VISUAL SURFACE INSPECTION IN PROCESSING LINES[1]

iLux Lighting Systems are a Tool for the Inspector for Immediate Verification of Findings from Automatic Surface Inspection Systems Without Additional Re-Coiling

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Abstract

The iLux lighting systems for visual surface inspection are typically mounted inside the inspection cabin and do separate illuminations for horizontal pass for top and bottom side as well as for the vertical pass from both sides. Every system can be customized to strip width and the space available. The iLux lighting system utilizes parallel beams of light by use of lamps with reflectors and patented light sails based on reflecting lamellas to allow for an increase in the detection of defects exposed during stoning and evaluation of the defects detected by the automatic inspection system. The indirect and directed light allows for superior image quality at a lower light intensity which in turn improves inspector performance by upward of 30%. Defect detection is paramount for steel producers if they provide galvanized steel for exposed automotive use and must as such produce top quality steel. iLux provides the best light for the human eye and the operators can do their work without being confused or blended by direct reflections on the material like from standard illumination by fluorescent tubes. Visual surface inspection is an important element in all production processes where surface quality is of vital interest. Not light intensity is important but directed and glare free illumination for easy defect detection. Lighting system has to be designed and optimized for the properties of the human eye and the different material qualities.

Key words: Quality and productivity; Visual surface inspection.

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1 INTRODUCTION

In all kind of industrial production processes a visual inspection is done to provide a good surface quality and to avoid defects to be delivered to customers or to avoid costs for conditioning of defects.
Anyhow lots of mistakes are done when an inspection area is prepared:

- mistake: most people say that a high light intensity is needed to see defects;
- mistake: all lamps are mounted around the inspection area to illuminate strip from all sides in order to find all defects;
- mistake: nobody takes care about the ability and sensitivity of human eye.

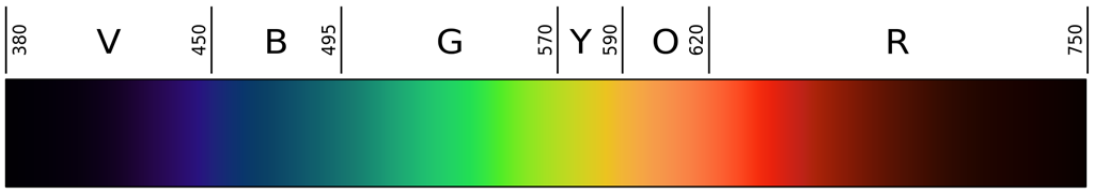
2 MATERIAL AND METHODS

The human eye in combination with our brain is a high sophisticated instrument. It can handle a high range of light intensity and we can “see” on a bright summer day as well as in a dark night.

Table 1 Light intensity from different light sources

LIGHT SOURCE	LIGHT INTENSITY
sun light at a sunny day	100.000 lx
at sun light in the shadow	10.000 lx
sun light on a day in winter	3.500 lx
flood light in a football stadium	1.400 lx
office / living room lighting	500 lx
candle light at 1 m distance	1 lx
full moon at clear sky	0,25 lx
starlit night at new moon	0,001 lx

We know from own experience that we all are able to handle these intensity differences. This is basically possible because our eye adjusts itself to different situations – similar to the aperture of a camera. If we have a high light intensity our pupil closes and reduces the amount of light coming to the retina where the light receptors are located. These receptors are connected via nerves to the brain.
Also we have different receptors inside the eye which are responsible for colors as well as for black and white. Two of the most important receptors are called rods and cones. When rods and cones are stimulated by light, they connect via the retina to the nerves and send signals to the brain. Our brain combines all signals to the picture we see.
Rods are mainly active at low light intensity and are responsible for monochrome viewing (black and white). Cones can handle high light intensity as well as colors. The total range of colors we can see is shown below. The scaling is done in wave length (Nanometer). All other light (wave length) below 380 nm and above 750 nm is not visible for our eyes.



