SURFACE VISION

BENEFITS OF COLOR CAMERA INSPECTION SYSTEMS FOR PULP CONTAMINANT DETECTION

APPLICATION NOTE

AMETEK® SURFACE VISION

INTRODUCTION

Color cameras have previously had a limited presence in automated surface inspection for the pulp industry. In the past, the inspection was performed using monochromatic charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) cameras.

Existing installations have proven that inspection systems using monochromatic cameras are fully capable of detecting contamination in the pulp. However, there are some limitations to these cameras when it comes to distinguishing certain contaminants – for example, dark spots and color plastic.

Advances in automated inspection technology have created the opportunity to address more challenging classification issues in pulp applications, using bilinear and trilinear sensors.

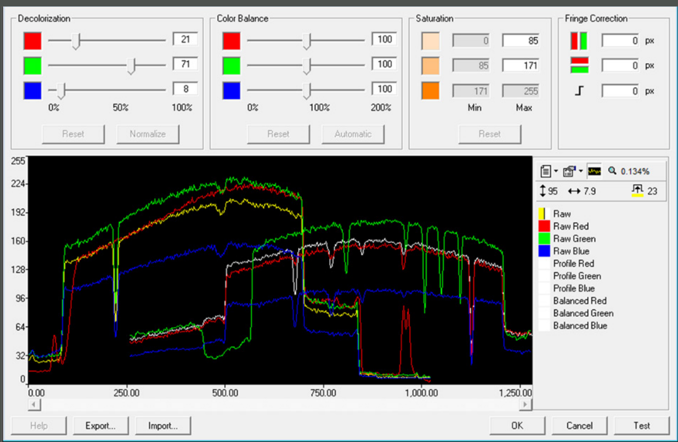

Figure 1: Signals from color cameras

DIRT COUNT FOR PULP APPLICATION

Pulp is an essential raw material for making paper. Its production is based on the chemical or mechanical separation of cellulose fibers. The source of these fibers may be wood, fiber crops, waste paper or rags; in some cases paper is made solely from wood pulp.

After processing, the pulp has a moisture content of as little as 10%. It is never completely uniform, as it contains different fibers and particles of various colors.

The dirt content of pulp is an important factor in determining its suitability for fine paper production. Dirt is defined by TAPPI as any foreign material in a pulp sheet which, when it is examined by reflected light, has a marked contrasting color and an equivalent black area of 0.04 mm² or greater.

Standards for quantifying the dirt content in pulp are set down in TAPPI T213, T437, T563 or ISO5350-2. The tests are statistical and are made in pulp and paper making laboratories.

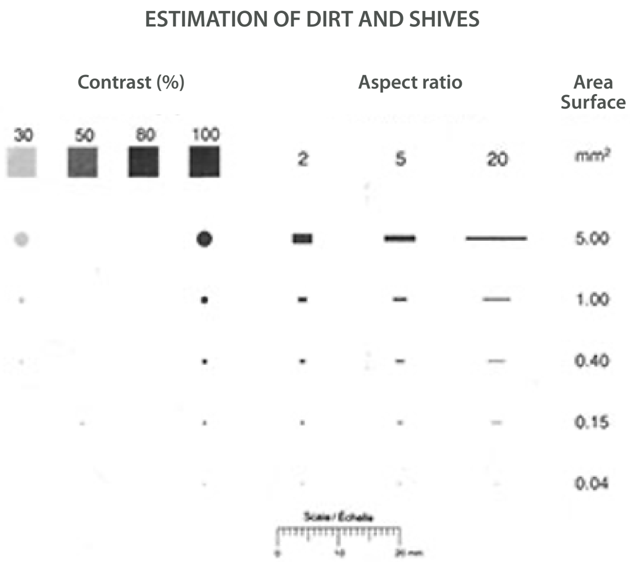

Figure 2: Estimation of dirt and shives EN ISO5350

ON-LINE 100% DIRT ANALYSIS

Multiple tools for online analysis of dirt content are available to the market. These systems are installed after the drying sections, and before pulp bailing. They consist of three major components: lights, sensor technology, and the image processing hardware and software.

Each component plays a key role in delivering effective detection and classification results.

