The rebirth of video inspection in strip processing

Combining the latest strobe lighting with continuous video systems provides clear images of defects 1–2mm in size on strip moving at up to 1,350m/min. This can provide improved efficiency to the strip inspection process, giving better and more consistent product quality, increased throughput at increased speeds, energy savings and cost reductions.

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With more than 120 variations of recognisable surface anomalies in the metals industry, each with varying degrees of severity, it is important that each anomaly be spotted at any point in the rolling process as soon as it occurs. The earlier that defects such as bruises, bulges, roll marks, scale, edge cracks, slivers, friction digs, stains, stickers, grind marks, laminations, scratches, pinchers, chatter and shape problems are detected, the faster steps can be taken to determine and eliminate the cause. This will enable a mill to stop further valued added processing, divert unacceptable material to less stringent orders and reschedule the rolling order to meet delivery schedules.

To facilitate more rapid defect detection, advances in industrial machine vision and PC technology are finding their way into a new generation of video inspection systems for steel mills. New image capture hardware, including digital video cameras and digital storage systems, combined with more powerful drivers and software, have created systems capable of recording more detailed images with fewer cameras, and providing more detailed playback. The new equipment continues to rely on strobe light systems whose capabilities keep pace with today's technological advances. The marriage of proven stroboscopic visual inspection to state-of-the-art mega-pixel image acquisition and viewing hardware now enables mill personnel to make even greater use of their experience to find defects as small as 1mm from a distance of 2–2.5m. Moreover, such systems can be installed for as little as US$100,000 and can be fully operable as soon as they are installed.

The spread of technology, which increasingly blurs the line between industrial and consumer markets, has created a clearer picture for steel mill managers. They now have access to remote video inspection systems, enabling them to view more of their production lines in more locations without additional manpower. While remote video capability is nothing new in the world of surface inspection, improved camera technology provides much better resolution and a wider field of view than previous generations of cameras. In addition, the open architecture of a PC-driven image acquisition system allows for viewing and/or post processing software to be installed on the Windows-based computers now commonly found in many steel mill production environments.

The new image capture and editing technologies continue to rely on industrial strobe lights, such as the Unilux Centurion or the HD851 found in steel mills worldwide for surface quality inspection. By combining proven industrial strobe lights with the latest electronics, inspectors can see smaller defects more readily, and engineers can study clearer images to correct problems faster and make necessary changes to their production specifications.

A basic two-camera system will meet the needs of a vast majority of hot and finishing mill applications worldwide as well as coating processing lines. Each camera, an 8-bit black-and-white unit with a video resolution of 1,392 x 1,040 pixels, can see a 1mm defect on a 1,600mm-wide strip moving at full production speeds of 1,350m/min. Each camera has its own display, a fast pixel response, 20in flat-panel screen with 1,600 x 2,000 native resolution and 500:1 contrast ratio, which can help inspectors spot even the slightest defects. This could be the difference in determining whether or not strip meets grade specifications.

STRATEGIC LOCATIONS

Light and camera arrays can be placed strategically in mills to meet a number of critical needs. With their ability to provide images from locations that are inaccessible or dangerous for mill personnel, remote video systems enable inspectors to monitor one or more places along the line that they had not been able to see because of inaccessibility or because there has not been enough manpower to staff an inspection site. Remote video lets an inspector monitor several inspection systems from a control room or a pulpit. Conversely, mills can place several monitors throughout the facility to display acquired images wherever personnel need to view them.

Giving inspectors access to more inspection points maximises the benefits of instant knowledge of defects ▷