Source: CRC Handbook of Fundamental Spectroscopic Correlation Charts

Figure 1. Spectral colors and corresponding wave length.

The light coming from the sun includes all these colors – the result of this wave length mixture is our (white) daylight. The daylight has an own color temperature (Kelvin) which is defined to an equivalent to the radiation of a black body radiator. This color temperature is mainly used for differentiation in light color for all kind of light sources.
The human eye feels comfortable with the sun light as it is his natural lighting source. Sun light has a color temperature of roughly 5800 K. All higher values are felt as cold light while lower values are known as warm light. So every light source is marked with the light temperature and sometimes also verbally named as “day light”, “warm white” or “cold white”.

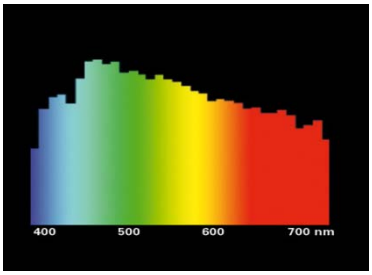


Figure 2. Spectral color sun light halide lamp.

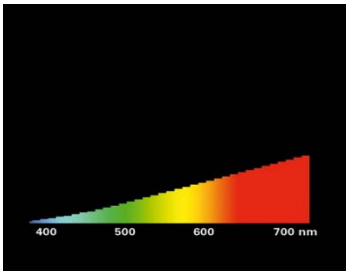


Figure 3. Spectral color light bulb.

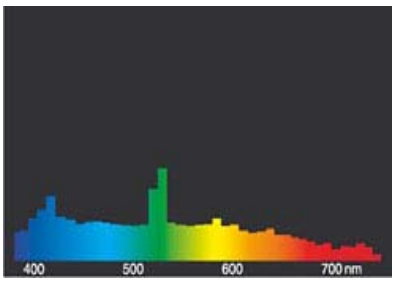


Figure 4. Spectral color metal.

The light of a light bulb is a warm light which helps people to feel comfortable. This light is preferred for living rooms. For visual surface inspection a metal halide lamp supplies optimal light. The light color (5000 K) is similar to sun light and is well-balanced with only a slight greenish touch.

3 RESULTS

Light color is responsible for human to feel comfortable. For easy defect detection we need another important feature – the light has to be nearly parallel. This shows also that sunlight is a very good light for defect detection – but unfortunately it is not available all time and not at all places. iLux lighting systems have both features so that it supplies light similar to sunlight. For optimal defect detection we need an

additional feature which is very important. The light has to be indirect – this means that the inspector should not “see” the light source on the surface to be inspected. If he can see the light source on the surface he will be blended – because the eye focusses automatically (naturally) to the brightest area.
How does iLux improve these important characteristics? The light of a metal halide lamp is sent via a reflector to the light sail. The light sail directs the light to the surface to be inspected.
By doing this the light is directed (nearly parallel) and indirect (no reflection of light source on the strip). The principle of iLux is patented as well.

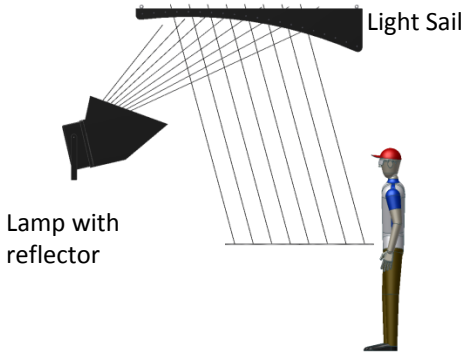


Figure 5. iLux principle.

To show the effect of directed light compared to diffuse light we use an example which everybody knows who goes skiing. In Figure 6 and 7 on the next page you can easily see the difference. Direct light in this example is the sunlight at a sunny day. Diffuse light is sunlight but on a cloudy day – the clouds generate the diffuse light.