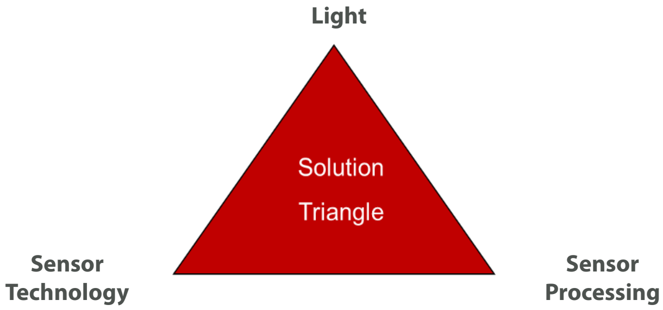

Figure 3: Machine vision solution triangle.

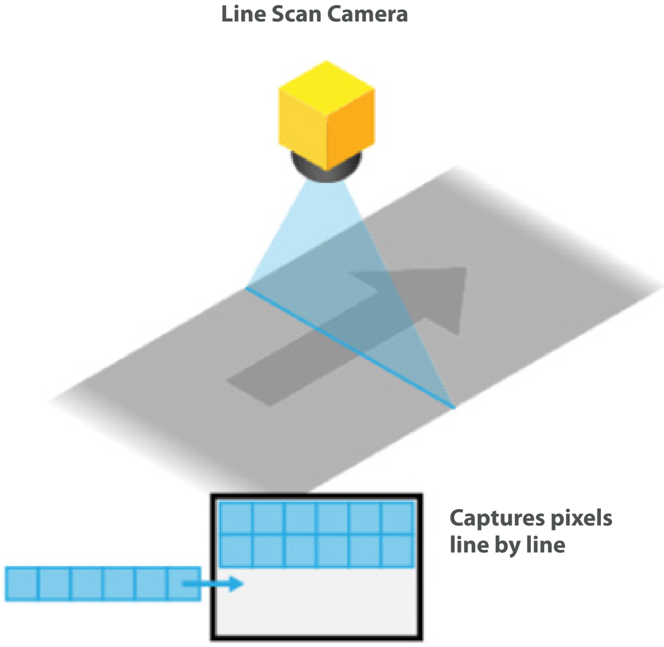

Figure 4: Line scan cameras illuminate and capture pixels line by line

AMETEK Surface Vision supplies automated inspection systems using multiple line scan cameras installed across the inspected material. Depending on the available space, width, and speed of the line, different cameras can be applied with sensor size ranging from 1k to 12k, and speeds up to 960MHz.

The inspection systems analyze the dried pulp in transmitted and/or reflected light (see Figure 5). In the transmission view technique, light penetrates the pulp. Areas with higher density are dark on the images, while those with lower density are lighter.

