

Parametric die faces in one hour

How 20 auto manufacturers and 20 tooling suppliers are reducing die design costs through automated software tools

The automotive industry shares a common goal to reduce new car development cycles from 48 - 60 months to only 24 months. To help achieve such a drastic reduction in "time-to-market", companies have focused on cutting tooling development time, which represents a large share of the total product development cycle.

Draw-die development – the creation of binder and addendum surface geometry for sheet-metal parts – has represented a particularly difficult challenge for automotive manufacturers and suppliers to reduce lead-time and tooling costs.

Over the past year, 20 automotive manufacturers and 20 leading tooling suppliers in Europe, North America and Asia have all implemented a new software to address this problem (see Figure 1).

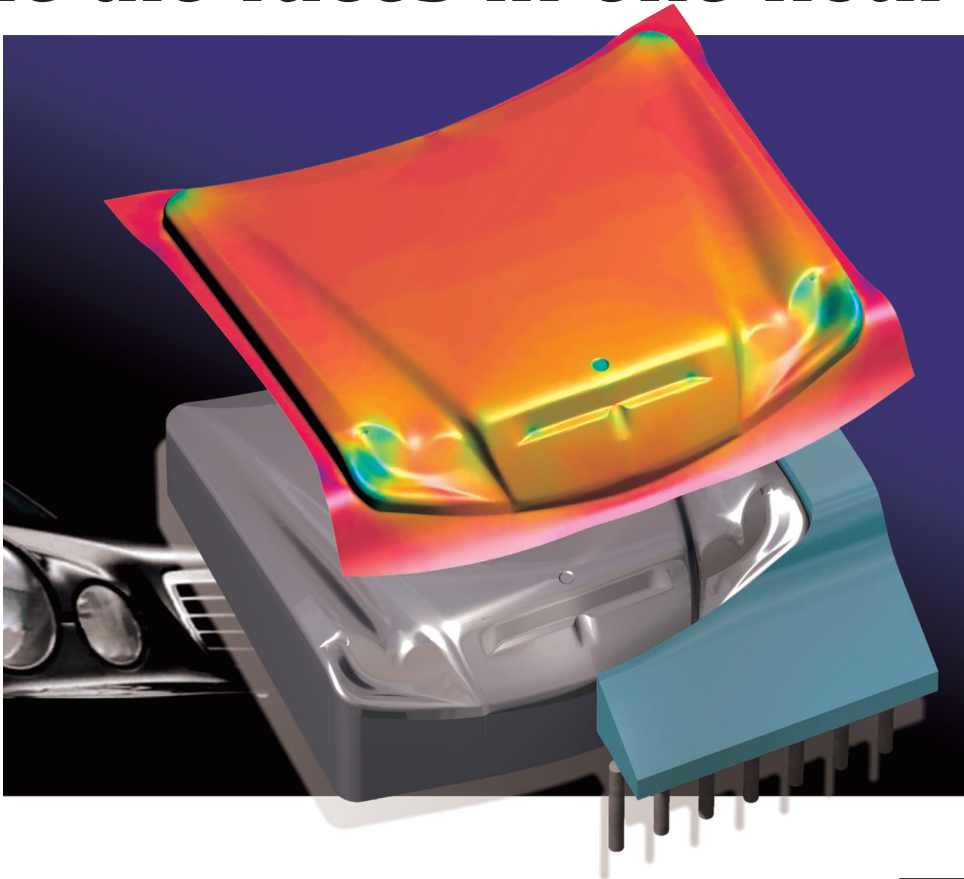
TRADITIONAL BINDER AND ADDENDUM DESIGN PROBLEMS

Once the product design department finalises the design of a new sheet metal part, for example a deck-lid, fender, bracket or cross-member, it is released to the feasibility and tooling departments who must then design an appropriate stamping die to fabricate the part.

