RT and the digital trend

Following an evening presentation at SAIW by Eli Dayan, NDT division manager for digital radiography developer, Vidisco, *African Fusion* talks to Hugo Vaughan, SAIW's radiographic testing (RT) lecturer and interpretation specialist and takes a tour of the Institute's newly acquired digital RT system.

Film-based radiography uses X-rays generated by an X-ray machine, or gamma rays from a decaying radioisotope, which are both high-energy electromagnetic streams that can penetrate most solid materials. These radioactive rays are sometimes called ionising rays because they have the energy to 'knock electrons' off metal atoms to form positively charged ions.

"During radiographic testing, the radiation travels through the test piece and onto the film, where it ionises the metallic grains on a sheet of film, in the same way as visible light would ionise photographic film," explains Vaughan. "The film then has to go through chemical processes that change the ionised grains into metallic black silver, and it strips off the non-ionised bromide grains that are not exposed. So you end up with a permanent greyscale image, where dark patches represent areas where radiation has passed straight through the test piece and light patches show where radiation and been absorbed or reflected away from the film for some reason," he adds.

Gamma rays from isotopes such as cobalt 60 or iridium 192 have the same net effect as X-rays, but when using decaying isotopes as the radiation source, "one has no control over the radioactivity". "With a half life of about 74 days, the radioactive energy of a piece of iridium halves in a little over two months. This means that exposure times have to be doubled to get the same result," Vaughan explains. "But with X-ray tubes, the radioactive energy required can be regulated by changing the electricity supply to the excitation circuits. The quality of X-ray radiographs is, therefore, often better because the source is more controllable," he tells *African Fusion.*

The use of isotopes becomes more convenient, however, when RT has to be done *in-situ*. "For site work, portability becomes the issue and isotopes can easily be transported to site using a sealed box that can be carried from test to test. X-ray tubes, on the other hand, are usually much bulkier and require a three-phase power connection.

Computed radiography (CR) at SAIW

In principle, the use of digital radiography is no different from traditional film, apart from the processing of the end image. "Instead of using a radiographic film, digital radiography uses either a digital detector array (DDA) or a phosphor-coated digital imaging plate to capture the image," Vaughan continues, "and no chemical processes are required to 'develop' digital images". "Digital radiography is much more sensitive to radiation than film, so much less intense radiation is needed, which generally means that the test piece need be exposed for far less time," Vaughan suggests, adding that "shorter exposure times translate directly into improved safety".

Also, digital systems remove the need to go into a darkroom to develop the film.

In the SAIW radiography laboratory, Vaughan demonstrates the phosphor image plate, a flexible, reusable mat-like plate that can be wrapped around a pipe during a test. This digital process is known as computed radiography (CR). The plate is stored in a cassette until it is needed. During the test, the plate is removed and exposed to radiation in exactly the same way as film would be. But instead of ionising metallic particles, the radiation dose raises the energy levels of electrons trapped inside the phosphor layer of the plate, creating a latent image.

The image plate is then passed through a red laser scanner that causes the trapped electrons to relax back to their original energy levels, causing light to be emitted. This light is then converted into the digital image. "As the scanner pulls the plate through, a red laser releases the latent image while, immediately behind, white light erases the plate ready for reuse," Vaughan explains. "The image plate can be used 1 000 times and while it is sensitive to bright light, it is not like film that will be ruined if exposed," he adds.

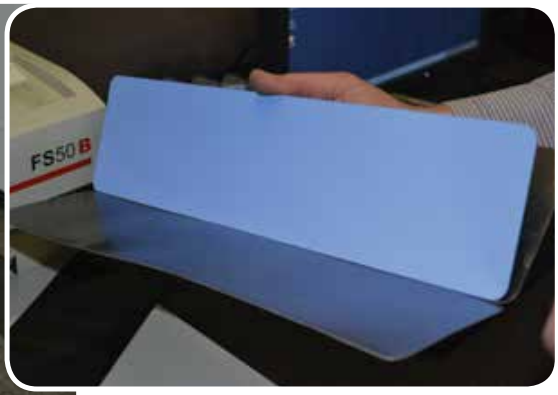
On the computer, Vaughan demonstrates how a digital radiographic image can be manipulated. He flips an image so that the test details can be read. "This is a plate butt weld with lack of full groove penetration and a little undercut," he points out. As soon as the radiograph has been downloaded, it can be marked up, annotated, printed or emailed to a client or colleague for a second opinion. From X-ray to printout, an RT test can be completed within 10 to 15 minutes using this system," he suggests.

"The sensitivity is also excellent," Vaughan continues, "This ASTM 1B 11 code refers to a penetrameter image, which indicates the resolution of a radiographic image. It is a very expensive transparent sticker with rows of accurately spaced platinum wires. If you can see the tiny wires and the gap between them on the image, then you will also be able to see a flaw of that similar size," he explains, adding that the resolution from a digital system is "generally better than film".

