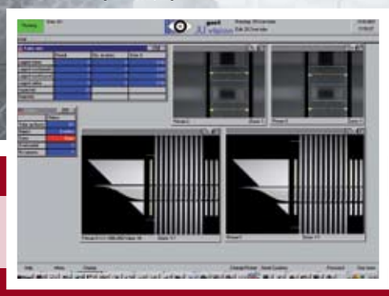
Tech Talk

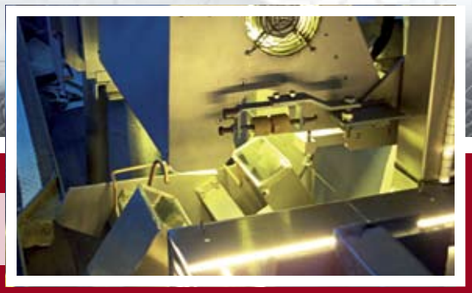
TECH TALK 2

Quality and inspection techniques for solar glass

Dynamic light box with striped pattern.



Glass tube inspection, operators screen.



Glass tube inspection, cameras and illumination.

Jørgen Læssøe discusses how glass inspection techniques are key for companies developing solar-based products.

Glass is a major component in solar energy systems. Many different glass products are used and they all have different quality issues.

Glass production is concentrated on large production facilities where efficiency and high throughput is the main feature. When producing in high volume and speed, it is not possible to rely on inspection by operators.

As such, there is no doubt that automatic inspection is the answer to achieving the required high quality.

Vision systems

Vision systems entered the industry in the 1980s and since then the technology has been under constant development. Automatic inspection is used in critical application such as pharmaceutical and medical device screening. The advances from these demanding fields are now getting into inspection applications where it is not a matter of life or death for a patient, but efficiency and survival for a factory or product line.

Mass production of glass is the only way to achieve a good quality and a profitable operation. Having a large throughput makes it possible to refine the process and understand and stabilize all the important production parameters.

A vision system shall detect the defects, classify them and measure the sizes. In production flows where sorting is possible, the vision system must generate a reject signal and discard the faulty product.

A key feature attained from automatic inspection is the statistical information. This can be used to monitor different batches of raw material, and production machinery settings. Automatic inspection is a key technology in achieving this goal.

As new glass components are developed new inspection challenges arise. This article deals with the different ways of assuring a constant and reliable quality by using vision systems.

Vision systems can tell the operators how the production is performing over time. Trend graphs can highlight defect count, dimensional drift and transparency measurements.

Flat glass inspection

Inspecting flat glass often requires light patterns. It is in the boundary between light and shadow certain defects become visible.

By taking several images as the material is transported past the camera, the vision system can measure the movement of the defect and thereby determine how deep into the product the defect is located in the glass. The closer the defect is to the camera the faster it will move through the picture field.

Formed glass

If the glass product is shaped a dynamic light box is often an integrated part of the vision system. The dynamic light box is a powerful LCD screen where the vision system can display computer generated images of lines, grids, circles or just a plain white background.

A pattern is displayed and the camera takes one exposure. The vision system analyses the image. Then the next pattern is displayed and a new image captured. This is analysed with a different algorithm to find just the kind of defects becoming visible with that special pattern. The sequence runs very fast. 30 displays and image analysis a second is possible.

By using the LCD screen colours, deviations in a coloured product can be highlighted and measured by the vision system.

Glass tube inspection

Glass tubes used for solar heating are made by a drawing process. Two main technologies are used. The Danner machine draws the glass horizontally from a mandrel. The Vello process is a vertical process where the glass is poured through an orifice.

The inspection challenges are the same for both processes. To cover the entire tube three or four cameras are used. Illumination is by high power sodium light. The images from the line scan cameras are joined and aligned in the vision computer and then the images are screened to find stone, knots, cord and airlines.

Stones are refractory material or foreign objects in the glass. These are visible and introduce stress. Knots are lumps of glass that have not been dissolved properly. Cord is a local deviation in wall thickness stretching over a long distance. Airlines are blisters that have been drawn into long thin lines.

Inspection on glass tubing used for backlighting of LCD screens demands defects detection down to 0.04 mm for stone and knot, airlines are down to 2 μm in diameter and down to 1 mm lengths. Production lines making glass tubes for backlighting runs at speeds up to 20 meters a second, so high speed cameras are used and the demand for computer processing is very high.

Glass tubes for solar heaters runs at a much slower speed, but the diameters are significantly higher making the inspected area larger.

Stress detection

Stress in glass can be revealed by using polarisers. The backlighting is filtered in the horizontal direction and in front of the lens a vertical polarised filter is placed. No light can pass through to the camera chip with the polarisers at 90 deg. to each other. Light shining through glass without stress does not turn the polarisation. If there are enclosed stones or knots, fragments of Pyrex, or other foreign transparent and none transparent defects, stress is introduced and the polarized light is turned a few degrees. The camera will then pick up these defects as stars or clouds. The sensitivity can be very high. Placing a drinking glass between the polarisers and pressing lightly with fingers is sufficient to generate detectable stress patterns.

Practical considerations.

To make a reliable vision system many design options must be selected carefully. Depending on the application, the engineer must chose between matrix cameras or line scan cameras. Matrix cameras make exposures, normally up to 100 frames a second, and contain 5 Megapixels.

Line scan cameras can have 4.000 pixels in a line and can transfer up to 60.000 lines a second. The image is generated by the movement of the product and requires a fairly steady transport speed. An exposure time of 1/60.000 second is very short and demands a lot of light.

The light source must be powerful and have a long service life. For glass tube inspection, which is done by line scan cameras, the light source should be shaped as a long narrow filament. Ordinary sodium street lighting is excellent for this purpose. The first glass tube inspection systems using sodium light were delivered in 2001, and it still has the original light bulbs installed, no replacement has been necessary.

Image analysis demands a lot of processing power. The largest systems for glass tube end inspection contained 7 Pentium computers capable of analysing totally 900 Megapixels a second.

Most systems today use a quad core processor providing parallel processing at a speed of up to 500 Mega pixels a second.

The vision system should not only analyse images and detect faults. It must also generate reject signals with a precision down to one millisecond. This requires special input and output modules with real time firmware timing.

The vision system can provide any kind of statistics. Data can be transferred over the network and stored for further processing. Standard spreadsheets can then be used to make in depth analysis on the production and quality.

Storing data is often required to document the production. Should complaints be received the data can be used to analyse the problem.

Remote control

The networking capabilities can also be made available to the system supplier. This enables the engineers developing the system to monitor the performance of the equipment and to see how the operators use the equipment. The system supplier can help the user getting familiar with the functions and settings and also modify programmes to make the system more user friendly.

Remote access is essential for quick service. The system monitors many internal parameters like temperatures, error messages from the software, fan and hard disk readings. When parameters get out of limits the system can send an email to the equipment supplier so preventive maintenance can be initiated before a breakdown occurs. Its effectiveness has been proved by servicing hundreds of installations in Asia from our offices in Copenhagen.

*Jørgen Læssøe is President of JLI Vision a/s
www.jli.dk