UNDERSTANDING SCALABILITY IN ALTAIR® INSPIRE™ FORM AN ENHANCED SPRINGBACK BENCHMARK STUDY

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Introduction

Organized by The Minerals & Metals Society (TMS) as part of the biannual Numisheet Conference, presented here are the results from a 2022 benchmark study comparing springback predictions from different metal forming software vendors: Altair® Inspire™ Form; Ansys LS-DYNA®; AutoForm Forming R10; and Stampack Xpress. During the conference, the Numisheet Benchmark Committee awarded the highest rating for the DP 980 steel, without stake beads category, to Inspire Form, which provides a complete metal stamping simulation environment.

In a follow-up exercise by Altair, included here are the results of a deeper exploration into the scalability of Inspire Form, a factor not included in the original benchmark study. By optimizing the hardware configuration, running identical simulations on a high-performance computing (HPC) appliance reduced compute time by more than 80%.

Why is Scalability Important?

Today, scalability is a fundamental aspect of the architecture and design of powerful software. It enables businesses to grow and adapt efficiently while maintaining performance and reliability, including:

- Performance: Despite increases in workload or users as a company grows, software needs to maintain performance while being responsive, fast, and accurate. Scalable software can ensure performance remains stable as data handling and the number of users increases.
- Cost Efficiency: Scalable systems can often be more cost-effective, e.g., instead of investing in a very powerful and expensive single server, organizations can add cheaper servers as needed.
- Flexibility and Adaptability: For businesses experiencing varying levels of demand, scalable software adapts to changes in workload, be they gradual increases or sudden spikes.
- Reliability and Reduced Downtime: Scalable systems can distribute the workload across multiple nodes or CPUs, providing continuous operation even if one node fails.
- Competitive Advantage: Companies with scalable systems can avoid major overhauls of their on-site IT infrastructure as demands increase.

- Cloud-based software solutions, such as Altair One®, are inherently scalable and agile enough to meet global business demands for 24/7 accessibility, handle geographic peaks and troughs cost-efficiently, and enable collaboration by users around the world.

Overview of the Numisheet Industry Benchmark

The benchmark study aims to compare the capabilities of different providers' metal forming software to predict the springback when forming a typical automotive component, such as those in B-pillars. The two materials used in the study were DP 980, a dual-phase steel common in vehicle body structures, and a widely used automotive grade 6xxxx-series aluminum alloy. The benchmark study defines the tooling geometry and related specifications, forming process, springback simulation setup, specifications of springback measurements, material data, and reporting[1].

Twist Die

A standardized tooling – known as the Auto/Steel Partnership (A/SP) Twist Die, shown in Figure 1 – is used because the formed panels tend to twist and exhibit wall side curl during springback. These effects are recognized as the most difficult types of springback to predict in order to control and compensate for in die design.

Springback is predicted in the benchmark study for formed panels stamped under two very different processing conditions: (1) with binder load to constrain metal flow; (2) a stake bead feature, which acts as a miniature punch, and contacts the metal towards the end of punch stroke to prevent any further flow of metal from the binder into the die cavity, which means in the final processing moments the draw forming changes to stretch forming.

