



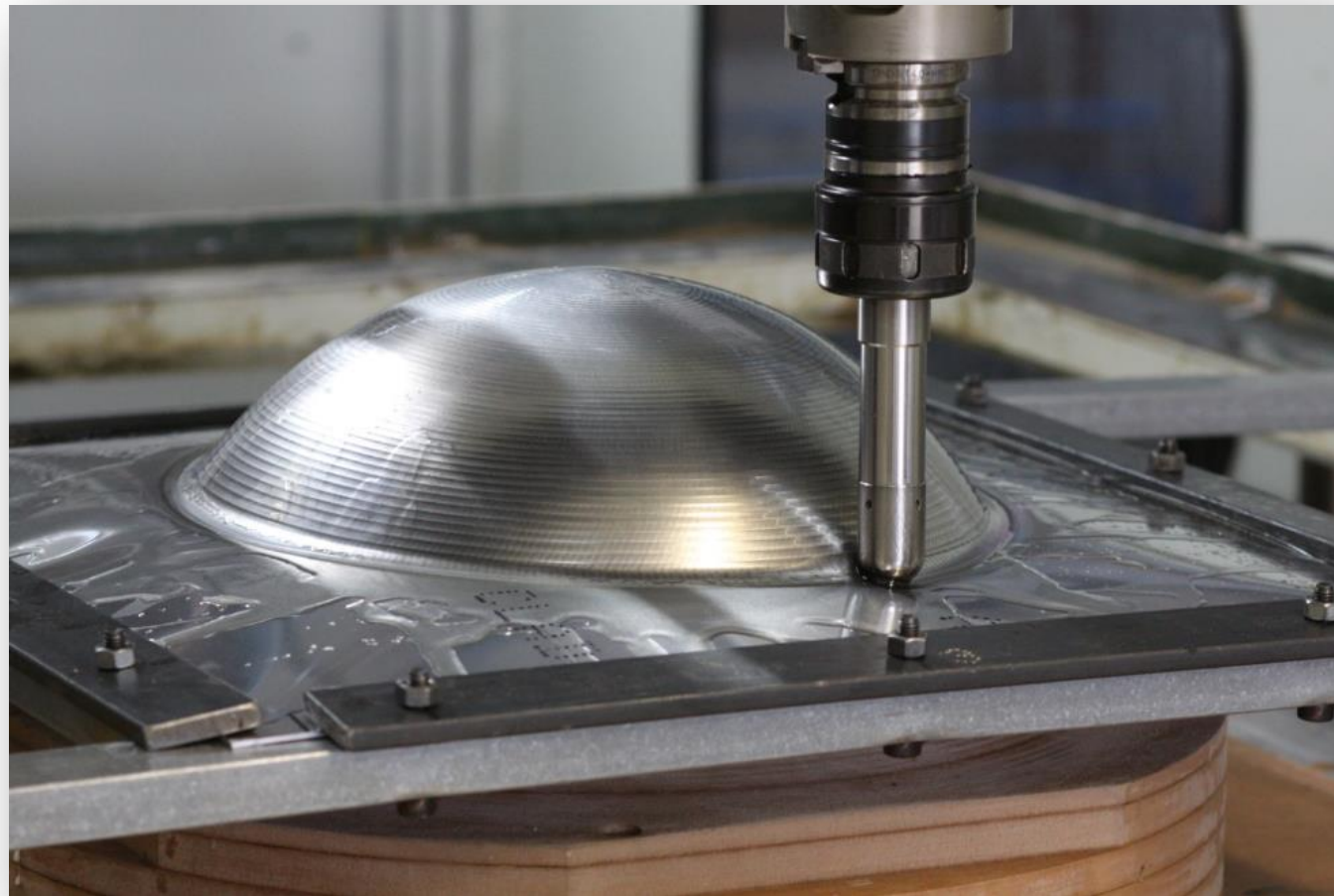
Engineering, Test & Technology
Boeing Research & Technology

Incremental Sheet Forming (ISF)

