



CROSS LIGHT INSPECTION FOR DETECTING SURFACE DEFECTS

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AS SEEN IN:

Steel
Millennium

Summary: Surface inspection has been greatly enhanced with the latest developments in LED technology utilised in stroboscopic inspection. The ability to precisely control flash duration time of LEDs now enables inspectors to have sharper and crisper images of the strip surface allowing them to detect finer anomalies. This control over light

timing also makes it possible to deploy the simultaneous use of bright field and dark field lighting such that surface imperfections are dramatically enhanced, making it easier for operators to see both common defects in surface quality as well as extremely subtle defects on coated and reflective surfaces.

HOW STROBOSCOPIC INSPECTION WORKS

A flash from a strobe light acts to freeze motion seen by the eye just as the camera shutter does for a photographer. A flash, with a duration of 10 to 20 microseconds, triggers a motion-freezing retinal response. An object moving at 600 meters per minute moves only 0.1 mm during this time - a distance so negligible it appears absolutely stationary to the eye. Thus motion blur is eliminated and contrast, critical to defect definition and detection, is enhanced.

Xenon-based strobe lights, although rated at 10 to 20 microsecond durations, are measured at 90% peak and, in reality these strobes had very long tail of discharge times that could easily extend over 100 to 200 microseconds. LED-based strobe lights enable precise timing of on- and off-time, so the exact flash duration (or on-time) of the light can be controlled (see figure 1). It is this characteristic of the LED stroboscopic light that allows sharper and crisper images as well as the capability to apply cross light inspection via strobe placement and algorithmic timing.

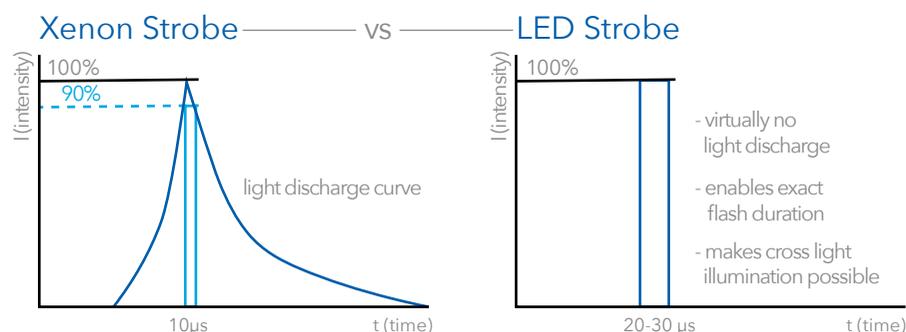


figure 1

BRIGHT FIELD AND DARK FIELD LIGHTING

To understand the application of cross light inspection one must first understand how incoming light will interact with a metal surface. With Bright Field lighting, the various rays of light on the steel surface will be specular, meaning the angle of incidence will equal the angle of reflection. With proper positioning of the light source, the reflective angle of the light is directed back to the inspector as a disperse light and displays defects as dark on a bright background. Defects such as scratches, dents, slivers, scale and holes are easily recognisable in this light. Bright Field lighting is generally used on dull or matte finished surfaces.

If the surface is smooth and shiny, a very high percentage of the light will be reflected back at the operator creating `hot spots` that can make inspection difficult. In these cases Dark Field lighting is applied. In Dark Field lighting, reflected light shines towards the strip at a steep angle and away from the inspector. The image of the surface that the inspector sees will tend to be dark since the majority of the light will not be reflected back to the inspector. If there is a defect on the surface that causes light to be scattered causing a change in the angle of the light, then the inspector will observe this defect as a light area on a dark background. On highly reflective surfaces, this angle of light will highlight scratches, build up and dross. Examples are shown in figure 2.



figure 2

CONFIGURING STROBOSCOPIC INSPECTION SYSTEMS

Proper placement of the light source is critical to achieve maximum performance. The following examples in figures 3-6 show various configurations of Bright Field and Dark Field lighting techniques in the order of simple to complex.

Figure 3 Simple Bright Field illumination with strobe lights opposite the inspection platform and shining towards the operator

Figure 4 Simple Bright Field illumination with strobe lights at a flat angle to strip from bottom

