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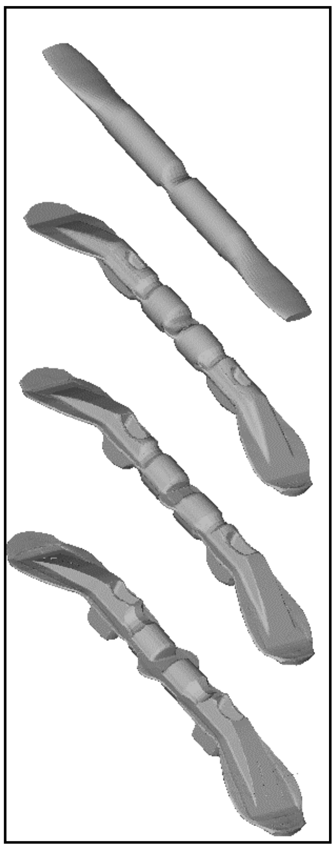
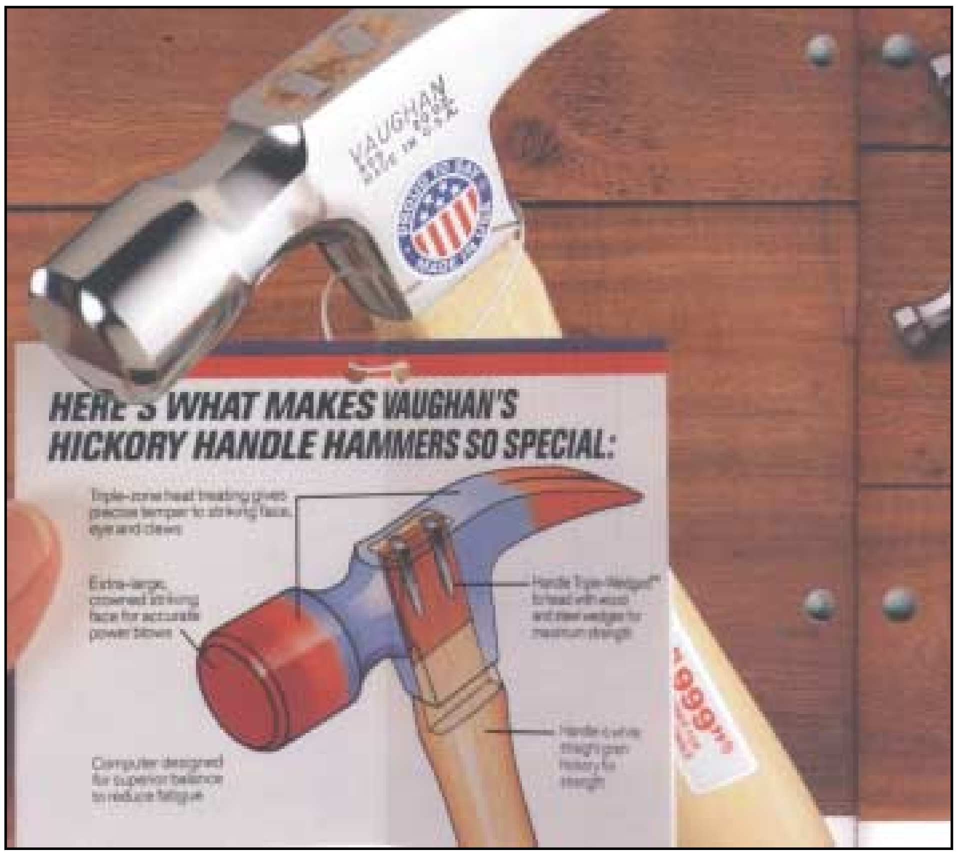
Forging Process Design for Vaughan's 999, 20 Oz. Claw Hammer, using MSC.SuperForge.

