Application of Scrap Shedding Simulation in Stamping Manufacturing

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Abstract

One of the most critical issues in stamping manufacturing today is the successful shedding of scrap from limited trim dies. Until recently, die tryout was the first opportunity to check the shed scrap feasibility of a trim die.

The newly developed scrap shed analytical module can be used for analyzing trim die scrap shed feasibility before die creation. It simulates Scrap shedding during or after the die is designed using Dynaform and LS-DYNA®. Scrap shedding simulation offers die designers and manufacturers the opportunity to closely examine a trim die's performance before die construction. With today's tighter die design timelines and reduced number of dies in manufacturing, it is more critical than ever to establish trim die design integrity as early as possible in the design process. This can be achieved through Dynaform scrap shedding simulation.

Dynaform scrap shedding uses a flexible body approach to simulate the exiting of scrap from the workstation. This allows for full interaction of all essential variables and forces acting on the die and sheet metal part. It allows for a real world simulation that calculates the effect of any changes in die speed, initial velocity, material properties or die design. Various trim operations, such as direct and cam trim, can be very easily simulated. Once a design defect is found, possible solutions can also undergo a virtual tryout in the Scrap Shedding simulation. It has a great impact on cost and timing when used in stamping engineering, and can be used to avoid the pitfalls of defective die design.

Introduction

One of the biggest issues facing sheet metal manufacturing today is the shutdown of trim dies during the production cycle to remove scrap. Excessive trim die shutdown causes production delays, reduces die efficiency, and dramatically increases production costs. Traditional trim die design relies on the die designer's expertise to ensure the finished trim die design will properly shed scrap. Traditional design does not use CAE simulation to illustrate how the scrap will fall off the trim tools, move through the die chutes, and exit the die through the bolster and floor openings. The final die design is assumed to properly shed scrap, unless die tryout shows otherwise. This system works fine when die tryout is successful. However, when die tryout shows the die did not properly shed scrap, the die has to either be scrapped or modified. This entails production delays, and increased trim die design costs. Today's tighter die design timelines have rendered the old trial and error method of trim die design validation a very risky proposition. A more scientific method of validating trim die design is needed. Scrap shedding simulation has filled this void in die design by creating a virtual die validation before die tryout. Its inception adds a higher degree of confidence in the trim die design, and attempts to identify potential problems before die design completion.

Scrap shedding simulation was born out of this need to add more confidence in the initial trim die design. Scrap shed simulation achieves this goal by simulating the movement of scrap through the die. It is intended to be used as an integral tool during the trim die design phase. This has the added benefit of validating design integrity as early as possible in the trim die design process. In recent years, the application of stamping simulation has grown enormously as the benefits of troubleshooting and optimizing die design processes on the computer, rather than through extensive shop trials have been realized. Scrap shedding simulation is another valuable tool to analyze one of the most important requirements of trim dies, the ability to effectively shed scrap.

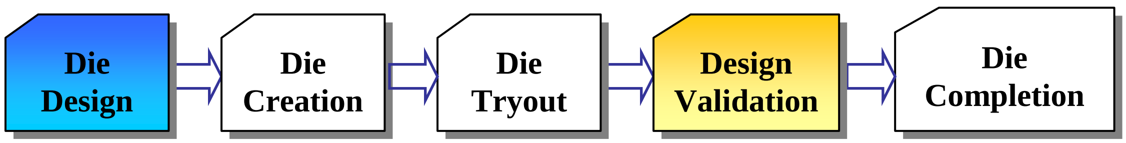


Figure 1: Traditional die design process without scrap shedding simulation

The disadvantage of traditional die design strategy is that trim die scrap shed is not validated until after die creation, in the die tryout stage. If the die does not shed properly, the die either has to be scrapped or modified. If the die modification strategy is chosen, die modification may result in destroying die structural integrity. Either option involves a lot of time and money, and makes it more difficult to meet today’s tight die design timelines.

