TRUEFLAW

E.ON

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2.1 E.ON REACTOR PRESSURE VESSEL NOZZLE INSPECTION ISSUE

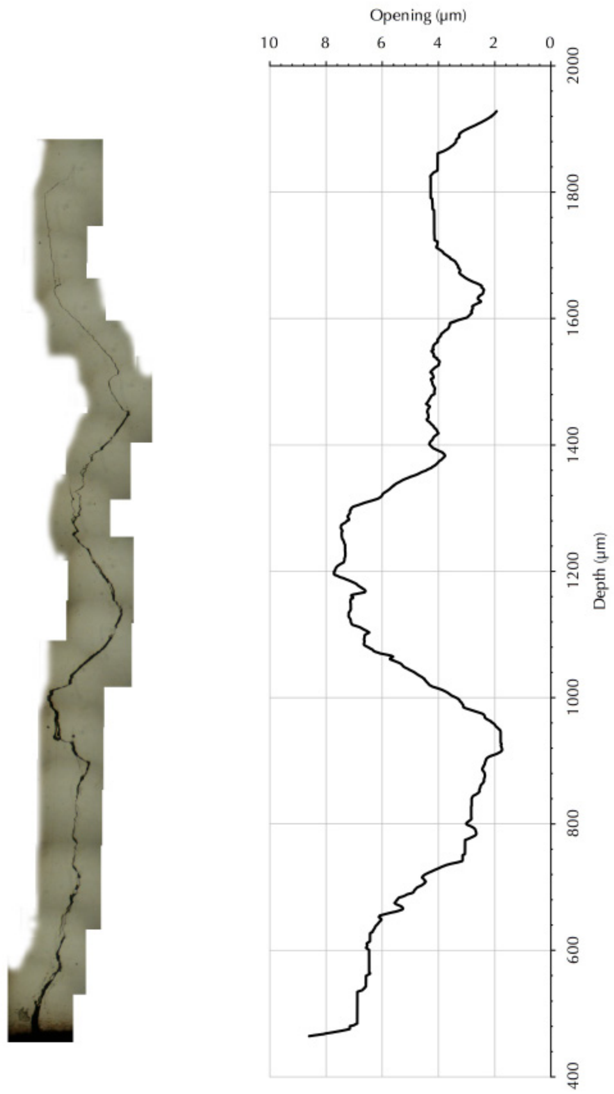
In the nuclear power plant of E.On in Brokdorf, Germany, non-destructive inspection of dissimilar welds is an important part of the inspection program in refuelling outages in nuclear power plants. The inspection of the inner weld surface in the reactor pressure vessel head nozzles of German PWR plants is complicated by geometrical constriction. This dissimilar metal weld is accessible only through a 1 mm thick gap, which the eddy current probe must pass trough. For this inspection a new eddy current technique had to be developed. Due to the geometrical limitations, the probe design had to ensure an extremely flat probe. The qualification of the inspection technique was performed with a test specimen made of a real nozzle using EDM notches as simulation of cracks according to applicable rules. Qualification was accepted before applying the inspection technique for inspections during outage of the plant in 2007.

During the in-service inspection in 2007, an indication was found close to the austenitic side of the dissimilar weld in one nozzle. The signal was not within the phase range of defects detected in the qualification and the signature was totally different from the signal of notches. The circumferential extent was small in respect to the length of the weld. So, the indication was not classified as a defect signal, nor was it a clear geometrical indication. It was decided to make further investigation to find out the reason of the signal.

One of the points to study in this investigation was to find out the difference between notch signals and the signals of real cracks. Next aim was to develop a visual technique able to inspect the inner weld surface through the 1 mm gap. A test specimen was made using an original nozzle made of vintage material. Due to need of realistic cracks and existing sample, in-situ grown cracks had to be used. Trueflaw was ordered to manufacture cracks in this new specimen, as well as, to make different EDM notches and notch fields as references.

E.On supplied an original nozzle to Trueflaw to be used as the test block. Part of the test block area was marked for validation. Trueflaw produced validation cracks of intended size to this area. The area containing the validation cracks was then cut out from the tube using electric discharge machining (EDM) and the cracks destructively examined to reveal the true crack depth. As the Trueflaw technology was first time used by E.On, E.On and consultant expert of the authority (TÜV) visited Trueflaw to follow the progress. Subsequent to the accepted validation result, the final cracks were manufactured and sample supplied to E.On.

There was a requirement for the crack to be a natural one with realistic opening profile. Due to this requirement, in addition to the normal crack validation, a cross-sectional sample was made to measure the crack opening profile in the depth direction. Next figure (Fig.3) shows a picture of the cross-sectional sample together with the opening profile measured.



a) b)

Figure 1
Crack opening profile in depth direction together with the measured opening profile.

With the manufactured cracks, the eddy current system qualification was repeated, and the phase range for defects could basically be verified with signal being reduced at the edges. With a crack having a secondary crack close to it, it could be proved, that no phase shift occurs, when more then one crack is in the area of influence of the probe. The new developed visual inspection technique (using special optical components and a CCD-chip together with an optical fibre lighting) was qualified as well. The applicability of the very small high resolution video probe (to be used in the gap of around 1 mm width) for the detection of cracks even from problematic view angles could be verified clearly with the natural cracks delivered by Trueflaw.

In the 2008 outage a second inspection of the reactor head penetration with the optimized qualification of the eddy current inspection and the visual inspection was made. The signal was found unchanged. It could be confirmed that the reason for the indication was of geometrical nature. In conclusion, a crack in the component could be excluded.

Furthermore, inspection processes were re-qualified and accepted for further use. With the real cracks used, a complex problem that otherwise would have lead to extended discussions and technical justifications with, for example, the need of disassembling the control rod drive mechanism, was solved.