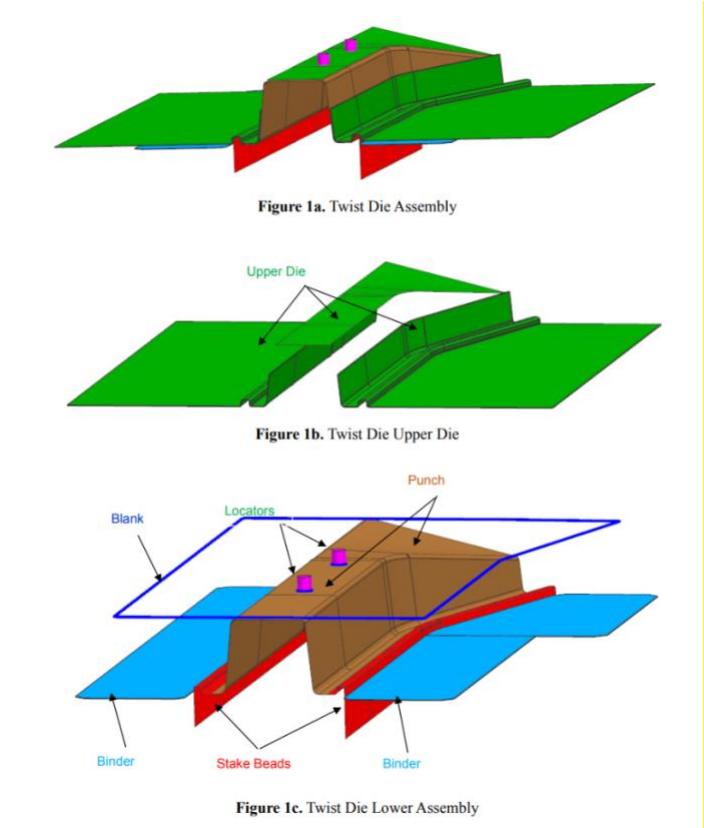


Figure 1a. Twist Die Assembly

Figure 1b. Twist Die Upper Die

Figure 1c. Twist Die Lower Assembly

Figure 1 – Configuration of Auto/Steel Partnership Twist Die [1]

Forming Process

For the materials to be formed, the blanks are laser cut, and the roll-direction specified in relation to its positioning on the tooling. The upper draw die is made up of three pieces that move down together as a solid part to a position (Binder Gap) that avoids friction restraining the blank during complete die closure to position (Z-Gap) above the punch; see Figure 2. Both upper and lower tool surfaces also have allowances for the metal thickness.

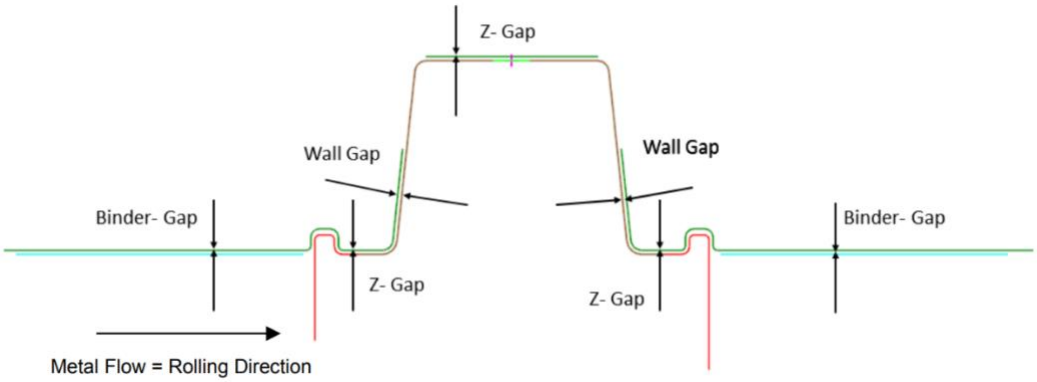


Figure 2 – Forming Process – Blank Configuration and Gaps [1]

Springback Simulation Set Up

In accordance with the Twist Die geometry, the three-point (A, B, C) method with six constraints is used in the springback analysis as seen in Figure 3.

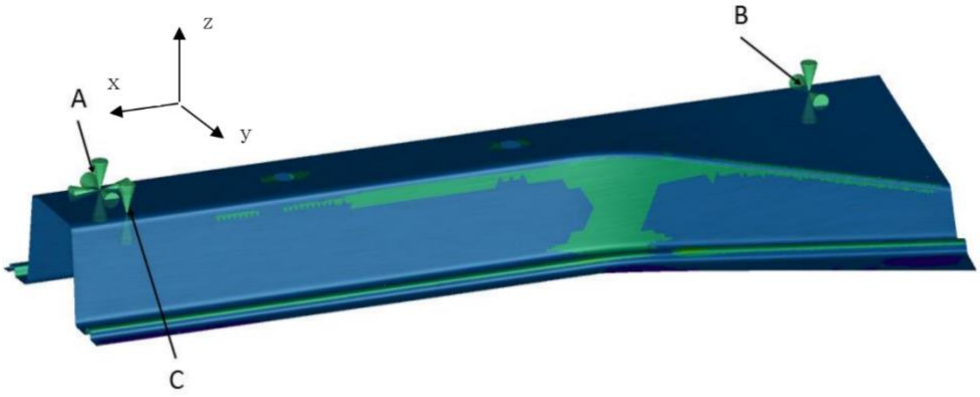


Figure 3 – Simulation Set-up for Springback Analysis [1]

The coordinate system for points, relative to the defined punch surface, are a fixed position throughout the forming process. These aim to enable an unambiguous comparison of the springback predictions and measurements by removing rigid body translations during the springback simulation.