The numerical simulation program, MSC.SuperForge, has been used to design a proper pre-form.
An initial simulation predicted a die under fill, which was confirmed by shop floor trials.
The pre-form was then re-designed to achieve complete die fill.
All simulations were performed with ***MSC.SuperForge 2002***





Introduction

The numerical simulation program, MSC.SuperForge, is used during the design of forging processes to minimize the number of required iterations and shop floor trials. This easy to use program is able to very accurately predict:

Material flow characteristics:

- Die Contact to predict die fill and under fill
- Distance to die
- Flash extension
- Folds
- Forward and Backward 'Particle Tracking'

Die load characteristics:

- Die load curves (Force vs. Stroke)
- Die stresses, to predict plastic deformation and cracking.

The program has a complete set of capabilities to address the needs of the forging designer:

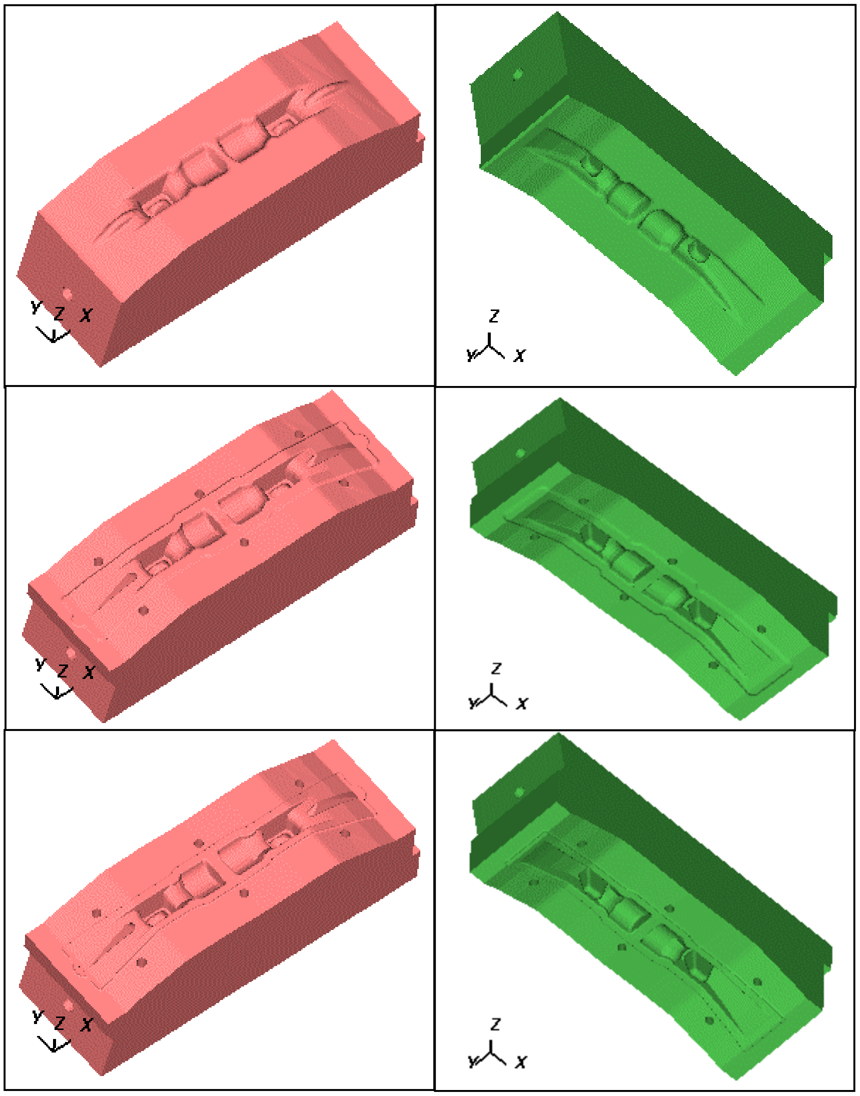
- CAD interface by means of STL files
- Complete set of press definitions
- Large material library for both Billet and Die
- Suited for Cold-, Warm-, and Hot-Forging
- Able to perform 2D and 3D simulations in same user environment
- Automatic positioning and settling of workpiece into die

A description of the theory and verification with academic examples can be found in [1-4].
A more complex application to extrusion can be found in [5-6].

