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An introduction to X-ray inspection for Engineers

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There are many different destructive and non-destructive methods that can be used to monitor and assess the quality of components, assemblies and finished products during the manufacturing process. However, only x-ray inspection allows engineers the ability to penetrate a wide range of visually opaque materials such as metals, plastics, ceramics or carbon fibre to reveal accurately any imperfections or defects that may be present.

Whilst it has long been used in the electronics industry for the inspection of components and assemblies, x-ray imaging has also been extensively used in other engineering applications including aerospace, automotive, pharmaceutical and military industries. There are however still many sectors where the potential of x-ray inspection remains to be fully exploited.

Non-destructive testing methods, and x-ray inspection in particular, offer numerous advantages over alternative testing techniques. One of x-ray inspection's biggest advantages is that it avoids any interference with the object being inspected. Destructive methods can involve the section and dismantling of objects and assemblies and can therefore disturb crucial evidence such as faults or defects. X-ray inspection on the other hand provides a clear picture of the situation, without any physical disturbance.

Under destructive testing methods, routine checks taken to ensure product quality can do more harm than good. For example, in the castings industry the dissection of a sample to check that hidden elements are free from unwanted voids or inclusions will destroy the casting. Regardless of whether a fault is found in an individual sample, there will still be uncertainty as to whether others in the same batch have faults or not. This hit and miss approach can make testing prohibitively costly in terms of both time and money.

A further limitation lies in the extent to which sectioning an object in a given plane will necessarily reveal faults. To take the example of an automotive cylinder head, unevenly distributed micro porosity in parts of the casting may be very hard to detect, even if you have a good idea of where to look for any problem areas.

As a non-destructive testing technique, x-ray inspection can, if necessary, allow 100% inspection of production. A variety of x-ray inspection systems are available to meet differing needs, whether it be for detailed inspection at a microscopic level or to penetrate heavy gauge metal.

Real time

One of the greatest benefits of modern x-ray inspection systems is real-time operation. When struck by an x-ray, a scintillator converts the signal to light which is then detected by a CCD camera or digital panel detection system. Imaging software can then be used to display an image on a standard computer screen for visual interpretation. Advanced software packages can be used to analyse, interpret, manipulate and store images electronically. Those seeking to maintain a permanent record of x-ray images can use highly cost effective CD or DVD media for image storage.

Traditionally, x-ray inspection equipment has used film-based technology. Indeed the man in the street's expectation of an x-ray image might typically be of a doctor holding up a sheet of film to a light box, looking for a broken limb or a foreign body.

The cumbersome and time-consuming nature of film techniques held back the development of x-ray imaging – a potential which is now being realised by real-time techniques. Electronic real-time imaging systems offer resolutions every bit as good as fine-grain x-ray film without the need for the same radiography skills, a processing laboratory and all the chemicals required for film development. In many production environments the instant imaging facility of real-time can save valuable time and money over the inevitable delays and expense of film processing. Images are displayed on screen as positive images, making it much easier to use intuitive skills to interpret images. X-ray film is in negative format – with the image reversed, which inexperienced users find difficult to interpret accurately. However, for those accustomed to looking at negative film, digital images can easily be inverted on screen as negatives if required.

These systems are not only ideal for identifying faults quickly during the initial manufacturing process but can be crucial when used for investigating a defect in a finished product which may have already been sold and returned by a customer. Potential issues can be solved in the fraction of time that they would have taken using film-based systems and substantially minimise any inconvenience to customers.

In a production environment systems can even be designed with Automatic Defect Recognition (ADR) to look for, recognise and create alerts for specifically known or suspected critical faults. This is a potentially huge labour-saving quality application.

Mini and Microfocus

More than any other factor, resolution determines what can be discerned from an x-ray image. Image resolution depends on two key factors: resolution of the image detector and the focus size of the x-ray source. For viewing very small test objects, such as in electronics, magnification must exceed 100 times and can go a high as 2,000 times. Even at such high magnifications the latest 1000 x 1000 pixel detectors can easily resolve the resulting x-ray images, so image resolution depends almost entirely on focal spot size of the x-ray source.

For electronics applications, the best micro focus systems (with a spot size of less than 5 microns) offer magnifications of in excess of 2,000 times. For larger components, where microscopic detail is not required, mini focus systems (with focal spots of between 100 and 500 microns) are better suited.

Computed Tomography (CT)

A further advance in x-ray inspection has come from computed tomography (CT).

Standard digital or real-time radiography can satisfy most needs as a quick method of inspecting components, locating and measuring defects and expressing three-dimensional structures in two dimensions. Above and beyond this, computed tomography allows engineers to assess volumetric data and build up a 3D picture of the internal and external structure of an object under inspection.

Tomography comes from the Greek word “tomos” meaning a slice. A picture is put together by aggregating the data of multiple fine x-ray “slices” taken through a solid object. A computer is then able to generate a range of different images in either 2D or 3D. Slice images and rendered views can be exported to standard format image files, and animation fly-bys can be created.

Transparent 3D images can be used to show, cracks, inclusions and voids or porosity within a casting, for example. And as all the data is stored in electronic formats, it is possible to manipulate images at any time after the initial x-ray inspection has been completed. This means old images can easily be revisited and re-rendered to show aspects that may not have been under consideration in the first instance.

Although computed tomography is already widely used in the medical field and allows doctors to put together advanced three-dimensional images of the human body, it is now being increasingly adopted for NDT inspection in commercial applications, in research and development and for production testing.

Applications and trends

X-ray inspection is a commonly used approach for process verification and control across nearly all industrial sectors and is now seen as a "must have" tool at the disposal of any proficient electronics/electrical/process/production engineer. Checking for short circuits, missing solder balls, misalignment, voiding within solder joints, inclusions, and non-wetting or open connections are the principal applications.

X-ray inspection can also be used for the inspection of virtually any visually opaque material including metals, plastics, ceramics and composites such as carbon fibre. The technology is widely used for the inspection of precision castings such as turbine blades for the aerospace and power generation industries, and for automotive castings such as engine blocks, suspension links and safety-critical components.

The use of x-ray inspection technology is set to grow further as new, more advanced systems come onto the market which are simpler and even easier for untrained personnel to operate. There is also a trend towards the production lower cost systems, which is enabling organisations for whom the technology was previously unaffordable to take full advantage of its potential.

About X-Tek Systems Ltd

X-Tek Systems is the premier manufacturer of real-time microfocus x-ray inspection equipment and high-resolution vacuum de-mountable x-ray sources. Its range of high quality microfocus x-ray systems offers high resolution, high-power, low maintenance and low cost of ownership. The X-Tek product range includes low cost bench-top systems, suitable for lightweight components, up to larger units with more complex functions, useful for inspecting electronic assemblies or engineering components in great detail.
X-Tek maintains a world-wide agent network and has a rapidly expanding international user base with installations throughout Asia, the USA and Western Europe. Major multinational companies using X-Tek equipment include AMD, Ericsson, Ti, IBM, Motorola and ASAT.

X-Tek real-time microfocus x-ray inspection equipment is used in a wide range of applications including: Electronics; Semiconductor Packaging; Non Destructive Testing, Pharmaceutical, Medical Research; Automotive; Aerospace; Nuclear; Construction, Ceramics, Composites, Food, Defence and Security.

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