Springback Measurement Specifications

To ensure consistent location of measurement and prediction of springback between different software simulation results, a series of planes perpendicular to the x-axis were specified based on the main features of the springback that occurs in this asymmetric panel. The results attained are compared with those obtained by experiment on steel and aluminum formed parts.

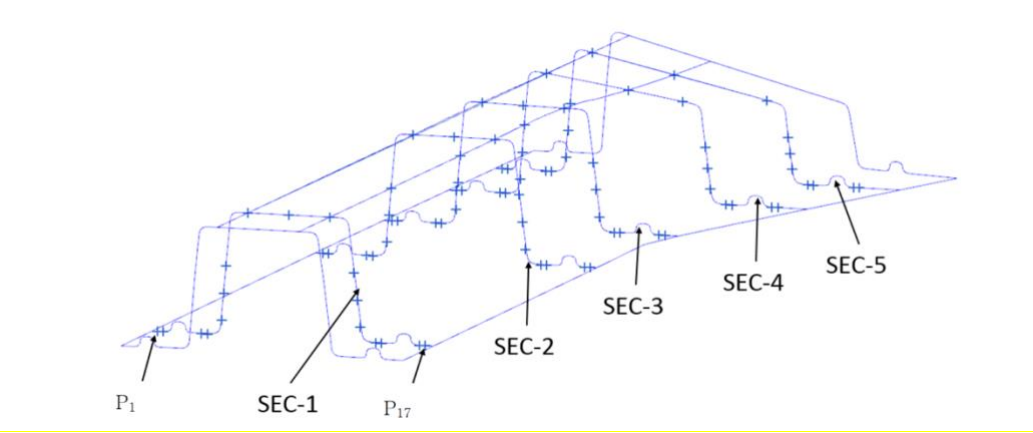


Figure 4 – Simulation Results – Standardized Geometry for Measurements [1]

Overview of Scalability Extended Benchmark

After the 2022 Numisheet benchmark, Altair explored further means of enhancing Inspire Form's accuracy and overall scalability while reducing its compute time., By utilizing a virtual appliance – a powerful solution for engineering challenges with optimization in mind – Altair's powerful HPC tools make it easy for engineers by boxing up software, system administration, and infrastructure as a service into a single, intuitive cloud-based platform.

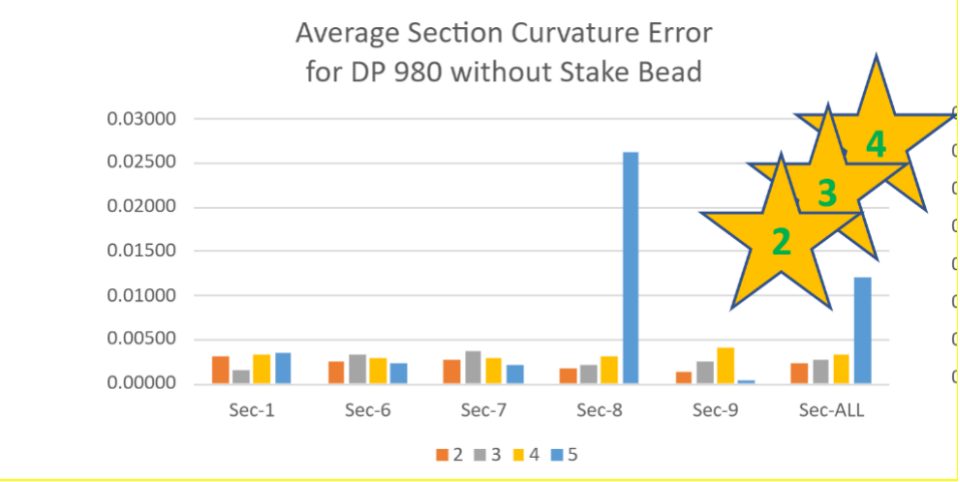
By exploiting the power of Intel®Xeon(R) Platinum-series CPUs, the springback and compute time results clearly show the effects of running the simulation on optimized CPUs hardware configurations. The results included here are generated using the same benchmark criteria as Numisheet. The only difference is the simulations are run on an HPC appliance, rather than a laptop.

