PhD in Mechanical Engineering

Research Title: Innovative tensile testing for brittle materials

Funded by
DIMEAS

Supervisors
Massimo Rossetto, massimo.rossetto@polito.it
Giorgio Chiandussi, giorgio.chiandussi@polito.it
Davide S. Paolino, davide.paolino@polito.it
Lorenzo Peroni, lorenzo.peroni@polito.it

Contact
http://www.dimeas.polito.it/en/research/research_groups/mechanics_of_materials_and_joints

Advanced engineering ceramics and carbon-carbon composites (C/C) have a number of material properties that have made them one of the most important classes of engineering materials. They have an extremely high specific strength and elastic modulus, maintain consistent performance at elevated temperatures, and have great resistance to wear and corrosion, which has contributed to their widespread use as bearing surfaces, heat resistance, and insulation applications (e.g., brake rotors and pads, space re-entry vehicle heat shields, and ball bearings in high speed and high temperature applications).

The strength properties of ceramics and C/C can be greatly reduced by the presence of internal and surface imperfections. When tensile tested, specimens are prone to fail close to the grip-sample interface. This is a clear sign of surface damage or internal crack initiation due to poor or improper testing procedures.

Several international standards (ASTM C1273, C1275, C1360, C1361) for tensile testing of ceramics are available. For carrying out standardized tests, specific and expensive
Fixtures and specimens are recommended but, despite that, anomalous failures may occur while testing. Therefore, the development of an effective and inexpensive procedure for the tensile testing of ceramics and C/C is a relevant research topic for engineers. The present research aims to overcome the limitations of the mechanical investigation of materials for getting the most complete analysis and modelling of materials behavior: up to now, the identification of strength and failure material models, especially in case of high strain-rates and temperatures, depends on the experimental results achievable by using facilities and testing procedures developed decades ago. In this sense, it is strictly needed a breakthrough in testing and analysis methodologies, in order to fill the gap in the availability of the experimental results at extreme loading conditions: frequently, structure or components are designed to be used in operating conditions which are beyond the ranges in which the materials have been tested. The reason is that at high temperature, the quantitative measurements of the mechanical response, starting from an experimental test, could be quite complex or even impossible. The common measuring devices (such as resistive strain-gages, piezoelectric sensors, etc) reach their limits and can no longer be used.

The main objectives of the research are:

- To propose a new protocol for the tensile testing of ceramics and C/C even at high temperature;
- To enhance the potentialities of the ultrasonic testing machines and other testing equipments available in DIMEAS, with the aim of extending their use also to the tensile testing of ceramics and C/C;
- To perform an extensive experimental campaign on ceramic and C/C materials typically adopted for structural applications;
- To collect innovative experimental results on ceramics and C/C and to extend their potential applications;
- To investigate the effects of internal and surface defects on the mechanical properties of ceramics and C/C.
- To draw relevant conclusions on the actual structural and thermal responses of advanced ceramics and C/C and to lead the future research about them.
Skills and competencies for the development of the activity

- Competencies learnt during the MSc degree in Mechanical Engineering;
- Enough acquaintance with:
  - Innovative materials;
  - Servo-hydraulic testing machines and ultrasonic testing machines;
  - Static, dynamic and fatigue testing;
  - Mechanical characterization of materials;
  - Quality control and defect analysis.