Springback in metal forming

In sheet metal forming the shape of the blank, obtained in the end of forming step, closely conforms the tools geometry. However, as soon as the loads are removed the elastically-driven change of the blank shape takes place. This process is called springback. In the automotive industry, engineering guidelines and finite element software are used in the design process of new sheet metal parts. Very often during the design process the amount of springback is numerically predicted. Based on this prediction the tools geometry and the process parameters are modified to obtain the required product shape.

Unfortunately, current accuracy of springback prediction is not sufficient. Therefore there is a need to start the extensive experimental trial and error process to determine the appropriate tool geometry and other parameters, which will enable to produce the required product shape. As a result, the product cost and the time from design to production are increased considerably.

An accurate prediction and control of springback phenomenon during full process modelling will allow tool designers to evaluate numerically the possibility of obtaining specified product shape and to perform necessary modifications based on this information only. If the experimental trial and error process is replaced by a reliable numerical procedure the production time and costs can be decreased drastically.

It is always difficult to establish the cause of discrepancy between the magnitudes of springback obtained in simulation and reality, especially for realistic industrial products. Springback is a complex physical phenomenon, which is very sensitive to numerous factors: variation of elastic properties of a material during deformation; elastic-plastic anisotropy and material hardening. If finite element modelling is employed for analysis of springback the accuracy of obtained solution is significantly affected by the factors that control the quality of simulation of forming operation. The most important of them include the method of unloading, time integration scheme, choice of element, blank and tool discretization and contact algorithm.

Preliminary results of the sensitivity analysis and performed literature study showed that the following factors have a large influence on prediction of springback:

- the element size, the element type and the amount of integration points through the thickness;
- the unloading method. If unloading is done gradually, similar to physical tools retraction, the springback may be not entirely elastic;
- selected yield criterion and the hardening function. The material model should be able to describe accurately the elastic-plastic anisotropy, variation of elastic modulus and the Bauschinger effect.

Some of the mentioned factors are relatively simple to take into consideration and their influence on predictability of springback is unambiguous. However, there are factors that require careful treatment and extra attention. Material modelling, for example, requires not only a careful selection of an appropriate yield function and hardening model, but also an extensive analysis of springback characteristics of sheet material by means of different test procedures.