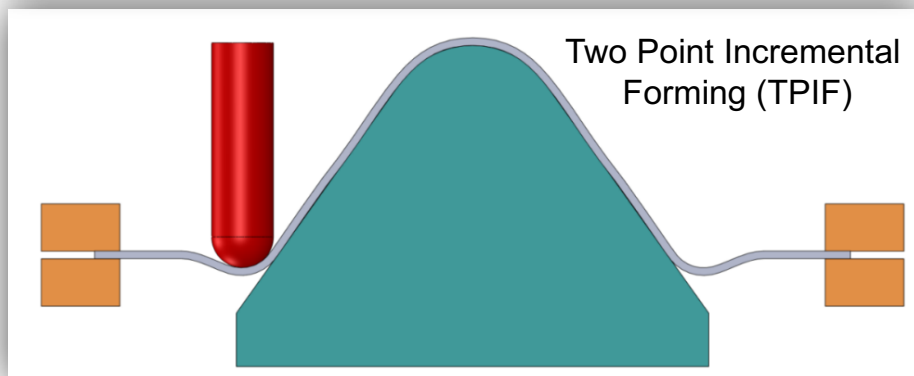
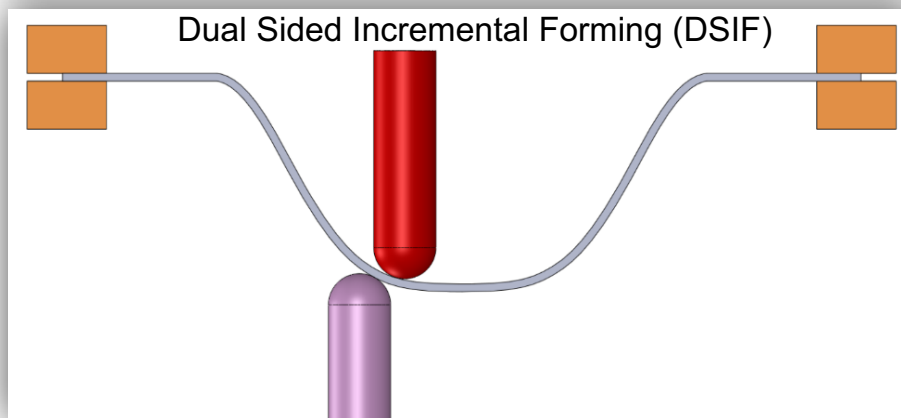
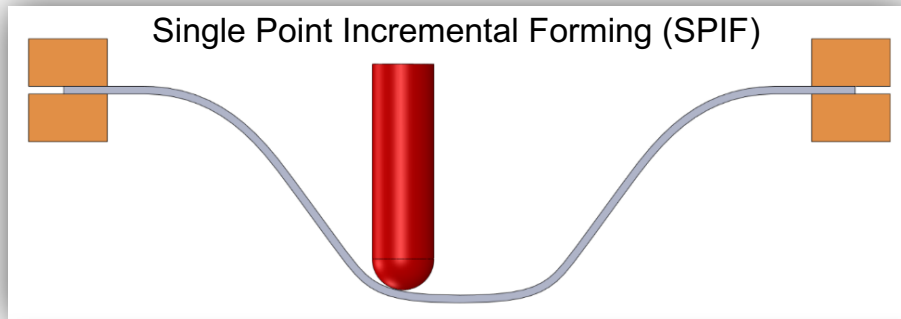
November 2017

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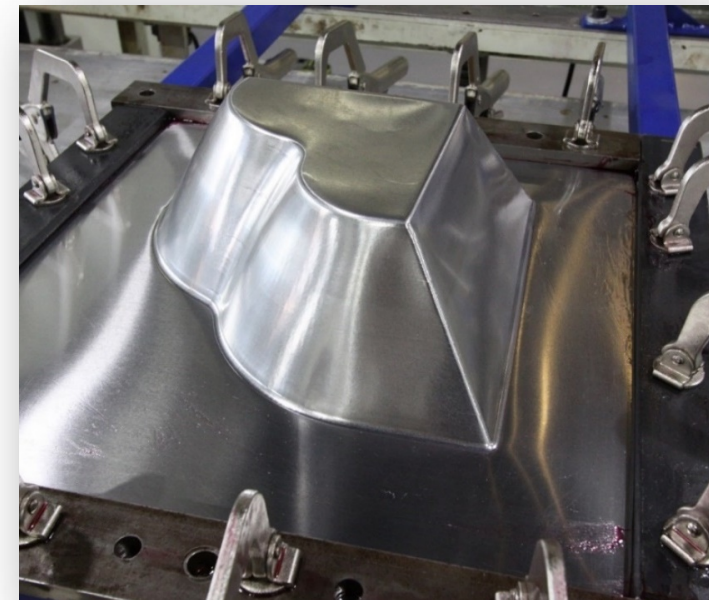
ISF is a means of forming sheet metal whereby a sheet is clamped into position and a ball nose tool, referred to as a stylus, is moved across a three dimensional toolpath. As the stylus traverses across its toolpath, it forces the sheet into position by plastically deforming the metal.