The traditional approach is for methods engineers and die designers to create or "build" the required binder and addendum surfaces in a CAD system. However, this method has three disadvantages:

1. Long lead time

Designing die faces in a conven-



Courtesy of DaimlerChrysler

AUTO MANUFACTURERS		TOOLING SUPPLIERS	
Audi	Germany	Batz	Spain
BMW	Germany	Comau (UTS)	Italy
DaimlerChrysler	USA, Germany	Christy Industries	USA
Fiat	Italy	EDAG	Germany
Ford	USA Turkey	Gestamp	Spain
General Motors	USA	Karmann	Germany
Honda	USA	Krupp Drauz	Germany
Iveco	Italy	Kuka Werkzeugbau	Germany
Mitsubishi	Japan	Laepple	Germany
Nissan	Japan	Mayflower	UK
Opel	Germany	Ogihara	USA
PSA Peugeot Citroën	France	PCI	France
Renault	France	SAT (Stola)	Italy
Saab	Sweden	Schuler	Germany
Scania	Sweden	Superior Cam	USA
Skoda	Czech Republic	Swindon Pressings	UK
Subaru	Japan	Tecnisabadell	Spain
Volvo	Sweden	Thyssen Nothelfer	Germany
VW	Germany	Tower Melegny	Germany
		Troy Design & Mfg	USA

tional CAD system is very time-consuming. For typical automotive skin panels and large inner panels, the average time required to complete a draw-die development ranges between 1-2 weeks. Even

Figure 1: 40 automotive and tooling companies engaged in driving down lead times and reducing cost

for small parts and structural components, several days are required.

2. High cost

Design modifications are expensive to make in a CAD system.

Cover story: Focus on Cadcam and simulation

Successful draw-die developments require the expertise of die designers and methods engineers with many years of practical experience and good CAD skills. Almost always, they make several iterations of design modifications before finalising a good stamping die (e.g. changing radii, adjusting drawbars). However, making such design modifications in a general purpose CAD system is cumbersome and slow. Mistakes, modifications, and especially the design of different "what-if" concepts for the binder and addendum, are costly.

Furthermore, when time runs out due to production deadlines, companies are forced to carry out tooling try-outs in the press, which is even more costly.

3. Low throughput

With a manual, CAD-based approach, the die designer must wait until the die surfaces are completed – several days or weeks – before carrying out virtual try-out simulations to check his designs for cracks, wrinkles and other stamping criteria. It is far more productive and cost-effective if the die designer immediately tries out his die concepts, discards unfeasible designs early on, and concentrates on further developing only his best design(s).

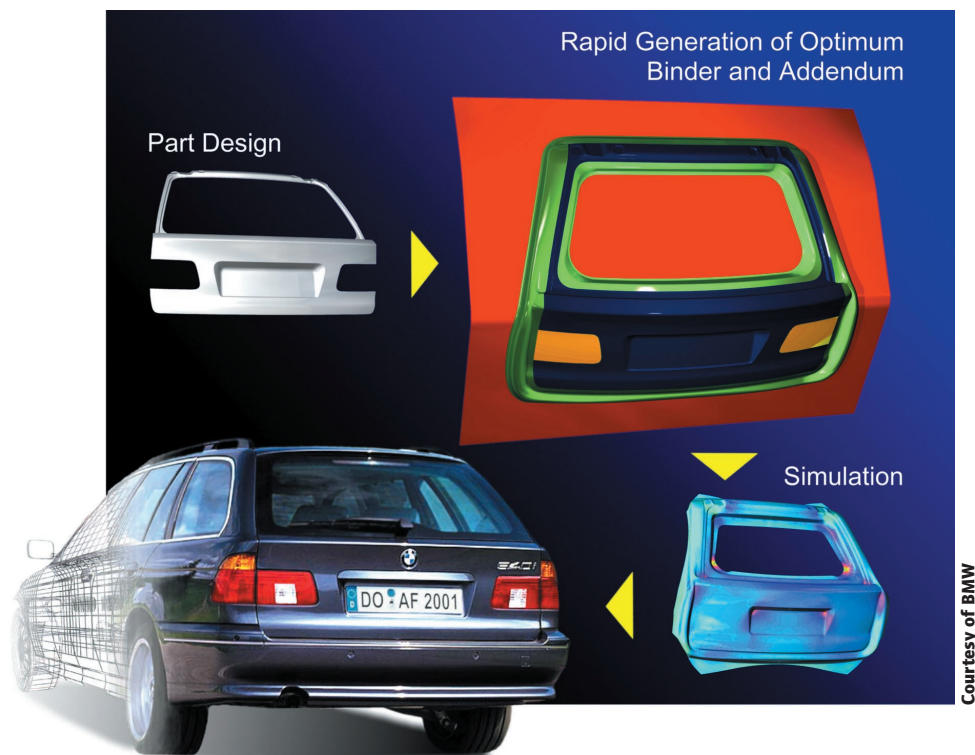
As a result of these drawbacks, several automotive companies participated in a program to develop a faster, more efficient and less costly method for die face design.

