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OPTIMIZATION OF PROTECTION EFFECT OF MULTI-PHASE MATERIALS SUBJECTED TO IMPACT LOADING

***Martin Herrenbrück[1] and Roman Lackner[2]**

[1] FG Computational Mechanics
Arcisstr. 21, 80333 München, Germany
herrenbrueck@bv.tum.de
http://cm.bv.tum.de

[2] FG Computational Mechanics
Arcisstr. 21, 80333 München, Germany
lackner@bv.tum.de
http://cm.bv.tum.de

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ABSTRACT

Protective structures which are used to reduce the effect of impact loading are encountered in many engineering disciplines (civil engineering, mechanical engineering, …) as well as in daily-life situations (e.g., packing of goods). In general, the performance of the employed materials is optimized as regards minimization of (*i*) the maximum penetration into the protective structure and/or (*ii*) the maximum load transferred through the protective structure in order to avoid harm and damage of persons and goods. So far, the proper design of protective structures was found by experience, trial-and-error design, and subsequent experimental validation.

In this paper, the performance of protective materials, related to the maximum penetration and the maximum transferred load as determined by means of numerical simulations, is described by so-called scaling relations. Hereby, based on the numerical results, the complex material response under impact loading, characterized by elastic, viscous, and plastic deformations is related to the respective elastic (analytical) solution (see e.g. [1,2]) by means of scaling relations. These relations are formulated in dimensionless manner, thus, being applicable to any material showing the model behaviour considered in the numerical simulations. With the elastic solution and the scaling relations at hand, goal-oriented optimization of the material performance as regards viscoelastic model parameters and strength properties becomes possible. In the next step, this optimization procedure is extended to layered (see e.g. [3,4]) and to multi-phase materials, exhibiting air voids and reinforcing particles and fibers, with the arrangement (material morphology) to be determined within the optimization framework. Respective results (material microstructure) obtained from different objective functions within the optimization process will be presented and discussed at the conference.

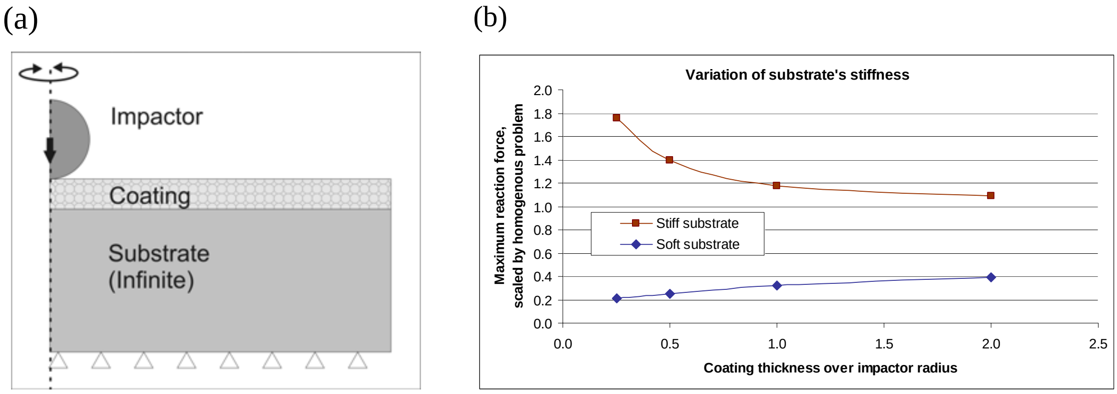

Figure 1: (a) Mechanical model considered in analysis of layered material systems and (b) scaled maximum transferred load as a function of coating thickness to impactor radius for a soft and a stiff substrate

Figure 1(a) illustrates the employed axisymmetric mechanical model which was used in the numerical simulation of layered material systems. As one example for the dimensionless relations, Figure 1(b) shows selected numerical results for several coating thicknesses (related to the impactor radius) the maximum transferred load (related to the result for a homogenous material sample) for a substrate being stiffer or softer, respectively, than the coating.

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