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Differences in Ultrasonic Indications – Thermal Fatigue Cracks and EDM Notches

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Abstract
Different types of artificial defects are used for a qualification of NDT methods. The representativeness of these defects, as compared to service induce flaws, is crucial when the performance of NDT method or inspector is evaluated.

Ultrasonic indications are highly dependent on defect characteristics like roughness, crack opening, tilt and branching. These characteristics are even more significant than the defect size. To develop performance and reliability of ultrasonic inspection methods and procedures more research on different type of discontinuity indications is needed.

In this study, indications from different types of discontinuities are measured using scanning acoustic microscope (SAM). The inspection item is austenitic stainless steel pipe with thermal fatigue cracks and similar size of EDM notches. Clear difference can be seen between indications from the EDM notches and from the thermal fatigue cracks.

Keywords: Ultrasound, ultrasonic inspection, scanning acoustic microscope (SAM), thermal fatigue, indication, discontinuity, defect, qualification

1 Introduction

Ultrasonic inspection is widely used NDT method for structural integrity inspections in power plants as well as in other industrial areas. Real components with real flaws are usually not available to be used in the practical tests and therefore during the qualification process of any non-destructive method as well as ultrasonic inspection method different test samples are needed to prove in practice the effectiveness of the testing system. The representativeness of used test sample is often crucial and therefore used test samples should have similar material, dimensions, geometry etc. as the real component. Also the defects that are expected to exist in real life should be represented in the test sample (figure 1.). Usually it is very difficult and expensive to produce real defects in the test structures and therefore artificial defects are often used as substitutes.

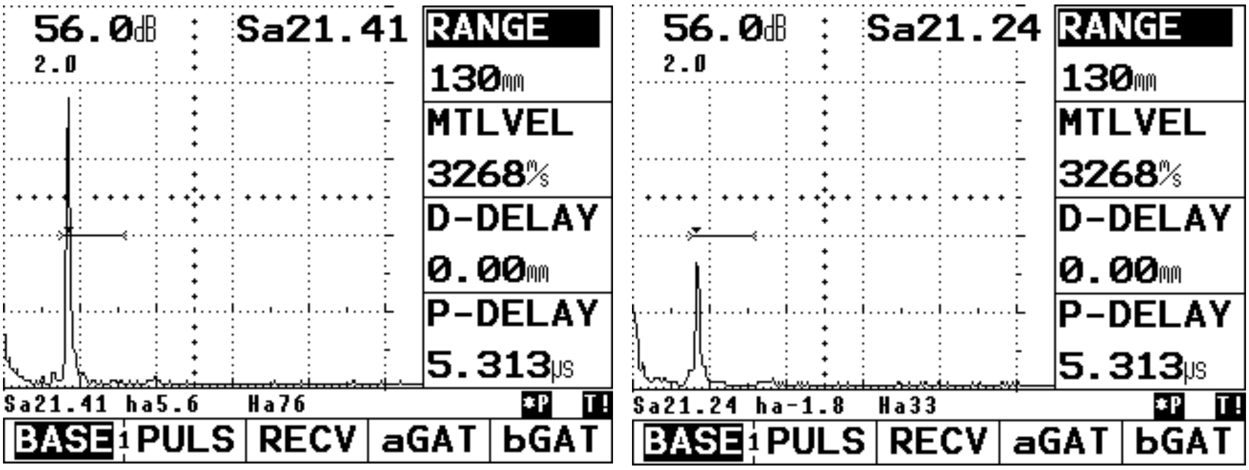


Figure 1. Indications from similar size of discontinuities produced by electric discharge machining (on the left) and thermal fatigue (on the right). Same equipment, probe, probe angle and gain used with both measurements.

Typical types of artificial defects are flat bottom holes, electric discharge machining (EDM) notches, welded defects and different types of fatigued defects.

2 Scanning Acoustic Microscope (SAM)

Scanning Acoustic Microscopy works by directing focused sound from a transducer at a small point on a target object. Sound hitting the object is either scattered, absorbed, reflected (scattered at 180°) or transmitted (scattered at 0°). It is possible to detect the scattered pulses travelling in a particular direction. A detected pulse informs of the presence of a boundary or object. The `time of flight' of the pulse is defined as the time taken for it to be emitted by an acoustic source, scattered by an object and received by the detector, which is usually coincident with the source. The time of flight can be used to determine the distance of the inhomogeneity from the source given knowledge of the speed through the medium.