This paper describes how MSC.SuperForge was used to study the complex material flow during the forging of a claw hammer. The hammer investigated is in production by Vaughan & Bushnell, Mfg,

Dies

The forging process contains 3 stages. The dies of the buster, blocker and finisher stages are shown in figures 1.



Buster

Blocker

Finisher

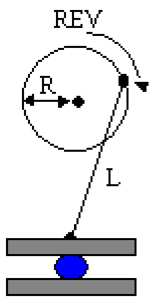
Bottom Dies

Top Dies

Figure 1: Forging Dies for buster, blocker and finisher

Press Data

The forging machine is a mechanical crank press (1300 Ton Maxi press). The characteristics of the press are specified in Table 1.



Crank Radius (R)	5”
Rod Length (L)	29”
Revolution Speed (REV)	80 Rev/Minute

Table 1: Forging press specifications

Material Data

The material data was taken from the material database of MSC.SuperForge, as specified in Table 2.

Die	H13 tool steel
Workpiece	AISI 1080

Table 2: Material specification for Die and Workpiece

Process Data

The process data for the 3 stages is given in Table 3.

Cooling Time before buster stage	2 seconds
Cooling Time in between stages	1 second
Interface Shear Friction	0.3
Pre-form temperature	2250 F
Die Temperature	600 F
Heat transfer coefficient from Die to Ambient	50 Watt/(m2*K)
Heat transfer coefficient from Die to Workpiece	6000 Watt/(m2*K)
Heat transfer coefficient from Workpiece to Ambient	50 Watt/(m2*K)
Flash Thickness at end of buster	0.100”
Flash Thickness at end of blocker	0.100”
Flash Thickness at end of finisher	0.072”
Finite Volume element size for buster	0.072”
Finite Volume element size for blocker	0.072”
Finite Volume element size for finisher	0.072”

Table 3: Process data

Pre-Form Shape and Dimensions

The billet is a cylindrical bar. This cylinder is roll forged before the buster stage, in a shape as shown in figure 2.

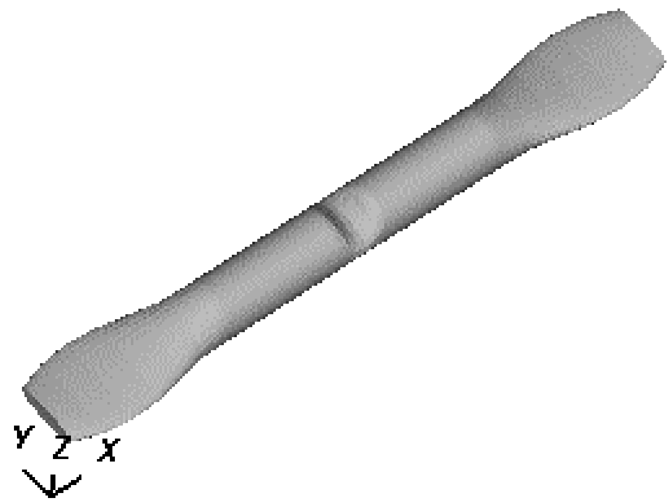


Figure 2: Pre-form shape before buster stage

The pre-form volumes are given in table 4.

Pre-form 1 (die under fill)	12.5214 in3
Pre-form 2 (complete die fill)	14.7011 in3

Table 4: Volume of the pre-forms

Results for Pre-Form 1

The results of the simulations and shop floor trial for pre-form 1are shown in figure 3.

