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# Invitation à la soutenance de thèse

## IMPLEMENTATION OF A DUAL HETEROGENEITY TEST IN STRESS AND TEMPERATURE FOR THE INVERSE IDENTIFICATION OF MATERIAL CONSTITUTIVE LAWS

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**10 Décembre 2025 à 14h**
Onera – Lille, Salle Kampé de Fériet

**Devant le jury composé de :**

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|---|---|---|
| Jean-Luc Bouvard | CEMEF, Mines Paris | Rapporteur |
| Benoît Blaysat | Institut Pascal, Université Clermont-Auvergne | Rapporteur |
| Julie Diani | LMS, École Polytechnique | Examinateur |
| Delphine Notta-Cuvier | INSA-Haut-de-France | Examinateur |
| Rian Seghir | Ecole Centrale de Nantes | Examinateur |
| Fabrice Pierron | MatchID Nv, Ghent University | Co-directeur de thèse |
| Bertrand Langrand | ONERA | Co-directeur de thèse |
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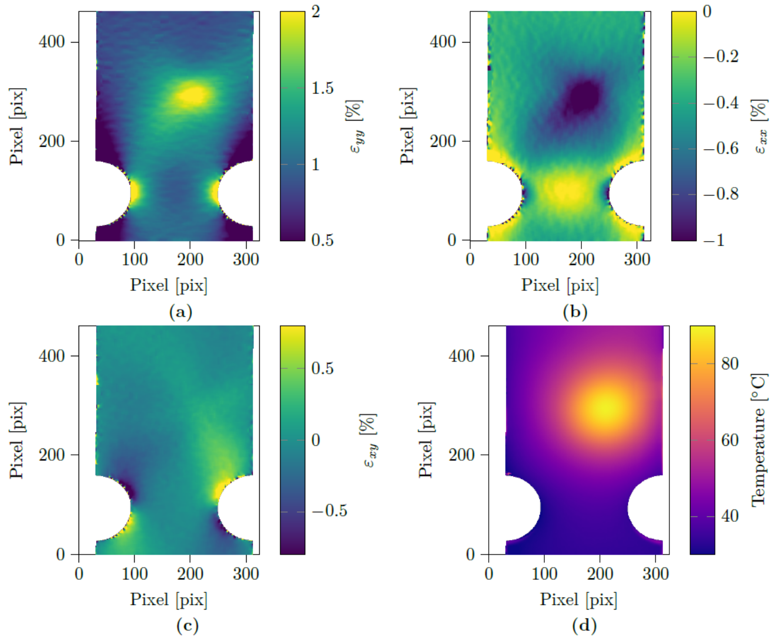
**Résumé**

This thesis work aims at implementing a test presenting two heterogeneities in stress and temperature for material characterisation. In the aerospace industry, certification programs are increasingly relying on model and simulation to reduce the number of physical tests performed upon structures. This virtual certification process relies on the predictive capabilities of the constitutive models for materials undergoing complex thermomechanical loadings. Standard material characterisation procedures are generally performed on normalised specimens and are based on assumptions of static equilibrium (i.e., statically determined) difficult to respect in practice and leading to large number of tests. With the recent developments of full-field optical measurement techniques for both kinematic and thermal quantities, there has been growing interest in developing statically indeterminate approaches for material characterisation based on heterogeneous experimental data, allowing to reduce the number of tests. This new experimental paradigm has been referred to as Material Testing 2.0. Until now, these approaches have primarily been applied to tests involving heterogeneities in strain and strain rate only. While recent studies have explored tests involving both strain rate and temperature gradients, those tests relied on temperature gradients generated by Gleeble thermomechanical testing machines and remain limited in terms of achievable temperature ranges.

In this work, a novel experimental design is developed for the introduction of the temperature gradient, allowing for control over the heat source position and the generated temperature range. For this proof of concept, a viscoelastic polymer (PMMA) is chosen for its sensitivity to temperature at low temperature ranges. The Virtual Fields Method is picked for the material characterisation. Numerical investigation

shows its reliability for the characterisation of linear viscoelastic behaviour for both isothermal and non-isothermal conditions. On the experimental part, a heating methodology is introduced for the generation of the thermal gradient. Then a methodology is introduced employing tools that enable the Lagrangian tracking of both kinematic and thermal data within the same reference frame. Measurement biases introduced by the presence of a heterogeneous temperature field in the specimen are then analysed. Finally, an experimental campaign is carried out with the developed methodology for the characterisation of PMMA.




*Kinematic and temperature fields obtained with the experimental protocol*

### Mots clés

Virtual Fields Method, Linear viscoelasticity, Optimisation, Thermomechanical heterogeneity, Generalized Maxwell model, Time-temperature superposition, Laplace transform