

# A PARAMETRIC AND USERFRIENDLY APPROACH TO INCREMENTAL PROCESS SIMULATION OF SHEET METAL FORMING

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## Summary:

With a steady increase in computational power and decrease in hardware costs during the last few years, the incremental process simulation in the area of sheet metal forming is considered a state-of-the-art tool during the development process at OEMs and many, mainly larger, suppliers. However, the existing pre-processing tools do not support a template based analysis setup that can prevent the need for highly skilled personnel in order to set-up an analysis application and, therefore; open the door for an LS-DYNA based stamping simulation for smaller companies that do not have the skill set and manpower available to do the analysis setup using existing tools.

The presented solution FormingSuite FastIncremental, is an analysis environment that provides the end user with a dramatically simplified solution for the setup process for incremental stamping analysis using the LS-DYNA solver. This is done through the automation of tool definition/extraction and an automated setup for blank on curved binder combined with other techniques to enable fast solving time.

To ensure an optimized solution time, a combination of inverse and incremental finite element tools is used. This combination can lead to enormous time savings in blank development and positioning, tool definition, binder wrap calculation as well as in simulation run-time while reliable results are produced. The user interface is CAD-like and geared towards an average industry practitioner; definition of complete forming processes as well as the application of boundary conditions is mapped on the first form geometry as it is commonly used on A-layouts in the industry.

Associative and regenerative mechanisms ensure that changes made to the first form geometry or to forming conditions are automatically propagated throughout the complete analysis process, ensuring that geometry, forming conditions and results are always in sync. This also means that in conjunction with an automated tool generation, the presented tool enables an automated batch mode processing for pre-defined part groups without any user interaction other than evaluating the calculated results.

## Keywords:

regenerative, associative, sheet metal forming.

## 1 INTRODUCTION

An incremental stamping can typically be done as soon as tooling geometry is available and an intended blank shape is known. It is then up to the user and the available pre-processing tool what has to be specified and done in what order during the setup process, if any order is necessary. In general, the available pre-processing tools are mainly aimed towards highly skilled and special trained personnel, people that do not need close guidance throughout the simulation setup. In this case the main intent of any new solution needs to be a speed up of the analysis setup in order to save time that is unnecessarily spent in repetitive actions during analysis setup.

However, with decreasing cost for computational power the finite element simulation of forming processes becomes more and more a commodity and hence, also of interest for smaller companies that might not have the skill set available that larger companies and OEMs have.

The presented application introduces a new approach to metal forming analysis and is improving the pre- and post-processing of stamping analysis for all groups of users – the high end user is supported through intelligent automation algorithms that prevent repetitive work; the less experienced user with premium user guidance and support throughout the complete analysis process.

CAD like associative and regenerative mechanism ensure that analysis input and results are always synchronized and a process tree always keeps the user updated on the status of the analysis.

The analysis setup as well as the post-processing is performed in a single software environment that is used for blank development, analysis setup, solving as well as post-processing of the results.

The implemented explicit incremental solver is LSTCs well known LS-DYNA and ensures the accuracy of the results.

## 2 AUTOMATED TOOL GENERATION AND ANALYSIS SETUP

The complete setup of the analysis is based on the so called 'first form geometry' of the part. The term 'first form geometry' is commonly used describing the part geometry including addendum and the boundary of the part after it is formed. This geometry in general can be used to determine the net shape blank and it also includes the geometrical information that is necessary for the creation of tooling geometries.

Based on the given geometrical information, a geometrical feature recognition done on the first form geometry ensures a proper separation of geometrical areas belonging to the punch, the die and the blank holder. Based on the gained intelligence, the geometrical engine is also used to support the user during the later definition of forming conditions and can, for example, automatically predict if a part is done as a crash form with a two piece die setup or a if a three piece draw die setup is used.

Figure 1 shows an example of a first form geometry and the extracted tool geometries solely based on these part geometries. In this case, the software will also be capable of extracting the curved binder geometry and consider this in the analysis.

To prevent possible failures and problems due to either surface or mesh offset of the separated tool geometries, an internal offset mechanism ensures that no physical offset of these tool geometries is necessary for the analysis. The extracted tool surfaces are also automatically extended, which allows the user to rely only on the pre-processor in a lot of cases without switching back and forth with a CAD-system to create necessary geometries.

