Flash-Radiography Instead of Traditional Radiography with Intermediate Carriers of Information

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Abstract
The E.O. Paton Electric Welding Institute of the NAS of Ukraine together with other organizations of Ukraine develops portable X-ray television equipment capable to perform digital processing of testing results. Radioscopic (on notebook screen) as well as radiographic images in hard copy or other forms can be made using it. Today, flash-memory compatible with any computer became popular carrier of information. The main advantages of such equipment lie in the following: - high efficiency and mobility; - high resolving capacity and stability of image; - digital image processing; - plotting of diagrams of distribution of image density; - possibility of image archiving; - performance of radioscopy and radiography functions; - small dimensions; - capability of testing of moving objects. Prospects are described for development of the radiation testing based on portable X-ray television systems, consisting of fine X-ray apparatus, electron-optical transformer, notebook with digital processing of X-ray and optical images. New technological capabilities of non-destructive testing based on the flash-radiography are shown.

Keywords: Radiographic Testing (RT), digital image processing, portable X-ray television system, flash-radiography

1. Introduction

Today radiation testing using X-ray and gamma-radiation, which can applied to the objects of any materials and provide more information on defect (type, form, size, location) than other types of non-destructive testing (magnetic, acoustic, penetrant etc.), has received the widest distribution. Radiography, included in the norms of manufacture and operation of industrial products, are the most frequently used method among the radiation ones. However, radiography has a series of significant disadvantages, i.e. high price of consumables, low efficiency, difficulty of receiving of information and its interpretation.

The E. O. Paton Electric Welding Institute of the NAS of Ukraine together with other organizations manufactures the transducers used in portable X-ray television equipment with digital processing of test results. Radioscopic (on notebook screen) as well as radiographic images in hard copy or other carrier of information can be received using such equipment. Today, flash-memory compatible with any computer became a popular carrier of information. Such a miniature flash drive of 15x20x2 mm size can contain information about quality of pipeline welds of more than 2000 km length.

2. Description of equipment for flash-radiography

Figure 1 shows structural scheme of portable X-ray television system for flash-radiography without intermediate carriers of information. It includes X-ray apparatus, remote control, scintillation X-ray screen, high-sensitive CCD-camera, computer (notebook) with internal and external memory (flash) which are contained in one or two hard cases. Low cost, sensitivity at 1.0-1.5% level, portability and electron memory, capability of computer technology realizing make exceptional this method of non-destructive testing. It will soon replace all methods of radiation testing with intermediate carriers of information.

High-sensitive CCD-camera of digital X-ray television system can be produced using different CCD-matrices (number of pixels can make 752x582, 1392x1040 and others). The camera is equipped with high aperture lens, providing small light loss during image transfer...
from X-ray screen to CCD-matrix. Enter of the images into computer is carried out through USB 2.0 interface. Efficient single-crystal screens of Customer-required size are used as scintillation X-ray screen.

Television camera has the capability to operate in a mode of adjusted duration of image collection to CCD-matrix and cooling is used for reduction of dark component and dark noises at large duration of collection. Collection time is several orders lower than auxiliary time at radiography with intermediate carriers of information.

Application of the mode of adjusted duration of CCD-matrix image collection allows efficient using for examination of small size pulse X-ray apparatuses, at elimination of low-frequency image flickers, and carrying out testing of the objects under field conditions and difficult to reach places.

Figure 2 shows a process of fixing of such equipment on four-tube pipeline of oxygen plant. Four stainless steel tubes of 18 mm diameter and general extension of several kilometers can be observed. At that, four parallel pipelines were examined simultaneously. Other methods of non-destructive testing are inefficient or can not be used in this case at all.

In comparison with other [2-5] technical solutions, the main advantages of such equipment lie in the following:

- Sensitivity 1.0-1.5%;
- High productivity and mobility;
- High resolution and stability of image;
- Simultaneous digital processing of X-ray and optical images;
- Possibility of archiving;
- Functions of radioscopy and radiography;
- Small size;
- Possibility of testing of moving objects in radioscopy mode.

Such XTV-03 system provides for sensitivity of radiation examination of around 1.5-2.0% that corresponds to sensitivity of radiography with intermediate carriers of information and good capability of detection of lack of penetration, pores, corrosion damages and similar defects. Flash-radiography significantly reduces cost and rise efficiency of non-destructive testing. Now it is possible to recall and archive only necessary information virtually without capacity limitation (type and size of found defects, pipeline wall thinning, presence and level of transported product etc.). Delivered equipment is portable, lightweight, completely digital and has operating field changed in the limits from 5x5 up to 30x30 cm. Transfer to the flash-radiography is possible using X-ray equipment possessed by Customer which can be non-portable.
Short specification of XTV-03:
- Weight of X-ray transducer, kg  5.5
- Capacity of analog-to-digital conversion of images, bit    16
- Resolution, line pairs/mm    3.5-8
- Controlled thickness on steel 50 mm

Besides, there is available current digital software for digital processing of images in order to increase their quality as well as archiving.

