LIGHTer PhD Network Seminar

27 October 2021

"Introducing atmosphere purity control and helium-rich gases for the laser powder bed fusion process" – Dr Camille Nicole Géraldine Pauzon, Chalmers University of Technology

Abstract

Recent results have put in evidence that the residual oxygen and nitrogen present in the laser powder bed fusion process atmosphere can be picked up by the processed material and exposed powder particles. The presentation will highlight how external oxygen control system can be implemented on printers, and to which extent different alloy systems (Fe-, Ni- and Ti-based) are sensitive to impurity exposure during the process. Additional insights on the use of helium to reduce spatter generation observed using high speed shadowgraphy and radiography will be presented.

"A Study on Sandwich Structures: Development, Mechanical Characterization and Numerical Modeling" – Dr Samuel Hammarberg**, Lule**å University of Technology

Abstract

Legislative demands force the automotive industry to reduce greenhouse gas (GHG) emissions. At the same time, crashworthiness must not be compromised. A vehicle's GHG emissions, such as carbon dioxide, is dependent on its fuel consumption. Lowering the vehicle weight, reducing fuel consumption, will therefor reduce emissions. Thus, high performance lightweight materials and structures are on demand. Several methods for achieving high-performance lightweight components are available. One of the most successful approaches has been replacing mild steels with press-hardened steels, e.g. ultra high strength steels (UHSS). In the press-hardening process, a low-alloyed boron steel blank is austenitized followed by simultaneously forming and cooling. By controlling cooling rates, a martensitic microstructure can be obtained, resulting in components with superior properties compared to mild steels. Other methods of achieving lightweight components include the usage of sandwich structures where stiff skins are bonded to a low-density core. In the present thesis, several types of sandwich structures are studied both numerically and experimentally.

A UHSS sandwich with a bidirectionlly corrugated core, intended for stiffness application, is manufactured and evaluated in three-point bending. Finite element models are utilized to recreate the three-point bend test. A large amount of finite elements are required for precise discretization of the core. The number of finite elements are reduced by replacing the sandwich with an homogeneous, equivalent model with input data obtained from analyzing representative volume elements (RVEs) of the core, subjected to periodic and homogeneous boundary conditions. Good agreement is found between experiments and finite element models. A UHSS sandwich with a partly perforated core is evaluated numerically for energy absorption applications. Several hole configurations for the core are evaluated with respect to specific energy absorption. A fracture criterion is utilized for the sandwich skins. Computational time is reduced by homogenization of the core using a stress-resultant based constitutive model. It is found that the sandwich concept allows for an increase in specific energy

absorption and that the computational time can be reduced while still being able to predict energy absorption.

An experimental methodology is developed for mechanical characterization of micro-sandwich materials. Tools are developed for loading the micro-sandwich in out-of-plane tension and shear, where digital image correlation is used for measuring displacements fields and fracture of the micro-sandwich core. Statistical methods are adopted for analyzing the variation in the mechanical properties of the micro-sandwich from which statistical means may be obtained.

The experimental data is used as input for constitutive models, simulating the micro-sandwich material subjected to peeling, using a T-peel test. The numerical models are validated against experiments, found to agree within one standard deviation, suggesting that the experimental methodology produces robust data. The present work has thus presented methods, further increasing the usability of UHSS with regard to lightweighting, and explored how such components may be simulated numerically with adequate accuracy and reasonable computation time. Furthermore, the present thesis contributes by presenting methods for characterizing micro-sandwich materials, including statistical methods for analyzing scatter in mechanical properties, and how such sandwich materials may be modeled, taking elastoplasticity and damage into account. These results opens up possibilities for further development and optimization of lightweight constructions.