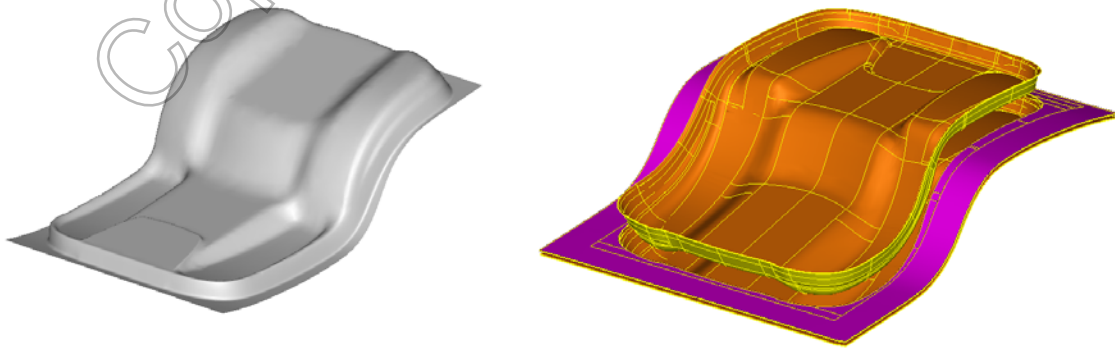


Figure 1: Example for automatic tool extraction

As commonly done during part and process design, the forming conditions are defined directly on the part, or, as in the presented process, on the first form geometry.

This provides the user a fast understanding what areas of the part are of importance for processing the geometry properly. After all necessary forming and boundary conditions are applied, a mapping algorithm ensures that all the conditions are translated correctly to the specific tool geometry and the defined forming conditions are also used to determine a initial net-shape blank.

For this step, a technology called Finite Increment Technology (FIT) is used. The FIT is based on a newly developed implicit incremental solver that allows large time increments and can handle multiple forming operations to determine very quickly the initial blank shape from a given part geometry. It can further be used to provide a first feedback on the forming feasibility of the part and, therefore, it can prevent the expense of multiple incremental analyses. Major problems in the part design can already be filtered out based on this fast analysis.

As the FIT analysis is done, the system provides a net-shape blank geometry that now can be used as the starting point to define a blank for the incremental forming analysis. Easy to use blank editing tools allow for manual addendum or removal of blank material on the edges and further nesting capabilities can be used to define a standard blank shape such as rectangular or trapezoidal blank (Figure 2) that then can be taken directly into the incremental analysis.

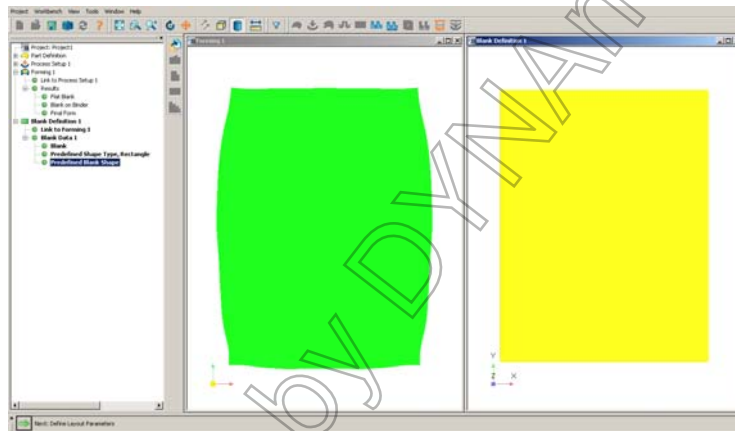


Figure 2: Nesting capabilities for definition of process blank

Blank meshing for the incremental analysis then is done automatically using the defined blank shape. If a curved binder analysis is done, the binder wrap analysis is done before the tools are positioned with respect to the blank.

