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Transition of failure mode in hot stamping of AA6082 tailor welded blanks

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Abstract

A novel sheet metal forming process, by manufacturing parts in a single sheet with varying thickness, has been employed in this work. It combines hot forming and cold-die quenching, also known as HFQ®, and the use of aluminium tailor welded blanks (TWBs) into a hybrid process. A series of hot stamping tests on the AA6082 TWBs were performed to investigate the deformation behaviour and failure features. Two failure modes, i.e. circumferential necking and parallel weld necking have been observed in the formed parts depending on the forming speed and thickness ratio of the TWBs. An advanced forming limit prediction model has been developed and further integrated into finite element simulation via a cloud-based multi-objective platform[*] to investigate the failure/necking features of AA6082 TWBs. The model incorporates the theories of Hosford yield function, the anisotropic nature of plastic deformation in sheet metals and the Marciniak-Kaczynski (M-K) theory. According to the theories, the incremental work per unit volume ratio ($d\bar{\varepsilon}_B \cdot \bar{\sigma}_B / d\bar{\varepsilon}_A \cdot \bar{\sigma}_A$) between *Zone* B (thickness imperfect zone) and *Zone* A (the remainder of the material) is a key parameter determining the formability, by which the complex failure features have been fundamentally studied. The transition of failure mode in a TWB was attributed to the joint effects of temperature, strain rate and loading path changes. Strain rate could accelerate the development of localised necking in the TWBs when the failure mode was in transition from the circumferential mode to parallel mode.

Keywords: hot stamping; tailor welded blank; failure mode; loading path; localised necking

[*] All the models presented in this paper are available as open access numerical modules at www.smartforming.com, an online knowledge-based cloud platform.