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A THERMOMECHANICALLY IMPLICIT COUPLED APPROACH FOR DAMAGE AND CRACK PROPAGATION

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Abstract. Advanced high-strength steels, aluminum or titanium alloys are gaining popularity in automotive and aeronautics applications because they exhibit a large ductility for a high strength level. As a result, these newly developed alloys are ideal for crash energy management, fatigue and durability of sensitive parts. With proper design strategy, these materials offer a great opportunity for weight reduction and crash performance. Therefore, the characterization of the mechanical properties of these materials has to be performed in the context of rate dependent plasticity at large strains and for both low and high strain rates.

In a finite element simulation of high strain rates phenomena, three main ingredients have to be taken into account. At first, adequate constitutive modeling including strain rate and temperature effects must be used to take into account high strain rate and the thermal softening of the material. Secondly, the study of fast phenomena such as crash must include a large strain formulation, as well as inertia effects. Thirdly, numerical solution algorithms have to evaluate accurately the evolution of positions and temperature all along the process.

Beyond thermomechanical constitutive equations, a general formulation including material damage, possibly coupled with element erosion to simulate crack propagation is proposed. These damage laws are able to describe the loss of strength of materials both for quasi-static phenomena as well as for dynamic problems.

In this lecture, we will present a consistent formulation able to take into account all the mentioned effects, including a fully implicit approach for element erosion due to damage in order to simulate crack propagation. The numerical model will be illustrated by different applications in metal forming and impact simulations.