E&I Research Studentship project proposal 2019

Project title: Development of a miniature testing technique for determining creep life of power plants

Supervisory team:
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Project Highlights:

- Novel imaging and computational techniques will be used to characterise the constitutive parameters of materials using a very small number of samples.
- Project outcomes will influence the methods used to determine the safety of critical components in power plants

Project Description:

The assessment of the life and structural integrity of nuclear power plants requires reliable knowledge of the mechanical properties of safety critical components. However, the properties of materials used in the construction of these power plants change during their service life. This can be due to thermal ageing, irradiation, creep damage, cyclic loading, reaction with the environment and components can develop unexpected damage (e.g. cracks) during operation or some combination of any or all of these effects.

Standard mechanical testing used for characterising material behaviour requires large samples and so to obtain mechanical property information of parts that are in service can only be done at the end of its life when it has already been replaced. Alternative approaches, such as inferring properties from in situ hardness measurements, have been suggested, but this only provides very limited amounts of information. An alternative and promising technique involves performing mechanical tests on non-standard miniature samples extracted from the surface region of interest in plant components. Typically, shallow "boat" samples (~30 mm diameter and 2.5 mm thick) are scooped from the surface region of interest and miniature test specimens (e.g. for tensile, Charpy impact, creep and fatigue tests) are extracted from them. However, this approach is currently under developed, with many novel approaches proposed but no consensus on the best way to obtain data that compares well to bulk methods.

One issue is that testing small samples of metal is not like testing a larger sample because typically the grain size of the metal is such that only a few grains are contained in the gauge section of a small sample. Also, since there is a limited amount of material available, the amount of data obtained from the sample needs to be maximised. For example, if the material is anisotropic, several test samples at different orientations are needed using standard the methodology.

This project will investigate the feasibility of obtaining all the in-plane components of constitutive parameters using a single tensile test specimen with a novel geometry. It will focus on determining elasto-plastic tensile properties from tests with a novel specimen design (Figure 1). The tests will be initially proved at room temperature with the intention to extend to high temperatures, to characterise time-dependent inelastic (creep) behaviour.

To get the most information from a small sample, it is proposed that digital image correlation (DIC) will be used to acquire full-field strain data during the tests Figure 2). The strain data from this technique will then be used as an input for the Virtual Fields Method (VFM), which is an inverse technique which predicts the material properties required to explain the deformation seen during the test. This can be employed to extract the full in-plane elasto-plastic constitutive parameters, and it is proposed that this could be extended further to cope with time dependent creep parameters. The ability to gain reliable creep strength information for an in-service part would represent a step change in nuclear plant lifing protocols and could help to make nuclear power safer and more cost effective in the years to come.

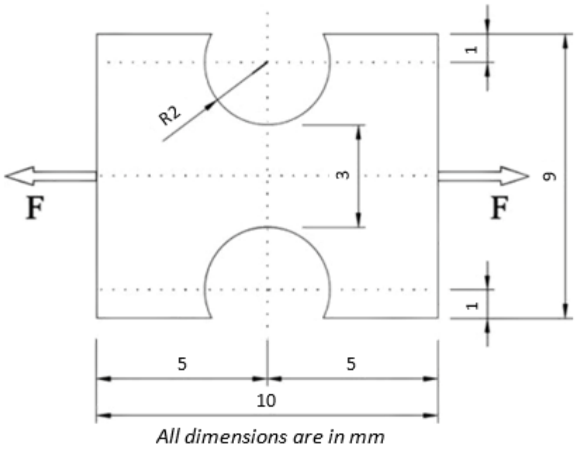

Figure 1: *Miniature waisted-specimen to be used in VFM analysis. (Adapted from [1])*

Figure 2: *DIC-Creep testing facility at OU*

Research Methods:

Tensile tests with waisted specimens cut from an isotropic material (e.g. 316L) with known constitutive parameters will be carried out at RT and high temperature. Compare VFM results with the published data.

1. Carry out similar tests as in 1 using specimens cut from an anisotropic material (e.g. rolled 316L sheet) at different orientations.
2. Carry out creep tests with a waisted specimen cut from an isotropic material. Develop VFM procedures to obtain creep behaviour of the material at various stresses using a single specimen.

References

[1] F. Pierron and Michel Grediac "The Virtual Fields Method", Springer, New York, 2012

Candidate Applications

Students should have a strong background in materials/metallurgy/physics, an interest it state-of-the-art materials characterisation techniques and a willingness to learn basic programming techniques. Experience of research in mechanics of materials is desirable. The student will join a well-established research group at the Open University, with a world class reputation in strain measurement.

Applicant must be willing to travel occasionally to attended international conferences or to use international research facilities when/if required.

Please contact Salih Gungor for further information (Salih.gungor@open.ac.uk).

Applications should include:

- 1000 word cover letter outlining how they are equipped in their educational background and expertise to conduct the research project,
- a CV including contact details of two academic references
- An Open University application form, downloadable from: http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process (Note: This is an Advertised studentship and you do not need to submit a proposal).
- IELTs English Language test scores on application. An average of 6.5 and no less than 6 in anyone of the four components. Applicant should have these results when applying.

Applications should be sent to **STEM-EI-Research@open.ac.uk** by 28 February 2019