Potential for Evaluating Residual Stress using Thermoelastic Stress Analysis

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1. Introduction

Thermoelastic Stress Analysis (TSA) is based on the small temperature changes that occur when a material is subject to a change in elastic strain, generally referred to as the 'thermoelastic effect'. It has been generally accepted that the linear form of the TSA relationship did not permit evaluations of residual stress; however, very small variations in the thermoelastic response resulting from the temperature dependence of elastic properties have enabled estimations to be performed. These variations in the thermoelastic response result in measured temperature change differences of a few mK, which are significantly less than those expected to be resolved in standard TSA. This work forms part of a project examining the potential of TSA to be used as a residual stress assessment tool, focusing on the change in thermoelastic constant, K, due to plastic deformation.

2. Motivation for Residual Stress Assessment

Destructive techniques	Non-destructive techniques
❖ Cheap	❖ Expensive
❖ Quick	❖ Time-consuming
❖ Destroy	❖ High-Skill

Requirement for a **CHEAPER**, **QUICKER** and **PORTABLE** non-contact, full field residual stress assessment technique.

✔ **T S A** has potential ⟹ but **very** small measurements
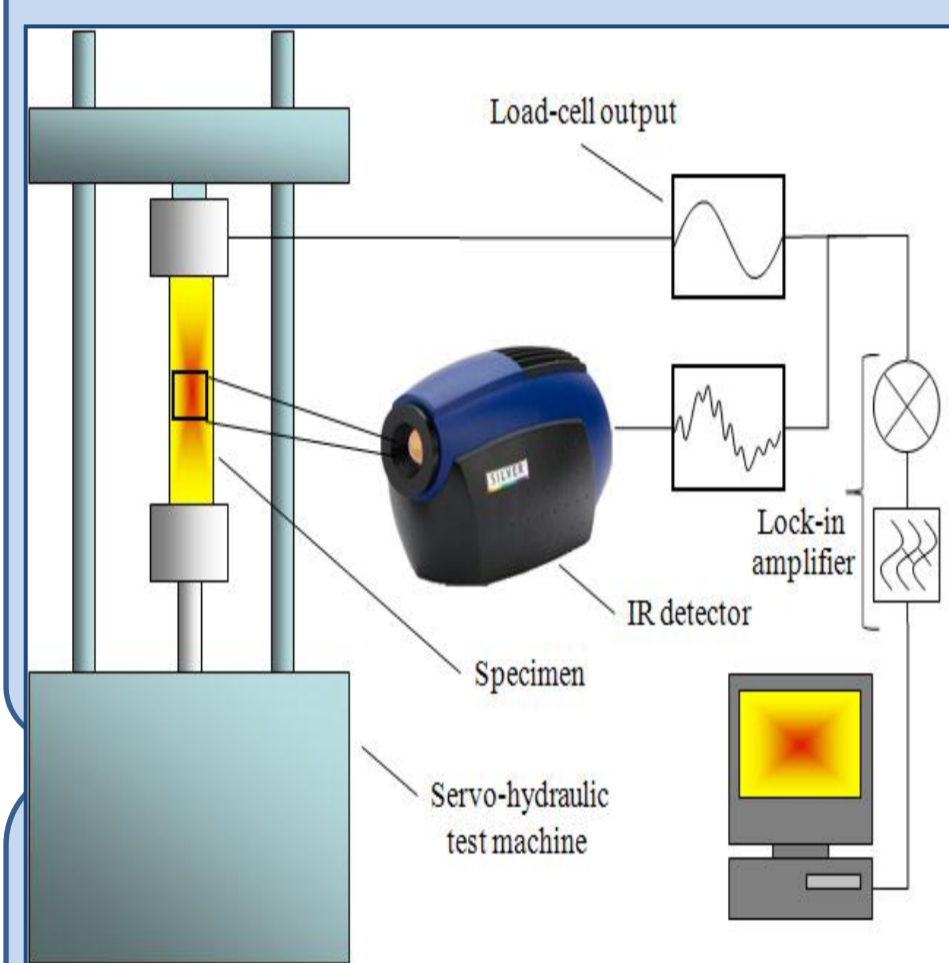
At present three approaches have been investigated for residual stress measurement using TSA. Two utilise the effect of mean stress on the thermoelastic response, the third investigates the effect of plastic deformation. This work examines the change in thermoelastic constant, K, due to plastic deformation

3. The change in thermoelastic constant K

• It has been shown that plastic strain modifies the thermoelastic constant, K, for some materials.

