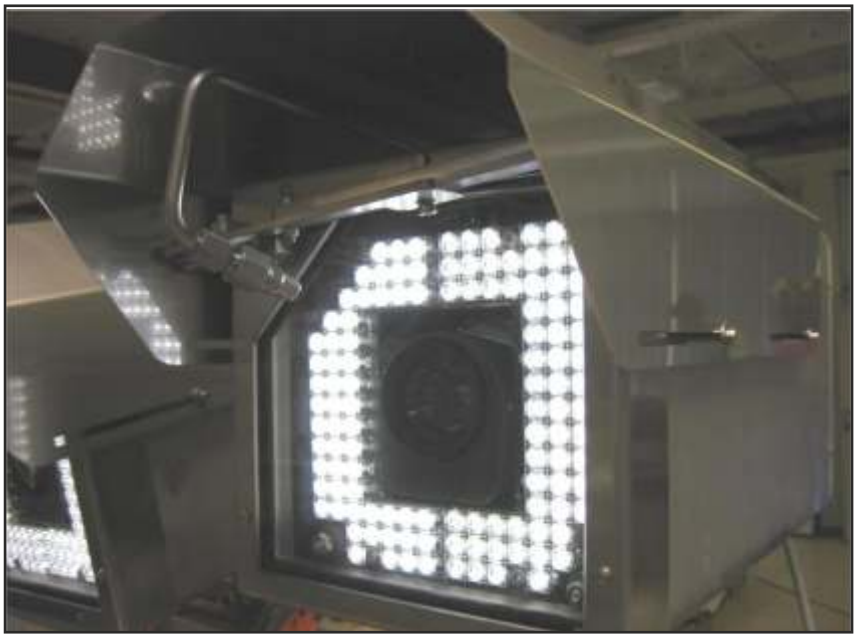

Fig 9: LedCam combined camera and LED Flash light housing

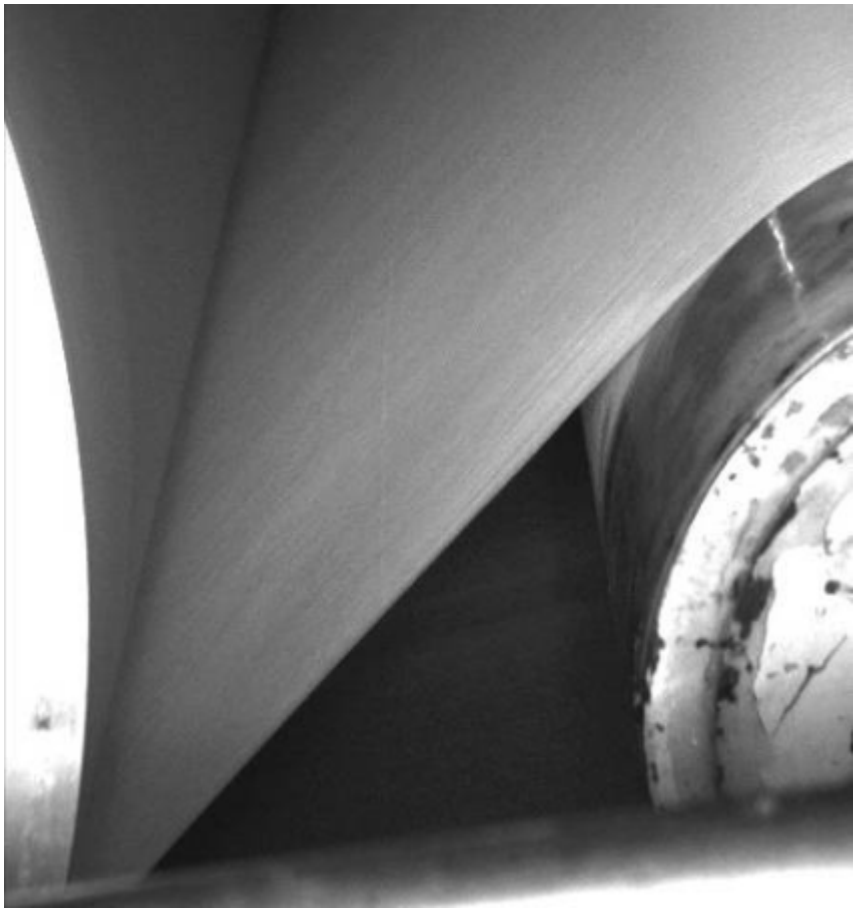

Fig. 10: Imprint of a felt joint on a fast fine paper machine

the LED and Camera housing and Fig. 10 a typical image quality with a felt joint imprint at 4th press of a fast US fine paper machine.