Simulation Results

The overall Numisheet benchmark criteria provided a comparison between accuracy, average section curvature error, and computation time, leading to an overall ranking of the software. The additional results demonstrate the accuracy and compute time improvements possible when the CPU configuration is optimized.

Average Section Curvature Error

Based on the overall rankings awarded by the Numisheet Benchmark Committee, Inspire Form received the highest rating for the DP 980 steel, without stake beads category. Figure 5 compares the section curvature error for the Numisheet benchmark DP 980 steel, without stake beads configuration.

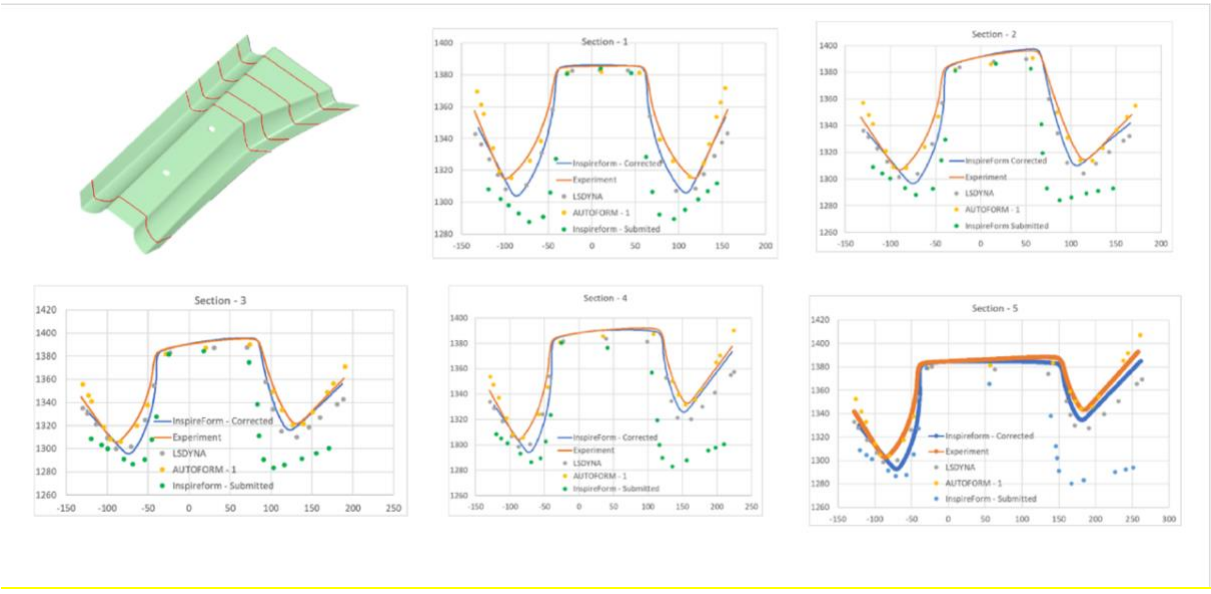


Key: 02 Altair Inspire Form; 03 & 04 AutoForm R10; 05 Stampack [2]

Figure 5 – Comparison between Section Curvature Error for Different Software Vendors | DP 980 Steel, Without Stake Beads Configuration [2]

Springback – DP 980 Steel, Without Stake Beads

Figure 6 includes the new results obtained after revisiting the model setup, regarding the gap between tools at the end of forming, enhancing the Yoshida hardening parameters in the material laws based on the cyclic tension compression test results shared by the Numisheet Benchmark Committee, and running identical simulations on an optimized hardware configuration. These results illustrate further improvements in predicting springback compared with experimental results. It's the best-case scenario for Inspire Form from the 2022 Numisheet study, shown as "submitted," compared with the "corrected" results run on an Altair HPC appliance.