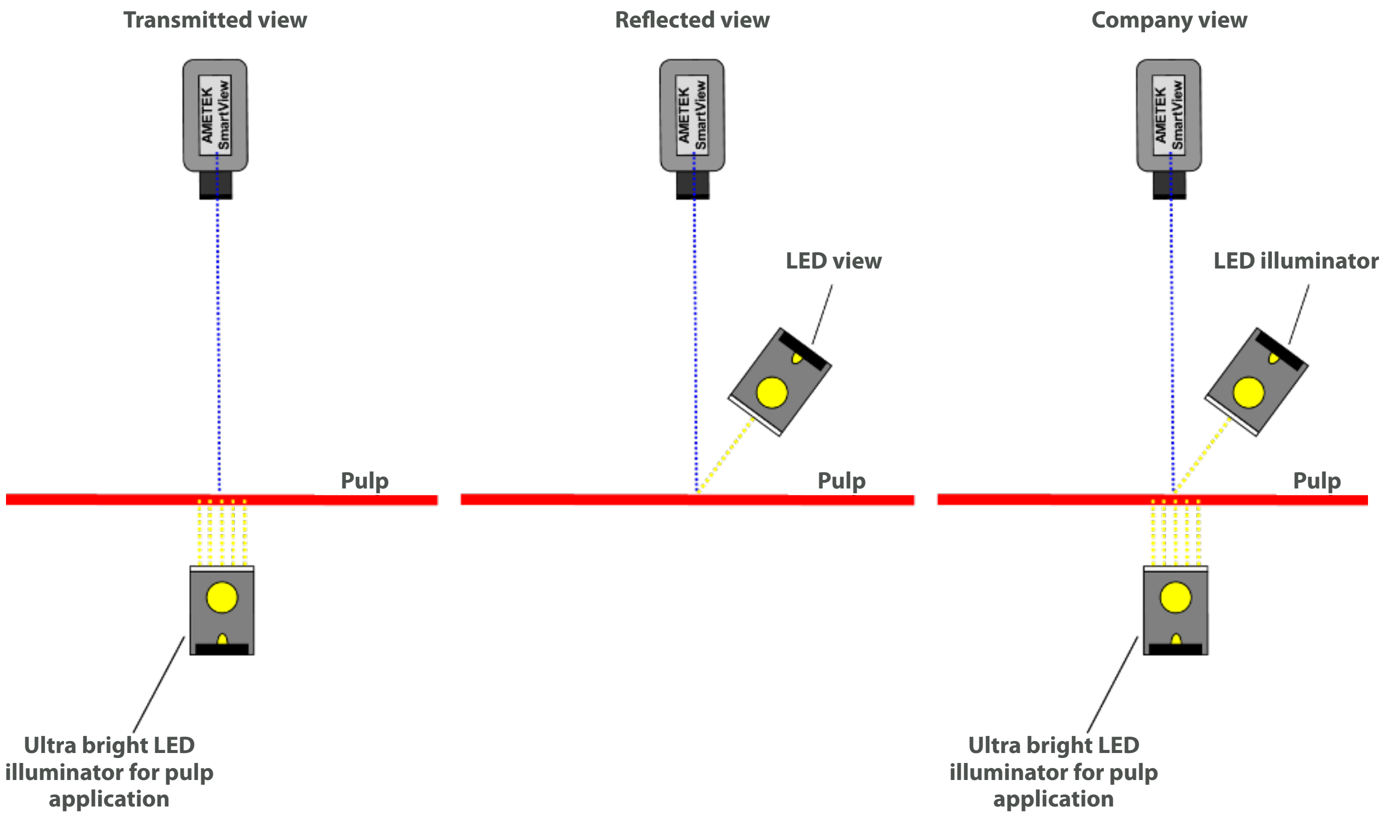

Figure 5: Optical setups for online pulp inspection.

The non-uniform nature of the pulp formation can affect the capability of this technique to detect contaminants. To overcome this, the pulp can be inspected using reflected light. This technique is highly effective in highlighting the surface defects present on the inspected surface.

In addition, assuming an equal distribution, the number of contaminations in the pulp can be extrapolated, based on the defects visible on the surface.

For an effective and accurate automated inspection system, AMETEK Surface Vision recommends using its SmartView® system optimized for pulp inspection, using a combined transmission-reflection view.

This delivers the best aspects of both techniques – the transmitted light reveals the objects with high density located in the pulp, and the reflected light reduces the influence of low-density areas which are brighter in the transmitted image.

The inspection image looks smoother, images of the defects from inspected surface are very sharp, and defects located inside the pulp are sufficiently visible.

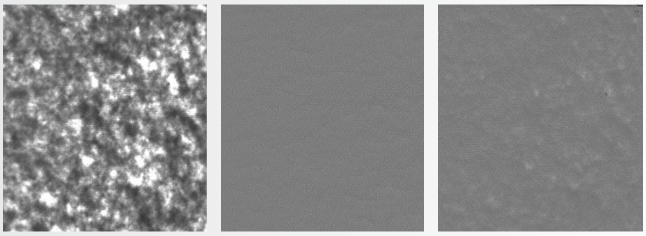

Figure 6: Images for different optical setups for online pulp inspection.

LINE SCAN DIRT COLOR ANALYSIS

While it is established that monochromatic cameras are highly effective at detecting contamination in the pulp, in some pulp-making processes contaminants may have different colors and the correct dirt classification may be important.

In these instances, color cameras can be considered for use in the pulp inspection system, again using a combined transmission-reflection view for on-line dirt detection and evaluation.

Alternatively, a two-view system can be used, with a reflection view installed looking at the top surface, and a combined view inspecting the bottom surface.

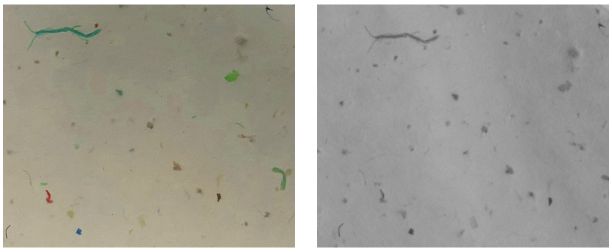

Figure 8: Examples of contaminants in color and monochromatic view side by side.

