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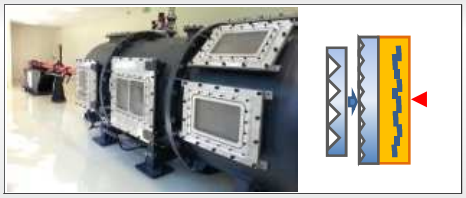
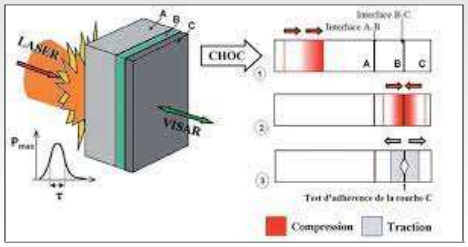
Analysis and numerical modelling of dynamic fragmentation processes in brittle materials over a wide strain-rate range

CONTEXT AND AIM OF THE PHD THESIS

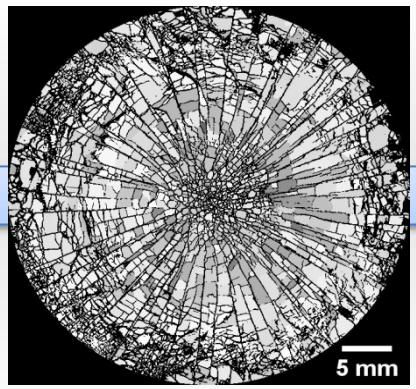
The analysis of multiple fragmentation processes involved in brittle materials, such as armour ceramics and ultra-high strength concretes, at high strain-rates has been a key area of the Brittle's CODEX chair developed for the last six years in 3SR research laboratory. Original experimental configurations, such as the shockless plate-impact spalling test, have been developed to experimentally characterize the dynamic strength and cracking density as a function of the strain rate in different brittle materials. However, many shortcomings persist in terms of range of loading-rates, location of the spalling area and quantification of the cracking density generated at high loading rates. In addition, discrete and continuous modelling approaches, although based on data of microtomography analysis, struggle to explain the cracking densities observed experimentally. This project proposes to develop new experimental configurations to refine the characterization of dynamic fragmentation processes over a much wider range of strain rates. Moreover, the development of numerical simulations based on a phase-field method will allow taking into account for the dissipated cracking energy of the material making it possible to better describe the phenomena of crack propagation at work in the processes of dynamic fragmentation. Finally, the numerical work should highlight the role of material parameters supposed to drive the high-strain-rate tensile strength of heterogeneous brittle materials.



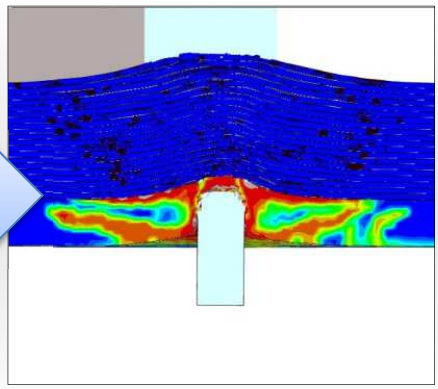
Shockless plate impact (3SR)



Laser shock for spalling test (ENSTA)



Micro-tomography analysis (3SR)



Numerical simulation (3SR, ENSTA)

KEYWORDS: Ceramics, Armour, Damage and fragmentation, Plate-impact experiments, Numerical modelling

HOST: 3SR Laboratory, Univ. Grenoble Alpes, Grenoble; ENSTA Bretagne, Brest

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CANDIDATE PROFILE

Level:	Master or engineering school (Bac +5)
Results in master:	Outstanding results
Fields:	Mechanics, materials, space and aircraft industry
Nationality:	No specifications

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 good background in mechanical or civil engineering, physics or applied mathematics, with strong analytical and computational skills and with interest for collaborating in an interdisciplinary project with a team-working attitude. Good communication in English is required.

APPLICATION

The candidates must provide a letter of motivation where they clearly state why, under their point of view, they should be enrolled in the project. At least, one recommendation letter from the scientist/s who mentored the candidate during her/his master studies is required. The letter must clearly expose the profile of the candidate with emphasis on the qualities making her/him suitable for being recruited. Additional recommendation letters from any other professor/professional will be welcomed.

BENEFITS

The successful candidate will be employed for 3 years and receive a salary about 2000 € per month. The PhD thesis will be conducted in relation with Saint-Gobain-Research Provence centre near Cavaillon, France.

REFERENCES

- Analysis of damage in impacted ceramics by means of X-ray micro-tomography analysis

Forquin P., Ando E. (2017) Application of micro-tomography and image analysis to the quantification of fragmentation in ceramics after impact loading. Phil. Trans. R. Soc. A 20160166. DOI: 10.1098/rsta.2016.0166.

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- Investigation of the tensile strength of armour ceramics by means of shockless spalling tests

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- Continuous and discrete approaches for modelling the dynamic fragmentation process

Forquin P., Blasone M., Georges D., Dargaud M. (2021) Continuous and discrete methods based on X-ray computed-tomography to model the fragmentation process in brittle solids over a wide range of strain-rates-application to three brittle materials, J. Mechanics and Physics of Solids, 152, 104412, DOI: 10.1016/j.jmps.2021.104412.

- Investigation of spallation process by laser induced shockwave testing

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Start of PhD thesis: from October 1st, 2023 to December 1st, 2023