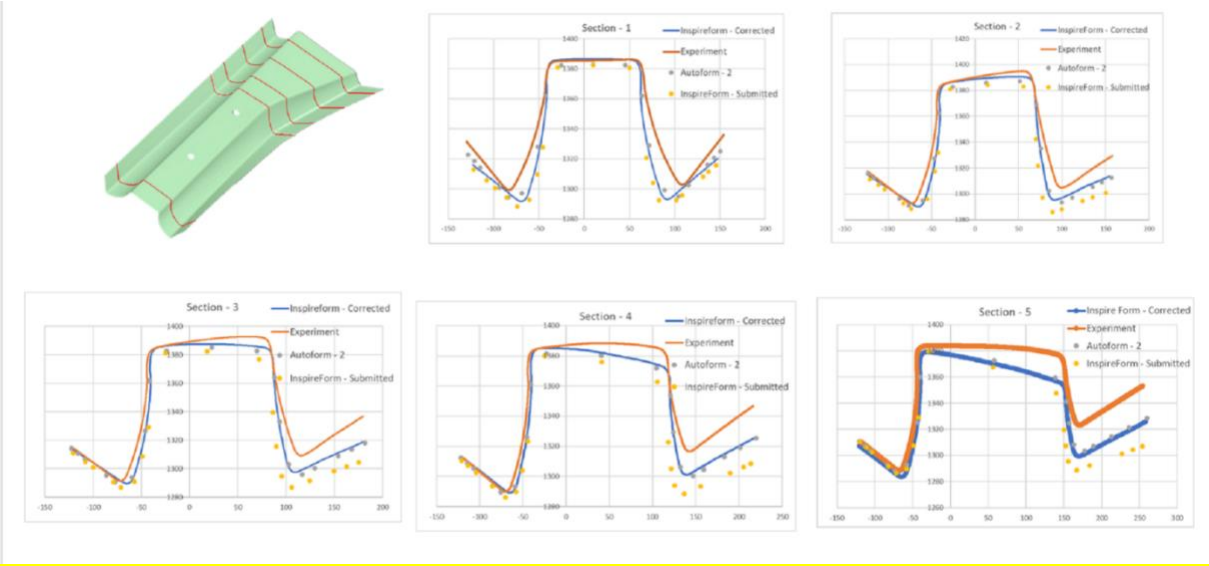


Key: Inspire Form (submitted): results from 2022 Numisheet benchmark; Inspire Form (corrected): results from optimized CPU hardware configuration

Figure 6 – Comparison between Optimized Hardware Simulation Results and Experiment for DP 980 Steel, Without Stake Beads

Springback – 6xxx-T4 Aluminum Alloy, Without Stake Beads

Repeating simulations of other Numisheet material using an optimized HPC appliance gave even better levels of improvement in the accuracy of the results compared with those “submitted” as part of the Numisheet study, as shown in Figure 7.

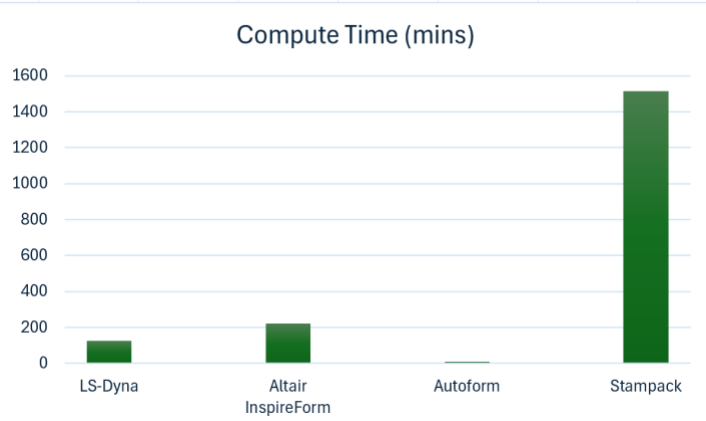


Key: Inspire Form (submitted): results from 2022 Numisheet benchmark; Inspire Form (corrected): results from optimized CPU hardware configuration

Figure 7 – Comparison between Optimized Hardware Simulation Results and Experiment for 6xxx-T4 Aluminum Alloy, Without Stake Beads

Compute Time

For each participant of the Numisheet benchmark, the compute times are shown in Figure 8. Inspire Form was run on a fairly standard laptop, whereas the hardware and configuration used for the other packages is unknown.