• If the change in K could be defined for a large range of plastic strain in a calibration specimen, the plastic strain in a component could be evaluated from a measured change in thermoelastic response.

• The residual stress contained within a component is related to the plastic strain that has occurred.

## 4a. Experimental Results – Stainless steel
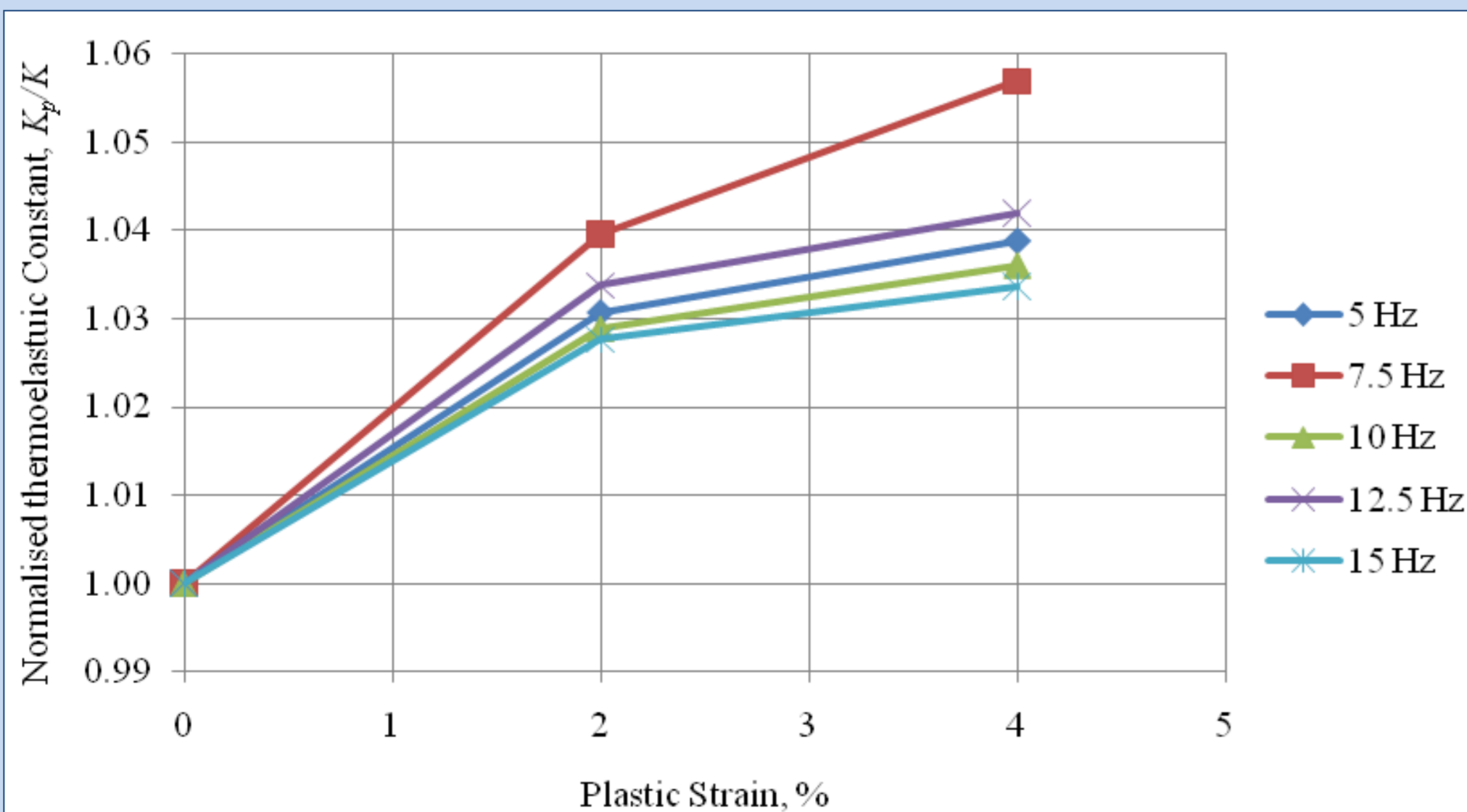
The thermoelastic constant for stainless steel 316L can be seen to increase with increasing plastic strain. Different loading frequencies have been used to evaluate the effect of the surface coating on the thermoelastic response.

