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Detection of Wall Thinning in Tube to Tubesheet Welds of steam generator by Microfocal Radiography

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Abstract

The tube to tube sheet (TTS) welds of steam generator of Prototype Fast Breeder Reactor (PFBR). This is because, sodium flows on shell side and water on tube side. Any failure would thus be catastrophic. The specifications for the evaluation of such welds are thus highly stringent. The maximum permissible value for internal concavity and convexity of TTS welds is 0.2 mm. It is easy to determine the external convexity and concavity due to availability of access by replica measurement. In the case of internal concavity and convexity, the technique of replica using dental compounds is quite difficult. Replication using silicon rubber compound and special hardware has been carried out by the authors. However, the cost of making one replica is more than Rs. 10,000 thus making this a highly unviable solution for shopfloor inspection of all joints. Earlier the authors have successfully developed procedures and adopted the same in shopfloor for the evaluation of these welds for defects by microfocal radiography. This paper presents the experimental results of procedure developed for quantitative evaluation of concavity in the tube to tubesheet welds by microfocal radiography.

Internal and external concavity in the range of 0.1 mm – 0.5 mm in steps of 0.1 mm was created in trial tube to tube welds using electro discharge machining. The concavity was calibrated by replica technique. The welds with concavity were subjected to microfocal radiography. The radiographs were digitized and profiled. After appropriate corrections for magnification, a calibration graph correlating the density as a function of concavity was established. However, the accuracy of measurements was found to be poor. Analysis indicated that one of the main factors that affects the accuracy of measurement is statistical variations in the photon flux and the non-linear magnification due to the emission angle. Incorporation of these parameters indicated that concavity could be determined with an accuracy of about $\pm$ 25 microns.

Thus, the detected concavity can have any value between 175 microns to 225 microns. While concavity in excess of 200 microns gets rejected (based on the limit specified by the PFBR specification) those weld joints whose concavity is in the range of 175 microns to 200 microns need a more accurate method for quantification. Replica technique based on silicon rubber compound is the most accurate with an accuracy of $\pm$ 10 microns. Based on these observations it is proposed to recommend that apart from the detection of defects for which microfocal radiography is being regularly employed, the microfocal radiographs can also be used as a first level of screening for the detection of concavity. In case of weld joints whose concavity is in the range of 175 - 200 microns, replica technique can be adopted to confirm the values.