INCREASING SENSITIVITY OF DIGITAL RADIOGRAPHY BY MEANS OF COMPUTER SIGNAL POST PROCESSING TO FIND DEFECTS ON COMPOSITE MATERIAL STRUCTURES

POVEĆANJE OSJETLJIVOSTI DIGITALNE RADIOGRAFIJE POMOĆU RAČUNALNE OBRADE SIGNALA NAKON NEDOSTATKA KOMPOZITNIH MATERIJALA STRUKTURE

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Abstract: *On truck-mounted concrete arm pump 1st, 2nd and 3rd sections are made of high strength steel and 4th, 5th and 6th arm sections are made of light and resistant CIFA carbotech composite material. This second part of truck is under vibration, stress and strain so is important to monitoring which will be the carbotech composite material response. The present work has the scope to study the main parameters that affect the quality of image, and show that this technique is very effective in the detection of defects with high sensitivity.*

Key words*: digital radiography, carbotech composite material, sensitivity.*

Sažetak: *Na kamion su montirane pumpe, prvi, drugi i treći dijelovi izrađeni su od čelika visoke čvrstoće i četvrtog, petog i šestog svjetla dijelovi izrađeni su od svjetlosti i otporne CIFA carbotech kompozitnih materijala. Ovaj drugi dio kamiona je pod vibracijom, stresom i naprezanjem, tako je važno za praćenje koji će biti od kompozitnog materijala.*

Ključne riječi: *digitalna radiografija, carbotech kompozitnog materijala, osjetljivost.*

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1. Introduction

The industrial radiography is a non - destructive method that uses the penetrating and ionizing, X - ray or gamma - ray radiation, that pas through the object, and the detector of the radiation. This method of NDT is very important to detect defects, internal and surface, likes porosity, cracks, lack of fusion, lack of penetration, foreign inclusions, differences in thickness, changes in structure, assembly details etc. in quality assurance of the piece, or structure conform standards, specifications or technical requirements [1].
The detector can be photographic film, held in a light-tight cassette that allows the rays to pass through the piece. To develop the image on film are needed chemicals. This process is knower like conventional radiography. Or are used sensitive detector that not requiring the use of chemical to produce the image. This process is knower like digital or computer aided radiography CR, or direct digital radiography DR. In digital radiography, a radiograph is created, not on conventional silver halide film, but with the use of another device that allows the radiograph to be represented as an array of discrete digital intensity values or pixels [2].
Computed Radiography, CR - uses an imaging plate, that's contains photo sensitive storage phosphors which retain the latent image. When the imaging plate is scanned with laser beam in the digitizer, the latent image information is released as visible light. The fundamental parameter of CR system is the relationship between plate and dimensions of scanner's spot that can be considered as like "film system" in conventional radiography [3].
Quality of image is very important in interpretation of defects, in conventional radiography quality of image is influenced by sensitivity of film, development process, and human factor over all; in CR is influenced by the kind of plate, scanner's parameters, quality of hardware and software, here the influence of human factor is decrease [4].

2. Digital radiography of composite materials

Composite materials have entered largely into use. Defects that appear in these materials may be, manufacturing defects as porosity, bonding defects, or defects during service life as delamination, cracks, and bond failures. Material under study is carbotech material, the same as in CIFA Concrete Pump arm. This pump arm is under vibration, stress and strain during service life, so above defects is possible, and is very important detecting them. To detect defects as yet, we have used different methods such as ultrasound, conventional X-ray and acoustic emission. Purpose of this article is to light up how to detect and evaluate the type and dimensions of defects in composite materials with digital radiography. Digital radiography system includes several parameters same as conventional radiography. X-ray tube and generator are the same. Digital radiography has the same x-ray positioning standards depending on the geometry of structures. Important like in conventional radiography, is to select interactive parameters in this process, optimum voltage kV, intensity mA, time sec versus each - other, depending from material, thickness in relation on the

sensitivity of plate or film. In both methods is used cassette or image receptor, which could be film or plate, placed inside plastic or rigid case between thin sheets of lead. There is still a latent image which can be processed into a manifest image, but in CR the image is earned scanning the plate and the one of the strong point of digital radiography is that, image can be processed by computer program to reach a good image quality. This is not possible in conventional radiography [5], [6].

3. Experiments

All our study is based in data processing of the measurements made on samples from CIFA concrete pump arm material. CIFA pump concrete arm is presented in figure 1, the sample taken from pump's arm is presented in figure 2. We have constructed sample block with artificial defects. Natural defects like delamination or bond failure are simulated through flat bottom holes and steps with various depth and thicknesses.