4b. Experimental Results – Feasibility
Realistic components – Cold Expanded Holes
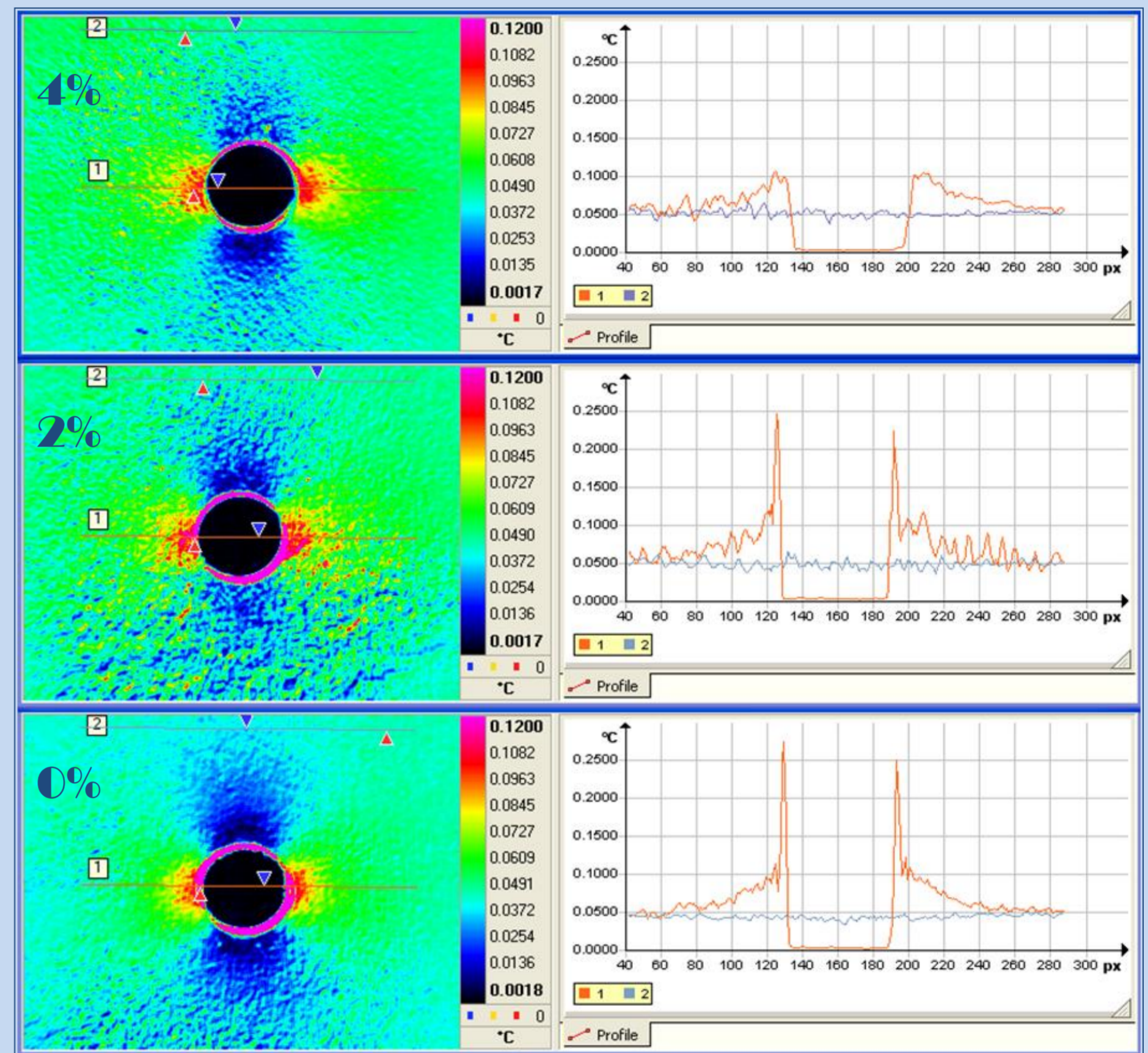
A variation in thermoelastic response from the areas around the cold expanded holes can be seen for each level of expansion (0%, 2%, 4%).
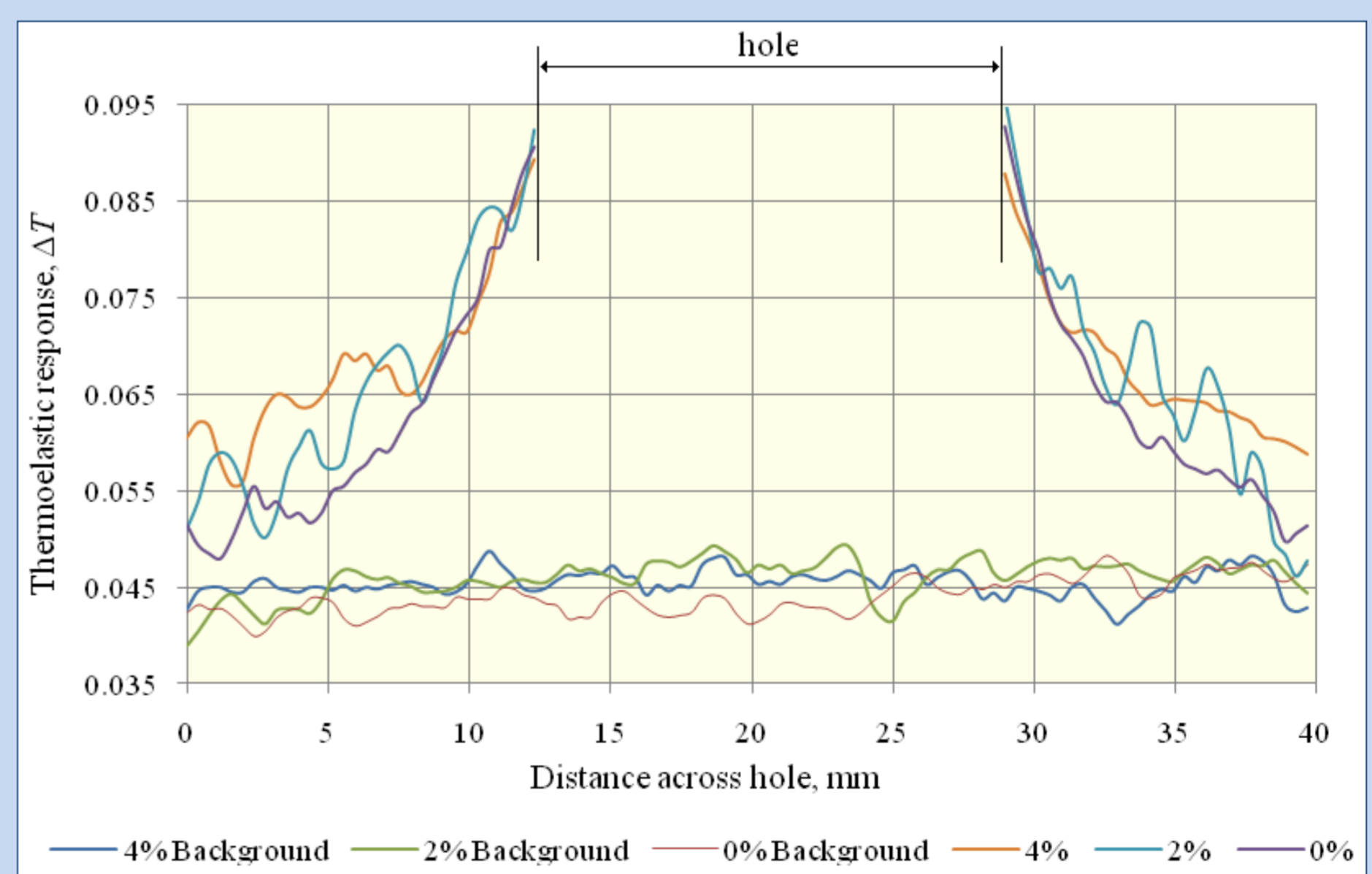
The differences in thermoelastic response could be due to the mean stress effect (which is prominent in aluminium) or plastic deformation due to hole expansion. Further work will investigate the origin of the changes. Noise can be seen around the holes and steps will be taken to minimise this, while maximising the thermoelastic signal and performing a point by point comparison of the data.

5. Conclusions

It is clear that the presence of residual stress modifies the thermoelastic response and that there *is* potential for TSA to be used as a residual stress assessment tool. These variations *are* detectable in realistic components, however the very small nature of the temperature change difference makes evaluation very difficult.