### 3 THE ANALYSIS STAGE

If the analysis is performed using a curved binder, the binder wrap analysis is done using inverse solver technology. With this approach, and the implementation of the newest inverse solver technology, FormingSuite FastIncremental offers an accurate way to calculate the blank in closed binder position and also offers enormous time saving capabilities for binder wrap calculation compared to an incremental approach. The typical solving time for an inverse binder wrap analysis is less than one minute and even with large sized blanks, the time is not considerably longer.

The inverse solver uses a shell element definition that accounts for additional bending strains in areas with tight radii and it also considers the shift of the neutral fibre in the sheet material during the pre-forming process. As a result of the binder wrap analysis, the preformed blank in binder wrap position is taken automatically into the incremental analysis where the positioning of the tool part geometries is then done.

As mentioned, the incremental forming analysis is based on LSTC's explicit LS-DYNA solver that is widely known for its accuracy. The only necessary interaction between the user and LS-DYNA is to select a template to control speed and accuracy of the analysis. After this selection, the user is not involved anymore until post-processing can be done. FormingSuite automatically creates the necessary input and the solver run is directly controlled within the analysis environment. During the analysis, the user is always kept informed on the status.

This template driven approach combined with the tool extraction, enables the analysis to be run completely remote as a batch application with the user involved only to check the results. This offers the possibility for enormous time savings due to automated analysis preparation.

#### 4 POST PROCESSING

One of the most important tasks in any forming analysis is the post-processing of the analysis results. For this task FormingSuite offers a post-processing environment that is laid out and adjusted especially to the needs of evaluating stamping simulations.

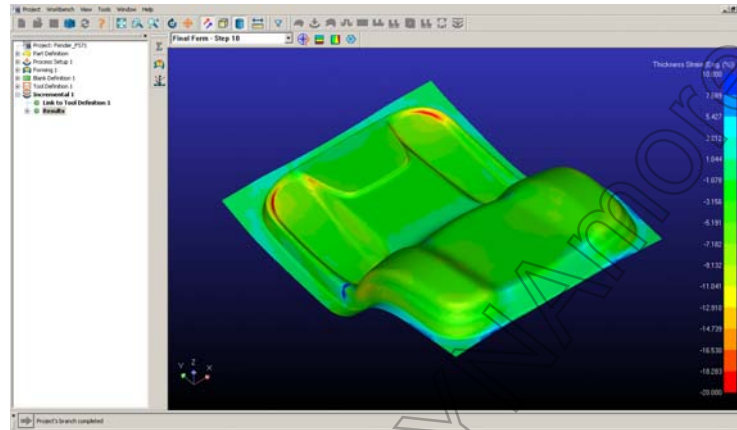


Figure 3: Post-processing

Results can be displayed as color plots on the part geometry and all available intermediate stages. Result plots along predefined cutting sections are available and the user can directly pick any point on the analyzed geometry to get a complete feedback on the results in the selected element.

#### 5 ASSOCIATIVITY AND REGENERATIVITY

One of the main areas of progress modern CAD systems have made compared to their predecessors, is the associativity and regenerativity offered to the user.

If any changes are made to a given CAD design, the application automatically propagates this change throughout the complete design structure and automatically updates all features that are linked to or affected by the change.

FormingSuite is introducing this behaviour into the finite element simulation on an analysis level. The complete analysis setup is performed in a regenerative and associative environment, any changes made to the part geometry and / or the forming conditions are propagated through the complete structure – which can consist only of the setup as well as contain results that are based on the previous input. To ensure that the user is always informed and can keep track on the status of the analysis, a CAD-like process tree is introduced.

During the process setup, this tree provides steady and very intuitive feedback to the user; for example: what stage of the setup process one is at or, in case changes are introduced, what leafs of the tree need to be updated in order to be 'in sync' with the provided input. Using the available automation, the analysis can then be regenerated without any further user interaction.

#### 6 CONCLUSION

A new approach to the finite element simulation in the area of sheet metal forming is introduced that improves the usability, as well as extends the range of applications for the incremental analysis of stamping processes using LS-DYNA. The template based approach, combined with an automated tool extraction, definition, and positioning, ensures the possibility to further introduce sheet metal forming analysis as a commodity, and even sets the base for a complete, or at least partially automated, analysis in a batch mode to release users from repetitive actions during analysis setup.