At the heart of the automatic event and defect detection are the latest Image Analysis Mathematics. Several heavy convolution, distribution analysis, adaptive median filtering etc. algorithms are applied to each image in real time. A defect does not need to be stronger than formation; it only must look different than formation. Fig. 6 shows detection results on a boxboard, where top layer was marked with water droplets. Droplets are no stronger than formation voids in the surrounding, they just look different. Image Analysis mathematics was able to pick up most of the water droplets.

Finally defects are classified with learning MLP Neural Network classifier. Traditionally classifiers have required intensive attention of true classifier specialists. Teaching may have taken years and has been difficult, almost impossible to adapt into changing machine conditions. MLP neuro network classifier is based on latest knowledge of image features and neuro networks and has very extensive mathematical software to produce a fine and detailed classification. The only specialist who is needed to teach classifier is the machine operator. He will follow WIS defect detection and classification results during his normal duties. Any moment, when he feels, that a defect has wrong name, he can rename it simply by choosing proper name out of a defect names pull down menu. Images also provide a perfect basis for complete formation analysis in CD and MD. Figure 8 displays a standardViconsys formation quality on a fast newsprint machine. Across the entire paper width the operator can view formation image as a sliding window. Viconsys PQV also calculates 3 variables presenting the key properties of formation. These variables are presented as profiles in CD and trend curves in MD. Data is also stored for long term.

To the papermaker the Viconsys system automatically creates disturbance event sequences. When a disturbance is detected somewhere for example, a tear hole at the center role, Viconsys opens the first image automatically in an event sequence display. Knowing the time delays between cameras, Viconsys now adds into the event sequence any disturbance detections from the following cameras resulting in a high resolution defect or a web break. Only, if the detected disturbance images fit into the time synchronization, within given tolerance, typically +- 1 frames, they will be displayed in one and same event sequence. Several sequences can be displayed simultaneously . A typical disturbance sequence display and new operator interface is presented in Fig. 5. Display technology based on .NET and dual displays, which allows quick and convenient viewing of all important disturbances automatically anywhere

and to anybody. System is fully programmed in DOT NET software, the Internet Software. This means seamless use of LAN and Internet simply using Explorer. No client servers are needed and there is great flexibility in distributing information out of systems 2 year SQL data base.

Results

Using unified Process and Quality Vison technology has potential to reduce web break losses by 50% and improve quality of delivered product.
There is a very simple way to calculate total break losses; total loss=lost salesvalue-value of recycled fiber. Very often margin calculations are mixed into Break loss calculation. Wrong. When there is a break in a paper machine or machine is still after break trying to reach quality specs, machine is creating all costs as usually and looses whole value of nonsaleable or not produced tonnage. Only recovery is the value of paper sent back into recycling. A simple example calculation: machine production 200 000 T/a, coated fine paper, sales value 600€/t, recycle fiber value 160€/t, average break losses 6%/a. Viconsys PQV reduces break losses down to 3%, increase in sold production 6000 t/a, net profit increase 6000 * (600-160)€= 1.320.000 €/a. Typical system cost is about 150 000€ and ROI between 1-2 months. This investment has the shortest payback time in paper industry.
On some troubled lines Viconsys customers have obtained up to 13% line efficiency improvements and several customers have been able to turn their troubled and to be closed machines into new corporate model production lines. Then the affect can be over 10 M€ and it may be the difference today in staying or not staying in business.
Especially high economical returns have been obtained on base paper OMC lines. On such lines the precise information from different stages of the long production chain has improved line total efficiency substantially.

Conclusions

The new Process and Quality Vision technology unifies currently separate WIS and WMS systems. The entire chain from the source of disturbance to the defect or break is created automatically and accurately using the latest technology and science achievements. Process and Quality Vision System allow much tighter control of machine performance and quality with less manpower. Economical influence to paper machine profitability can be enormous and make a machine competitive in today's very tough business environment.