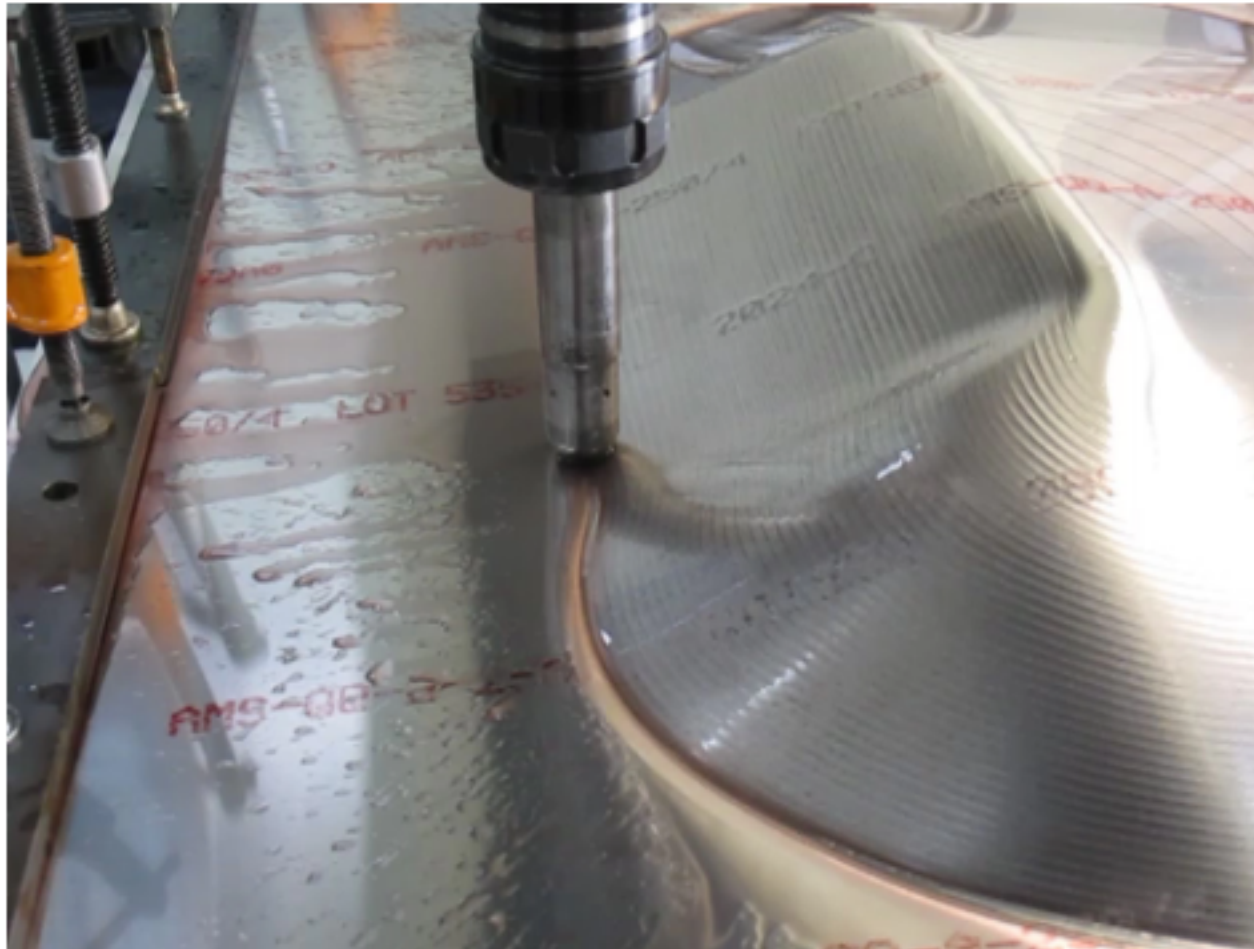
Different Types of Incremental Sheet Forming