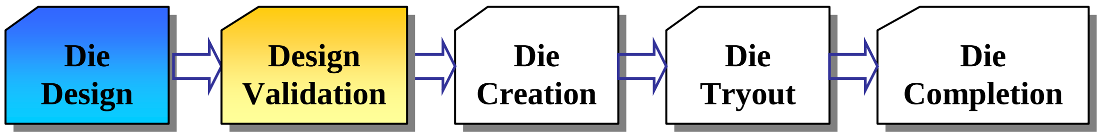


Figure 2: Die design using scrap shedding Simulation

Figure 2 illustrates how scrap shedding analysis offers the advantage of performing a virtual die validation before the die is created and undergoes die tryout. Potential design defects can be detected and corrected in the design phase, before die creation. This offers the additional advantage of die modification being performed by the die designer. He is the one best able to maintain die structural integrity during the modification process.

eta/DYNAFORM scrap shedding module supports direct trim, cam trim and piercing operations. Through this module the user is able to accurately simulate the effects of all three operations on the shedding of scrap within the trim die.

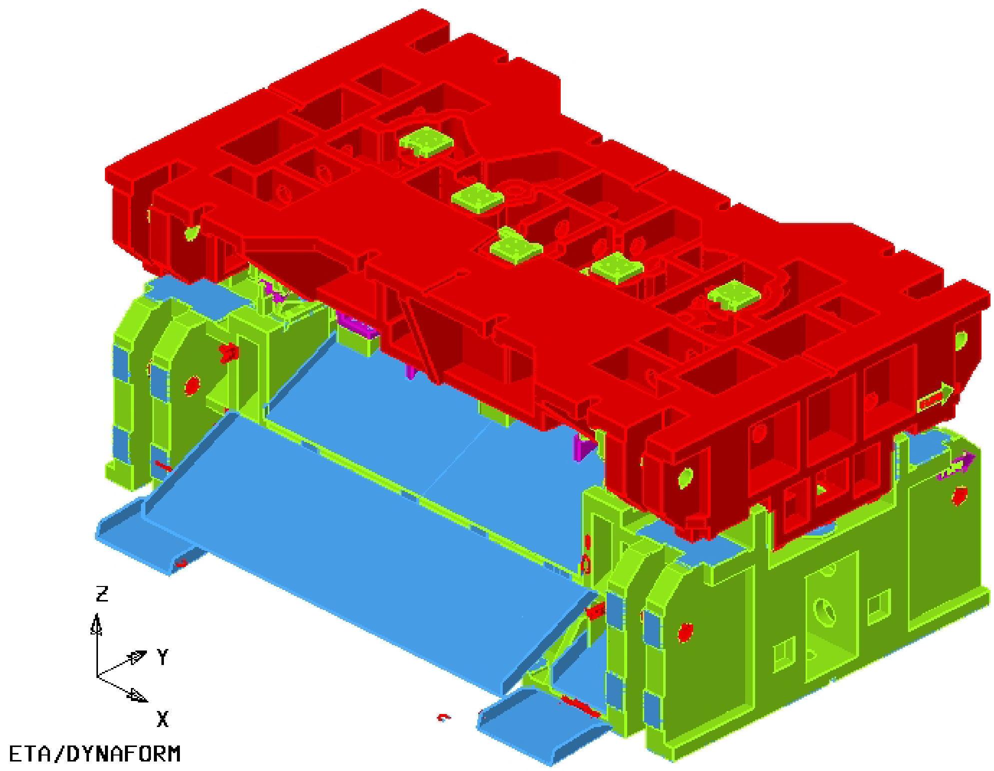


Figure 3: An illustration of a typical trim die set

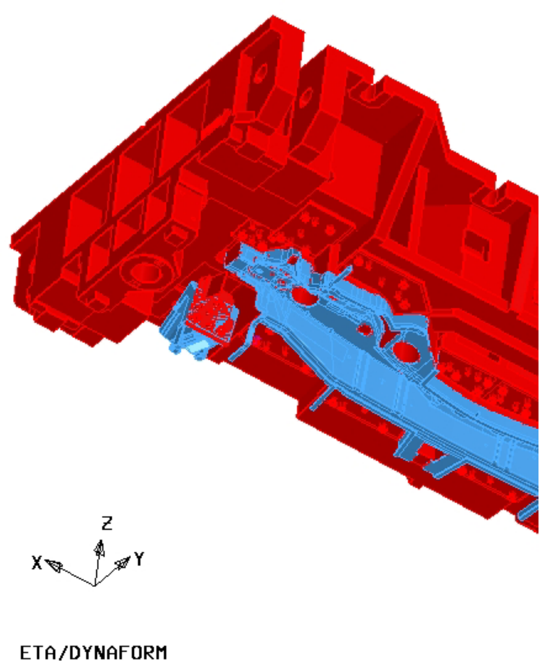


Figure 4: An illustration of a typical upper trim die

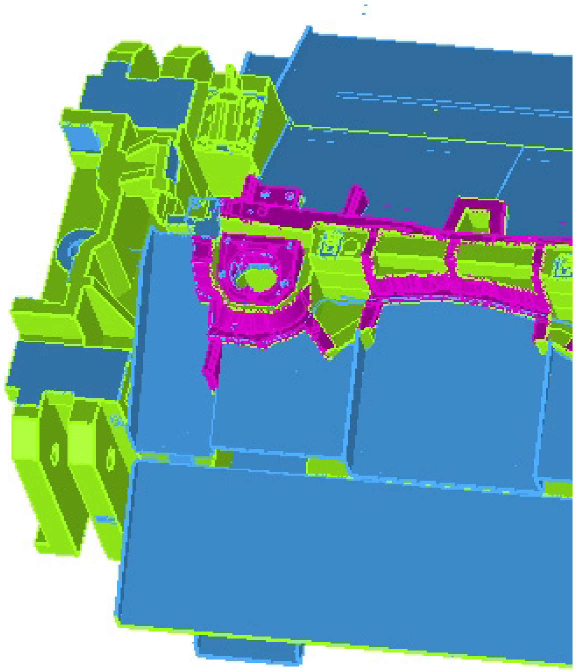


