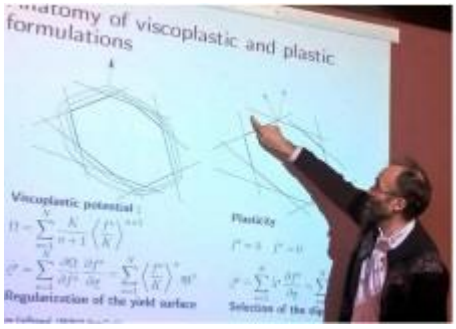
FIMECC Breakthrough Materials Doctoral School boosts modeling expertize

07.03.2016 15:02

FIMECC's industry-driven Breakthrough Materials Doctoral School sets special focus on integrated computational materials engineering (ICME) to solve critical industrial research challenges through multiscale modelling. New digital tools are used to build comprehensive understanding and concrete solutions to control material properties from microstructure to product design. This will speed up product development and greatly improve predictability of product endurance in demanding industrial applications. A world-leading expert in the field, Professor Georges Cailletaud from École Nationale Supérieure des Mines de Paris, Centre des Matériaux, joined the 5th FIMECC doctoral school seminar at SSAB in Hämeenlinna 26.-27.1.2016 as a keynote speaker and key research collaborator.



Professor Georges Cailletaud is a widely regarded expert in the materials modeling and simulations with an extensive history in industrial driven research and academic endeavors in mechanics of materials. His research history covers a spectrum of industrial application in which the simulation based material design approach has proven high quality results and cost efficient R&D. The Professor's current research interests include material and damage modeling in multiscale and multiphysics environments, from microstructure scale to large component level, which are essential in the application oriented research to obtain overall understanding in the material performance at every level.

From deep science to concrete solutions

In the keynote talk, Prof. Cailletaud emphasized the importance of simulation work in the material design because of the existing limitations and costs of solely experiment based research. The application related examples presented during his talk gave an easy to understand path from the processing-structure-properties-performance idealism to the solid results. For example, the design of new type of material in *aircraft turbine blades* began from the evaluation of different grain structures, which lead to the development a new type of single crystal material by simulations and experiments. The solution was found less damage prone improving the material lifespan of the turbine blades yielding cost savings, increasing reliability and providing safer use of the turbines in many conditions.

From the material modeling point of view the Prof. Cailletaud's keynote expanded the perspectives of macroscopic and microscopic simulations. The educational part of the talk on crystal plasticity modeling broaden the view on microstructural modeling of various materials. The complex phenomena controlling the plastic flow, damage, fatigue, and overall performance of a microstructure is only captured with suitable models that describe the physical behavior. Validation of the models, such as failure criteria, with experiments and characterization is a major part of understanding the material behavior and the origin of the failure processes. The performance of a material can be improved or deteriorated by the design and processing of the material leading to a certain microstructure. The combination of microscale modeling to the macroscopic application level simulations fills the gaps between the physical length and time scales. The Professor gave a detailed example that local shear by dislocations generating a gradient in a grained material can lead to nucleation of fatigue cracks increasing the risks of failure in the components; the information

extracted from the microstructure modeling was implemented in the failure risk analysis in the application model highlighting the importance of digitalized approach. Finally, he insisted and encouraged that the doctoral students would pursue very original aspects in their work to provide fresh ideas and solutions, everything should not always be done as it was done in the past.

Intensive research collaboration with high impact
The participating doctoral students had a great opportunity to discuss their research with the Professor and get advice on experimental and modeling issues. A lot of positive discussion and interest was raised from the PhD candidates' seminar presentations due to their high level and industrial based nature. The latest results on wear, modeling, and material development topics were covered elucidating the future trends in cost saving and innovative wear resistant and multi-purpose materials & solutions. The Professor quoted on the seminar topics and deliverance as:

"I was very pleased to be an actor of the scientific sessions in this event for several reasons, says Prof. Cailletaud.

"I am personally convinced that industrial needs can be the source of very nice scientific problems so that a strong partnership between companies and universities is one of the keys for a excellent applied research in the field of advanced engineering. The purpose of FIMECC is exactly to develop this type of interaction. I was impressed to see that the whole Finnish community is involved in the programme, with many companies, with a large funding and enough time to generate strong links between people on each side" he continues.

"Obviously the result is excellent. It was demonstrated by the quality of all the presentations by the students. The seminar offers the opportunity for older students to summarize their work and for the beginners to open their eyes on the large research field covered by the doctoral school. The subjects are all motivated by an industrial application and they generally include an important testing part. In some cases, a suggestion would be to introduce a little bit more numerical simulation, but this might be a difficult task since the topic is real world with a lot of interacting physical rules and complex thermomechanical states. Clearly the position of the group is at the cutting edge of the field", summarized Prof. Cailletaud.

Hands-on research collaboration has already been initiated between the MINES ParisTech and FIMECC Breakthrough Materials Doctoral school through the six-months research exchange of a PhD student Matti Lindroos, Tampere University of Technology. The co-operation focusing on crystal plasticity modeling of ultra-high strength wear resistant steels investigated in the Fimecc Breakthrough Steels and Applications programme has proven novel encouraging results. The key issue is combining microstructural modeling and sharp data from specific experimental tests simulating real wear conditions in selected applications. This valuable collaboration between the Fimecc doctoral school and MINES ParisTech will be continued to boost high quality industrial driven R&D with the aid of multi-scale modeling.

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