SPIF Part



TPIF Part

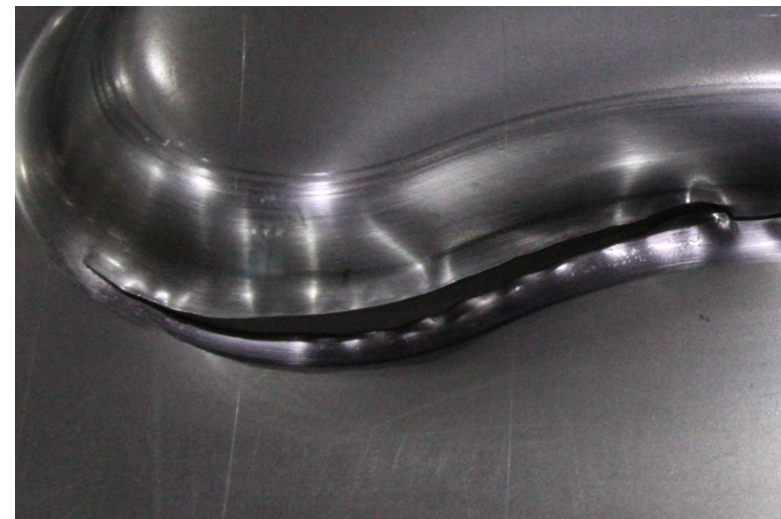


Advantages of ISF

- **ISF is intended for the rapid production of a small number of parts.**
- **The ISF process can be performed without a die, or with an inexpensive and quick to manufacture plastic or timber die**
 - Unlike traditional forming methods, there is no need to manufacture a costly steel die.
- **Very flexible in what shapes can be formed.**
- **Small parts can be made on a standard CNC machine.**
- **This makes the process ideal for:**
 - Rapid prototyping of sheet metal parts; and
 - Manufacturing replacement sheet metal parts if/when the die has been scrapped (including from scan data).
- **Current interest in ISF**
 - Aerospace, automotive, medical.

Disadvantages of ISF

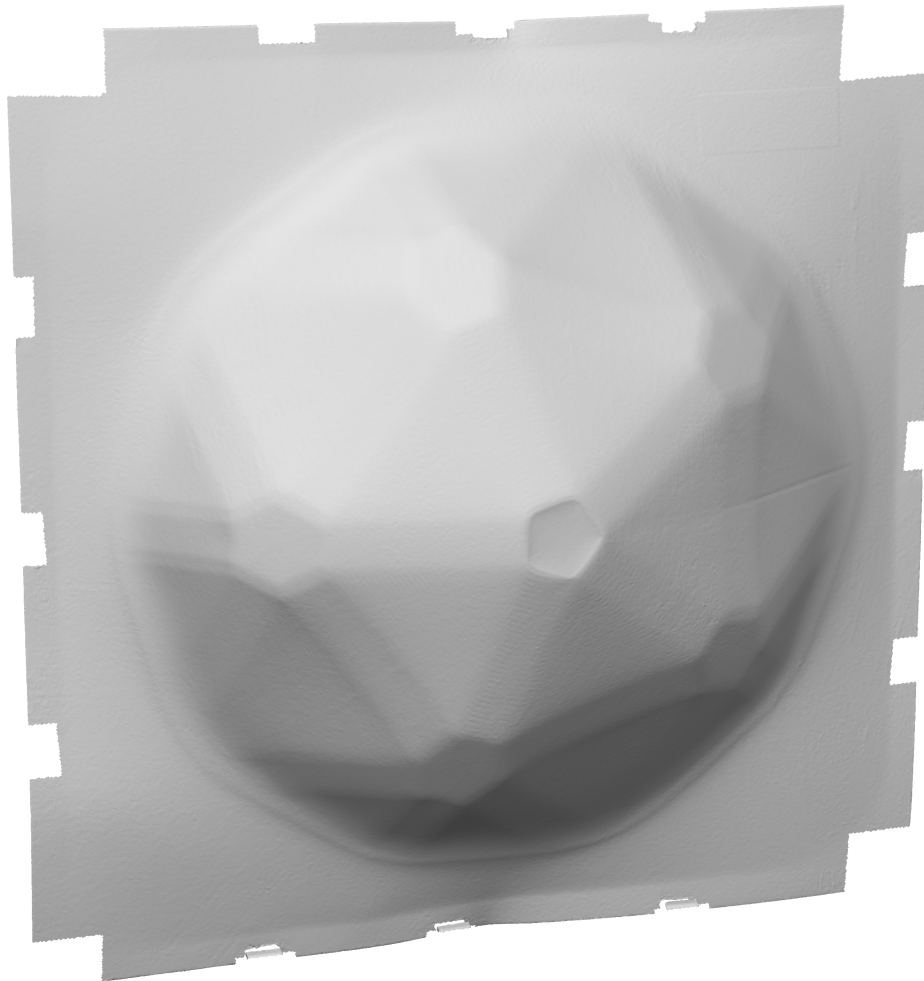
- At the moment, the ISF process is not for mass production.
- Large/thick parts need specialised machines.
- Part thin-out depends heavily on slope.
- Failure criterion is complex (and not fully characterised).
- At the moment, quality of parts is heavily dependent on the expertise of the machine operator and CAM programmer.
- Current practice is mostly trial-and-error based.