Vaughan reveals that many bigger companies in South Africa have already started using digital systems and momentum is picking up. "Like digital photography, digital radiography is more in line with the skills of the younger generation, who have been brought up in with computers, tablets and digital images. This is the future," he says, adding that SAIW is currently gearing up to offer digital radiography courses, which should start early next year.

Direct radiography (DR) from Vidisco

Vidisco's Eli Dayan presented on the topic 'High quality imaging with DDAs'



Left: The Institute's CR scanner used to transform the latent image captured in the imaging plate into a digital radiographic image. Above: A phosphor-coated digital imaging plate used for CR digital radiography.

at an SAIW evening meeting in June. The company has its roots in CCD-based imaging for the security industry, but is now a dedicated OEM for digital radiography systems.

"We have adopted amorphous silicon DDA technology, which is the standard now used in the medical world," says Dayan. "DR is the same as film-based radiography in that the penetration geometry and all of the physics remain unchanged," he begins, pointing to a slide of an X-ray source, an item being inspected and "instead of film being exposed, we have a DDA panel, which collects photons and converts them into a digital image that is immediately sent to a laptop or computer".

A particular specialism of Vidisco is portable systems that can use pulsed X-ray sources. "These are very safe. They have a high kV, but a very low mA and produce a very low dose. You can stand within 5,0 m of these sources and you will barely get a reading on a survey meter," Dayan reveals. This pulsed X-ray source "can also replace the use of isotopes in many applications, not entirely, but it makes the use of safe X-ray machine feasible at many offsite locations".

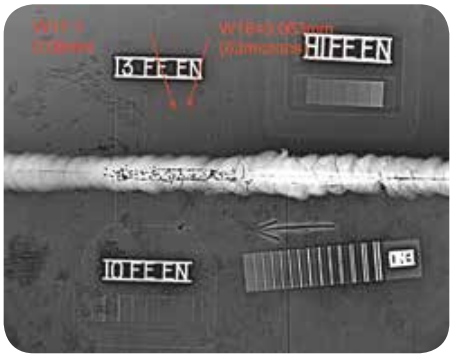
Each of the panel pixels (sensors) in a DDA translates the radiation it received into one image pixel on the computer. "Typically, the pixel size varies between 75 µm and 144 µm, but pixel size is not the most important measure of the quality and sensitivity of a DR panel," adds Dayan. A high SNR or signal to noise ratio is more important as it is the main factor which determines the sensitivity or detectability of small defects. Basic spatial resolution (BSR), which is the effective pixel size, will always be higher than the theoretical pixel size. For example, if the actual pixel size is 50 µm, it does not mean that a 50 µm defect can be seen. Generally, the two most important parameters affecting the quality of an image from a DDA panel are the SNR and the BSR.

Also enhancing the analytical possibilities of digital radiography is the dynamic range or the bit depth. "Dynamic range is about the number of shades of grey. Film or a computer screen can usually differentiate between 256 shades of grey, but using a 14 bit digital system, we are producing images with 16 383 grey levels – or 65 535 if using a 16 bit system. One cannot see or present this amount of information all at once so we use software tools to allow human eyes, which themselves are limited to about 100 shades of grey, to see all of the information", Dayan explains.

Using as a software tool called window levelling to focus on a feature on the image, "instead of looking at the entire thickness range, it is possible to scroll through different thicknesses and enhance them". "This allows a high latitude image to be transformed into a high contrast image from a single radiograph, something that cannot be done with film. At the end of the day a high dynamic range DR system will show different thicknesses of the same material or different materials, all from one image," he says

The biggest advantages of digital systems relates to time. "A good radiographic inspector can set up, take a shot and process a traditional image in about 25 to 30 minutes. With DR, the majority of the time will be spent on the system set-up, which might take a fairly skilled operator with some experience about five minutes. The exposure time is also substantially reduced, to typically between half a second and five seconds. The total time to get a radiographic image from a digital system is therefore close to the five minute set-up time," Dayan estimates.

Hugo Vaughan, SAIW's radiographic testing (RT) lecturer and interpretation specialist, demonstrates the Institute's new CR digital radiography system.



A digital radiograph of a butt weld on an 8,0 mm steel plate taken using Vidisco's DDA-based radiography (DR) system. A 1,0 sec exposure using an X-ray tube set at 150 kV and 4,0 mA was applied, representing a much lower radiation dose than film-based radiography would have required.

And there is also no longer a need for a darkroom and processing chemicals, while the lower dose significantly reduces the size of isolation zones and the need to evacuate people from the vicinity.

Vidisco's DR systems are locally available through Techtra Engineering.