Figure 6. Mogul slope with parallel light .

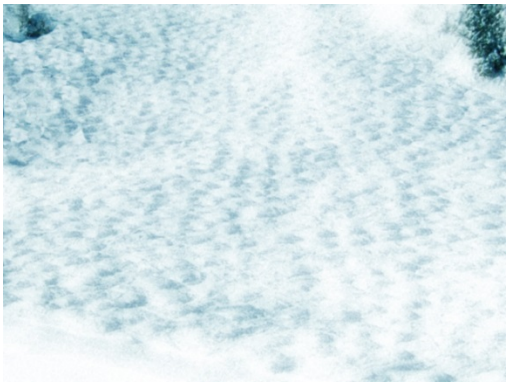


Figure 7. Mogul slope with diffuse light.

Only with parallel light the contours are clearly visible. Diffuse light is smoother and supplies no clear view. Transforming this effect to visual surface inspection we use the Figures 8 and 9.

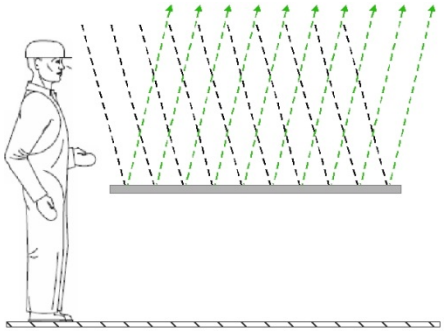


Figure 8. Parallel light for inspection.

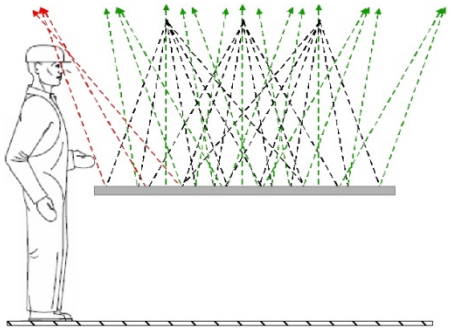


Figure 9. Diffuse light for inspection.

By knowing these effects it is self-explaining that diffuse light for visual inspection is not the best tool as the inspector has to strengthen his eyes and defects are not easy to find.
If visual surface inspection is done with nearly parallel light another positive effect shows up. By using nearly parallel light (Figure 10) every defect sends a signal to the eyes of the inspector as defects reflect diffuse and are “blinking”.
The inspector is not forced to scan the surface with his eyes as the defects sends out an optical signal.
As all ambient light in a production line is coming from diffuse light sources it is very important to protect the parallel light against this influence by using a “light shield” or a curtain.
Even daylight i.e. sunlight can disturb the effect.

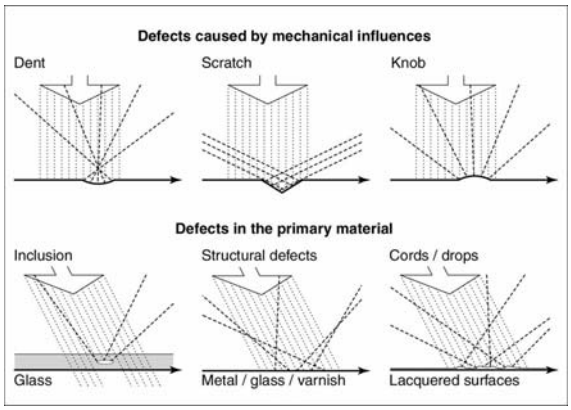


Figure 10. Reflections of different defects.

4 DISCUSSION

In most installations the parallel light is directed under an angle to the strip surface. Depending on the position of the inspector he can have a positive or a negative angle which is also called “Bright Field” or “Dark Field”. In a bright field inspection the reflected light is going in direction of inspector. The dark field reflects the light away from the inspector. Depending on surface brightness and reflectivity the inspector can change his position to have the best result for defect detection.