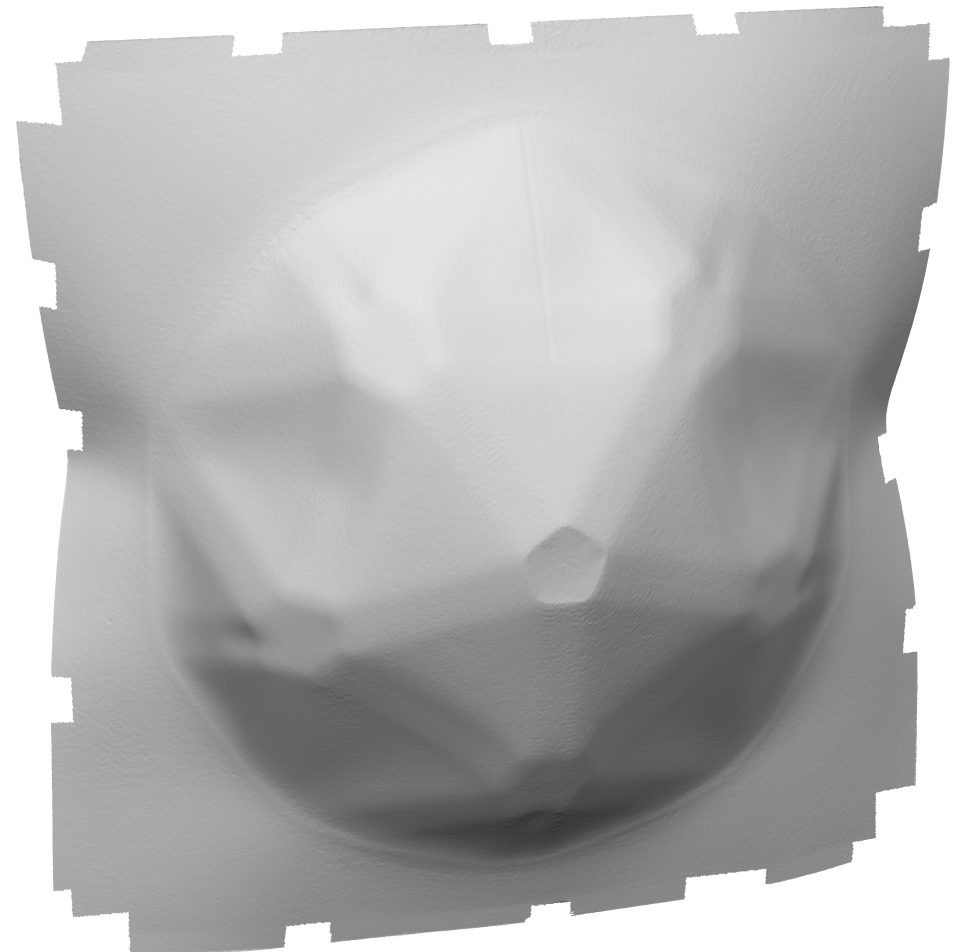
Material : AMS 6345 (0.040")

Why the need for Simulation in Manufacturing?

