OUTCOME

PhD position in Marie Skłodowska-Curie ITN-ETN

The outstanding challenge in Solid Mechanics: engineering structures subjected to extreme loading conditions

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In this project we aim to train early-stage researchers in what is referred to as an outstanding challenge in solid mechanics: developing novel solutions for the analysis and design of aerospace and defense structures subjected to extreme loading conditions. Structural elements used in aerospace and defense industries are frequently subjected to a large variety of unusually severe thermo-mechanical solicitations. One easily realizes that this type of structures (e.g. components for satellites) has to be designed to sustain extreme temperatures, which may vary hundred degrees in short periods of time, and extreme mechanical loadings like hypervelocity impacts. New specific structural solutions are constantly developed to fulfill such requirements, which place these industrial sectors in the forefront of the technological innovation. We have formed a consortium composed of 3 academic and 4 industrial partners which aims at developing specific training for early-stage researchers within the field of aerospace and defense structures subjected to severe thermo-mechanical loads. The leitmotif of this ITN is to train creative and innovative researchers ready to face structural-engineering challenges which arise in the vanguard of technological innovation. OUTCOME is a unique opportunity for 8 motivated early-stage researchers that are willing to set the basis of their scientific career within the field of Solid Mechanics.

PhD Research

A new convex yield function to model the ductile damage of structures under extreme loading conditions

Host

Universidad Carlos III of Madrid

Supervisor

Professor Guadalupe Vadillo

Synopsis

The derivation of the Gurson yield function relies on spherical and cylindrical voids with the simplifying assumption that the matrix surrounding the void is perfectly plastic. The model was afterwards modified by introducing two parameters, q_1 and q_2, to adjust the predictions to numerical results of cylindrical and spherical voids in strain hardening materials. The Gurson-Tvergaard-Needleman (GTN) model is given in terms of a macroscopic yield criterion and the evolution law of a single microscopic variable, the void volume fraction. Despite the apparent success and wide popularity of the GTN model in predicting ductile damage, it still suffers from several limitations such as its inaccuracy to properly model material effects as strain rate hardening and thermal softening or its inapplicability to model ductile damage under low stress triaxiality (shear dominated deformations). While considerable

improvements have been made on the study of void growth and coalescence in porous viscoplastic solids, further research still need to be done in order to resolve the interplay of strain rate hardening and thermal softening on the damage evolution of ductile materials, specifically under shear dominated problems.

Research outputs

An original **yield function** which, as distinctive feature, includes strain rate hardening and temperature dependences of the material flow stress. The yield function will be implemented into a Finite Element code (ABAQUS) to predict practical cases of damage development in aerospace and defense structural materials.

Multidisciplinary / intersectoral research approach:

The ESR will develop at the **University Carlos III of Madrid** the main issues of the mathematical formulation of a new Gurson-type yield function which shall include the effects of material strain rate hardening and thermal softening. The ESR will conduct a secondment at the **TECHNION** where she/he will perform experiments using rate and temperature sensitive ductile metals for validation of the new yield function that will be developed. Additionally, the ESR will conduct a secondment in France and visit the **University of Lorraine** and **CIMULEC**. At the University of Lorraine he/she will incorporate strain rate hardening effects in the new yield function to be proposed. At CIMULEC he/she will analyze and model (real) practical applications in which ductile damage endangers the integrity of printed circuit boards.

Training activities

The successful candidate will have access to the PhD program of the **University Carlos III of Madrid** as well as to the training activities organized within the OUTCOME consortium. These activities include, among others:

- **Attendance to the Workshop**: Extreme structural mechanics in aerospace applications to be organized by AEROSERTEC in Madrid.
- **Attendance to the Workshop**: Extreme structural mechanics in defense applications to be organized by RAFAEL in HAIFA.
- **Attendance to the course**: Horizon 2020 Proposal Development to be organized by EUROPA Media in Budapest.
- **Attendance of the course:** Damage and failure of solids subjected to extreme loading conditions to be organized by the University of Lorraine.
- **Attendance to the course**: From PhD to Scientific Leadership to be organized by Yellow Research in Madrid.
- **Attendance to international conferences** on damage and failure of engineering materials.

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Benefits

The successful candidate will be employed for 3 years and receive a **financial package plus an additional mobility and family allowance** according to the rules for Early Stage Researchers (ESRs) in an EU Marie Skłodowska-Curie Actions Innovative Training Networks (ITN):

- Living allowance – 3035.36€ (per month)
- Mobility allowance – 600€ (per month)
- Family allowance – 500€ (per month – if applicable)

This amount is a gross contribution to the salary costs. Net salary will result from deducting all compulsory social security/direct taxes from the gross salary according to the law applicable to the agreement concluded with the ESR.

Additional information about the funding provided by the ITN projects can be found in: http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-msca_en.pdf

Key publications

Tvergaard, V. Influence of voids on shear band instabilities under plane strain conditions. *International Journal of Fracture.* 1981; 17: 389-407.

Tvergaard, V. On localization in ductile materials containing spherical voids. *International Journal of Fracture*. 1982; 18: 237-252.

Gurson, A.L. Continuum theory of ductile rupture by void nucleation and growth part I. yield criteria and flow rules for porous ductile media. *Journal of Engineering Materials and Technology*. 1977; 99: 2-15.

Vadillo, G., Zaera, R., Fernández-Sáez, J. Consistent integration of the constitutive equations of Gurson materials under adiabatic conditions. *Computer Methods in Applied Mechanics and Engineering*, 2008; 197:1280-1295

Vadillo, G., Fernández-Sáez, J. An analysis of Gurson model with parameters dependent on triaxiality based on unitary cells. *European Journal of Mechanics* A/Solids. 2009; 28: 417-427

Vadillo, G., Reboul, J., Fernández-Sáez, J. A modified Gurson model to account for the influence of the Lode parameter at high triaxialities. *European Journal of Mechanics A/Solids*. 2016; 56: 31-44

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Profile

We are looking for highly motivated candidates who want to pursue a scientific career in mechanical engineering (academic or industrial). An ideal candidate would have a background in mechanical or civil engineering, physics or mathematics and a strong interest in collaborating with a team working attitude in an interdisciplinary project. Good communication in English is required.

To apply for the proposed Thesis, and in order to meet the specific requirements of the Marie Skłodowska-Curie funded PhDs, the candidates must not have resided or carried out their main activity (work, studies…) in **Spain** for more than 12 months in the last 3 years. Candidates must have a MSc degree or obtain a MSc degree by August 2016.

Applications

The candidates must provide a letter of motivation where they clearly state why, under their point of view, they should be enrolled in OUTCOME.

At least, one recommendation letter from the scientist/s who mentored the candidate during his/her master studies is required. The letter must clearly expose the profile of the candidate with emphasis in the qualities which make him/her suitable for being recruited in OUTCOME. Additional recommendation letters from any other professor/professional will be welcomed.

We are committed to provide flexible hours and home working conditions for researchers having family obligations. The following web-site contains relevant information **related to the EU equal opportunities policy** https://ec.europa.eu/research/science-society/women/wir/index_en.html. Moreover, the web-site http://www.partnerjob.com/ facilitates geographic mobility by providing help to find a job for an accompanying partner.

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Contact details

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The application period closes in June 2016

The PhD starts in September 2016