Figure 5: An illustration of a typical lower trim die

Scrap Shedding Simulation Process

I. Simulation Setup

The first step in Dynaform scrap shed setup is to import the trim die CAD data and draw panel CAD file. Once imported the data is separated into draw panel, trim die, trim die tools, die chutes and bolster.

Then all files to be used are meshed and checked. Scrap pieces may be included in the die files. If not, the scrap pieces are created from the draw panel file in eta/DYNAFORM using the mesh modification functions in the scrap shed module. Then all files are input into the scrap shed module and the job is submitted.

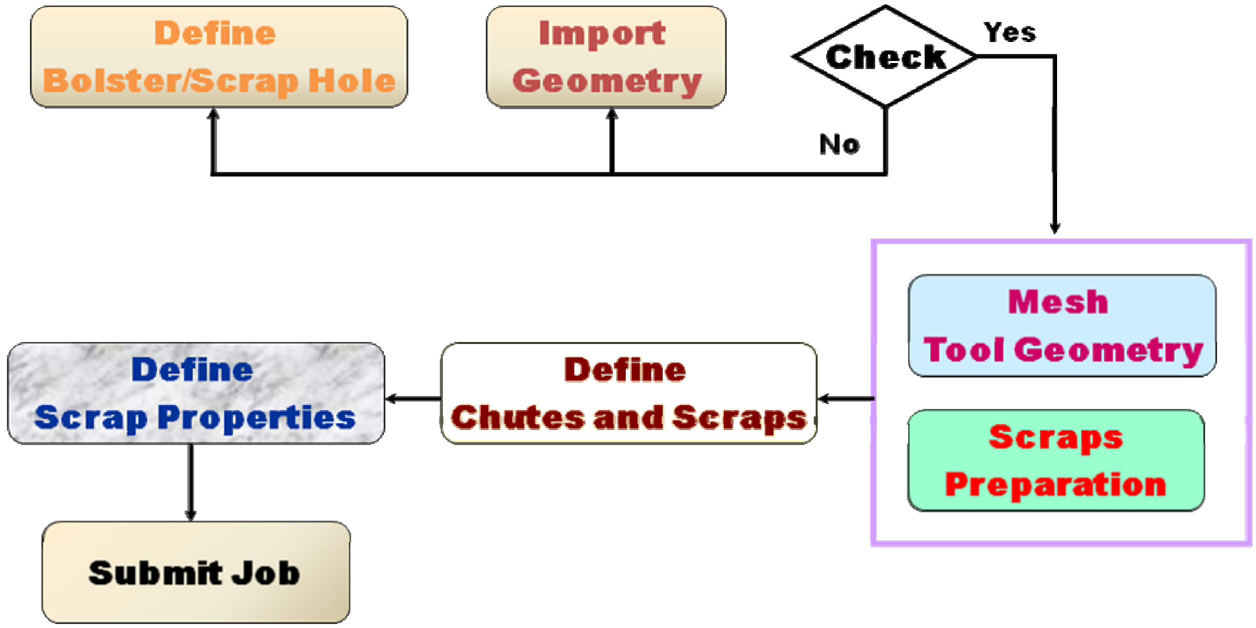


Figure 6: Scrap shed simulation setup process

II. Analyze Results

The completed simulation results are viewed in the eta/DYNAFORM post processor. The analysis will show potential problems with scrap getting stuck within the die, scrap getting stuck on the tools, or scrap that does not properly exit the die through the chutes and bolster holes in the floor.