Inspection systems capture color images of the product or surface, and use these to calculate the color features for each defect found. They do this by using all the pixels that belong to a defect to calculate the average values for hue, saturation and intensity for that defect.

So, if a single defect has multiple colors, the resulting values will not represent this correctly, since the average calculation delivers only the values for a single color.

To overcome this issue, most common cameras for this application use bilinear and trilinear sensors.

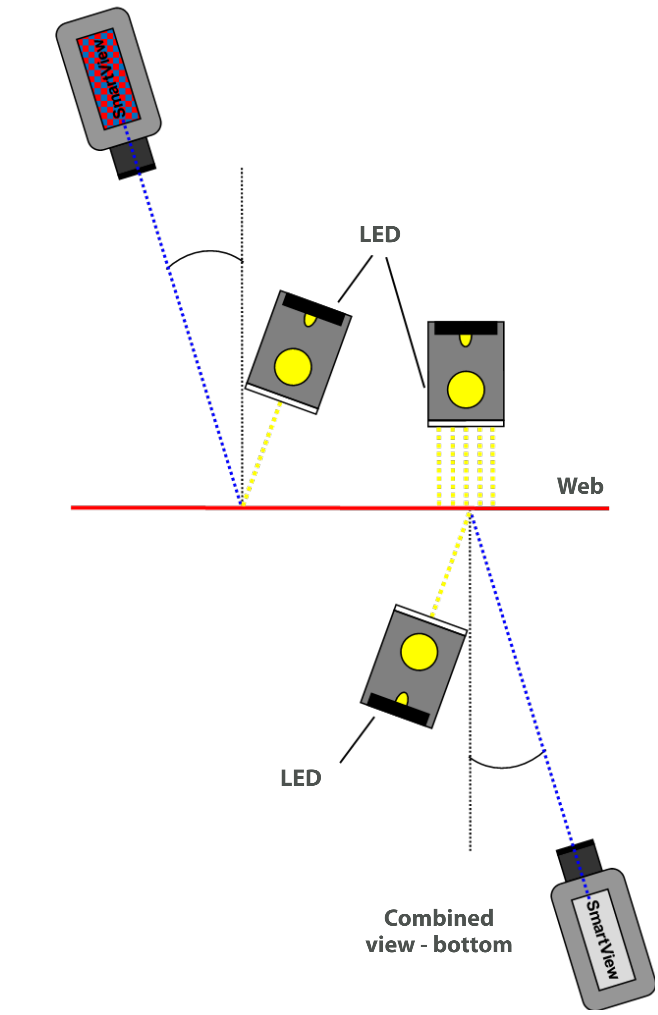

Figure 7: SmartView pulp inspection – color camera system

BILINEAR SENSORS

A bilinear camera captures color using two lines from the same image location to determine the color of a pixel. Two methods are used to capture these two lines. One method captures one line with blue and green pixels and the other line with red and green pixels (see Figure 9). The other method captures one green line while the other line is red and blue (see Figure 10).

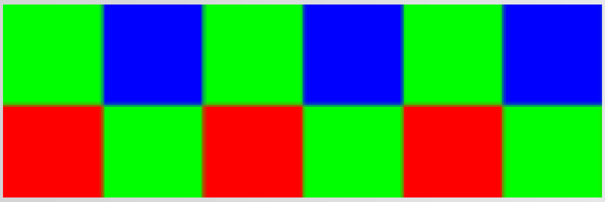

Figure 9: Bilinear camera capture – Bayer Pattern

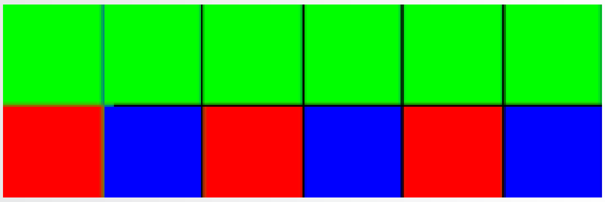

Figure 10: Bilinear camera capture – every other line is green

TRILINEAR SENSORS

A trilinear camera captures three lines for each row: one red, one blue, and one green. When the image passes the three lines of pixels, the red, blue and green components for the same image location are captured at a different time, as dictated by the line spacing illustrated in Figure 11.