PARAMETRIC AND FULLY INTEGRATED SOFTWARE

AutoForm-DieDesigner software is the result of a development effort led by AutoForm Engineering GmbH (developers of sheet metal forming software) in cooperation with tooling departments at BMW and Audi, and with technical feedback from DaimlerChrysler and General Motors.

The software reduces tooling development time through rapid parametric design of die faces, and their immediate verification and optimisation with integrated stamping simulation modules.

It is specialised for generating binder and addendum surfaces, and



Courtesy of BMW

The software reduces tooling development time through rapid parametric design of die faces, and their immediate verification and optimisation with integrated stamping simulation modules.

for evaluating the feasibility of draw-die developments and prototype tools. Its three most important innovations are:

- Fully parametric features,
- Complete integration with virtual try-out software modules, and
- An automatic optimiser.

The software's parametric approach is based on analytical engineering principles. It also conforms to the die engineering practice of using surface profiles (arcs and angles) to design die faces and is compatible with various CAD data formats.

DIE FACES COMPLETE DRAW-DIE DEVELOPMENTS IN ONE HOUR

Using the software, it takes about one hour to design the complete die faces starting from only the CAD surface data of the part. This includes the following steps:

- Determination of tip-angle
- Filleting of sharp edges (variable radii)
- Filling of holes
- Part modifications (morphing)
- Design of the fill surface between double-attached parts
- Over-crowning
- Binder design
- Design of outer (and if required, inner) addendum
- Unfolding of flanges
- Generation of the tools

As all the generated die surfaces are parametric, subsequent modifications (die engineering changes) are implemented in seconds. These die surfaces and simulation results can easily be exported using IGES, VDAFS or mesh formats to other software applications, e.g. pattern-making, structural/crash analysis modules, etc.

EASY PART DESIGN MODIFICATIONS

As almost all part designs are subject to revisions and improvements even after they have been "officially released" to the die design department, the software allows for this.

After the parameterised binder and addendum have been created for a specific part, one can then replace that part with another (similar) part design with a modified design and the software will automatically adjust the binder and addendum accordingly.

This is an important time-saving feature as it allows the original addendum and binder geometry that is created, to be re-used for future design revisions of the part.

In addition, automatic filleting and the ability to vary fillet radii on the part geometry, saves considerable time and allows virtual try-outs to be carried out earlier in the product and tooling development cycles.

DIRECT PARAMETRIC LINK TO STAMPING SIMULATION SOFTWARE

As a result of the software's integrated system approach and full parametric linking, all die face designs can be immediately evaluated with one-step or incremental simulation modules.

One-step simulation results are considerably more reliable when based on the complete die face – as generated by the software – rather than on the part only. An added benefit is that these refined results are made possible earlier in the design cycle. They are available within a few minutes and include the required blank outline and various stamping feasibility criteria (see Figure 5).

The incremental module is used for high accuracy and virtual try-outs of the complete stamping process. Results include predictions of wrinkles, cracks, skid and impact lines, surface quality, etc. Incremental try-out results are typically available within 1 hour to 3 hours, depending on the size and complexity of the part and the desired accuracy.

DESIGN OF PARAMETRIC DIE FACES FOR AUDI TT



Figure 2-A: The part geometry (CAD surfaces) of an Audi TT rear fender.

Courtesy of Audi



Figure 2-B: The initial binder surface (yellow) automatically created in a few seconds, using only the CAD surface data in Figure 2-A as input. The user can then modify the binder geometry with surface profiles.

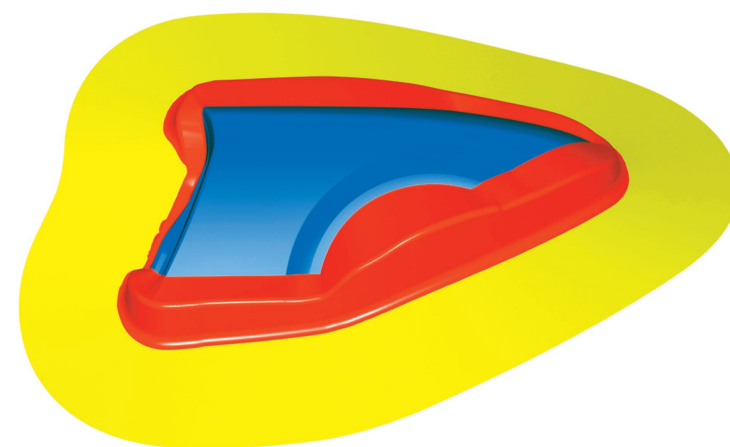


Figure 2-C: View of the automatically generated addendum surface (red), based on default profiles.