III. Die Design Validation

The final step in the analysis process is to make a final determination whether the current die design can be validated as a die that will properly shed scrap.

If the trim die does not pass the virtual scrap shed validation, it must undergo design change. The scrap shedding simulation is repeated using a modified trim die. eta/DYNAFORM scrap shedding analysis also offers the additional advantage of doing a virtual tryout on multiple die designs to ensure the best option is chosen.

Scrap Shedding Simulation – A Case Study

This section will describe in some detail a recent scrap shed project, a fender outer trim die. This die is a one stage trim die composed of both direct trim and cam trim tools. The die makes the primary trim on the fender panel, to ready it for the next step in completion of the fender panel. In a single operation it trims the panel and generates multiple scrap pieces that must be shed from the die. The bolster on this die has no internal disposal holes; all scrap exits the die from the four sides of the bolster. Figure 7 illustrates the lower die, bolster, die chutes and scrap generated by the trim operation, ready to be shed from the die.

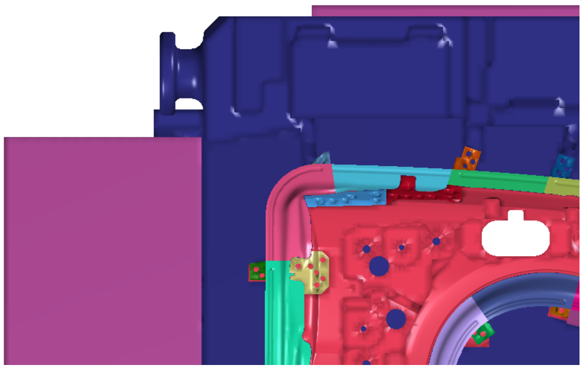


Image courtesy of Ford

Figure 7: Lower trim die showing die chutes and scrap generated

The first step in generating a scrap shedding simulation is to define the press bolster based on information provided in stamping process. Next import the components used in the simulation. In this case the inputs are the drawn panel, drawn panel trim lines, trim tools, lower die, and lower die chutes. Once these components are imported, simulation setup can begin.

The steps in simulation setup for this panel include:

1. Trim panel using the trim line provided to create the outer trim piece for the panel. (This results in the initial panel outer trim piece.)
2. Overlay outer trim piece onto lower die trim tools
3. Use trim tools to split the outer panel trim into the multiple scrap pieces that will be shed from the die.
4. Import and mesh the bolster, die, background data
5. Check all components for proper placement and clearance
6. Run the simulation
7. Review results (and re-run simulation if necessary)
8. Make determination whether current die design can be validated to properly shed scrap
9. Report out final results of scrap shed trim die validation analysis

The inner and outer trim lines illustrated in Figure 8 are used to trim the panel in eta/DYNAFORM to create the total scrap to be trimmed from the panel. The trimmed panel is illustrated in Figure 9.

