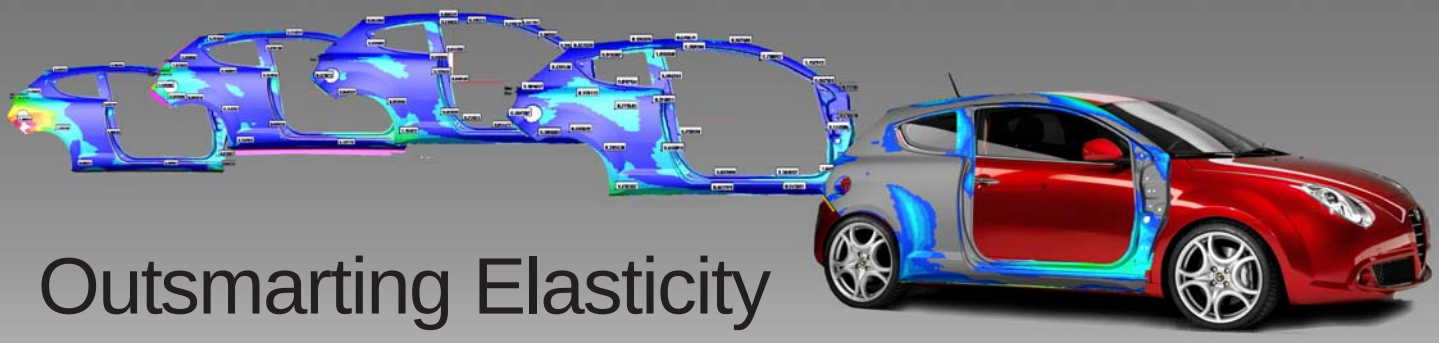


Outsmarting Elasticity

With an holistic approach for material springback compensation the effort for the die design can be reduced dramatically

by Ulrich Feldhaus

Not only from a technical point of view the planning of metal forming processes is a major challenge, especially in the automotive industry. More than ever economic aspects play a decisive role – traditional 'Trial and Error' methods are often incompatible with lean production processes. Numerical simulation programs enable a time and cost saving 'Right the First Time'. But even with the usage of those programs significant additional savings are possible. With its 'Holistic Springback Compensation' the Italian metal forming specialist Nuova Tecnocam, in cooperation with ESI Group and FIAT, has developed a much more efficient and accurate method for the springback compensation.

The material springback is one of the most difficult problems designers and process planners have to deal with. In spite to get the planned target geometry this springback has to be compensated by modifying the geometry of the dies. For a long time the physical tryout and the built of prototype dies was and is an established practise without any alternative.

side panel Fiat 500, sheet metal after drawing

Rigid economic basic conditions (shorter development cycles, longer die lifes), increasing quality standards (shorter tolerances, defined crash behaviour) and new material technologies are hard to reconcile with those iterative proceedings which quickly can cause six-figure costs and may have serious consequences, up to a delayed start of production and losings in total revenue.

Even designated metal forming specialists are more and more confronted with tasks which can't be solved efficiently with conventional methods.

It doesn't wonder that enterprises increase use numerical simulation programs for the calculation and the optimization of metal forming processes and dies.

No realistic simulation without springback

The advantages of numerical simulation – fast, early and cost saving analysis and optimization of designs – are sufficiently known and of course even valid for metal forming.

The first steps in that direction in the early eighties were rather moderate and more suited to confirm the rightness of the approach as that they could be used industrially. Today in innovative enterprises this method is an inherent part of the product development and process planning.

One of the pioneers of sheet metal forming is the French based ESI Group, which has a high expertise for the simulation of dynamics und manufacturing processes. ESI-solutions like PAM-STAMP or PAM-CRASH are widely spreaded over the manufacturing industry and integrated with solution scenarios, which sustainably support a multi-discipline collaboration and a Simulation Based Design.