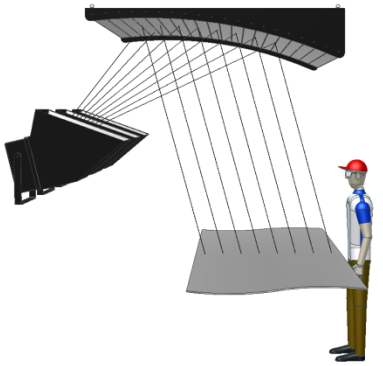


Figure 11. Bright field inspection.

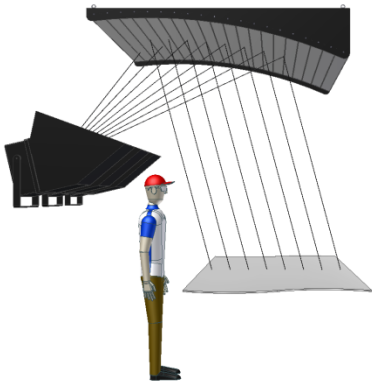
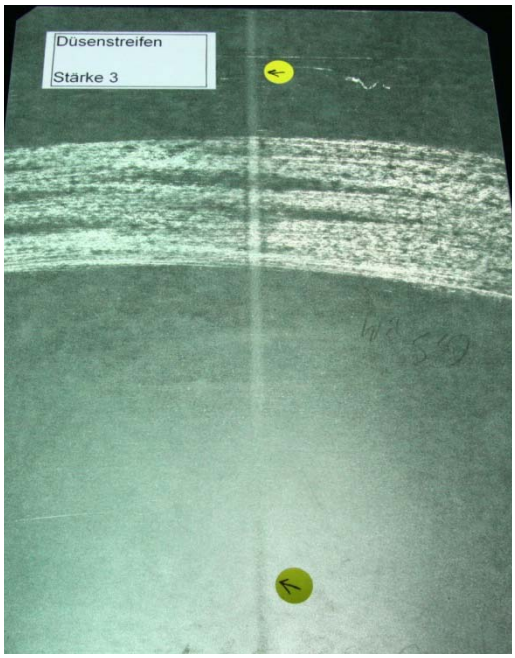
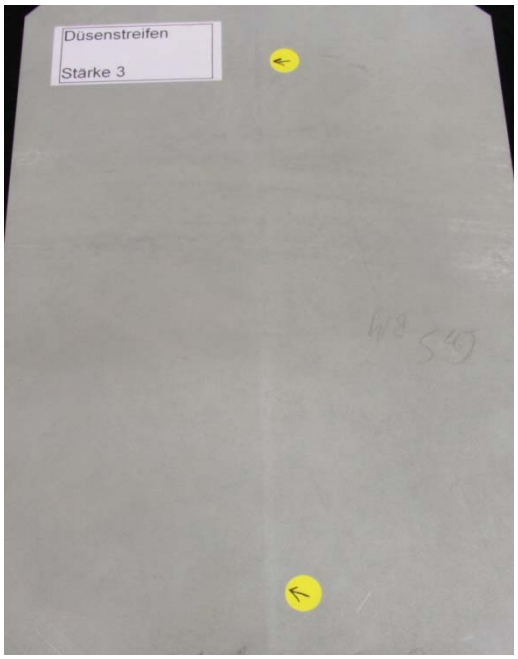


Figure 12. Dark field inspection.

Beside this features iLux lighting systems have another advantage which is also very important. The light source itself is not visible on the surface to be inspected. Based on the double reflection by use of a reflector and the light sail® a homogenous light is shown on the strip. If you use diffuse and direct illumination you will always see a reflection of the light source on the surface – which will blend the inspector. Some examples for defect detection with iLux lighting systems compared to standard illumination are shown in Figures 13 and 14.



Source ThyssenKrupp Steel Europe GmbH
Figure 13. Nozzle streak with iLux Lighting.