Additional try-outs can be launched at once because of parametric linking. For example, based on the initial results, the user can make modifications to the addendum geometry, and the

various tool geometries required for the next simulations are automatically updated. Similarly, if the user modifies the punch opening line, drawbead positions are automatically adjusted.

Cover story: Focus on Cadcam and simulation

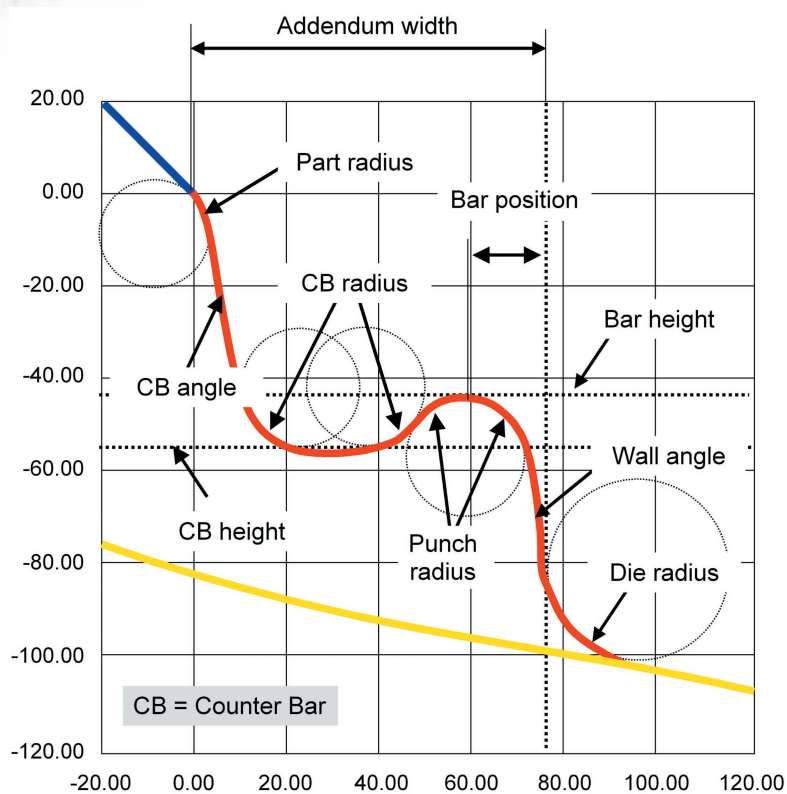


Figure 3-A: A typical addendum profile (red line) and its defining parameters. Within a few seconds, the user can change these "master" global profile parameters, for example to increase the die radius.

In addition, the user can also make local surface modifications to the addendum, by changing local profile parameters or directly manipulating contours such as the punch opening line, bar height, etc.

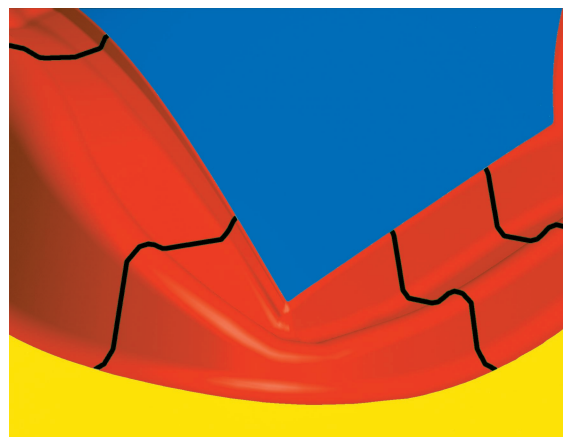


Figure 3-B: A drawbar that is created by modifying the parameters of local addendum profiles (black).

