L.4: Inspection software for x-ray gamma auto radiograph of FBTR fuel pin

An inspection system for the evaluation of X-ray Gamma Auto Radiograph (XGAR) of Fast Breeder Test Reactor (FBTR) fuel pins is developed. A typical fuel pin used in FBTR consists of an active stack length of ~320 ± 1.5 mm with insulation pellets on both ends of active stack. There are SS components such as plenum tube and pellet support disc on one side and a spring along with spring support on the other side of the active stack. All these components are encapsulated within a SS tube to form FBTR fuel pin. After welding of end plug at both ends, this pin is inspected for correctness of loaded components and measurement of stack length. To inspect this fuel pin XGAR image of this pin is obtained on x-ray film.

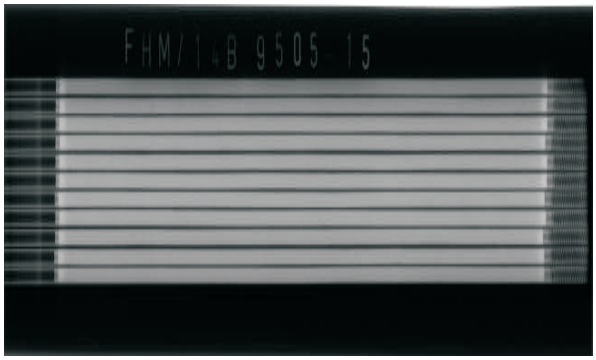

Fig. L.4.1: Digitized image of XGAR film of ten fuel pins.

A digitized image of the XGAR film is generated using an optical scanner. This scanner generates a 16-bit grayscale image and it has a high speed USB interface. The digitization is carried out at 1000 dpi resolution.

In order to obtain an XGAR image on a film (Figure L.4.1), typically ten fuel pins are arranged side by side. A typical FBTR fuel pin should have all its components arranged in predefined sequence.

The inspection software processes the XGAR film image to detect the number of fuel pins and separates out each pin image from the image of cluster of pins. Image processing algorithms have been developed to analyse extracted image of individual fuel pin for presence of various components and their correct sequence. The software further computes the active pellet stack length for each fuel pin, which is an important parameter. The software then generates an accept / reject decision, depending on whether all the components are present in correct sequence and the active stack length is within the tolerance.

The intensity profile drawn across the active stack (Figure L.4.2) ensures whether the pellets are properly placed within the fuel pin. The valleys (notches) in this stack profile are used to compute gap between pellets. The intensity profile along the insulation pellet near to pellet support disc shows the accuracy of the coupling between plenum tube and pellet support disc. The software also detects presence of any anomolous pellet within the active stack length.

This software corrects any tilt; due to incorrect placing of the film on the scanner and generates consistent results for a given XGAR. Top plug weld (TPW) number, which is the identity for the fuel pin, is automatically extracted and detailed report in spread sheet format is generated.

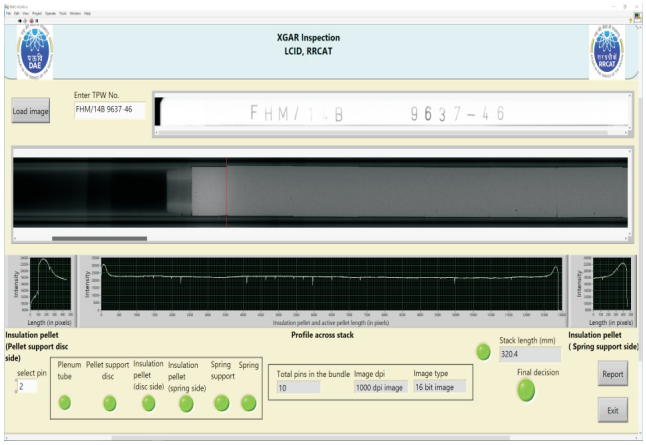

Fig. L.4.2: Screenshot of the XGAR inspection software.

Time taken by this software to analyze a fuel pin cluster consisting of 10 FBTR fuel pins is ~ 1 second. Moreover, a detailed digitized image is displayed on a 27 inch, 4K UHD display monitor for the user who can validate the correctness of automatic decision, if necessary.

This inspection system is commissioned at Nuclear Fuel Group, BARC.

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