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OPEN PhD POSITION
in European Training Network (ETN)

We are looking for a dedicated and highly motivated Early Stage Researcher (ESR), who will join our team to craft the future of ceramic materials and large structures for high temperature industrial applications.

ATHOR description (4 years ETN project starting in October 2017)

Refractories are heat-resistant materials used as inner linings of high temperature furnaces, reactors and processing units. ATHOR (Advanced THermomechanical multiscale mOdeling of Refractory linings) is an innovative, collaborative and interdisciplinary project that brings together 6 academic beneficiaries and 8 private partners. The main objective is to develop high-end engineering technologies in material engineering and numerical simulations thanks to an intensive cooperation between academia, raw materials suppliers, refractory producers and end-users. Starting from material characterization, all significant properties will be investigated, including fracture behaviour, tension and compression creep behaviour, corrosion and thermal shock resistance. The interdisciplinary aspects will be addressed thanks to a multiscale approach looking at the influences of micro-, meso- and macro-characteristics on each other. To conduct their research and interlink the different topics, the 15 recruited researchers will take advantage of the most sophisticated numerical tools to model, design and predict the life of different lining configurations in critical operation conditions. The ATHOR network is deeply committed to provide a combination of research and training activities which will support and enlarge the initiative of the Federation for International Refractory Research and Education (**FIRE**).

Specific subject of ESR3 (one of 15 ESRs of the ATHOR ETN project)

Micro-mechanical approach with the discrete element method

Objectives: To conduct developments of numerical tools based on the discrete element method (DEM) for investigation of the relationships between microstructure and thermomechanical properties of model materials. These developments include debonding, thermomechanical coupling, crack-closure and anisotropic behaviours. These developments will lead to a "virtual numerical lab" able to provide tensile, dilatometry, fracture mechanics or thermal shock virtual tests for virtual characterizations. The related developments will be integrated to the free DEM software **GranOO** in order to promote the dissemination of this innovative and original numerical field. The coupling with the Finite Element Method (FEM) may also be investigated to enhance multi-scale modelling taking into account complex boundary conditions.

Expected Results: Validation of the method in regards to experimental observations provided by other WP in terms of (i) mesoscopic thermomechanical properties such as Coefficient of Thermal Expansion , Young's modulus, Poisson's ratio and fracture toughness and (ii) microscopic observations such as fracture coalescence under thermal and mechanical loadings dynamically observed in scanning electron microscopy. Proposition of simple laws to optimize the microstructure design that drives thermomechanical strength for model refractories. Tackle some scientific locks such as no stress-strain constitutive laws and descriptions, fastidious calibration of key parameters that limit the usage of DEM by industrial actors.

Keywords: Refractories, thermal properties, mechanics, discrete element, thermal mechanics, cracks

Applicant Profile: Master level in Materials Science with an excellent background in continuum mechanics and numerical methods in applied mechanics. Excellent communication skills (both written and oral) in English. C++ and python programming skills will be appreciated.

PhD main locations: The recruited ESR is given the opportunity to conduct 3 years of PhD studies at the **SPCTS** (Science des Procédés Céramiques et de Traitements de Surface) research laboratory (UMR **CNRS** 7315) installed in the Centre Européen de la Céramique (**CEC**) belong to the **University of Limoges**, France, but also to visit other network partners for secondments (**COC - Leoben**, **ALTEO - Gardanne**), and to attend the training events of the network.

Main contacts:

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More details about ATHOR project, requirements for the candidates and recruitment procedure:
https://ucloud.unilim.fr/public/etn-athor_project_and_esrs_recruitment_procedure.pdf

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