Your presentation at the Crash Simulation Summit will look at the question of modeling thin-walled composites for crash simulation. Could you briefly outline the concept for readers and what new knowledge they will be able to take away with them?

Thin-walled tubes represent the front rails, which are the primary energy absorbing structures in vehicles. In frontal impact, the front rails are subjected to axial crash load. Axial crash of tubes is the benchmark problem to gauge the capability of crash simulations. The axial crash simulation of composite tubes is a very challenging problem. Composite tubes can absorb twice or more energy than steel rails of the same weight. The superior energy absorption of composites is attributed to the extensive damage and failure of the materials. To simulate the behavior of composites with damage and failure, however, is difficult. Normally, the constitutive models are valid to the point where material reaches its peak load carrying ability. They are not adequate to describe the behavior of materials with significant damage. In early days, to match the simulations with the experimental results, material characterization is needed. Now, the experimental conditions are relatively easy to control. The problem is how to describe the behavior of materials with significant damage. The ultimate goal of CAE is to provide the optimal design with the least cost. The knowledge of material behavior is critical for CAE. Therefore, the constitutive models need to be developed and validated with experimental results to ensure the accuracy of simulations.

The accuracy of CAE prediction depends on material modeling. Accurate material models are critical for any CAE analysis. What do you see as the most important hurdles to overcome in implementing CAE and FAE technologies for safety testing of lightweight materials? What optimizations need to be implemented?

The accuracy of simulation result, which is affected by many factors, such as material modeling, mesh quality, accuracy of algorithm etc. The product development can be regarded as a multi-objective optimization problem. Thus, a multi-objective optimization solver, which can be adapted with different CAE solvers, is needed.

What are some of the potential applications and implications of improved material models and more accurate safety simulations to the manufacture of lightweight vehicles?

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In my presentation, I will discuss the requirements for composite material models for different types of vehicle structures. I will also present the key developments in axial crash simulation of composite tubes. We are working on coupled damage-plasticity models for composites. The improved material models together with a new shell-beam method for thin-walled structures have resulted in promising improvement in axial crash simulations of composite tubes.

Parameter optimization is a powerful tool. The constitutive models for crash simulations inevitably have many parameters. Some of them are difficult to measure. If we have experimental results covering enough load cases, parameter optimization may help us to get the set of parameters which provides best correlations for the load cases tested. I have done some work several years ago. It is effective. On the other hand, one must know that these values are not necessarily valid for a new load case.

To increase the use of composites in crash critical structures, we have to be able to predict the crashworthiness of the structure as we do for metal parts. Good material models, robust and accurate safety simulations are critical to vehicle lightweighting.

What do you see as the most important hurdles to overcome in implementing CAE and FEA technologies for safety testing of lightweight materials? What optimizations need to be implemented?

With high fidelity FEA simulations, different design options can be evaluated through virtual testing before they are built. Virtual design and validation is critical to car makers. If the simulation technology is not ready for a material, extra tests will have to be conducted. This is a hurdle for the use of composites in crash critical components. For crash simulations, we still have some gaps comparing to metallic materials. As mentioned in the response to the 1st question, we need to differentiate the types of vehicle structures. In many cases, we can bridge the gaps with the existing technology.

I am not sure about “What optimizations need to be implemented?” Do you talk about optimization as a topic or optimization within the context of material modeling? Indeed it was referring to optimization within the context of material modeling.

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What are some of the potential applications and implications of improved material models and more accurate safety simulations to the manufacture of lightweight vehicles?

FEA simulations have changed the landscape of automotive design. The car manufacturer will not turn back the wheel to a testing intensive design procedure as it was before the computer age. To increase the use of composites in crash critical structures, we have to be able to predict the crashworthiness of the structure as we do for metal parts. Good material models, robust and accurate safety simulations are critical to vehicle lightweighting. As I mentioned early, the technology for crash simulation of composite structures has improved a lot. Ideally, these new developments need to be examined carefully through some coordinated effort. Individual teams can only carry the research to a certain extent. It ups to the users – automotive industry to continue. I think this conference provides a good forum for such discussions.

Which presentation/panel discussion are you especially excited about during the Lightweight Vehicle Interiors summit 2016?

All panels are very interesting. In addition to composite modeling, I am also interested in modeling of multi-material joining. Modeling joints is another challenging topic. I worked on modeling of adhesively bonded automotive structures in the past. In recent years, we worked on simulations of metal cutting using constitutive models developed in house and we developed a new test to obtain the critical model parameters. We were able to show that metal cutting is predictable with these efforts. If there is an opportunity, I would like to participate the modeling of multi-material joining.