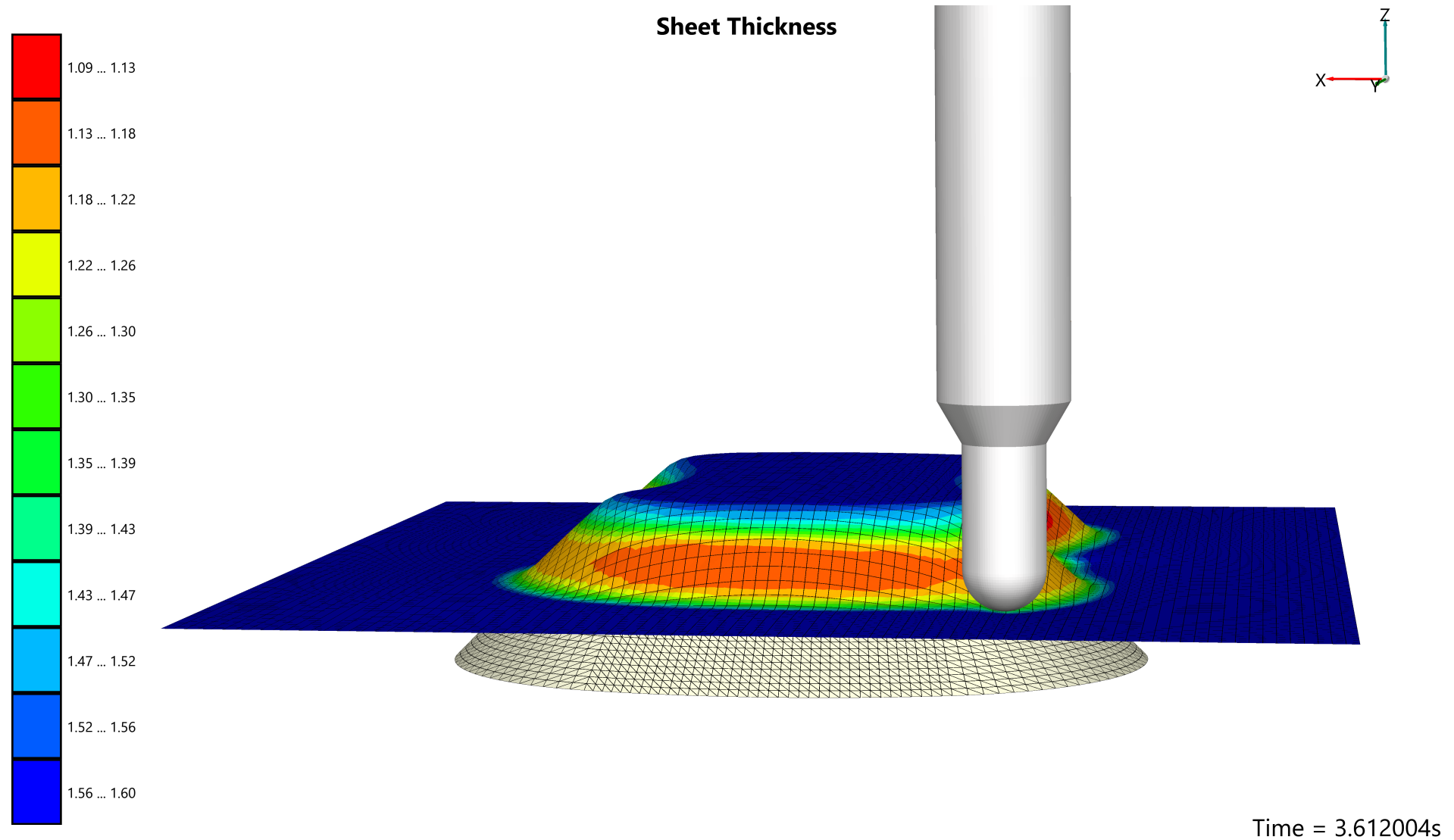
2024-0 Aluminium Alloy, 1mm Thick



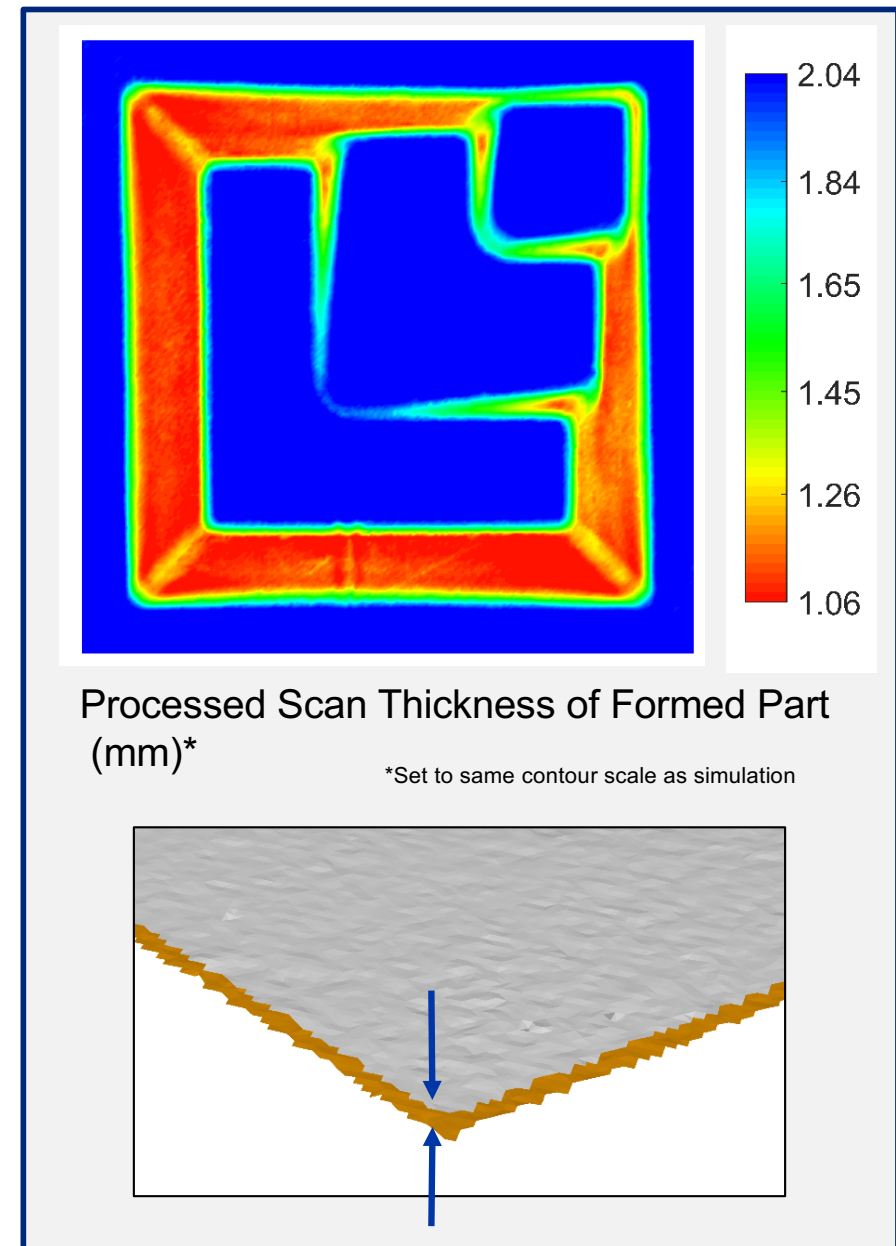