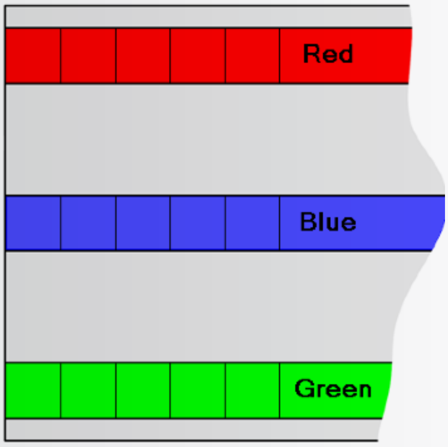

Figure 11: Three lines captured by trilinear cameras

ILLUMINATION

Modern inspection systems use white LED lighting for transmission and reflection inspection channels. Inspection of the dried pulp in transmitted light requires significant amounts of light, so ultra-bright LED illuminators with liquid cooling are recommended.

Light intensity can be adjusted automatically based on the grammature (weight in grams per square meter) of the pulp and contamination of the optical components.

IMAGE PROCESSING AND DETECTION ALGORITHMS

The SmartView inspection system scans the surface, then looks at the inspected surface and normalizes the image. Images of objects that look different to the background are analyzed further. SmartView independently analyzes the reflected and transmitted light, assigning pixels into bright and dark bins (Figure 12).

Each object is described by more than 200 features which can be used for filtration and classification. The number and intensity of the individual pixels in the object is used to determine the size and aspect ratio of the defect.

The system calculates the total scanned area, area of the defect box, and the number of dark or color pixels. Multiple tools have been designed for the dirt count in dry pulp inspection.

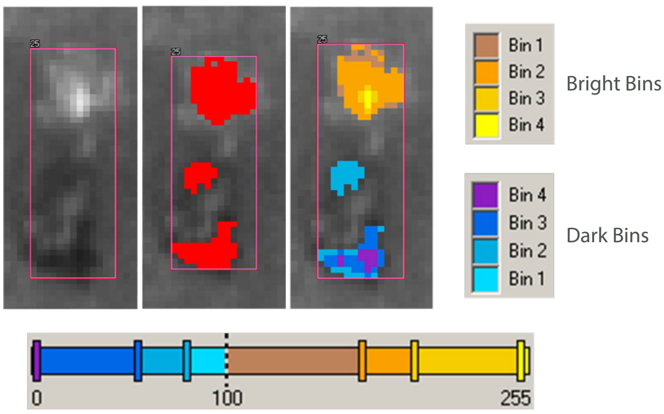

Figure 12: SmartView bright and dark bins

COLOR IDENTIFICATION

Two methods are used to identify a specific color in SmartView. One is the RGB color model, which uses values for red, green and blue to produce a broad array of colors.

The other, used in the SmartView system, is HSI which uses values for hue, saturation and intensity to produce the array of colors.

Hue – represents the color

Saturation – how vivid or pure the color is, ranging from gray (0% saturation) to pure color (100%)

Intensity – the lightness or darkness of a specific color ranging from black (no intensity) to white (full intensity)

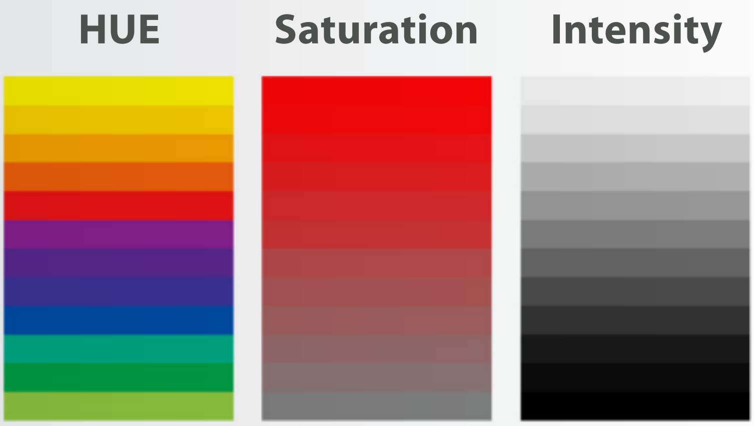

Figure 13: SmartView color identification

DIRT CLASSES

Dirt classes were created within Classifier Manager to match the TAPPI Equivalent Black Area definition. This is defined as the area of a round black spot on the white background of the TAPPI Dirt Estimation Chart that makes the same visual impression as the dirt speck on the material in which it is embedded.

