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**В. Васильків, д-р. техн. наук, проф., Л. Данильченко, канд. техн. наук, доц.**
Тернопільський національний технічний університет імені Івана Пулюя, Україна

## МОДЕЛЮВАННЯ ПРОЦЕСІВ ВІДПРУЖИНЕННЯ ПРИ ФОРМУВАННІ ДЕТАЛЕЙ З ЛИСТОВОГО МАТЕРІАЛУ

**V. Vasylkiv, Dr., Prof., L. Danylchenko, Ph.D., Assoc. Prof.**

## SIMULATION OF SPRINGBACK PROCESSES IN SHEET METAL PARTS FORMING

Sheet metal forming is a wide spread technology in almost all kind of industrial domains for the production of an enormous variety of parts and shapes. This forming technology is controlled by an enormous amount of parameters such as the material properties or the tribological behavior and lubrication conditions. The growing number of materials and design variants, associated with the stringent requirements on precision also contribute for the increasing complexity of this forming technology. In this contect the numerical simulation became a tool of increasing importance for the process analysis.

Several properties and phenomena like the tensile strength and elastic behavior, anisotropy resulting from sheet rolling conditions and lubrication are accountable for geometrical and dimensional precision. Besides the material properties, the springback is also influenced by the tools design, so it is necessary to develop finite element codes that consistently predict this type of geometrical defects [1].

Several computer codes have been developed in order to reduce the number of try-outs in the optimization of the forming tools. However, a very precise prediction of springback deviation by means of a finite element analysis is still not available. The introduction of new materials such as aluminum alloys and high strength steels in order to improve fuel economy, emissions and safety requirements, increases this challenge since they present in general larger springback deviations. The finite element simulations of springback are more sensitive to numerical tolerances than the forming simulations, including effects of element type as well as shape and size of finite elements mesh. In terms of integration schemes almost every approaches have been tried. Typically explicit methods are used for the forming operations for which they are less expensive in terms of CPU time.

For the springback simulations this relation inverts, and that is why many commercial codes couple explicit forming with implicit springback simulations. However, coupling explicit to implicit methods may be efficient in terms of CPU time, but a bad option in terms of reliability and accuracy of results. In fact, explicit methods do not guarantee the final equilibrium of the deformable body, implying that the final stresses and strains may be completely wrong. Since the shape of the final part in a sheet metal forming operation depends mainly on the amount of elastic energy stored during the forming stage it seems consensual that better results will be attained with implicit methods coupled for both forming and springback. In terms of unloading scheme two different strategies are known to conduct to similar results: the first one corresponds to reverse the tools movement until the loss of contact and can be understood as a simple continuation of the forming process; the second corresponds to replace the tools by the corresponding forces and these are consecutively decreased until vanished. The first method has a better agreement with the real processes allowing to take into account changes in contact areas between the blank sheet and tools during the removing. However, this procedure leads to a duplication of the CPU computation time due to the phases necessary to reverse the tools movement.

In sheet metal forming, at the end of the forming phase the blank sheet is subjected to internal stresses due to the restrictions imposed by the tools. Once the tools are removed, the stress state tries to relax until a residual stress state is achieved. Springback, induced by the elastic or elastoplastic recovery make the part shape distort from the expected product shape. This is a key factor for the validation of a forming process.

Proposed simulation of springback processes in sheet metal forming based on tool displacement. This scheme can be understood as a simple continuation of the forming process. The removing of the tools is divided in the same number of steps, as there are tools to remove. In each of these steps, the movement of the tools is reversed. Lets consider, for instance, a deformation process involving a blank holder, a punch and a die. In the deformation process the blank holder was moved in the direction of the blank sheet until it reaches an imposed force. Then the punch starts its movement until a certain depth. The first step, in order to predict springback, is to reverse the movement of the punch until complete lost of contact. Then invert the previous movement of the blank holder to lose contact. At the end of these steps, the blank sheet can still be trapped in the die walls. An extra step is needed to complete springback evaluation; the die must move away from the blank sheet. In this last step an extra care is also needed, supplementary boundary conditions should be introduced in order to prevent rigid body motion and avoid convergence problems. For this unloading scheme it is also important to guarantee that the tool, after its removal, do not interfere in further simulation phases. For instance, during the die displacement the blank sheet must not enter in contact with the blank holder again.

This simulation can correspond to an enormous increase of CPU time, since now one needs to reverse the complete movement of the punch and blank holder, but also to perform the movement of the die as an extra step at the end of the process.

Two algorithms followed for each stage and step of the removing of the tools is the same as for the forming phase, presented in Fig.1.

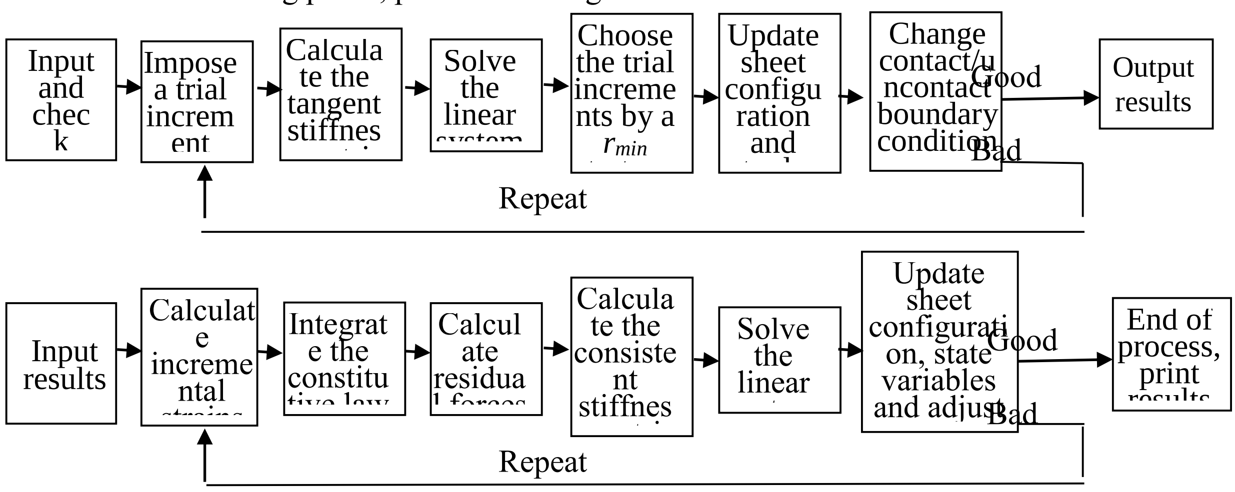


Figure1 - Algorithms of springback simulation in sheet metal forming

Today, simulation of sheet metal parts forming processes are performed using finite element methods The most important goals in this process are vertification on the manufacturability of the sheet metal parts and obtaining vital information on optimum tool design.

References:

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