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Material and component behavior of light weight steels under complex loadings at high strain rates

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For a reliable prediction of component behavior under crash loading, extensive information about the material behavior under high strain rates and complex loading situations are necessary. Therefore for lightweight steel sheets commonly used in automotive constructions high speed tests were performed for different stress states from shear loading to uniaxial and multiaxial loading situations as well as quasi-static and dynamic Nakajima tests. The transient strain fields on the surface of the specimens were recorded with high speed video cameras and evaluated with 2D and 3D digital image correlation (DIC). Under elevated test speeds the heat generated by conversion of plastic work cannot be dissipated completely. Therefore temperature increases and leads to material softening. To quantify local temperature increase the transient temperature fields in the highly deformed zones on the surface of the specimens were recorded with a high speed infrared camera. Partly more than 200 K temperature increase was measured. With those experimentally determined data material failure models can be calibrated considering stress triaxiality, strain rate and temperature dependency. For model validation quasi-static and dynamic component tests were performed and the experimental and numerical results for the absorbed energy are compared. Based on this data base material and failure models for crash simulation can be developed and improved with regard to prediction quality of energy absorption and failure under crash loading.