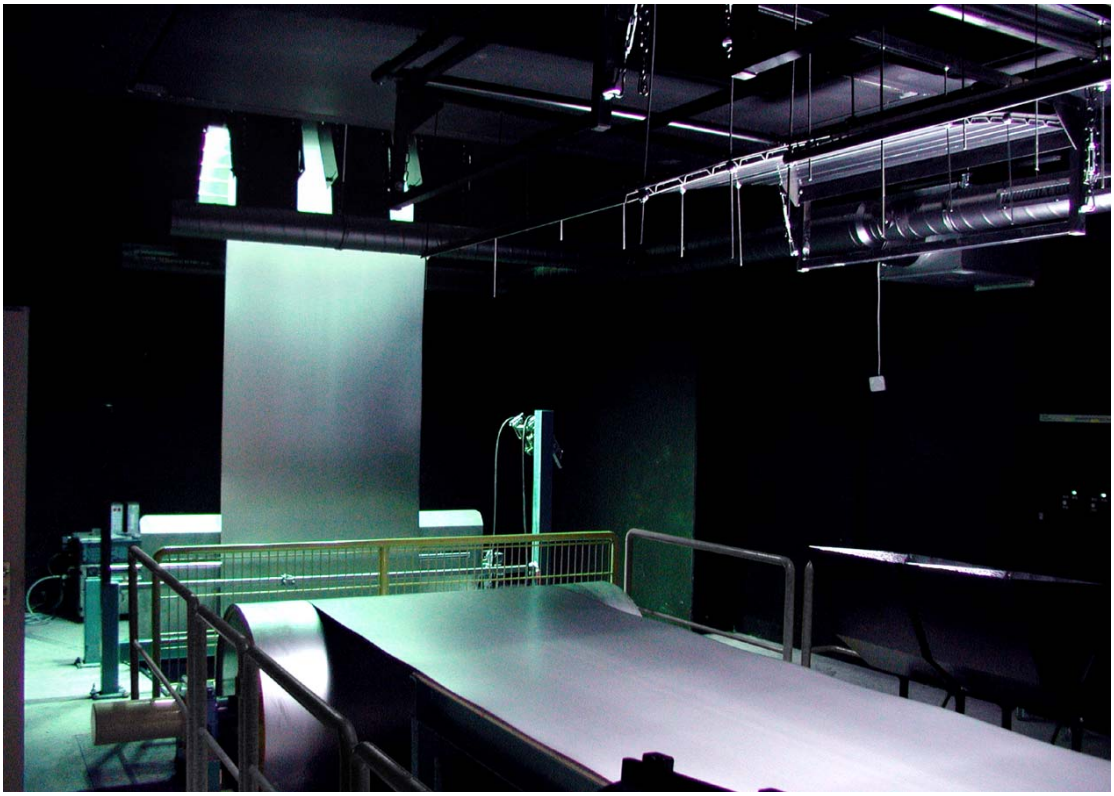
Source ThyssenKrupp Steel Europe GmbH
Figure 14. Nozzle streak standard illumination.

As mentioned before the color of the metal halide lamp is near to daylight with a slight tendency to green. This is the reason for the greenish impression of the picture.

5 CONCLUSION

Visual surface inspection is done in inspection cabins of processing lines complimentary to camera based automatic surface inspection which is installed some 100 m upstream. Automatic detection is done at line speed. All defects found by SIS are displayed on the monitor in inspection room. Now inspector can decide which defects he has to evaluate to deliver only best quality to his customer. To decide

about the further processing of the coil the inspector needs the best lighting available.
Visual surface inspection is an important element in all production processes where surface quality is of vital interest. Not light intensity is important but directed and glare free illumination for easy defect detection. Lighting system has to be designed and optimized for the properties of the human eye and the different material qualities.



Source VH Lichttechnische Spezialgeräte GmbH

Figure 15. Installation in a Continuous Galvanizing Line.