Note: Average figure for both AutoForm contributors

Figure 8 – Compute Times for Numisheet Benchmark Participating Software [2]

To demonstrate the importance of optimizing the hardware configuration and scalability of Inspire Form on HPC, Figure 9 clearly shows the effects of running identical simulations on CPUs comprising different domains, cores, and threads. Compared with the Inspire Form result from the Numisheet study, this represents over an 80% reduction in compute time.

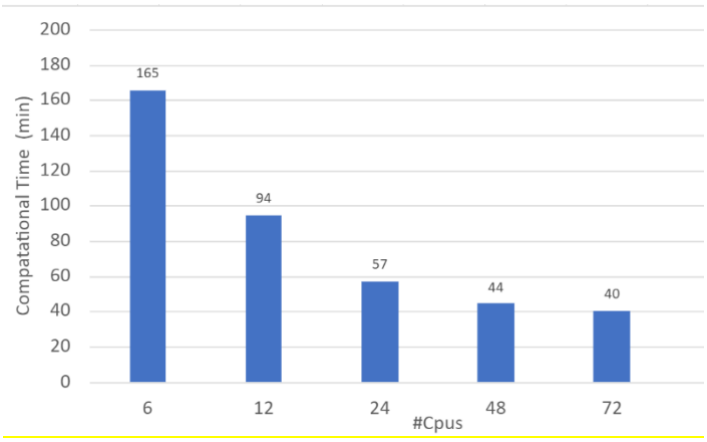


Figure 9 – Reduction of Compute Time by Optimizing HPC Hardware Configuration

Concluding Remarks

With a market saturated with many competing products from an increasing variety of software vendors, potential customers turn to the results of benchmark studies to measure how well a software solution performs under stipulated conditions and compare it against competing products. Since the outcome can help an organization select the most suitable solution for their application, a well-instituted benchmark should cover the overall combination of metrics such as accuracy compared with experiment, performance, reliability, resource uses, and scalability.

Here, the exploration into the scalability of Inspire Form, which provides a complete metal stamping simulation environment, demonstrates not only the accuracy of the predicted springback by simulation compared with experimental results, but also over 80% reduction in compute time when run on an optimized hardware configuration.

For engineers to fully capitalize on the simulation-driven revolution, having enterprise-wide access to modern software solutions – coupled with proven scalability to tackle the highs and lows of global demand – is essential. Altair offers the solutions and proven expertise to aid a seamless transition into true digital engineering. Here's how:

- Altair Units, (URL https://altair.com/altair-units) our patented, units-based subscription licensing model for software, gives full access to our software tools whenever engineers need them, allowing them to decide when, where, and how they want different tools without needing to worry about access.
- Altair One, (URL https://altair.com/altair-one/) our revolutionary cloud innovation gateway, streamlines collaborative engineering, data engineering, and analytical application development. It provides access to software tools, data, and computing resources, meaning customers can gain the benefits of scalability by adding Units when needed and avoiding any additional IT overheads – all while unleashing the power of AI at every step of the product development life cycle.
- Altair's appliance-based on-site and on-cloud solutions (URL https://altair.com/altair-unlimited-virtual-appliance) make the step seamless for engineers to concentrate on the engineering challenges and leave the administration to Altair.

What is Inspire Form?

Inspire Form (URL https://altair.com/inspire-form) empowers a new level of simulation-driven design for modeling and visualizing feasibility analysis in both press and design coordinate systems. It introduces handling of pinching and ironing of sheets between tools at discrete locations and enables the creation of line drawbeads from tool surface features. Now, sheet material characteristics can also be modeled using advanced yield criteria. These enhancements are particularly beneficial for design engineers focusing on stamping feasibility, as well as manufacturing and tool and die engineers in the automotive and consumer electronics industries.

References

[1] 2020 NUMISHEET BENCHMARK 1 — Springback Prediction of Twist Die Panel (Version 2. Jan 28, 2020)

[2] Presentation of results for 2022 NUMISHEET BENCHMARK #1 - Springback Prediction of Twist Die Panel | Novel use of stake beads to reduce sidewall curl and springback