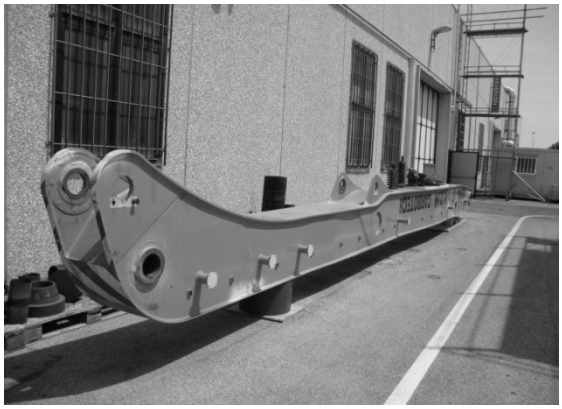

Figure 1. Cifa pump concrete arm

Figure 2. Sample pump arm

Sample block number 1 is described by real photo and technical drawing, in figures 3 and 4. Table of dimensions of the holes and steps for this sample are 1 and 2. Sample block number 2 is described in figures 5, 6 and 7.
With these 2 samples we tried that in approximately 20mm thickness, to realize a full spectrum of dimensions that give to us possibility to build very accurate diagrams, like exposure charts, characteristic curve, diagram of energy, gradient of contrast,

sensitivity. Diagrams as mentioned above are very important to understand right relation between tension, intensity and time for composite material.

Figure 3. Cifa sample, block nr 1

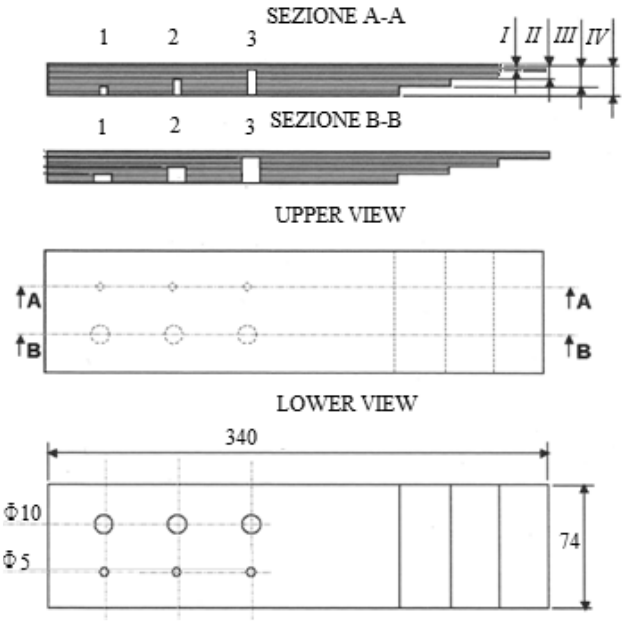

Figure 4.Technical drawing, block nr 1

Hole	1	2	3
Depth	15mm	10mm	5mm

Table 1. Hole depth for block 1.

Step	I	II	III	IV
Thickness	6mm	10.8mm	15.75mm	20.5mm

Table 2. Step thickness for block 1.

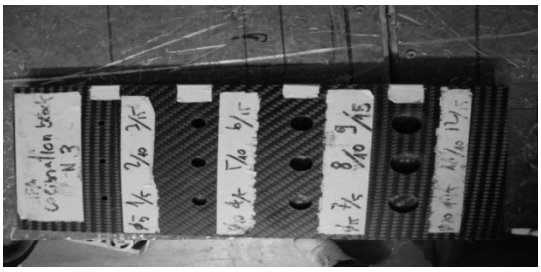

Figure 5. Cifa sample, block nr 2

The diagrams are built with both ways, conventional and digital radiography. In digital radiography the time of exposure is a third compare with conventional radiography, for the same energy and intensity, course in the same samples. So, saving time is another strong point of digital radiography.