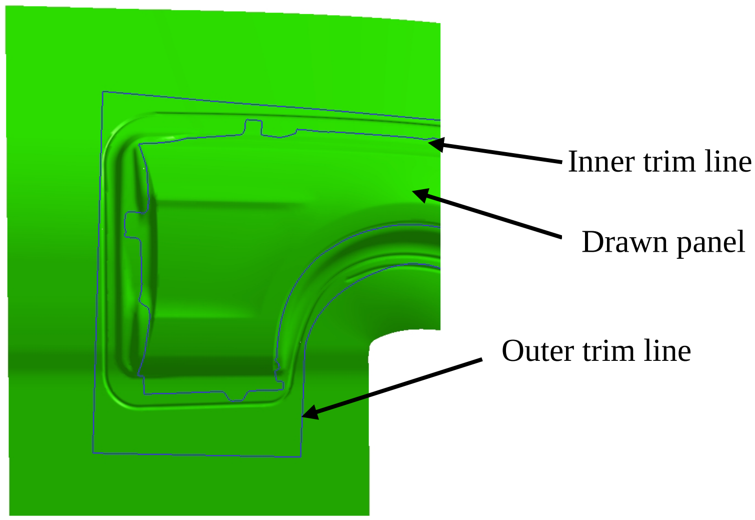


Figure 8: Fender drawn panel with inner and outer trim lines

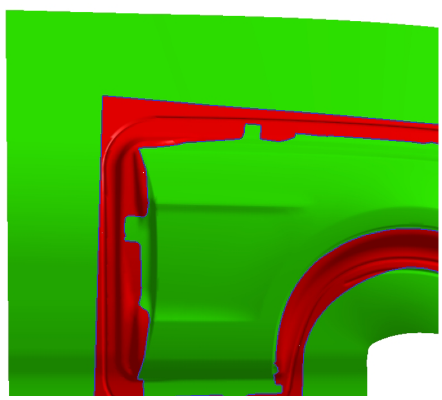


Figure 9: Trim operation completed on Fender drawn panel

The initial scrap piece is then split into the multiple pieces to be shed by the die. This is done by using the lancing function in eta/DYNAFORM scrap shed module. The scrap generated in figure 9 is overlaid with the lower die trim steels illustrated in Figure 10.

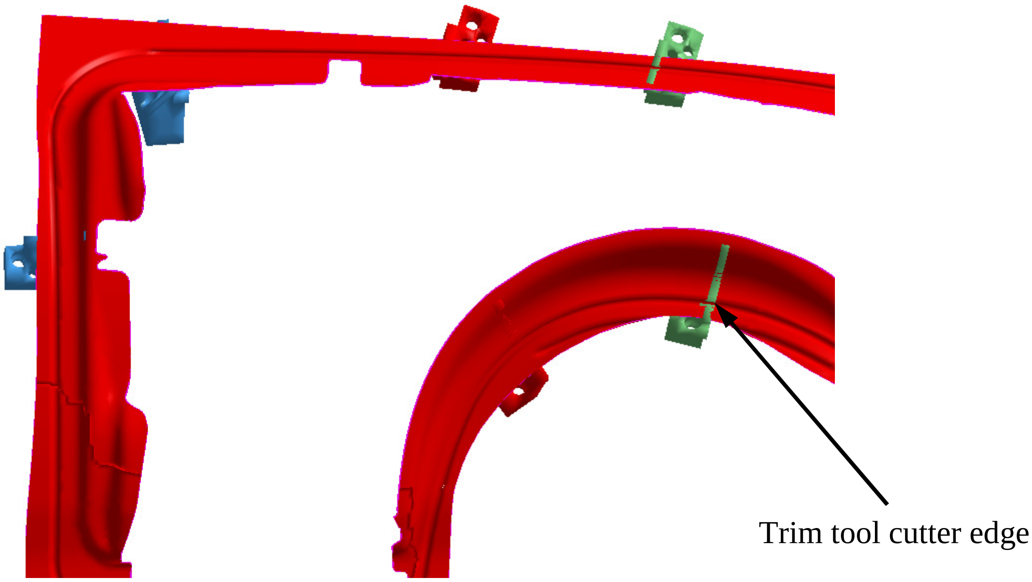
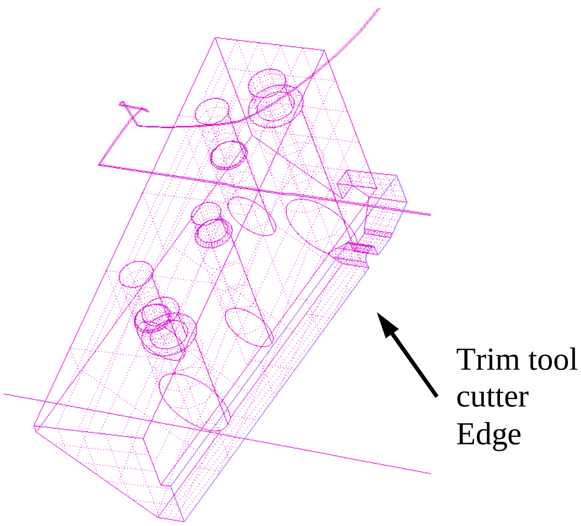


Figure 10: Overlaid total scrap with trim steels

Before the lancing operation, the trim tool cutter edge must be extracted from the tool. The cutter edge is used by the lancing function to create the lance line used to trim the scrap. Figures 11 and 12 illustrate the trim tool cutter edge extraction process performed in eta/DYNAFORM. The trim tool edge is overlaid on the total scrap part to use as a guide line when splitting the scrap with the lancing function. Figure 13 illustrates a completed lancing operation. The result is a scrap piece created for the simulation. This operation is completed 13 more times to create the twelve pieces required for simulation.