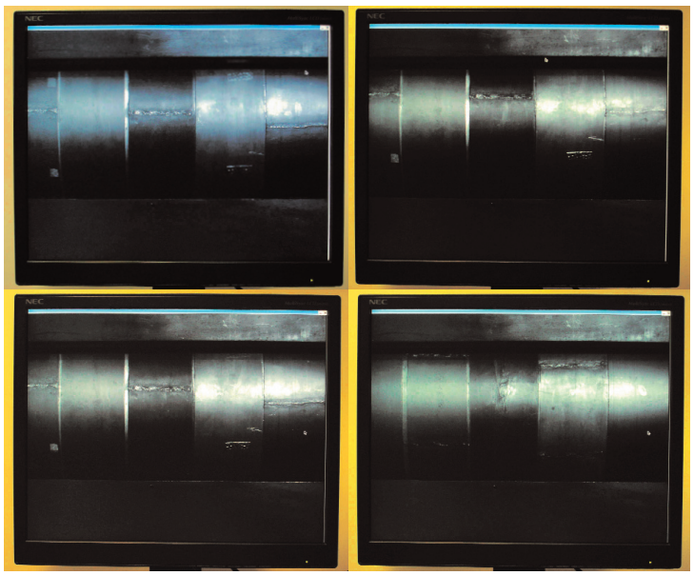

Fig.1 Sequence of frames from video monitor

gained by visual inspection. Typically located before the recoiler or at critical inspection points along the process, operators at control consoles can now see the strip without leaving their workstations. This is essential on coating lines, where any one of hundreds of rolls on multiple platform levels could be the source of a problem. Tactically locating inspection cameras in cooling towers or after accumulators quickly provides the location of problems in the process.

On galvanising lines, where towers can hold 1–3km of steel, operators can use the images to narrow down the location of a defect's cause and use a portable stroboscopic inspection light, such as a Unilux Miti-Lite, to view the strip at strategic points of the processing line to resolve problems quickly before 15–20 coils with anomalies start to accumulate.

In remote video inspection operation, positioning the cameras to cover the maximum width of 1.6m, each frame will capture an image an area of approximately 1,000 x 750cm. This set-up will have some overlapping of each camera's field of vision to ensure complete coverage of the strip. If the video system captures images at 30 frames/sec, the strip can travel at 22.5m/sec (1,350m/min), and the system will provide 100% coverage.

THE BASICS OF VIDEO FOR INSPECTION

The best video inspection results are achieved when the image capture equipment is placed in an array consisting of stroboscopic surface inspection lighting, such as the Unilux Centurion or HD851, and high-resolution video cameras. By matching the strobe light's intensity and illumination pattern to the product and line speed, the system can provide clear, sharp images of a strip moving at up to 1,350m/min. The equipment array is then connected to the Unilux Video Inspection Controller unit and then to the ultra high resolution LCD monitor. The monitor and controller can be located in a control room overlooking the mill floor, a pulpit anywhere on the floor or even a remote location in the mill. In practical terms, the feasibility of any location within the mill depends on the DVI splitter and fibre optic connections. Higher quality image transmission technology permits a system to send clearer images over a longer distance in a shorter time period.

In operation, as the strip passes the array of image capture equipment, the pulse of the strobe lights 'freezes' the motion of the strip, and the video camera sends a crisp, clear 'snapshot' image to the monitor. In actuality, the images will appear as a continuous stream of snapshots, providing a comprehensive, real-time view of the strip at the inspection point. This will essentially give mill personnel the same view of a strip that they have been accustomed to seeing with stroboscopic inspection.

Looking at the image, an operator can spot defects as small as 1–2mm. *Figure 1* shows a sequence of frames from a video monitor. Based on the type of defect and the operator's knowledge of the product and mill, the image can tell him if the defect is significant enough to downgrade or scrap the coil or if it will still meet the customer's specification. If the defect is severe enough, the operator can halt production until the source of the defect is found and corrected and redirect the coil for another use if possible. If desired, the operator can capture and save portions of the strip. Pre-alarm recording allows for up to 30 seconds of imaging data to be permanently saved to disk in addition to the images being saved while the 'save' button is engaged.

The main defects such as repetitive roll marks, scratches, edge cracks, rust and holes on hot and cold rolled material account for 75% of rejected product. These are easily detected by an image capture system with stroboscopic lighting. In finishing process mills, the coating flaws such as laminations, high dross, voids and scratches are also very visible on the monitors for the operators to see.

PLUG AND PLAY

The system is ready for use as soon as everything is connected and integrated. There is no software to train for finding and categorising defects, nor is there a library to build. Mills can best utilise the video system by making better use of each inspector's knowledge of the process and the product being run. Better cameras and the possibility of economically placing cameras in a greater variety of strategic locations all contribute to improved product inspection.

Unlike automatic inspection systems that show only pictures of the limited number of defect types programmed into the system, the remote video inspection system lets operators and inspectors see any defect that may occur. For mills with automated systems, a remote video system enables them to confirm the automatic system is working and not missing problems that will cause customer rejection later after product is delivered. Should a new anomaly occur in the process, a remote video system will enable mill engineers to take provisions to program the defect into the automatic system's library. The simplicity of integrating the latest image capture systems and strobe lights with a variety of computer systems makes video inspection systems operable in a matter of hours.