3. Advantages of flash-radiography implemented by the E. O. Paton Electric Welding Institute

X-ray and optical images of the object can be simultaneously displayed on the notebook screen by Customer request. Besides, they can be combined, analyzed and corrected, their separate fragments can be chosen and superimposed one into another and other operations in accordance with digital computer technologies are capable to be carried out. User-friendly software allows performance of accurate examinations of the parts. This rises efficiency and expand zones of testing, whereas cost and duration of examination using intermediate carriers of information (films, semi-conductor plates) depends on number of expositions. The concept of “exposition” is changed in traditional understanding in the case of flash-technology. Any objects from plastics, metal, concert, composites with effective thickness on steel up to 50 mm can be exposed to multiangle examination and tested for their real quality more accurately than in limited number of expositions. NDT cost does not restrict number of expositions in flash-radiography.

Modular structure of XTV-03 set allows using it for technical, customs and medical tasks. This equipment is compatible with radioisotope sources, portable and commercial, pulse and continuous sources of X-ray radiation, including microfocus radiation unit.

Flash-radiography in contrast to other types of digital radiation testing requires no intermediate carriers of information, metal screens, cassettes for films and plates, reagents, special rooms and additional time for work with intermediate carriers of information. The flash-radiography is the most visual portable non-destructive method of testing without consumables and specific requirements to object geometry (roughness, curvature, thickness, diameter etc.) for all branches of industry. Storage of the images and their digital processing before archiving provides for the best quality evaluation.

Systems of XTV-03 type are designed for technical inspection experts, customs services and professionals dealing with monitoring and comparable testing of the assemblies, operation of which is continued in defect presence. Flash-radiography systems are manufactured considering specific requirements of the Customer and allow:
- Providing examination of difficult-to-reach objects, in particular, at object movement, in addition to reducing of time and cost of procedures;
- Receiving results from the most dangerous section of the object in real time;
- Eliminating disassembly of the object and removal of insulation before its examination;
- Archiving all results, recording and carrying out comparative analysis, transmitting by e-mail and reproducing information.

Virtually any X-ray equipment of the customer can be used for the flash-radiography. Specification for production of CCD-transducer requires the following information, namely size of operating fields, information about object (material, thickness, speed of movement etc.), necessary relative sensitivity of testing, parameters of found defects and requirements to image processing.
4. Examples of application of flash-radiography systems

Flash-radiography systems, allowing testing and examination of the most various objects, are widely used all over the world. Figures 3-15 show the examples of such system application. Figures 3, 14-15 gives the X-ray images from works [2-6] and ones received using systems similar to XTV-03.

Figure 4. Porosity is evaluated by five-point scale

Figure 3. Brazed assembly of aircraft turbine

Figure 5. Weld: porosity, cracks and lack of penetration

Figure 6. Valve

Figure 7. Pipe joint through 2 walls

Figure 8. Corrosion under insulation

Figure 9. Insulated pipe

Figure 10. Cut off cord of conveyor belt

Figure 11. Brazing of copper pipes

Figure 12. Casting
Figures 3-15 require no special explanations. Refer to slide library and imbedded data base during flash-radiography allows analyzing images and send them to number of interested addressees. Photos and videos are stored and sent together with corresponding X-ray images. There is a function of database query for simplification of searching and other examples of application of computer technologies. «Mini» design of the flash-technologies, i.e. using mini equipment, mini screens and mini radiation units, are in particular perspective. There are procedures of scaling and automatic calibration at digital 5-fold increase which allows operator detecting and examining the finest peculiarities of the object internal structure. Available are the functions of color coding of the images (pseudocolor), contrasting, inversion (positive-negative), plotting of histograms of image intensity, applying of dimension grid and marking of additional information on the image, determining of object size on the image, filtering of digital noise etc.

Capabilities of famous Vidisco system, the best device of flash-radiography found distribution all over the world, are well known. In our case the simplified equipment can be assembled by Customer order for realizing of flash-technology from available in his possession elements (X-ray device, computer, cables, auxiliary elements, fasteners, racks etc.), i.e. by individual design, considering Customer possibilities. Such an approach to implementation of flash-radiography is directed on numerous Customers with limited financial capabilities in all branches of industry.

5. Conclusions

1. Flash-radiography systems can be easily designed on individual projects considering technical capabilities of the Customer, aiming at cost reduction and rising of radiation examination efficiency. Transfer to the flash-radiography is easily regained.
2. Distribution of flash-radiography, requiring no consumables, significantly expands volumes and areas of radiation testing application.
3. Application of portable equipment of XTV-03 type allows solving the technological problems which can be solved only using stationary multiangle tomogram. The flash-radiography solves the problems of movable and inaccessible objects.
4. Wide application of the flash-radiography is expected in the case of use of mini transducers being moved in zone of testing for detection of internal defects in difficult-to-reach places, where application of other types of non-destructive testing (ultrasonic, eddy-current, magnetic) is impossible, as well as in robotization of technological processes.
5. Implementation of the digital flash-radiography reduces application of traditional radiography with intermediate carriers of information (films, plates etc.) and means for information reading off. This decreases costs and rise operating efficiency of non-destructive testing, promote distribution of information about quality of technological
processes in electron form and on-line prevention of deviations in the technological processes.

6. The E. O. Paton Electric Welding Institute carries out the flash-radiography using the same technical means (X-ray devices, fasteners, reference specimens, computers etc.) that applied in radiography with intermediate carriers of information.

References