Pioneer in metal forming simulation

The French based ESI Group is one of the leading suppliers of digital simulation software for prototyping and manufacturing processes. Its simulation solutions like PAM-STAMP or PAM-CRASH are widely spreaded in the manufacturing industry and integrated with solution scenarios that sustainably support a multi-discipline collaboration and a simulation based design.

With PAM-STAMP 2G and Diemaker for CatiaV5 ESI Group covers the complete sheet metal forming process, from early feasibility studies up to die design and the optimisation of method planning.

The simulation takes into account all process relevant aspects and parameters and offers a broad variety of tools for validation, quality assurance and optimization. Design changes and improvements can be realized quickly and with small efforts.

Specialist for sheet metal forming

One of the companies which use PAM-STAMP is the Italian sheet metal forming specialist Nuova Teknocam (NT).

The 1992 founded company is an ESI-partner with main activities in drawing design, methodology development of sheet metal dies, feasibility, validation and virtual tryout of complete sheet metal forming processes. With its competence Nuova Teknocam is working not only for FIAT and its suppliers since years.

Holistic approach increases efficiency

Powered by the experiences they hade collected over a couple of years, NT was looking for a way to use the simulation programs even more effective. The result is called 'Holistic Springback Compensation'.

In contrast to traditional proceedings, where for every single step a target

Bild 1: Conventional sheet metal forming process

geometry has to be defined and a springback compensation has to be done, the holistic springback compensation is based on a first sequential simulation of all relevant metal forming steps. In a next step, supported by different tools and methods, it will be evaluated in which phase a compensation would be most

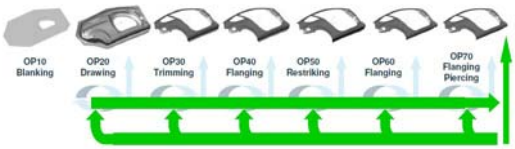


Bild 2: Process of 'Holistic Springback Compensation

efficient and how much that compensation would be.

Methods for springback compensation

Centre of all strategies for springback compensation is of course the precise calculation of the springback. In this area ESI Group, in tight cooperation with leading manufacturing companies, has made great efforts and is one of the leading suppliers today.

For the springback compensation itself different methods are known, like e.g. the DA-method (Displacement Adjustment), the SF-method (Spring Forward) or the HI-Methode (Heuristic Iterative). Finally it adds up to derive a measurement for the local die modifications by the difference between target geometry and final geometry multiplied with a negative factor.

For the sheet metal forming simulation and for the calculation of the material springback NT uses PAM-STAMP 2G. For the compensation itself and the reverse engineering they use Think3 and Omnicad. The die design is made with the CAD-systems CATIA V5 and Autocad.

Four steps to success

It is understandable that NT doesn't want to put all its cards on the table. But without disclosing to many secrets one can describe the procedure as process of four steps:

- sensitivity analysis: under consideration of the drawbead lines position and the blank shape parametric trends are evaluated.
- identification of areas to be modified: derivation of the distribution of angles between local normal before and after springback. Gradients of angles are determined highlighting the location of greater sensitivity
- identification of the most influential operation: by superimposing the springback geometries of all operations the one with most influence on the region to compensate is highlighted. Compensation addresses the origin of the problem to act from the „early" stage of error development. If the resultant shape does not match the further operations compensation is „transferred" to other operations.
- Die compensation: uses a standard geometric approach is used where the CAD is transformed using outside tools like OMNICAD and THINK-DESIGN. Compensation is done for the most influential operation.

Theoretical advantages are validated in everydays practice

In several projects the theoretical advantages of the new methodology were validated in everydays practice e. g. at the panel of a FIAT street car.