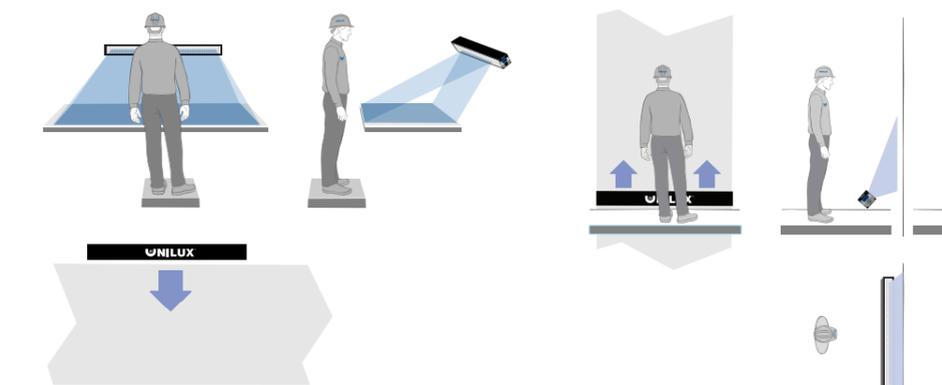


figure 3

figure 4

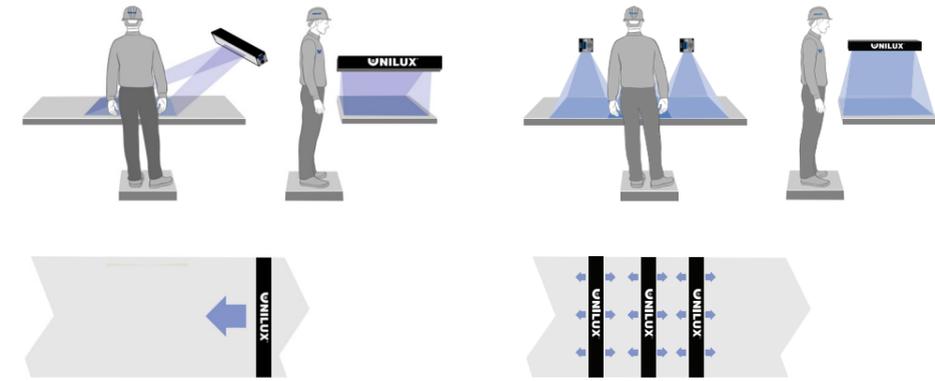


figure 5

figure 6

Figure 5 Simple Dark Field illumination shines the light across the strip and parallel to the inspector

Figure 6 Stroboscopic inspection lights are mounted above the strip and pointed straight down to achieve Dark Field inspection as the light does not reflect to the operator

CROSS LIGHT INSPECTION

Depending on the material and rolling process, either Bright Field or Dark Field techniques would be selected. Since every rolling process can produce multiple anomalies that would be enhanced visually by both lighting techniques, surface imperfections become more apparent when lit from multiple angles. The use of both techniques simultaneously, or cross light inspection, can now be achieved for the first time with stroboscopic inspection systems using LED diodes instead of xenon bulbs. These are illustrated in figures 7 and 8.

With the long burn time of xenon bulbs, it was not possible to use Bright Field and Dark Field lighting techniques at the same time because the flash durations would overlap images to the eye, thus cancelling each other out. With LED strobes, we can now deploy an algorithm to control flash duration so that different light sources can be triggered simultaneously to create a single perfect image.

Figure 7. A combination of bright field (shining towards the operator) and dark field (parallel to the inspector) for various defects in horizontal inspection

Figure 8. A combination of bright field (shining towards the operator) and dark field (parallel to the inspector) for various defects in vertical inspection

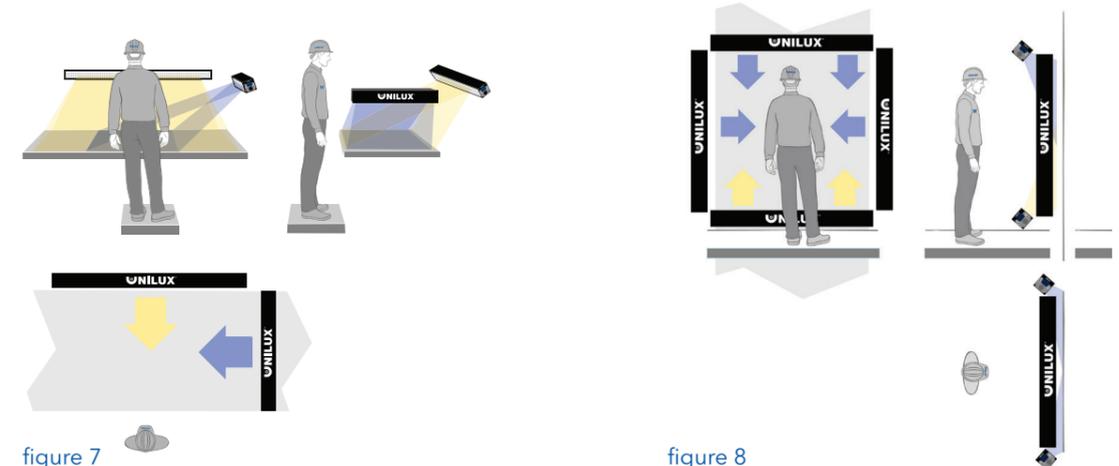


figure 7

figure 8

PLANT APPLICATION

- This system works at any strip speed, but the advantages are maximised for any speed above 50m/min.
- Retrofitting is very easy and does not necessarily need factory support, although it tends to be welcomed by users.
- It is suitable for both as-rolled i.e. scaled surfaces, and bright rolled steel. These require different illumination setups and we work on site with the customer to achieve the best results.
- We are currently commissioning this system at two mills in Europe.

SUMMARY

To detect defects on steel strips, good lighting contrast has always been essential. Until recently, mills have had to choose between Bright Field or Dark Field illumination. LED technology for stroboscopic inspection now allows inspectors to gain the same technological advantages that previously were only available using cameras. The ability to synchronise multiple lights has led to the development of algorithms that, when paired with stroboscopic inspection light positioning, provides optimum visual inspection at far less cost than camera-based systems. Cross light inspection affords metal producers better inspection capability. Operators have greater insight to the quality of the steel they are producing to increase yield and reduce customer rejections.

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