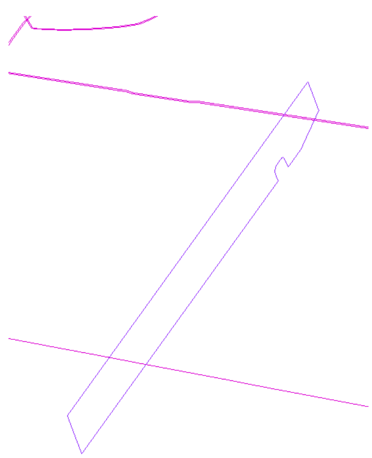


Figure 11: Trim tool edge

Figure 12: Extracted cutter

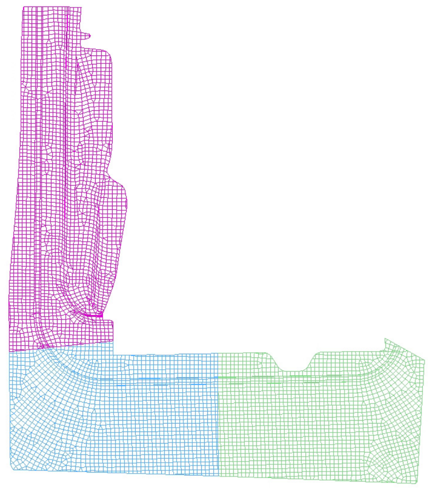


Figure 13: Completed lancing operation, resulting in scrap piece creation

After all the scrap pieces are created, the scrap shed components are ready to be input in the scrap shed module. This is done from the scrap shed graphic user interface, as shown in figure 14. The chutes part list contains the die, press bolster and chutes. The drawn panel is loaded into the draw panel part list. The scrap pieces are loaded into the scrap part list.

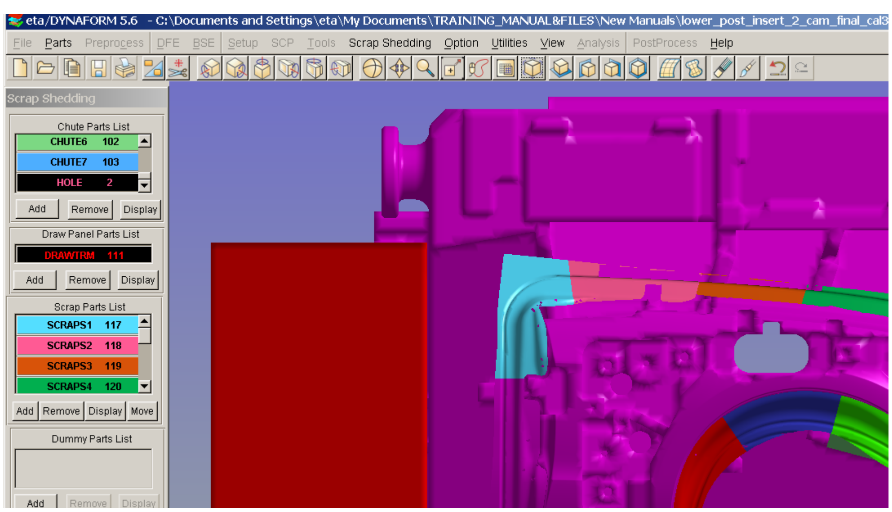


Figure 14: Scrap shedding graphic user interface

The next step in simulation setup is to allocate trim force by assigning initial velocity to the scrap along the cutting edge. Each trim edge has its own velocity, which must be assigned to the scrap to obtain proper simulation results. Figure 15 shows velocity properly assigned to scrap. The arrows shown signify the velocity applied to scrap. After verifying that velocity has been properly applied, the job is ready for submission in the job submitter illustrated in Figure 16.