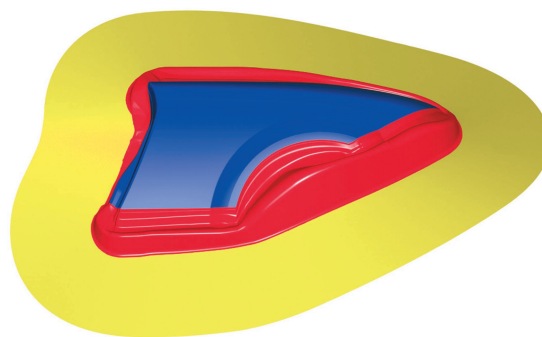
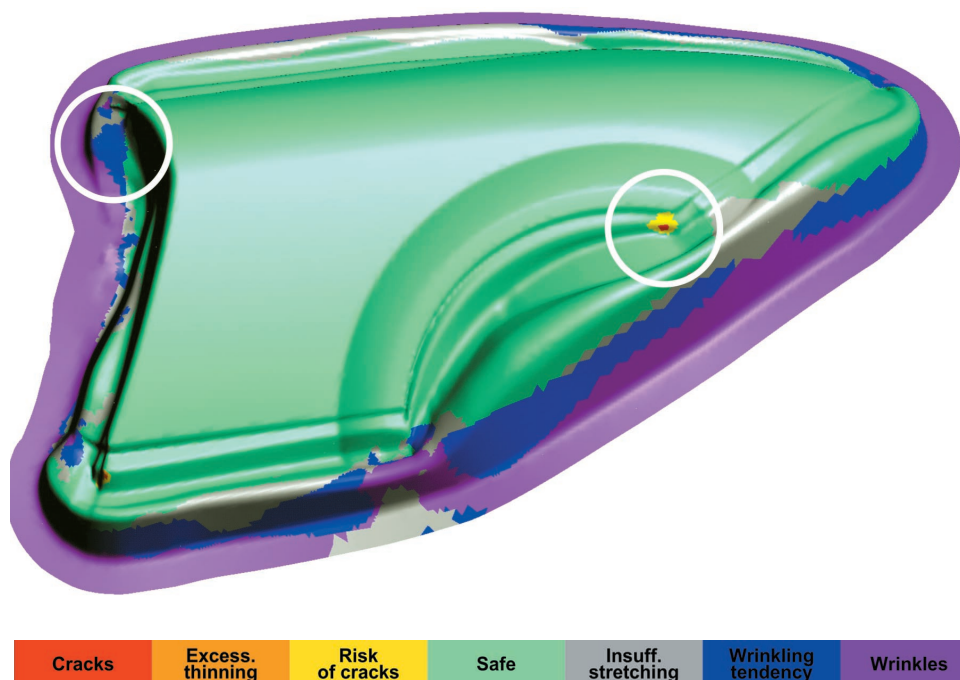


Figure 4: The complete die face for the Audi TT rear fender, created in about 1 hour using 28 customised surface profiles.

ONE-STEP FORMABILITY SIMULATION

Figure 5: The results of a one-step simulation taking into account the binder and addendum from Figure 4. The stamping feasibility results were calculated in 2 minutes. The colour plot shows a summary of various stamping feasibility criteria. The circled area on the left shows a risk of wrinkles on the addendum, very near to the part boundary. The circled area on the right shows a crack.

Based on one-step results, the general die concept can be evaluated early in the design cycle, and if necessary, modifications to the part geometry can be recommended. Furthermore, the resulting blank outline can be used to design the initial blank outline for an incremental virtual try-out.



Cover story: Focus on Cadcam and simulation**AUTOMATIC OPTIMISATION OF TOOLING AND STAMPING PROCESS**

To further improve the die face designs, the software includes an integrated optimiser module. The user first specifies the allowable ranges for tool geometry and stamping parameters. The optimiser then automatically determines the "best" design within these ranges through multiple one-step or incremental simulations, to achieve the target function: for example, elimination of cracks and wrinkles, uniform surface stretching, no excessive thinning. Tool geometry parameters include part, die and drawbar radii, drawbar height, wall angles, over-crown, etc. Stamping parameters include binder forces, drawbead strength, blank outline, etc.

Benefits

Within the first year of using AutoForm-DieDesigner, auto manufacturers and tooling suppliers have already reported the following savings:

- Reduced binder development time by 60%
- Reduction by a factor of 4-5, in the time from CAD part design until completed virtual try-outs
- Reduction of die face development time from one week down to one day
- Almost 50% reduction in actual die try-out time and tooling costs
- Two week reduction of tooling development time, by using the generated die faces to order castings for the dies.

Although it is too early to quantify all benefits, companies also expect improved part quality and stamping reliability due to the optimisation of their designs.