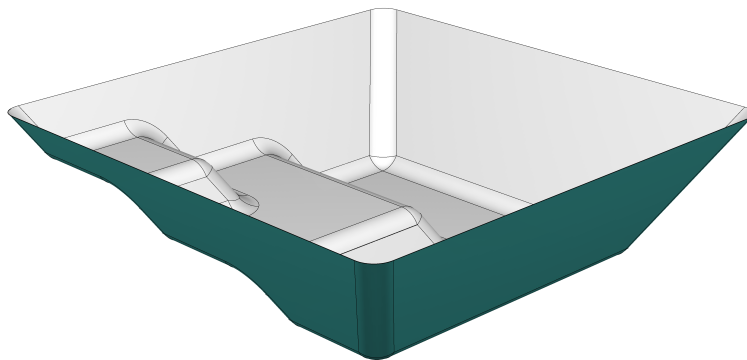
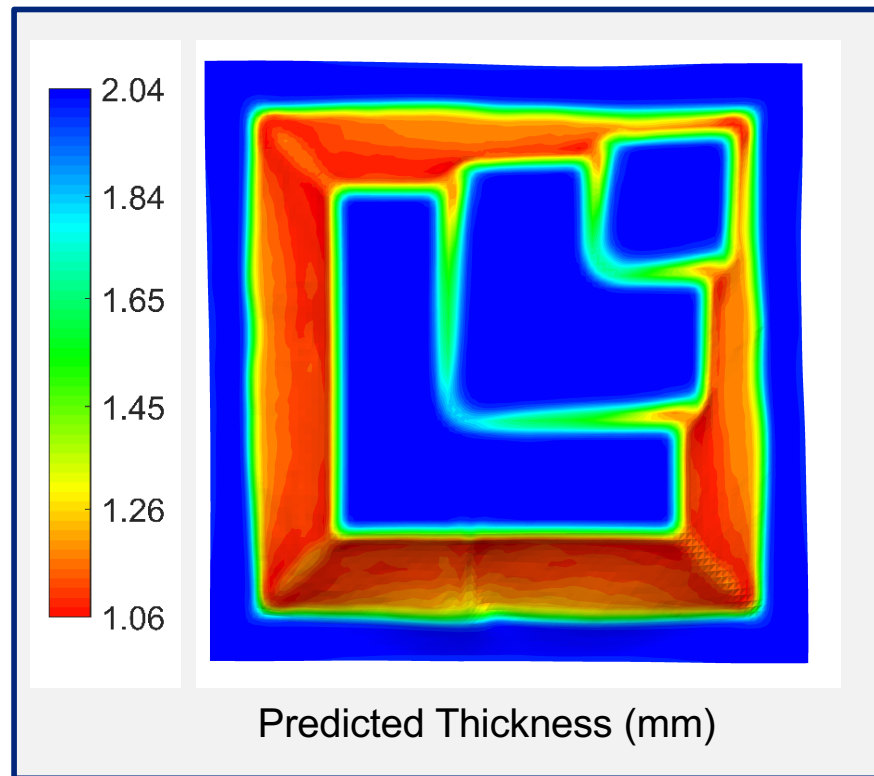
Stainless Steel, 0.5mm Thick