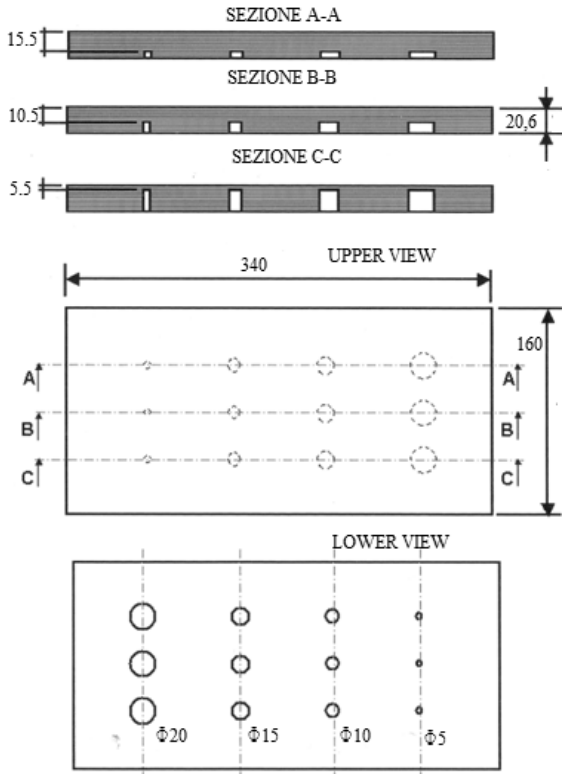

Figure 6. Technical drawing, block nr 2

From all diagrams have built during our study, have chosen to give in this paper, a more meaningful diagram, characteristic curve and contrast gradient versus relative exposure figure 7. The desirable grey level of image defined from our study is from 25000 to 45000. As far as exposure time increase, the grey levels increase too, increasing quickly the contrast. Since contrast is very important in image quality, and its change or growth occurs for small interval of time, allows us to make a remark of mentioned above, that time has a great influence on image quality and is a parameter which is very important and should be better defined.

Figure 7. Characteristic curve and gradient versus relative exposure

System performed parameters must be determined initially and monitoring regularly to ensure the results.
According to EN 462 the best measure system is using the Duplex Wire figure 8. According to UNI EN 1478-1, the resolution criterion for the evaluation of duplex wire consists: two wires of a pair wire are resolved if the dip between the line max is greater than 20% of the max intensity.

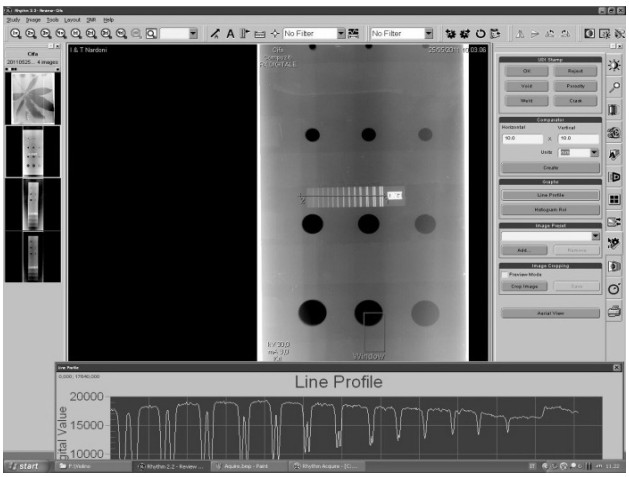

Figure 8. Sensitivity, duplex wire, block nr 2

From line profile is possible to calculate the sensitivity. As seen in figure 9 is the apparent difference between the wires in the order of 7, where the diameter of the wires are 0.40mm and spacing unsharpness 0.200mm, so we are secure for sensitivity 2%. Wires in order of 8 have the diameter 0.32mm and spacing unsharpness 0.160mm that are not clearly resolved, so we can't be sure to reach the sensitivity 1.6%, when the unsharpness is not clear and visible.
To reach this sensitivity is possible with the post processing step through the second part of program Rythem Review. Zooming the parts facilitate the way to analyze the image and give the professional conclusion from technicians.
So we can be sure to reach the sensitivity 1.6% that is satisfactory. The improvements can be saved like image but the raw image is untouchable and can be available for the users, to have always bank of data base. The improvements can be saved like image but the raw image is untouchable and can be available for the users, to have always bank of data base.

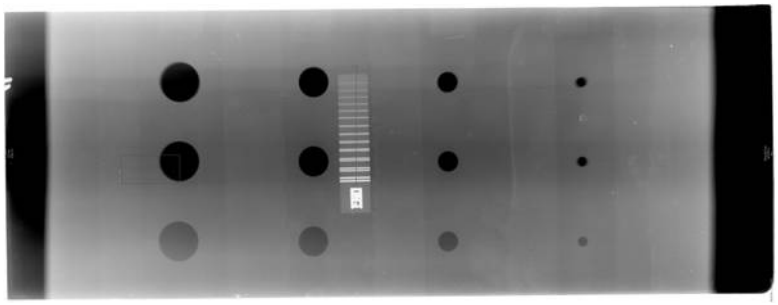

Fig. 9. Raw image, block nr2

At figure 9 is raw image of sample block 2 with the duplex wire on it. All different thickness flat bottoms on this sample are visible with good quality. After the post processing we can reach good results for two classes A and B.

