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IN-SITU CORROSION SMALL PUNCH TEST ON STRESS CORROSION CRACKING WITH DIGITAL IMAGE CORRELATION

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Abstract
A small punch test (SPT) setup has been designed to allow monitoring the initiation and propagation of stress corrosion cracking (SCC) with digital image correlation (DIC). This paper reports the design of the setup, the method of accelerating the corrosion progress and correlation of the stress corrosion cracks.

1. Introduction
In the UK, spent AGR (advance gas-cooled reactor) fuel is temporarily stored in the cooling ponds at Sellafield Ltd. waiting for permanent storage. Although the condition of the ponds is monitored and regulated, the spent fuel cladding can develop SCC due to the effect of RIS (radiation induced sensitisation) from the neutron irradiation during operation of the reactor. To better monitor SCC of the spent fuel cladding, the development of a new SPT setup, which can allow the initiation of SCC and monitoring with DIC, was proposed. Small punch test is a widely used method in nuclear industry because it only requires a small piece of materials. It is also a versatile method as it can allow the introduction of a corrosive environment and can accommodate DIC. Stress corrosion cracking is caused by a combination of susceptible materials, corrosive environment and stress, and all three factors have been studied in present study. After the initiation of SCC, DIC has been added to the system, and different patterns and the effect of fluid have been studied.

2. Results
Three factors governing the development of SCC have been incorporated in our SPT:

- Susceptible materials: To simulate the irradiation effect on fuel cladding (20-25-Nb stainless steel), thermally sensitised surrogate material (304 stainless steel) was used, which became susceptible to SCC after ageing at 600 °C for 50 hours,
- Corrosive environment: the standard SPT design has been modified to allow a circulation of a corrosive solution (fig.1.a), and a study on the corrosive solution found that heated sodium thiosulphate at 1000 ppm can accelerate SCC while allowing a clear view for the DIC.
- Stress: It was confirmed that SPT can apply load on the material (304 stainless steel) to its failure. A load of 1.5 kN was found sufficient to introduce a stress that can initiate SCC.

By combining these three factors, a new SPT setup was developed (fig.1.a). A trial experiment was conducted by applying a constant load of 1.5 kN on a thermally sensitised 304 stainless steel SPT sample, which was in a circulation of a heated 1000 ppm sodium thiosulphate. After 113 hours, several stress corrosion cracks were successfully developed (fig.1.b, c).

Digital image correlation was then introduced to the SPT system. Key aspects of the DIC in the corrosive environment has been studied:

- Patterns: two pattern methods have been compared; painting and etching. Although the painted surface had better correlation before placing the sample into the corrosive environment, the paint could cause large pitting corrosion on the surface interfering the development SCC. Etching however was found to be not affected by corrosion, and it was selected as the preferred patterning method for DIC.
- Effects of fluid on DIC: the fluid can cause optical effects interfering with DIC including bubbles and shadow effect from the lighting. A coaxial lighting system was introduced to minimise the effect of the fluid and a procedure to reduce other effects was devised.

By resolving the issues with DIC in a corrosive fluid environment, SSC was observed in new SPT setup.

