

## Optimum forming strategies with a 3D reconfigurable die

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# Optimum Forming Strategies with a 3D Reconfigurable Die

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## Discrete Die Forming

A reconfigurable die is an adequate solution for small lot and prototyping manufacturing processes, where conventional rigid dies are too expensive, especially when a rubber pad forming configuration is chosen with an additional rubber layer to prevent dimpling.

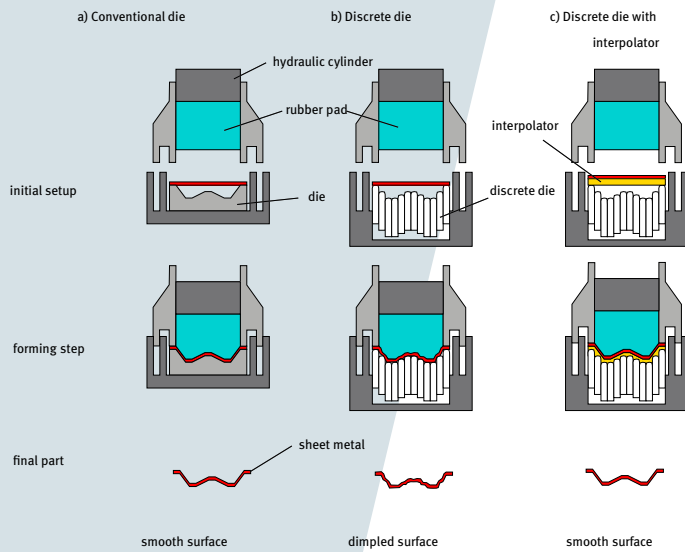


Figure 1 Rubber pad forming with conventional die, discrete die and interpolator.

This technique has a great potential for many applications with an increasing demand of special, personalized products, e.g. medical applications. Furthermore it can be used as a research tool to investigate strain path dependent material behavior through an efficient multi-step manufacturing process.

## Research Method

A fully automated forming device has been developed where 1846 elements are reconfigured within a working volume of  $40 \times 50 \times 25 \text{ mm}^3$  in 5 minutes.

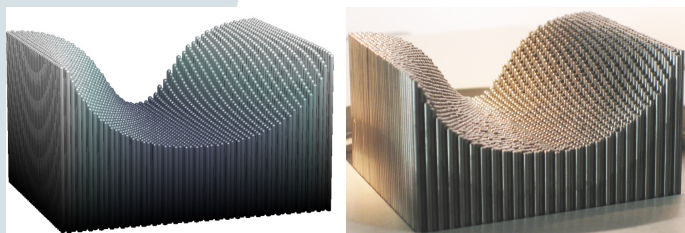


Figure 2 The digital input geometry (left) and the real discrete surface (right) of the forming device.

The Teodosiu strain path dependent model has been used to optimize the thickness distribution of a benchmark product which is manufactured by applying 8 different loading paths.

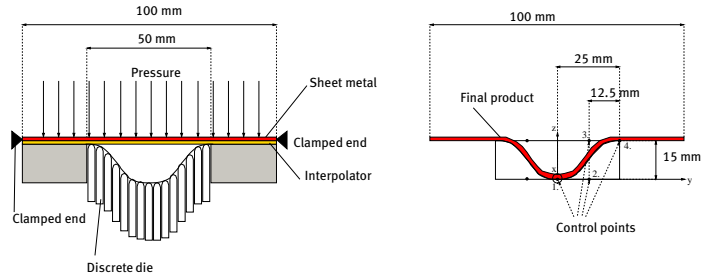


Figure 3 Benchmark product of DC06 steel. The die shape is defined according a Bezier curve, which is determined by four control points.

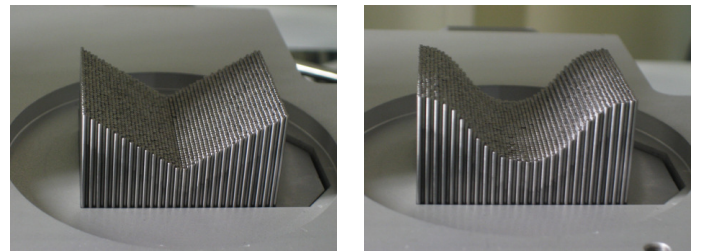


Figure 4 Starting with 8 different die geometries, e.g. the geometry on the left, the final benchmark product is manufactured during 10 sequential steps, ending with the geometry on the right.

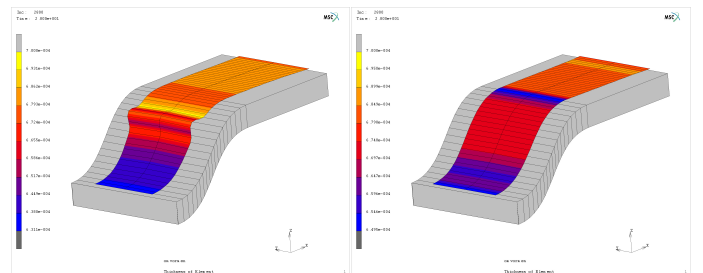


Figure 5 The final thickness distribution is presented for two forming paths. A wrinkle is formed on the left whereas a nearly homogeneous thickness reduction can be observed on the right.

## Conclusions

- A fully automated reconfigurable die has been developed and used as a research tool for investigating strain path dependent material behavior.
- For DC06 steel, all 19 material parameters for the Teodosiu model have been determined by various experiments (pure bending, tensile and shear tests) combined with a finite difference method.
- An optimum forming sequence is proposed and validated with the discrete die for the multi-step fabrication of a benchmark product.
- The developed discrete die concept has a great potential for many forming applications where traditional dies are too expensive.