Once the strobe lights and cameras are installed and the video inputs are connected, the remote video inspection system's simple menu-driven software can be programmed in a matter of hours for video capture, storage and replay. Depending on the speed of the line and view of the camera, the system will intelligently capture only the images required to provide 100% coverage of the strip. Although the operator will view the strip in streaming video, only enough frames required to see 100% of the strip will be saved for review. Pre-programming for this type of inspection and review greatly reduces both set-up time and storage capacity. Recipes can be established ahead of time and tweaked at the time of commissioning, helping a mill get the system operational even faster. Any number of recipes can be saved and recalled for use as dictated by mill or customer needs

To operate the system, an operator uses a controller unit that contains a series of fixed-function pushbuttons and a multifunction menu-driven display. Typically supplied by the strobe light manufacturer, the controller can be combined with a pair of monitors to form an inspection station for top and bottom side views of the strip. Two separate controllers can be accommodated, effectively creating two independent inspection stations at a single location The digital control communication network and a fibre optic digital video transmission system allow for distances of 1km or more between the CEB – the central electronics box in which all the connections, computers and recorders reside – and each controller/monitor inspection station, providing sufficient range for most mills.

The mill provides an inspect signal interface, normally connected to a contact closure. This indicates the presence of steel that needs to be inspected, and it can turn on the video inspection system only for the time inspection is required. The mill can also provide strip identification data to the controller. When the operator saves a portion of the imaging, the mill-supplied strip-identification data and the date and time stamp all become part of the quality record.

The connections from the controller PC to the remotely located imaging array are made through a junction box that contains various interface modules, remote diagnostic modules, cooling equipment and power supplies. The junction box also provides the control signals for the stroboscopic lighting system used to illuminate the strip for the cameras (see *Figure 2*).

In operation, the stroboscopic flash is synchronised to the camera video signal picture rate and internal electronic shutter interval. This ensures that each new image of the strip is acquired only during the short time that the strip is illuminated. The electronic shutter helps eliminate the blur of ambient light falling on the moving strip by maximising the ratio of stroboscopic light to ambient light.

A captured image size of 80cm x 1m will enable an operator/inspector to view and detect surface defects as small as 1–2mm. This is calculated by dividing the picture size dimensions by the overall system video resolution of 1,040 pixels by 1,392 pixels.

The latest generation of high-speed, high-resolution machine vision cameras is capable of resolving defects as small as 1–2mm from a distance of 2–2.5m. In addition, two cameras now have the resolution to cover 2m-wide strips instead of the four cameras, as were previously required. The wider field of vision eliminates the need to zoom in or pan out when using fewer cameras, and it allows inspectors to see a specific area of the strip faster because less manipulation is required.

VIEWING AND STORAGE

Mill operators can choose from three viewing modes for inspection, selected from the Video Inspection Controller unit:

- Live Mode displays each video picture generated at the standard video rate of 30 frames per second
- Stop Mode provides a still image at the video monitor for close examination of the strip surface image
- Go Mode provides a stream of still images that are displayed at a rate selected by the operator. The rate can range from one picture every four seconds to 30 pictures or frames per second

The viewing mode applies only to the pictures displayed on the selected monitor. In addition to monitoring the strip from a control room or pulpit, images from the array can be sent to another monitor in another location, such as an engineering office

Short-term storage is handled through a high capacity RAID storage sub-system It can store up to an hour's worth of high-resolution images, depending upon the type of video compression used (Lossless or lossey) and speed of ▷