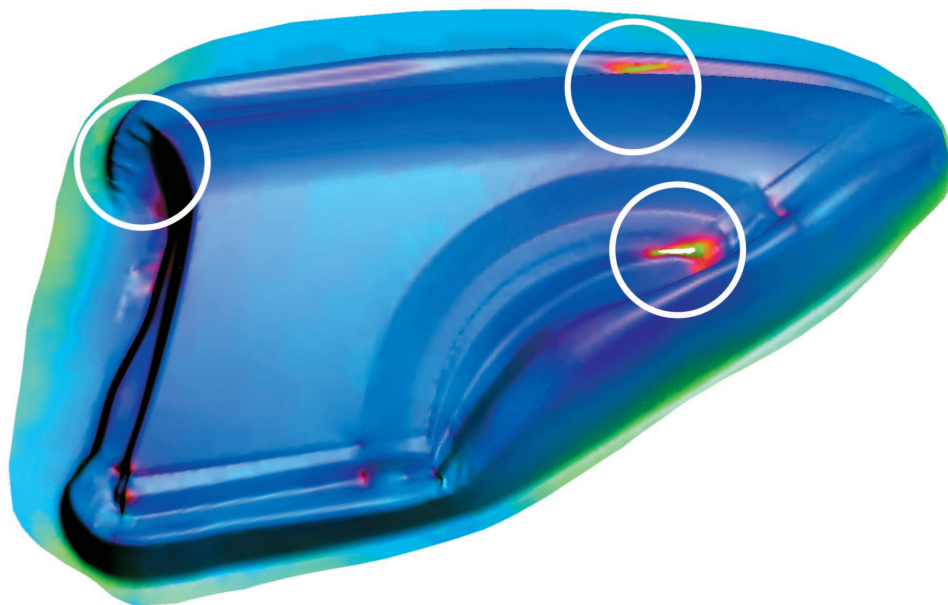
ISMR**INCREMENTAL STAMPING TRY-OUT SIMULATION**

Figure 6: The results of an accurate incremental try-out simulation of the complete stamping process, using the die faces from Figure 4.

The colour plot shows the predicted thickness distribution; excessive thinning zones are in red and yellow (two circled areas on the right). The simulation also shows wrinkles in the circled area on the left. These try-out results were obtained in about 50 minutes.

The die designer can then make modifications to his original die concept to smooth out the wrinkles and eliminate the cracks, for example by changing drawbar and wall heights, radii, etc. Furthermore, results such as wrinkling, splitting, skid mark progression, etc. can be visualised at each step of the drawing process.

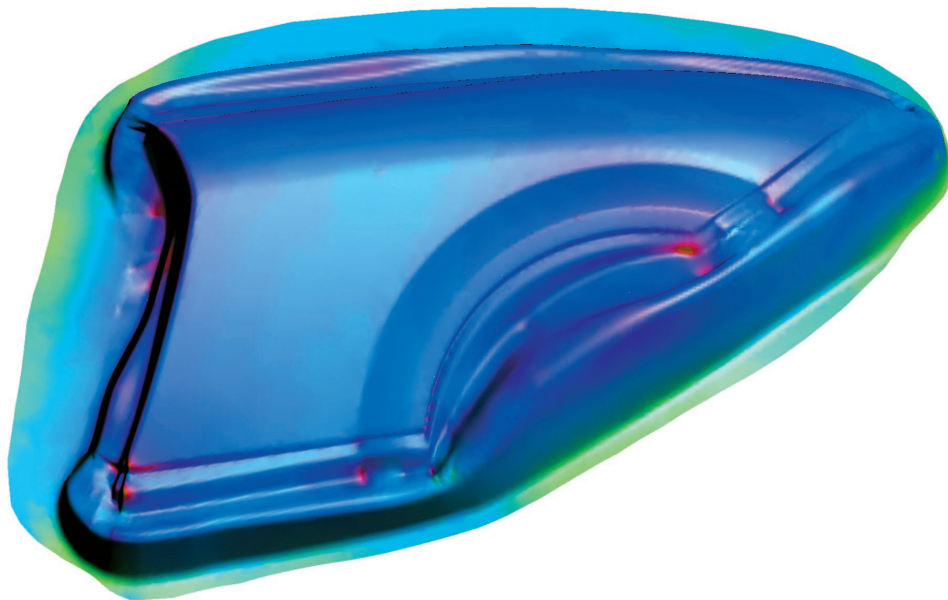
OPTIMISATION

Figure 7: The results of optimisation of the initial incremental try-out in Figure 6.

The two crack zones were eliminated and the wrinkling zone was minimised and moved away from the part boundary.

Automatic optimisation can help the die designer to find the best parameters for his design. It can also help the process engineer to determine the best stamping conditions.