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# Inverse Identification of Asymmetric Creep Parameters Using the I-DIC Technique

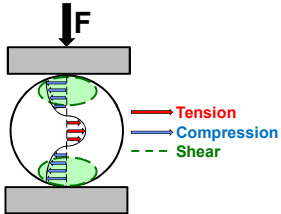
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Advanced Thermomechanical multiscale mODelling of Refractory Linings

## 1 – Introduction:

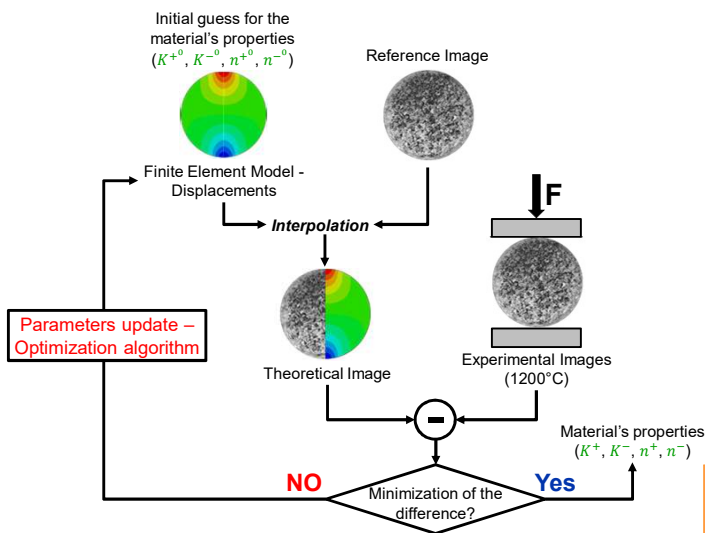
- The **creep characterization of refractory materials** at high temperatures requires **complex tests**
- This work intends to apply the **Integrated Digital Image Correlation** technique to the determination of the **secondary creep properties of refractories at high temperatures**
- It's expected to fully characterize the materials (tension, compression and shear) using a **reduced number of tests**, making use of the Brazilian test
- Images taken at **1200°C** were **virtually deformed** using an **asymmetric creep law** (different behavior under tension and compression) with known materials' parameters. Later, starting from an initial guess for the parameters, an inverse identification was run to check the I-DIC software robustness

## 2 – Brazilian test:



The **Brazilian test** presents a complex stress distribution, with **tension, compression and shear** observed in the sample at the same time. This allows the identification of the asymmetric behavior using a **reduce number of tests**

## 3 – I-DIC algorithm:



## 4 – Mathematical model:

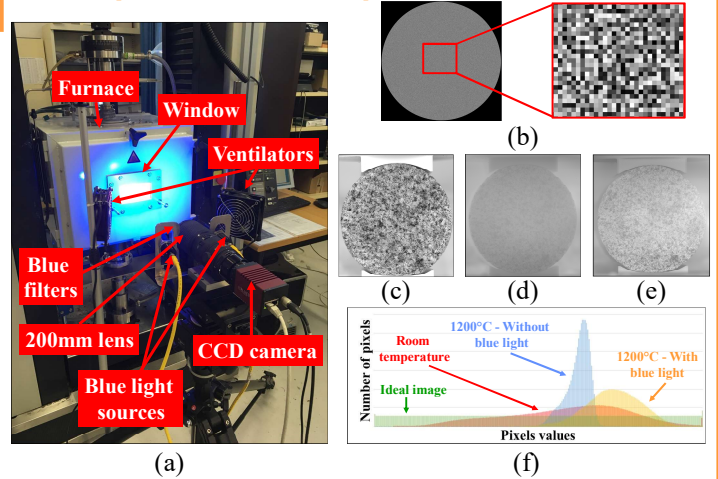
Asymmetric viscoplastic strain rate<sup>1</sup>

$$\dot{\epsilon}^p = \frac{3}{2} \frac{s^+}{\sigma_{eq}^+} \left( \frac{\langle \sigma_{eq}^+ - \sigma_y^+ \rangle}{K^+} \right)^{n^+} - \frac{3}{2} \frac{s^-}{\sigma_{eq}^-} \left( \frac{\langle \sigma_{eq}^- - \sigma_y^- \rangle}{K^-} \right)^{n^-}$$

where  $\sigma_y$  is the yield stress,  $s$  is the deviatoric stress and  $\sigma_{eq}$  is the von Mises stress.

<sup>1</sup>E. Blond, N. Schmitt, F. Hild, P. Blumenfeld, J. Poirier, Journal of the European Ceramic Society, 25(11) 1819-1827 (2005).

## 5 – Experimental setup:



(a) High temperature test setup and Brazilian test samples used with I-DIC. (b) Virtual image. (c) Room temperature. (d) 1200°C without using the blue lights. (e) 1200°C using the blue lights. (f) Images' histograms.

## 6 – Results:

A Genetic Algorithm was used to perform the inverse identification of the parameters. Tables 1 and 2 show the reference values used to create the deformed images, the range of variation used in the optimization and the identification results.

Table 1 – Reference values for the creep properties

	Reference values		Range of variation	
	Tension	$K^+ = 5773.5$	$n^+ = 2$	$K_{min}^+ = 5000$
$n_{max}^+ = 2.2$				$n_{min}^+ = 1.8$
Compression		$K^- = 1.0 \times 10^6$	$n^- = 1.5$	$K_{min}^- = 5.0 \times 10^5$
	$n_{max}^- = 1.8$			$n_{min}^- = 1.2$

Table 2 – Three best solutions given by the Genetic Algorithm

	Solution 1		Solution 2		Solution 3	
	Value	Error	Value	Error	Value	Error
$K^+$	5127.6	-11.19%	5543.3	-3.99%	5264.70	-8.81%
$n^+$	2.01	0.27%	1.99	-0.46%	1.99	-0.58%
$K^-$	9.71E+05	-2.91%	1.25E+06	24.97%	1.08E+06	8.14%
$n^-$	1.51	0.71%	1.48	-1.10%	1.51	0.35%

## 7 – Conclusions:

- The **I-DIC technique** is a convenient option to perform **inverse identification of mechanical parameters at high temperatures**
- For future works, the creep parameters of refractory materials will be identified using **experimental images**

## ESR Position 09

## Supervisors & University

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