Dirt classes can be defined by intensity, shape, irregularity, and over 200 other features.

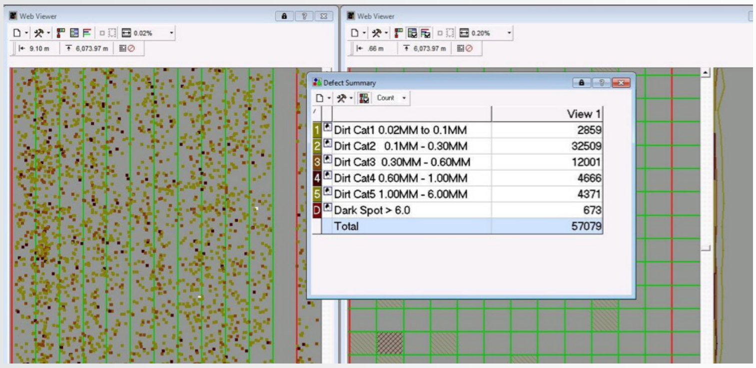

Figure 14: Dirt classes

PARTS PER MILLION

Parts per million (PPM) is a quality index that expresses defect area as a percentage ratio of the total product area, and can be displayed on the operator console or exported to the inspection summary report. Users can select either the total detected area or selected gray bins for this calculation.

A visual index is also available to correct for sampling and contrast effects when the pixel size is of the order of the minimum defect size. This number is based on the TAPPI Equivalent Black Area definition. A correction factor can be adjusted to calibrate results to an off-line measurement system.

The PPM data is updated at each row height interval, as defined in the Tile Definition, and a total value is displayed for completed inspections.

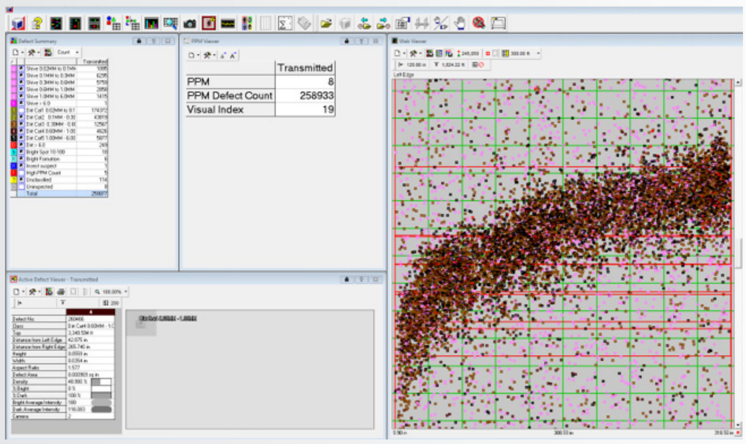

Figure 15: PPM data displayed for completed inspections

OPEN SQL DATABASE

An open SQL database with customized reporting system can query and calculate the PPM, number and area of defects per pulp area and weight. The trends generated help with precise process control.

CUSTOMER REACTION

Our AMETEK Surface Vision Sales Director Europe was recently involved in the implementation of a major pulp inspection project. He said: "The initial configuration proposed for this pulp application was a version of our existing systems for this market.

"However, when we visited the customer to introduce our solution, their Quality Manager emphasized that one of their key quality issues were plastic pieces. When the customer receives the pulp, it is contained within a plastic cover. It is, therefore, quite common that some plastic pieces get torn apart when the plastic is being removed.

"This is a major quality issue for the customer: plastic looks colored compared to the pulp. The best way, not only to detect these plastic pieces, but also to differentiate this specific defect from others, was therefore color cameras.

"The benefits of color cameras convinced the customer about our proposed solution, which was a key factor in their decision to use our system for this project."

