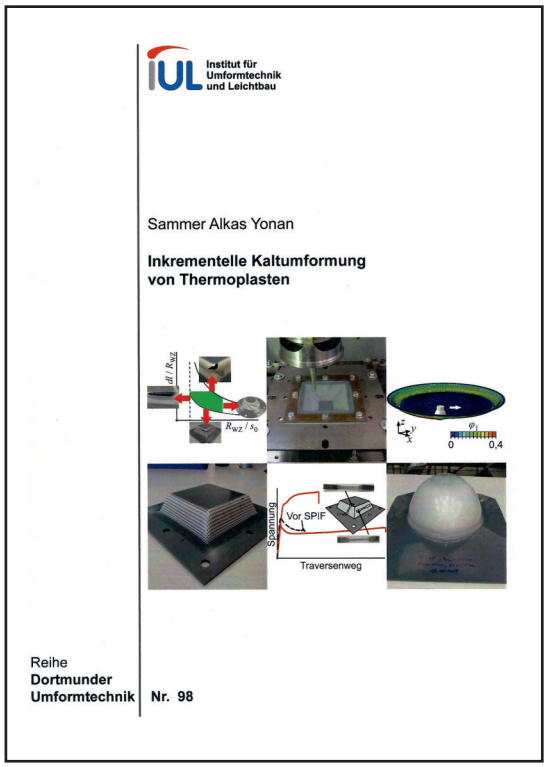
English version below

Institut für Umformtechnik und Leichtbau

Inkrementelle Kaltumformung von Thermoplasten

Sammer Alkas Yonan



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Zusammenfassung

Single point incremental forming is a flexible sheet forming process that gradually produces parts by a pin-like tool in small forming zones. The aim of this work is to analyse and develop the single point incremental cold forming process of thermoplastics to contribute to its establishment as an alternative for prototyping and small batch production. To achieve that, fundamental investigations with regard to formability of thermoplastics through the example of PC, PE-HD, and PVC at room temperature as well as experimental and numerical analysis of this forming process are performed.

Specific material characterisation tests show non-linear rate-dependent mechanical behavior during cold forming of thermoplastics. Stretch loading induces an alignment of molecular chains resulting in higher strength along the loading direction. This leads, unlike metals, to stabilisation and spreading of necked area. At cyclic loading, kinematic hardening is verified.

Experimental investigations of single point incremental forming of thermoplastics reveal part properties, forming limits, and tool forces depending on process parameters. Initial sheet thickness, tool radius, and vertical tool infeed are identified to be the key process parameters. The forming process induces plastic anisotropy in part resulting in higher strength along the part wall. Based on part properties and occurring failure modes, a process window using dimensionless parameters and defining a safe working area is created to allow reliable process design. The fracture forming limit line is verified to be the maximum achievable strain by incremental forming of thermoplastics. This is determined from fracture strains at tensile and bulge tests.

Numerical investigations are performed to analyse the states of stress and strain during the forming process depending on key process parameters. For this purpose, a specially created viscoplastic material model is used. Simulations using a simplified 3D model reveal alternating bending and unbending superimposed by tension and high contact stress during forming.

Multi-stage strategy is applied to control the strain path during incremental forming and hence extend the process limit defined by a maximum wall angle. For the design of multi-stage Processes, the acquired knowledge about plastic anisotropy, safe working area, and forming limits are applied.

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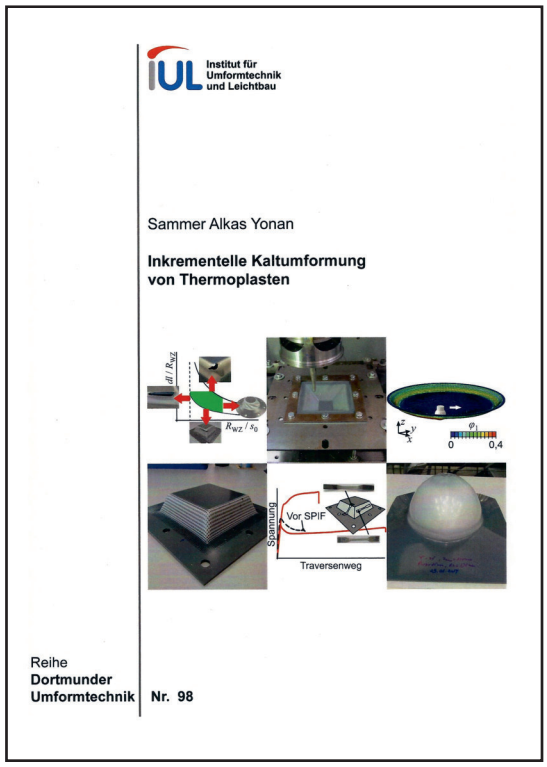
Incremental cold forming of thermoplastics

Sammer Alkas Yonan



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