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Peter Ulintz presents "Computer-Based Metalforming Simulation" at PMA's Designing and Building Stamping Dies seminar on December 5-6 in Nashville, TN. Check www.metalforming.com for this and other seminars.

TOOLING BY DESIGN | PETER ULINTZ

Process Design: An Incremental Approach

Last month, we discussed a process-modeling technique commonly used to simulate metalforming operations; we refer to this technique as the one-step method. One-step methods are used during product development and process planning to assess manufacturing feasibility.

Other techniques using incremental solvers (codes) also are available. Incremental solvers are used for detail evaluation, with the focus primarily on the development of the tool process. These codes visually display the contact of the punch with the steel sheet at incremental points throughout the manufacturing process.

Incremental analysis, inherently more sophisticated, requires more preprocessing steps and computing time than do one-step methods. But the advantages of incremental codes offset the additional time and effort required. Users can conduct a series of virtual die tryouts using precise blank shapes and specific material properties on production-intent tooling geometry. Besides formability assessments, trimline optimization, springback analysis and process sensitivity studies also may be carried out. Depending on process complexity, this could take as long as a day or two, or only a few hours.

In addition to material properties and a defined blank, the forming punch, die cavity, pressure pad and draw beads also are modeled for analysis. To simplify modeling, only the surface geometry of the tooling is required. The simulation software sets boundary conditions for the tooling surfaces so that the computer automatically interprets them as rigid, nondeformable bodies rather than as thin flexible surfaces. Working with surfaces greatly reduces preprocessing time while increasing computational speeds.

Incremental solutions will display actual wrinkle shapes, sizes and location, whereas one-step codes can only identify areas that may potentially wrinkle. Incremental solutions also will identify splitting areas while accurately predicting strain, stress and thickness distributions.

It is generally ideal to use one-step and incremental codes as complementary tools in the die-design process. Flat-blank results from a one-step analysis can be used as input data for incremental analysis. In Fig. 1, the blank output was determined by a one-step

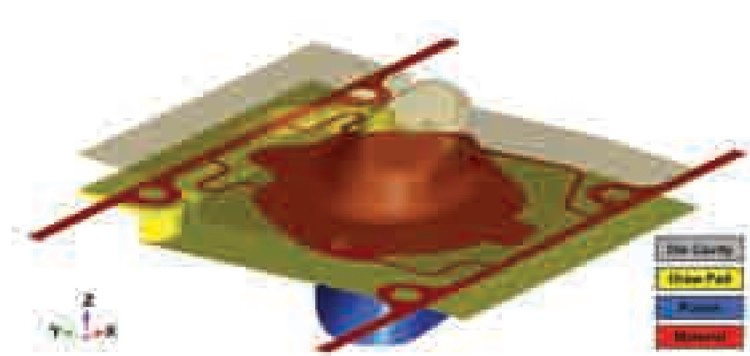

Fig. 1—Blank, punch, die and pressure-pad models.

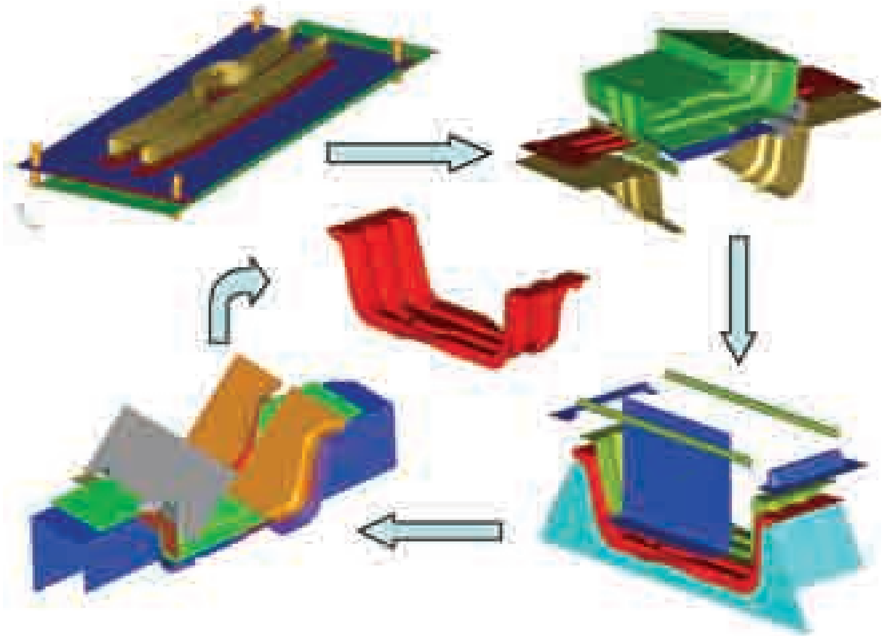

Fig. 2—Incremental analysis conducted from blank to finished part.

solution; you may recognize this blank (in red) from last month's column.

In addition to the blank and progressive-die carrier, the forming punch, die cavity and draw pad also are modeled. When a draw pad (blankholder) is modeled, the quantity, location and pressure profiles of the nitrogen cylinders also are specified. Including pressure profiles, which describe the relationship between the rises in gas pressure vs. cylinder stroking distance, provides realistic evaluation of the process mechanics.

Unlike the one-step codes, incremental codes are not restricted to a single forming operation. It is therefore common to model all the forming operations using incremental codes, as Fig. 2 illustrates. Modeling all the process steps allows strains generated in previous forming operations to be carried over to subsequent operations. This is particularly important because strain history plays an important role in accurate formability and springback prediction.

Perhaps the greatest advantage incremental codes offer is the ability to see the blank deform in small incremental steps in a "see-through" die. How often have you encountered a problem with a tool in the press shop and tried to watch what happens as you slowly inch the slide down? Eventually, you lose sight of what's happening as the die closes. Wouldn't you have a better opportunity to solve the problem if you could see exactly what was happening inside of the die? Incremental codes allow us to do just that, making this technology valuable in troubleshooting press-shop problems as well.

My last four columns have focused primarily on process-modeling techniques in general, and metalforming simulation in particular, and for very good reasons. External pressures to reduce lead time and lower die costs, coupled with internal pressures to win more business and avoid costly mistakes, require the use of these science-based engineering methods. To remain competitive, science-based die engineering is rapidly replacing traditional experienced-based engineering in die shops and press shops around the world.

Are you still relying on experienced-based engineering methods? If so, and your next job requires forming parts from an unfamiliar material or developing a complex forming operation, your next experience may be a costly one. **MF**