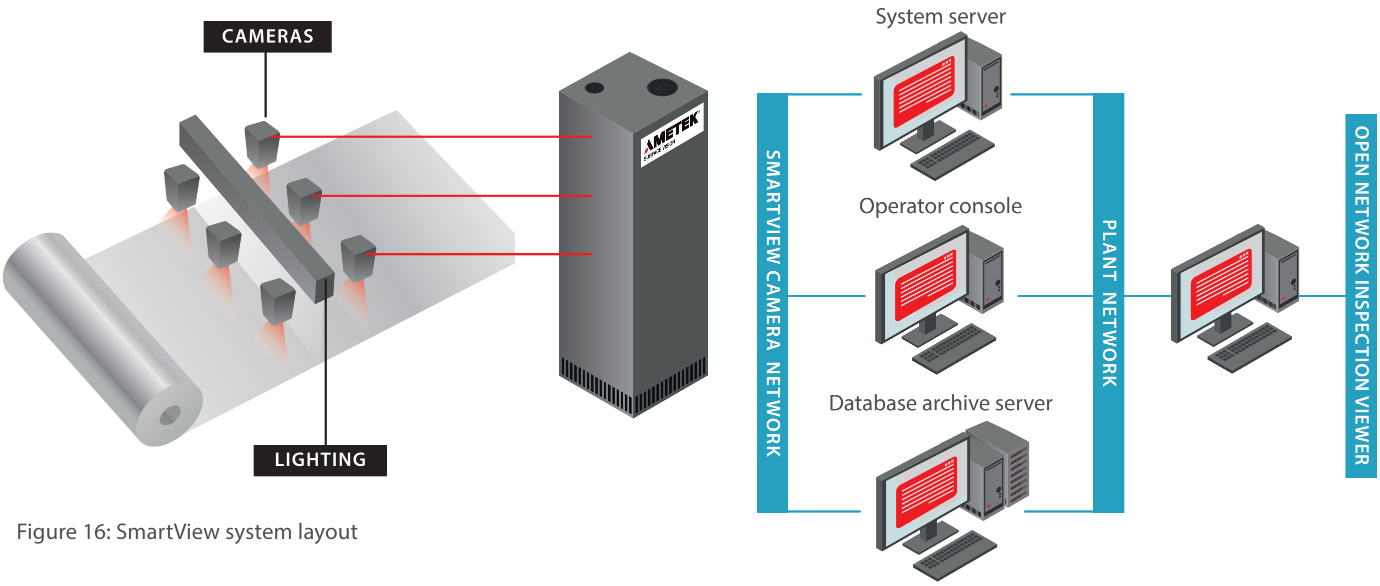

Figure 16: SmartView system layout

CONCLUSION

Surface inspection systems available to the pulp and paper market successfully support the pulp making process by providing 100% inspection of the pulp. The statistical tools implemented in the modern systems can provide reliable real-time information regarding the process and pulp quality. Reports generated by dirt count systems deliver a clear indication of the quality of the raw material, suggesting any necessary maintenance operations.

SMARTVIEW – THE KEY ADVANTAGES FOR PULP INSPECTION

- A reliable surface inspection system based on the SmartView platform, proven in more than 2500 installations
- Expertise from AMETEK's vision team – pioneers in machine vision
- Tools specifically designed for pulp inspection (defect area statistics, dirt count, PPM)
- Color cameras

SURFACEVISION

ABOUT AMETEK SURFACE VISION

AMETEK Surface Vision is the world leader in automated online surface inspection and monitoring solutions. Our broad product range is optimized for the monitoring and inspection of webs and surfaces, and for process surveillance applications.

The SmartView and SmartAdvisor® product lines deliver robust, flexible solutions to continuous production processes across a number of industries, with hundreds of customers and more than 3,000 installations worldwide.

Our systems have become vital to increasing efficiency, streamlining operations, improving product quality and reducing costs and waste in industrial processes. Manufacturers in the metals, paper, plastics and nonwovens industries rely on our solutions to detect surface flaws or defects, and optimize process efficiency, at their production facilities across the globe.

We continue to innovate, providing cutting-edge technologies and world-class technical support that delivers highly accurate defect data, high-definition video, intelligent grading, archiving and detailed reporting. Customers who use AMETEK Surface Vision's services get the benefits of:

- **Reduced operational costs**
- **Process optimization**
- **Reduced process upsets (breaks, wash-ups, etc.)**
- **Improved product quality**
- **Maximized yield**
- **More thorough and objective grading of material**
- **Detection, classification and visualization of defects**
- **Minimized need for manual inspections**
- **Inspection reports you need, in a form you can use**

Based in Hayward, California, AMETEK Surface Vision has offices and sales representatives around the world. We are part of the Process and Analytical Instruments Division of AMETEK Inc., a leading global manufacturer of electronic instruments and electromechanical devices.

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