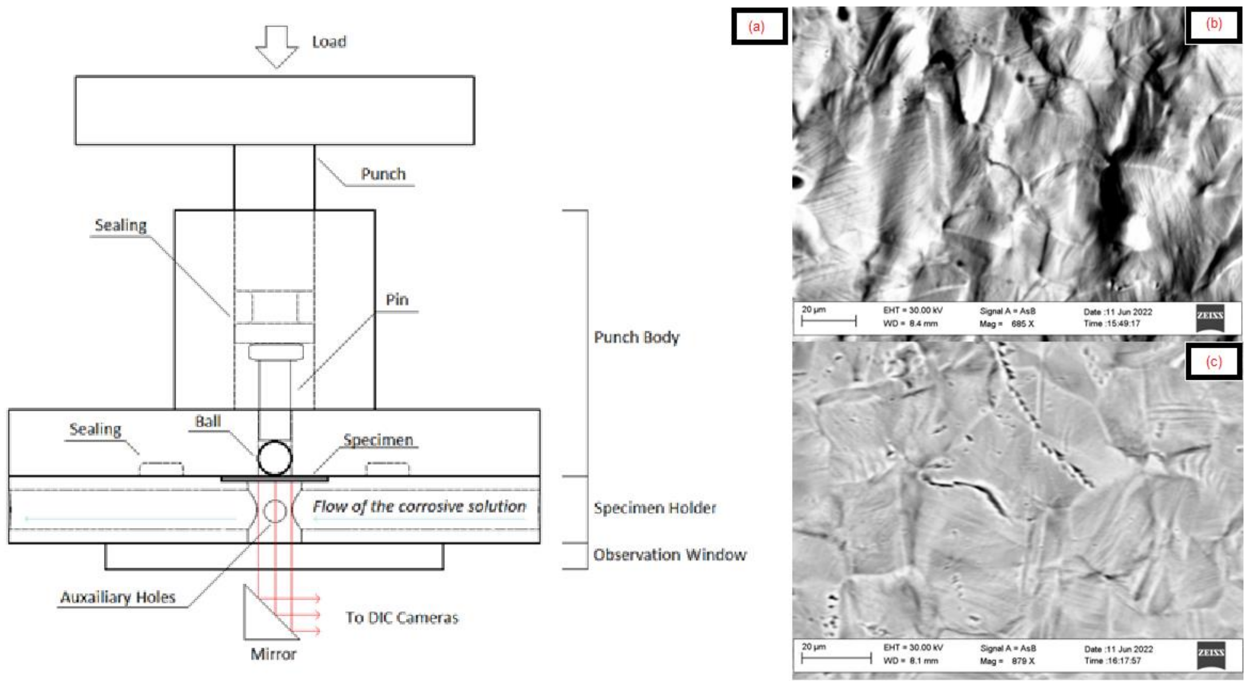

Fig.1 (a) new SPT setup that with a corrosive solution loop, (b) and (c) SCCs developed by SPT

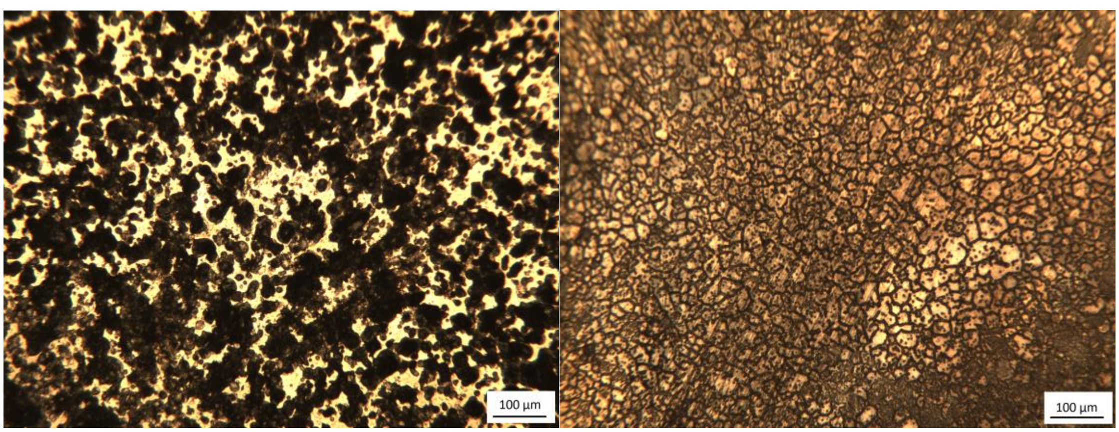

Fig.2 painted sample surface after corrosion (left) and etched sample surface after corrosion (right)

3. Conclusions

A new SPT for SCC with DIC monitoring has been developed. SCCs were initiated by applying the specific combination of the susceptible materials a corrosive environment and stress. With the special patterns and minimising the effect of the fluid on DIC, these SCCs were observed by DIC.

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