Internship at ISAE-SUPAERO / ICA for six/eight month

Title: Dynamic behavior modeling of the materials constituting a ceramic-composite protective structure: High velocity impact of ceramic-composite human protection

Supervisor : Pr. Frédéric LACHAUD / Pr. Eric PAROISSIEN

1) Background

This work concerns the study failure of specific composite plates for human protection.

Nowadays, one of the main challenges encountered in the field of defense is the development of high-performance light structures for the protection of personnel, more specifically in the context of protection of combatants. Indeed, man has always known conflicts in which he had to protect from external threats to survive. The first Western armors found date from 500 years BC in present-day Greece and were made of bronze and leather. They were meant to protect themselves. slashing and stun weapons in hand-to-hand combat. These protections have evolved over the centuries in order to adapt to the evolution of armaments. Today, the threats faced by soldiers during conflicts are mainly ballistic (firearm ammunition, shrapnel, etc.). The protections for this type of threat are bulletproof vests. A bulletproof vest is ballistic protective equipment, intended to protect the vital organs of the rib cage against the terminal effects of a projectile, by opposing its penetration and by absorbing the energy delivered by the projectile to the 'impact.

ISAE-SUPAERO and Institut Clément Ader work on the design of a specific composite panel for human protection. In order to predict damage and failure during high velocity impact loadings, numerical models have to introduce failure, damage and delamination propagation.

Materials used is bulk ceramic and polyethylene laminates. A mechanical characterization was carried out on a previous study in order to investigate their behavior under static and dynamic loadings and to determine the properties and parameters of the selected constitutive models. Specific tests have been carried out such as plate impact tests on ceramic or laboratory projectile impact on the composite alone. A diffuse damage model was selected for the composite to describe the failure mechanisms observed during tests, up to perforation. Regarding ceramics, a probabilistic behavior model and an equation of state capable of representing anisotropic damage in dynamic tension, and an elastoplastic-like behavior in compression for fragmented ceramics has been proposed. This model has been implemented in Abaqus® Explicit in the form of a user material model.

The numerical models initially developed during Camalet's thesis are available.

2) **The Internship**

In this context the objective of the intern is:

Bibliography

- Damage and failure of composite laminates
- Cohesive zone model
- Delamination of composite materials

Training 10 h(teacher: Frédéric LACHAUD)

- *Specific Damage and failure courses of composites materials*
- *Abaqus UMAT and VUMAT creation*
- *How to realize a good experimental/numerical tests*

Test campaign

- New Test for delamination initiation identification (3 pts bending, L-Shape 4 pts bending…etc)
- New test for failure energy caracterisationCT, CC, SENB sample for examples
- Impact test of 3 materials composite plate (ceramics, interface, UD polyethylene laminate)

Numerical approach

- Validation of the VUMAT model according some meso-scale sample,
- Fracture mechanic test modelling with different numerical methods,
- Impact modeling on Abaqus explicit / LSDYNA composite plates
- Perform comparison study for high velocity impact tests.

The candidate should have knowledge on composite materials, FE modeling, and design of aircrafts.

This research internship is in collaboration with DGA

To apply

Date: from October/November 2022 to April/May 2023 or March 2023 to August/September 2023

Duration: 6/8 months

Remuneration: 650¤ per month

Contacts : send a CV and letter

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References

- Tristant CAMALET

Caractérisation et modélisation du comportement dynamique des matériaux constituant une structure de protection céramique-composite. These de l'Université de Strasbourg 2020.

- Long H. Nguyen a, c, *, Shannon Ryan b, c, Stephen J. Cimpoeru b, c, Adrian P. Mouritz a, Adrian C. Orifici a

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Mark K. Hazzarda,b,∗, Richard S. Traska, Ulrich Heissererb, Mirre Van Der Kampb,Stephen R. Halletta
Finite element modelling of Dyneema® composites: From quasi-static rates to ballistic impact
https://doi.org/10.1016/j.compositesa.2018.09.005