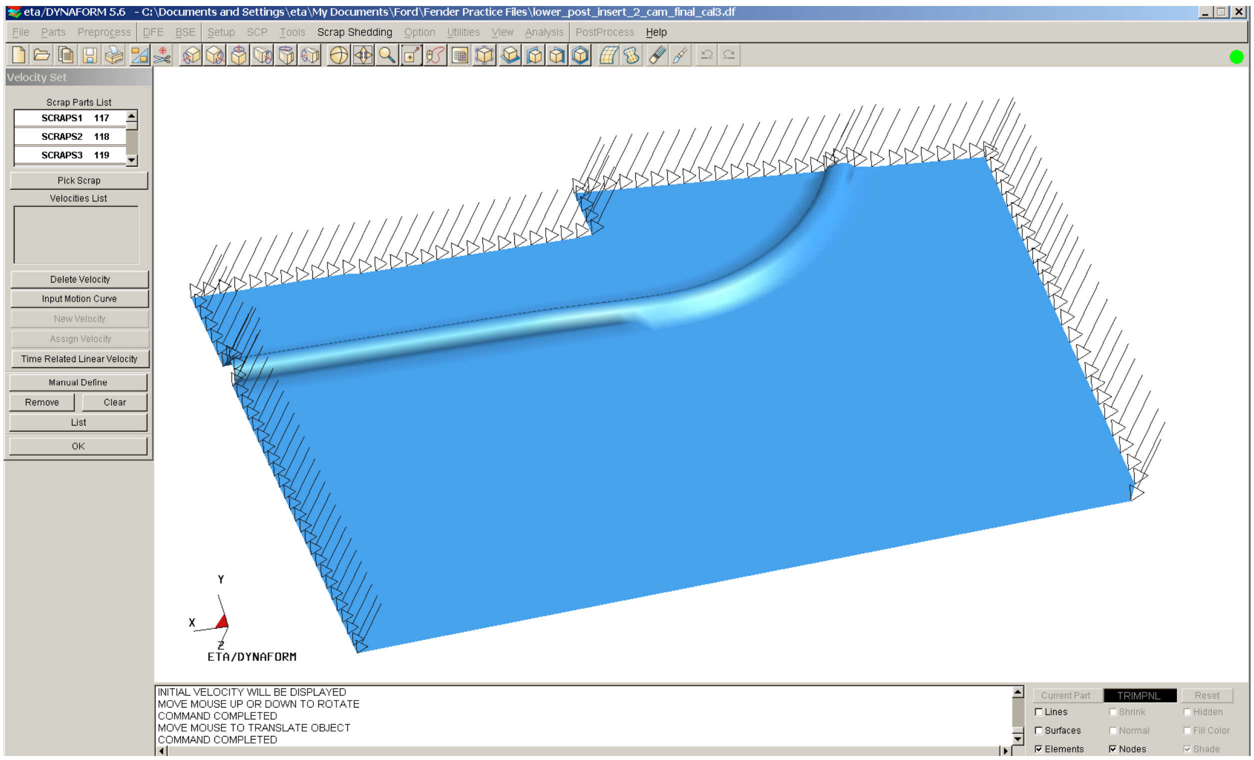


Figure 15: An illustration showing applied linear velocity on scrap

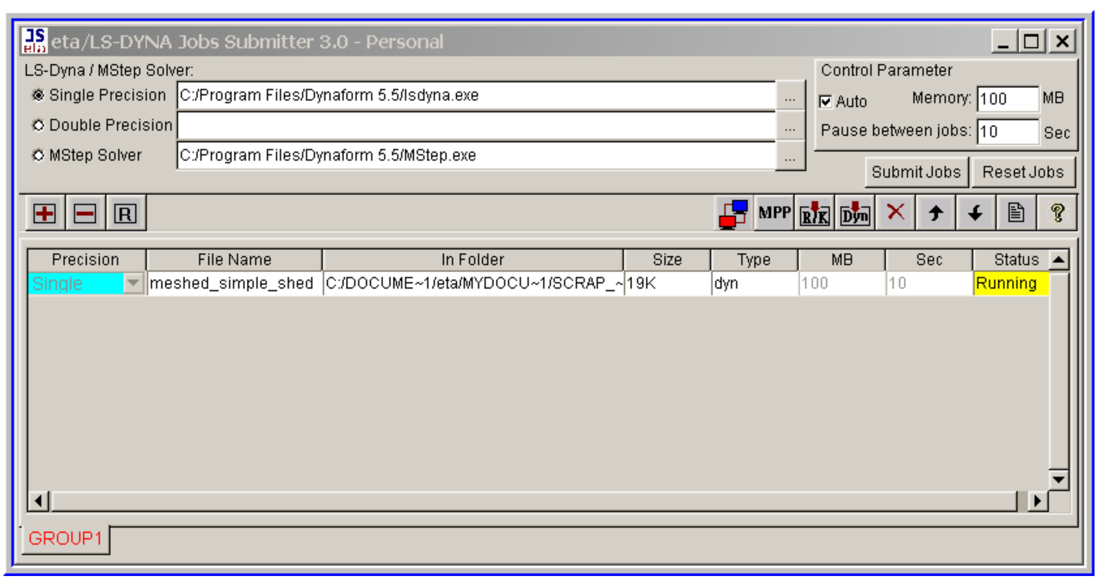


Figure 16: Job submitter

After the simulation is completed, the results are reviewed in the post processor. Observation of the post processor results are used to determine if the simulation results are acceptable. Then a virtual trim die validation decision is made to determine if current die design will properly shed scrap. If not, the die is redesigned to ensure the scrap will shed properly. An illustration of scrap shedding results is shown in Figure 17.

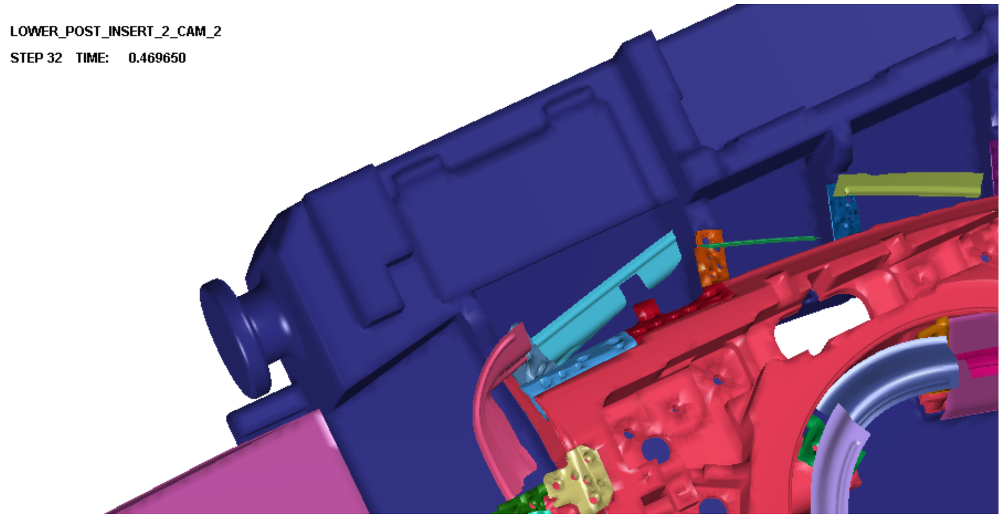


Figure 17: Completed simulation viewed in Post Processor

Conclusions

This paper presents another feature in the latest evolution of eta/DYNAFORM, which is an LS-DYNA based sheet metal forming simulation technology. For nearly a decade, eta/DYNAFORM software has evolved dramatically to provide cutting edge simulation technology for the tool and die industry, stamping industry and automotive OEMs. Other recent impressive capabilities implemented in eta/DYNAFORM 5.6 include the Die Face Engineering, Re-Engineering, Blank Size Engineering (BSE), Springback Compensation Process (SCP), Die Structure Analysis (DSI), Sheet Metal Transfer and Handling (SMTH), hot forming and tubular hydroforming. These brand new capabilities, and scrap shedding simulation, aim to help stamping CAE engineers resolve stamping engineering issues during the vehicle development cycle. Continuous development of new stamping CAE technology is the key to ensure seamless integration of stamping CAE throughout the vehicle development cycle and die development. Scrap shedding simulation offers one more effective method using CAE simulation to save design time, dollars and shorten tooling implementation timelines. These new CAE innovations enable manufactures to meet the challenges faced by today's competitive environment, and help them continue to push the boundaries of stamping CAE in the coming decades.

Acknowledgement

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