7. Conclusion

Digital radiography has significant advantages like: exposure time reduction, no need for chemical development process what bring it to friendly to environment, easily post-processing, no material limitations, no temperature limitations and no need for preparation work or remove coatings or insulation.
The image can be acceptable if the grey level is between 25000 - 40000 counts.
For the same performance parameters of testing, like voltage and intensity, geometry and material, in digital radiography, exposure times have great influence in image quality. The plate is very sensitive versus exposure time. Small changes of time in the sense of growth will reflect increase of the contrast, leading to improvement of image quality. Proper selection of testing parameters will be finalized with good quality of image, or achievement of the sensitivity of detection determined by the standard. Even when this is not achieved at the beginning, this target is completely possible by second part of Rythem program, through the virtual image processing.
Through this program is possible to improve image, by changing light or contrast, application of different filter, enhance the contours, etc, and to measure accurately the defects, corrosion, etc.
Sensitivity post processing rich 2% or less, consequently accepted by the code.

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2. UNI EN 1478-1: 2005 Non-destructive testing -

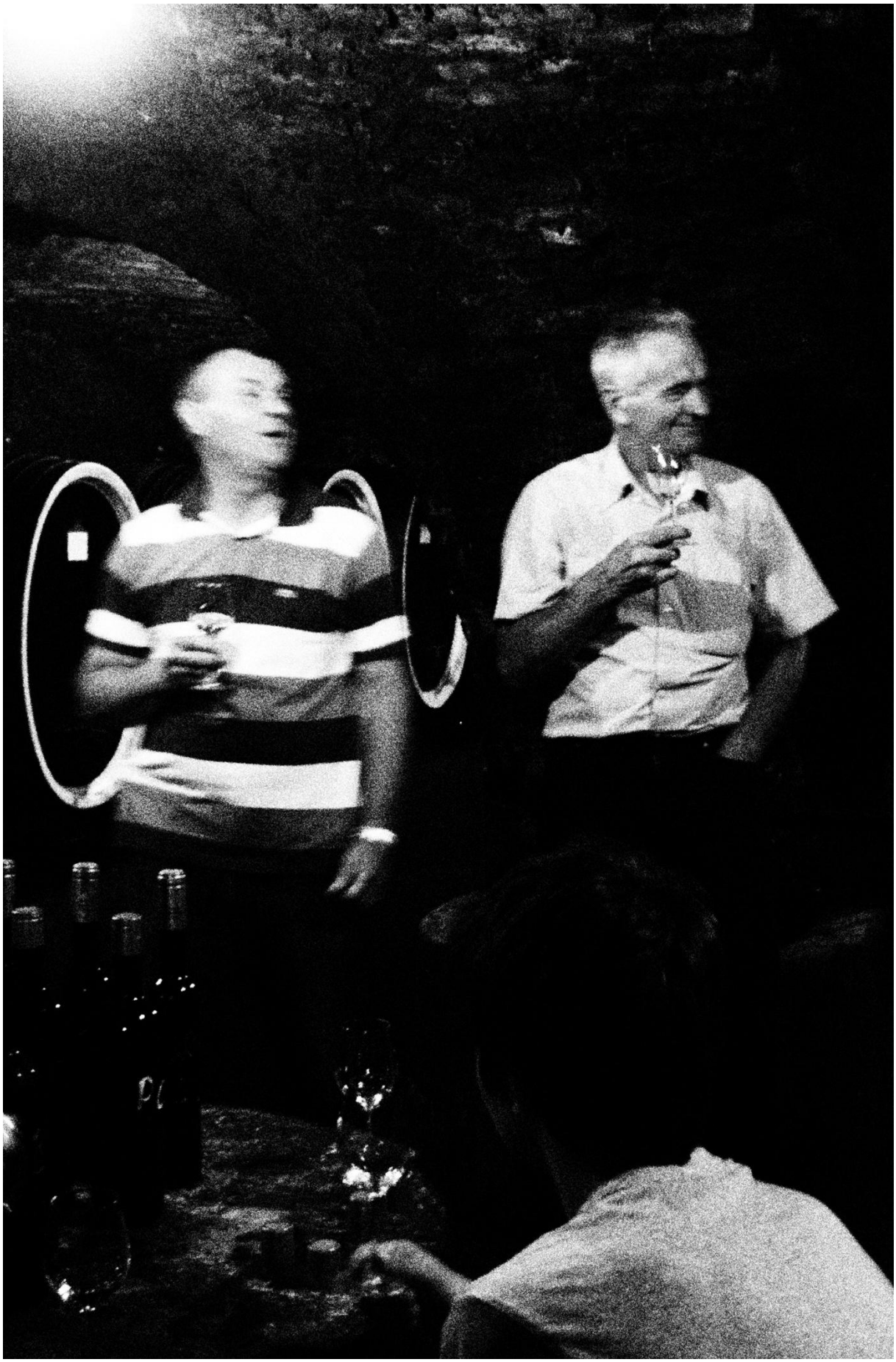

Photo 119. Wine tasting in Kutjevo / Vinska degustacija u Kutjevu