Based on the measurement, a value is assigned to the location investigated. The transducer (or object) is moved slightly and then insonified again. This process is repeated in a systematic pattern until the entire region of interest has been investigated. Often the values for each point are assembled into an image of the object. The contrast seen in the image is based either on the object's geometry or material composition. The resolution of the image is limited either by the physical scanning resolution or the width of the sound beam (which in turn is determined by the frequency of the sound).

3 Stainless steel pipe sample

3.1 Thermal Fatigue Crack

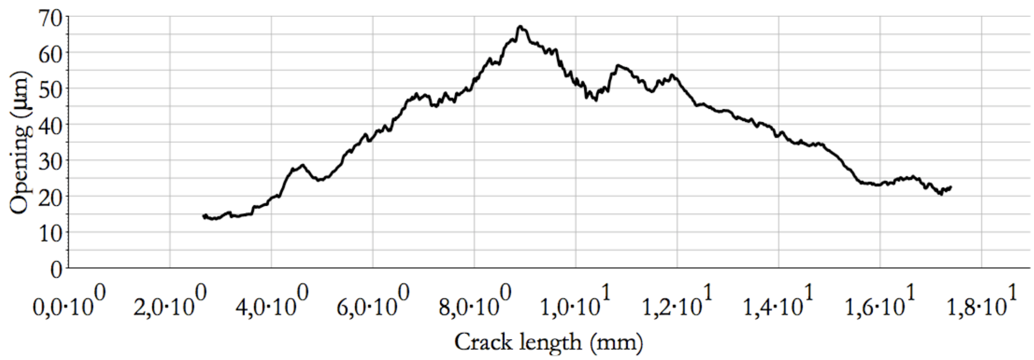
Representative controlled artificial cracks can be produced in-situ with thermal fatigue. The use of grown cracks based on the thermal fatigue production process has increased markedly during the last few years. Furthermore, the amount of different applications has become larger thus covering today most of the NDE inspection techniques and targets in the nuclear field.

Capability of this technique to produce realistic, representative flaws has been analysed by comparing the crack characteristics to the characteristics measured from service-induced flaws. This comparison has been made against measured values from service-induced flaws reported by Wåle. In general, thermal fatigue flaws are representative for most of the service-induced flaws, when used as a reflector for different NDE development, training and qualification purposes.

In present study, a tube sample with three thermal fatigue flaws were used. The produced flaws were characterized by surface microscopy. Figure 1. shows example surface image from one of the cracks. The measured crack surface opening profile and roughness are shown in Figure 2.

Figure 1. Example surface microscopy image.

a)



b)

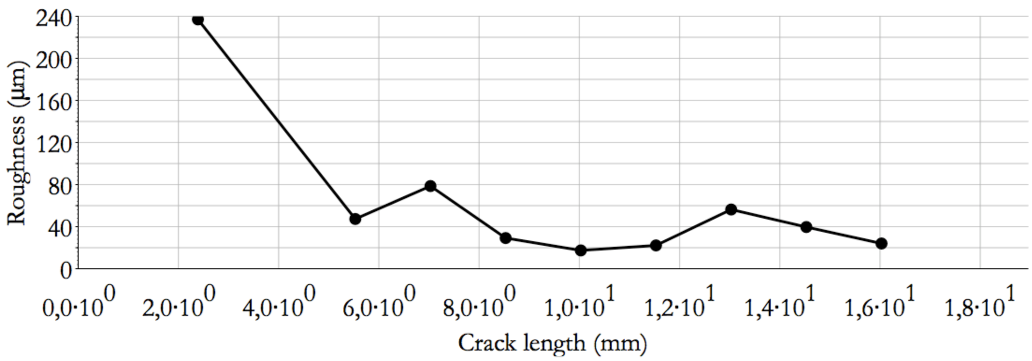


Figure 2. Measured crack surface opening (a) and R_z roughness (b).

The depth of these cracks is known through destructive examination of a validation cracks produced with the same local sequence.

3.2 Electric Discharge Machining (EDM)

4 Ultrasonic testing and results

Test setup
Conventional
Scanning acoustic microscope (SAM)
Phased Array?

5 Conclusions