AI-Based Predictions of Forming Effects for Enhanced Crash Simulation

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Background.

Crash simulations are an integral part of virtual vehicle development, as they enable a sound assessment and optimization of passive safety already in the early design phases. However, conventional modeling approaches often neglect the influence of upstream manufacturing processes such as deep drawing, which can significantly affect material behavior in crash scenarios.

Procedure

To enhance the predictive capability of crash simulations at these early concept stages, a specialized tool has been developed that enables consistent parameterization of FE crash models – even in the absence of detailed manufacturing predictions, such as those obtained from deep drawing simulations [1]. In this way, manufacturing-related effects can be anticipated and integrated into structural design at an early stage, thereby increasing both the efficiency and the reliability of the overall development process.

A key distinguishing feature of the proposed approach is the significant acceleration of predictions of plastic strains and sheet thickness distributions in forming processes. While conventional FEM-based simulations typically require computation times ranging from several minutes to hours, the presented AI methodology provides predictions within just a few seconds.

Of particular note is that these predictions are generated entirely without FEM calculations. This not only eliminates the dependency on high-performance computing resources but also achieves an unprecedented level of efficiency in early structural assessment.

The methodology relies solely on the geometric definition of the component, with coarse FE shell meshes, as commonly used in crash simulations, being fully sufficient as input. This establishes a continuous workflow in which forming-related effects are seamlessly integrated into crash modeling, enabling a scalable and resource-efficient parameterization of full-vehicle models. Verification and validation of the approach were carried out using LS-DYNA forming simulations, incorporating both low-fidelity and high-fidelity deep drawing models [2].

This publication introduces a novel, physics-informed AI approach that enables the parameterization of full-vehicle crash models while accounting for manufacturing-specific effects. The integration of these AI-based predictions leads to a substantial improvement in the physical accuracy of crash simulations.

Key findings

- Drastic acceleration of forming predictions (AI-based, FEM-free)
- Consistent parameterization of FE full-vehicle crash models in early concept stages

References

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