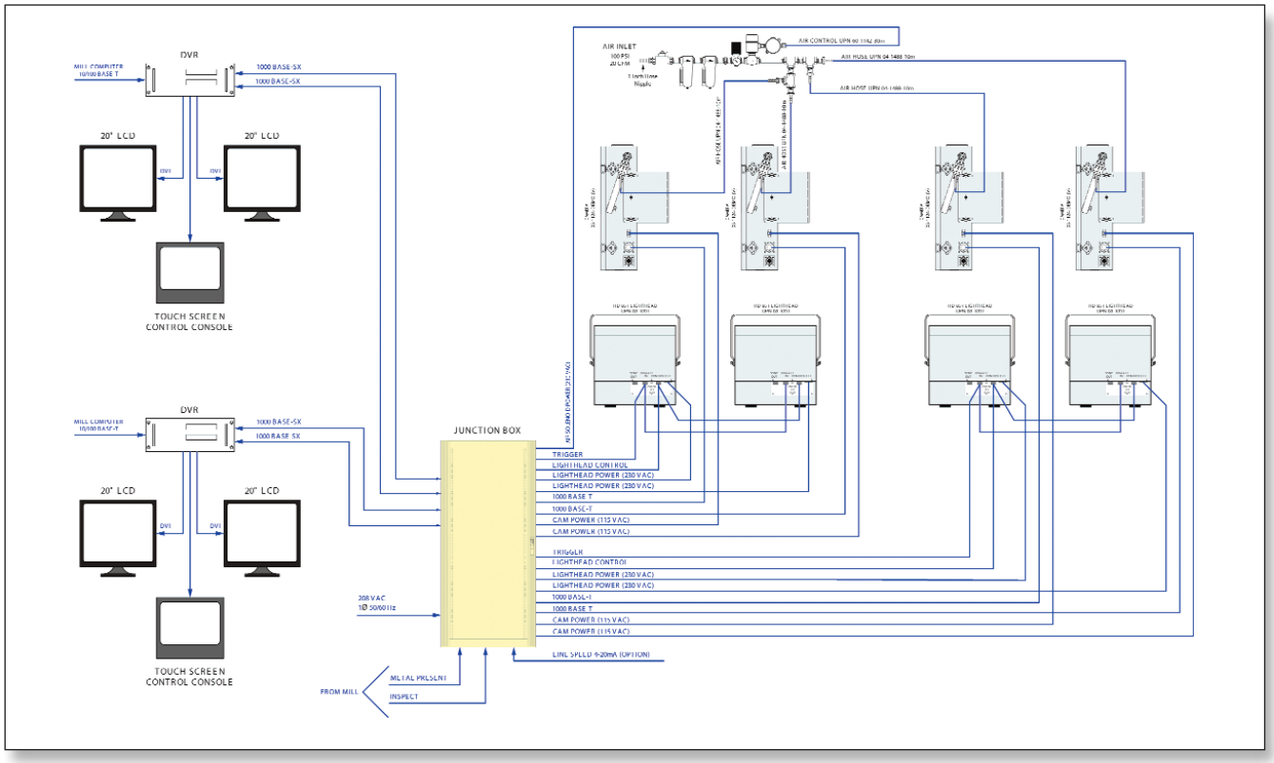

Fig.2 Digital control communication network

the strip. This is typically sufficient to determine the cause of a specific defect and to correct it. Playback from the drive includes a search mode for forward/reverse and fast/slow control to enhance the viewing image. By using the unit's auto record mode, the recording of each individual strip/coil can be indexed to the inspect signal provided by the mill or host computer. This enables instant access to complete coils for a quick review of surface quality.

A high-resolution printer can generate hard copies of images, enabling a mill to preserve the details of a specific defect and to compile a defect library that can be used for future reference or inspection training. The captured image files can be stored on commercially available medium for playback to study a specific problem recorded by the system.

SUMMARY

Stroboscopic inspection systems for continuous processes can provide improved efficiency to the inspection process, better and more consistent product quality, increased throughput at increased speeds, energy savings in the production process and an overall improvement in bottom line cost. Combining the latest strobe lighting with the video system enables a mill to have 'more eyes' in more places, where personnel can control product quality much more effectively.

For single-side inspection, newer remote video inspection systems can be installed for as little as US$100,000. Double-side inspection systems can be installed for US$175,000 or less. In addition to being cheaper than other defect detection and classification systems, a system based solely on strobe lights and image capture hardware and software can help a mill recover its investment in a much shorter time – weeks to months instead of years. That is because the system can be put into operation immediately, and it can be fine-tuned almost instantaneously as a mill's inspection needs change. It becomes an ideal tool for mills with limited capital budgets that want to compete in the global marketplace.

A properly specified and installed video inspection system will give workers the tool they need to do a better job by providing clear, consistent visual information on what is going on in the production process. This will help a mill focus on steel quality, where the ability to greatly reduce customer rejections and scrap both save money and build customer confidence. MS

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