Example of Simulation Result



Comparison to Formed Parts



Current Challenges

- Spring-back compensation (and general shape accuracy).
- Control of thinning.
- Materials testing needed to quantify impact of ISF process on material properties.
- Specifications/standards outlining when a part is appropriate for manufacturing via ISF.



Material : Al 2024-T0 (0.063")

Current Research – The Advanced Queensland Innovation Partnership (Boeing – UQ – QMI Solutions)

- **Stream 1 : Accurate solver**
 - Improved solver efficiency
 - Improved solver accuracy
 - Different element types and formulations.
 - Constitutive models (and associated materials testing).
- **Stream 2 : Intermediate shapes**
 - Try to delay thinning and manage spring-back via forming intermediate shapes.
- **Stream 3 : Feedback and control**
 - Try to achieve accurate final product through a partially (and ultimately fully) automated control mechanism.

Concluding Remarks

- **Manufacturing is moving from reliance on expertise of machine operators to more computer/simulation based optimisation (and automation).**
- **Simultaneously, models are becoming increasingly complex [e.g. anisotropic plasticity and damage models are becoming increasingly difficult to fit].**
- **Results :**
 - There is increasing reliance on black-box algorithms & commercial software.
 - Methods are applied to problems for which they are ill-suited.
- **There is an increasing need for faster and more accurate simulation tools.**
- **University-Industry-Government partnership is very fruitful.**

