**ANNEXE 1**

# Entreprises, pour proposer un sujet de thèse soutenue par le dispositif CIFRE, merci de remplir les champs suivants, et d'envoyer le document à : cifre@anrt.asso.fr

*Si vous souhaitez ajouter un descriptif plus détaillé de l'offre à votre annonce, merci de le joindre accompagné de ce formulaire.*

- **Nom de l'entreprise* :** ESI Group
- **Ville et code postal* :** 94513 Rungis (close to Paris)
- **Nom du laboratoire académique partenaire (si déjà connu) :** IRDL – Lorient - France
- **Numéro de reconnaissance du laboratoire :** FRE CNRS 3744
- **Thématique de recherche en une phrase *(sans aucun caractère confidentiel)* * :**

Virtual forming of metallic sheet materials: influence of complex strain paths on service life prediction

- **Descriptif de la thématique de recherche *(sans aucun caractère confidentiel)* *** :

The project takes place within the general framework of the virtual forming of metallic sheet structures, like automotive structural parts, that undergo firstly deep drawing operations involving large equivalent plastic strains and ductile damage, and secondly cyclic loadings during their lifetime. To gain weight via decreasing the material thickness, accurate and predictive new models of the material behavior should be used, that will consider both the forming steps and the subsequent in-service loadings.

cf. the two following pages for a detailed presentation

- **Descriptif du poste* :** The PhD student will conduct the work mainly at IRDL (Lorient – France) in interaction with ESI Group (Rungis) and as part of a global project with Troyes (France) and Seoul (South Korea).
- **Date de recrutement* :** 1rst October 2017
- **Adresse e-mail à laquelle le candidat doit envoyer sa candidature* :**

sandrine.thuillier@univ-ubs.fr

*champs obligatoires

IRDL - FRE CNRS 3744
Université Bretagne Sud/University of South Brittany
Rue de Saint Maudé – BP92116
56321 Lorient Cedex – FRANCE
http://irdl.fr/

ESI Group
Parc d'Affaires SILIC
99 rue des Solets – BP 80112
94513 Rungis Cedex - FRANCE
https://www.esi-group.com

PhD proposal
CIFRE fellowship between UBS – ESI Group

**Virtual forming of metallic sheet materials: influence of complex strain paths on service life prediction**

Academic supervisors: Pr Sandrine THUILLIER – Pr Pierre-Yves MANACH
Industrial supervisor: Mr Jean-Louis DUVAL
Date of recruitment: October 2017 (after validation by ANRT)
Duration: 3 years
How to apply: send CV+motivation letter+grades by email to S. Thuillier
**sandrine.thuillier@univ-ubs.fr**

The project takes place within the general framework of the virtual forming of metallic sheet structures, like automotive structural parts, that undergo firstly deep drawing operations involving large equivalent plastic strains and ductile damage, and secondly cyclic loadings during their lifetime. To gain weight via decreasing the material thickness, accurate and predictive new models of the material behavior should be developed, that will consider both the forming steps and the subsequent in-service loadings.

This PhD study is part of a global project in virtual forming, aiming at developing an original model for the static and cyclic mechanical behavior of metallic sheets, including ductile damage and rupture. ESI Group coordinates this project, which involves three academic partners: University of Technology of Troyes in France (Troyes, France), Seoul University (South Korea) and IRDL, University of South Brittany (Lorient, France). Two advanced models [1,2] of the mechanical behavior at room temperature of metallic materials, taking account of strain path changes, are already implemented in finite element codes. As these models involve complex hardening, anisotropy and its evolution with strain, viscosity, ductile damage and rupture, a dedicated and reliable procedure to identify material parameters should be proposed. Moreover, such models aim at representing finely the mechanical behavior of materials and should give accurate predictions of the service life of a part based on the final state reached after forming. Therefore, **the aim of the PhD** is to investigate the influence of the forming step on the service life of a structural part, with a special focus on the identification procedure of material parameters and on the validation for forming and in-life predictions. A combined experimental and numerical approach is to be developed.

**A first part** of the study is dedicated to the identification of material parameters. Conventional tests, like tension on straight or notched samples, simple shear, plane strain tension, biaxial tension [3,4] as well as heterogeneous tests [3,5] will be considered. This step should lead to a reliable parameter set; indeed, as the number of material parameters increases with the model complexity, issues related to the stability of the solution will also be addressed. Moreover, dedicated indicators relevant to analyze the quality of the mechanical information related to a specific test, with regards to the mechanical model, must be proposed, to build a reliable database for the identification.

**Secondly**, a validation step is necessary, to highlight the interest of such models. Validation should involve multi-step forming operations and loadings representative of in-service conditions. IRDL has gained a recognized competence in developing specific devices to represent, at the laboratory scale, phenomena occurring at a larger scale in the industry, e.g. for surface defects [6], hemming [7] and twisting [8], and up to rupture [4,9].

**Finally**, the industrial aim is to contribute to the development of optimization of material parameters for complex models involving a large number of parameters, within the dedicated ESI product Virtual Material Lab, which is still under development. The idea is to provide to the end user a numerical tool to determine the optimal number and type of tests necessary for the identification.

The PhD student will conduct this work mainly at IRDL (Lorient – France) in interaction with ESI. Due to the international collaboration of the global project, the applicant should have a good level in English.
Skills: numerical simulation with finite element codes (Abaqus, PAM-STAMP), constitutive equations, mechanical tests and post-processing of data, digital image correlation data post-processing and comparison with experiments, optimization algorithms for material parameters identification.

References

[1] F. Barlat, G. Vincze, J.J. Gracio, M.G. Lee, E.F. Rauch, C. Tomé, *Enhancements of homogenous anisotropic hardening model and application to mild and dual-phase steels* International Journal of Plasticity 58 (2014) 201-218
[2] K. Saanouni *Damage Mechanics in Metal Forming: Advanced Modeling and Numerical Simulation* ISTE, John Wiley & Sons, London (2012)
[3] S. Zhang, L. Léotoing, D. Guines, S. Thuillier, S. Zang, *Calibration of anisotropic yield criterion with conventional tests or biaxial test*, International Journal of Mechanical Sciences 85 (2014) 142-151
[4] N. Souto, A. G. Andrade-Campos, S. Thuillier, *Material parameter identification within an integrated methodology considering anisotropy, hardening and rupture*, accepted in Journal of Materials Processing Technology (2015)
[5] S. Zhang, L. Léotoing, D. Guines, S. Thuillier, *Potential of the cross biaxial test for anisotropy characterization based on heterogeneous strain field*, accepted in Experimental Mechanics (2014)
[6] A. Le Port, S. Thuillier, P.Y. Manach, *Characterization of surface defects after flanging of metallic sheets*, Journal of Materials Processing Technology 211 (2011) 2062-2071
[7] N. Le Maoût, P.Y. Manach, S. Thuillier, *Influence of prestrain on the numerical simulation of the roller hemming process*, Journal of Materials Processing Technology 212 (2012) 450-457
[8] C.H. Pham, S. Thuillier, P.Y. Manach, *Twisting analysis of ultra-thin metallic sheets*, Journal of Materials Processing Technology 214 (2014) 844-855
[9] A. Kacem, A. Krichen, P.Y. Manach, S. Thuillier, Y.W. Yoon, *Damage prediction in the hole-flanging process of aluminium alloys*, Engineering Fracture Mechanics 99 (2013) 251-265 Engineering Fracture Mechanics (2013)