The engineering process for design and optimisation of the dies and the manufacturing parameters is defined by five phases:

1. First die design and process definition (tearing at 100 mm)
2. Corrections of the initial design (tearing at 2 mm)
3. Optimisation of the die by e.g. drawbeads and first tolerance checks (no more tearing)
4. Elimination of sheet internal tensions
5. Tolerance match and avoidance of surface defects

For the fifth phase the 'Holistic Springback Compensation' was used for the following operations:

– OP20 Drawing
- OP40 Flanging
- OP50 Restriking
- OP60 Flanging

Significant time savings and quality improvements

The methodology has been proved to be stable and robust. The improvements for some critical points are listed in (Tab. 1). At each iteration for springback compensation all forming criteria have to be addressed (plasticity, tearing, wrinkles, shape defects). The results document impressively the potential of the new methodology:

- Time reduction for the tuning of geometry and process (5.000/6.000 hours) with the holisitic method by more than 25 percent (statement: FIAT).
- Tolerances can be met without physical tryout. The differences between the physical die and the virtual results are within +/- 0.5 mm.

Advantages for the process chain

Promising methods and optimal process parameters can be evaluated in front of the manufacturing of the dies. By early simulation eventually necessary modifications of the final part are possible without influence on project plans and times.

Status and Outlook

With its approach of a holistic springback compensation NT has done an important step to make sheet metal forming simulation more efficient.

The methodology isn't yet integrated with a commercial software process. That is why in this early phase a manual effort is necessary for the execution of the individual steps. But thereare plans about an automated and easier to use software solution, which would cause a further process acceleration.

Until a commercial solution including PAM-STAMP 2G, additional post-processors integrated with the Visual-STAMP environment and Visual-Process-Tools for the holistic methodology are available, ESI and Nuova Teknocam will offer according consultancy services for critical parts.

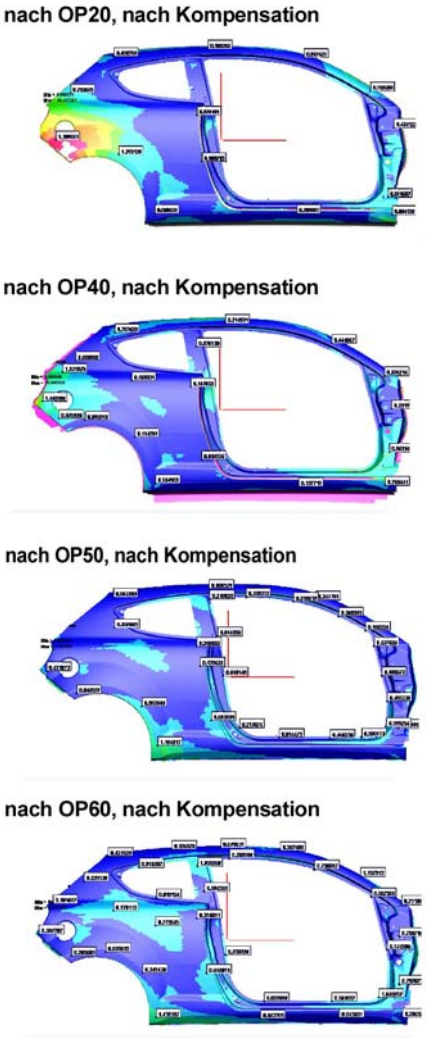
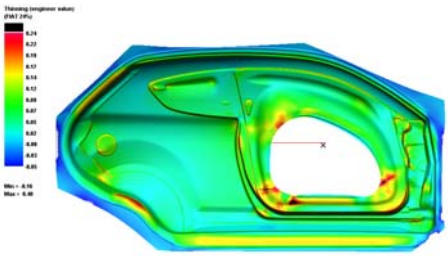


Bild 3: Geometry error after compensation Operationen

Future plans

But even other companies in the automotive industry are on the way developing similar solutions. On the other hand it is a matter of fact - NT - that these projects haven't reached the quality and maturity of the NT solution yet. Internally the advantage is estimated of 12 to 18 months. For sure, NT will do its best to conserve this advantage for the future.



sheet metal after drawing, thinning analysis
Alfa Romeo MiTo side panel

The aims reach much farther than the already reached status. The forming process is just one part of the manufacturing process. Assembly und fixture of components can even cause deformations and a deviation from the defined design goal. For the future NT plans to incorporate these effects into their holistic springback compensation too.