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Optimum path and discrete 3D forming

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Introduction

Discrete die forming is a useful concept in a small-lot production environment because different products can be made with the same reconfigurable die and many resources are saved. From a scientific point of view: a discrete die allows a changing strain path during forming; products with an optimized internal strain distribution can be produced, e.g. the lifetime of parts carrying cyclic (thermal) loading can be enhanced considerably.

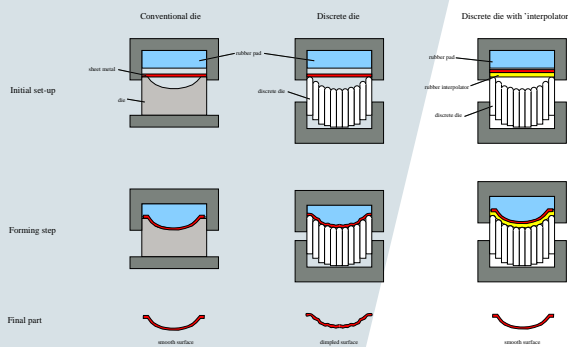


Figure 1 Rubber pad forming with conventional die, reconfigurable die and interpolator.

Objective

A numerical tool to calculate, using non-proportional forming-limit diagrams, time-varying boundary conditions of a deformation process, yielding different internal strain distributions in geometrically identical products. Validation will be done by using an experimental set-up. The numerical tool controls the internal strain distribution by means of non-proportional forming-limit diagrams.



Figure 2 Prototype of discrete die, surface dimensions: 20x30 mm, forming pressures up to 5 ton.

Methods

- Experimental deformation process with discrete die prototype in which the strain path is variable.
- Determination of strain distribution and product geometry with photogrammetry technique.
- Numerical algorithm, providing boundary conditions for an optimal deformation process.

Results

Using the discrete die and photogrammetry technique, two geometrically equal products are produced with different strain distributions.

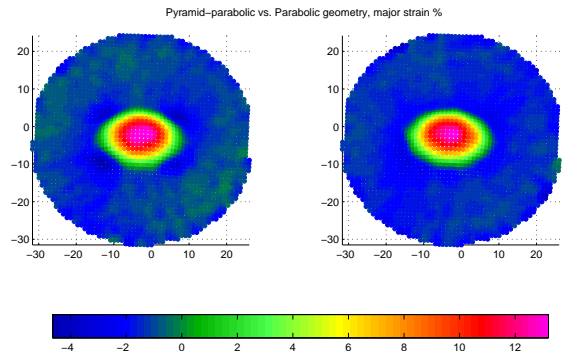


Figure 3 Distribution of major plastic strain for two geometrically identical products.

Using the reconfigurable die, a product without defects is produced with an intermediate forming step.

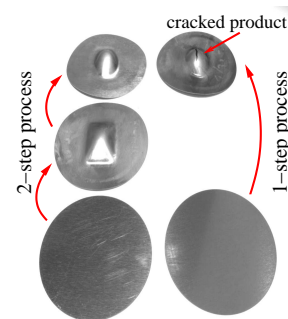


Figure 4 Multi-step forming experiment with discrete die.

Discussion

- Non-proportional loading tests must be done for model input.
- Implement numerical tool within FEM framework.
- Criterion must be formulated to determine optimal strain distribution.
- Automated control of discrete die is preferable.

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