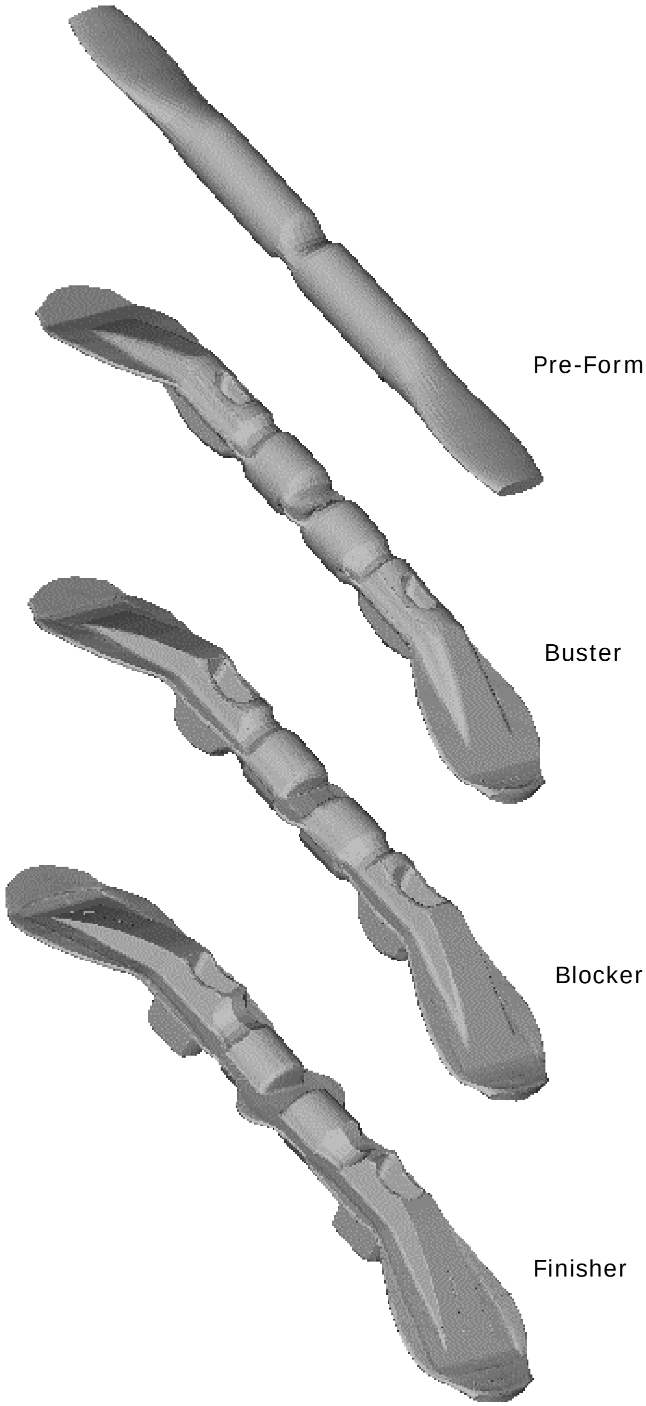


Figure 3a: Simulated Material Flow for Pre-form 1

Figure 3b: Comparison of final shape for pre-form 1

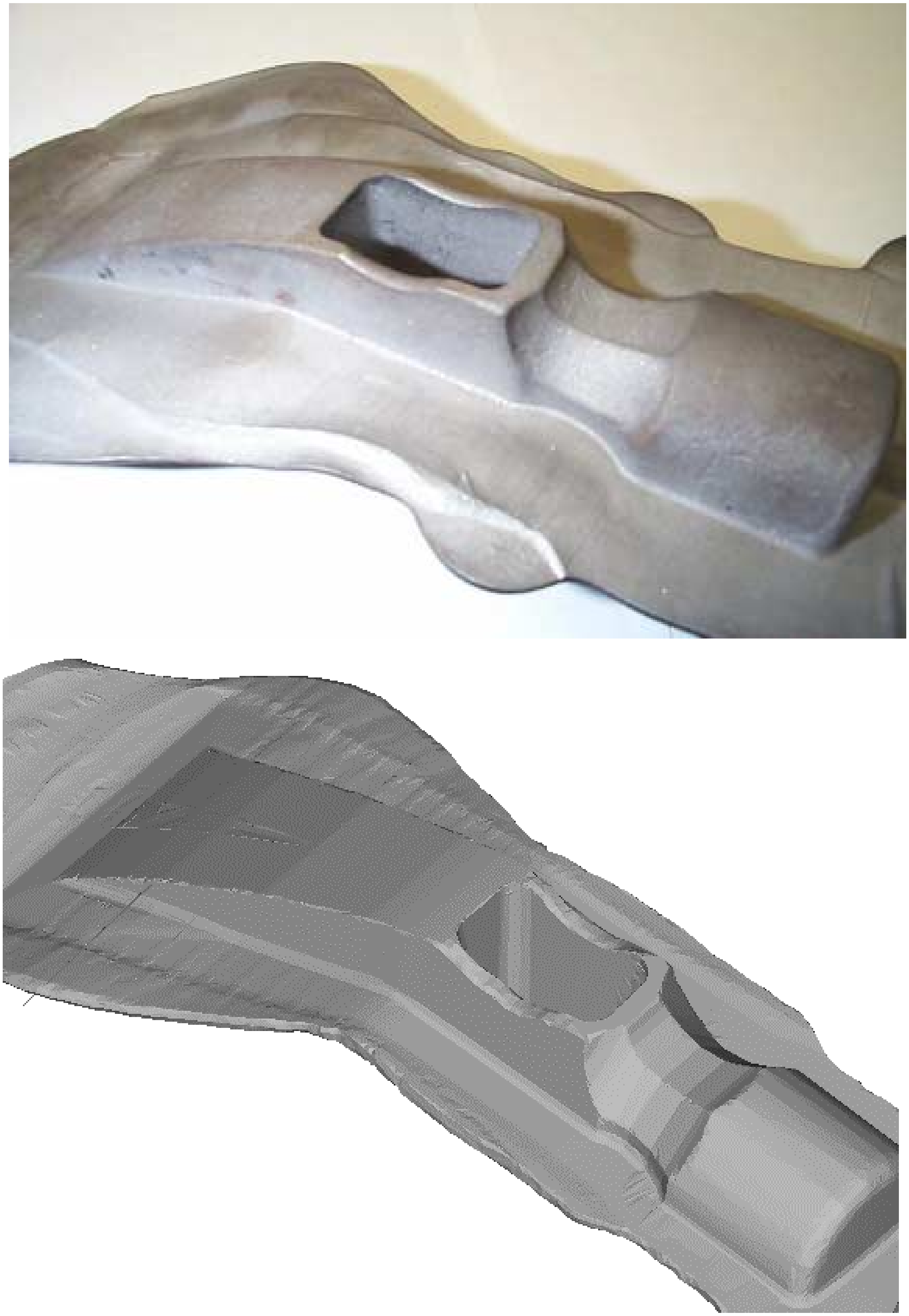


Figure 3c: Detail – Under fill: Comparison of final shape for pre-form 1

Results for Pre-Form 2

The results of the simulations and shop floor trial for pre-form 2 are shown in figure 4. To minimize the required simulation time, only a ¼ model was simulated.

Figure 4a: Simulated Material Flow, compared to shop floor trial, for Pre-form 2 (¼ model)

Figure 4b: Detail – Complete fill: Comparison of final shape for pre-form 2

Model Preparation and CPU Time

The simulations were run on a DELL 530, using one 1.7 GHz Pentium 4 processor. The time required setting up the models, and the required CPU time is given in table 5.

Pre-form 1 – Total Model Setup Time	30 minutes
Pre-form 1 – CPU Time Buster (Full Model)	22 hours
Pre-form 1 – CPU Time Blocker (Full Model)	29 hours
Pre-form 1 – CPU Time Finisher (Full Model)	23 hours
Pre-form 2 – Total Model Setup Time	21 hours
Pre-form 2 – CPU Time Buster (¼ Model)	8 hours
Pre-form 2 – CPU Time Blocker (¼ Model)	10 hours
Pre-form 2 – CPU Time Finisher (¼ Model)	7 hours

Table 5: Model Preparation and CPU Time

Discussion of Results and Conclusion

A case study has been presented, showing how MSC.SuperForge was used to aid in the pre-form (re-) design of a Claw Hammer. The simulation results compared very well with the shop floor trials:

1. Pre-Form 1 does not completely fill the dies. The location and the extend of under fill was predicted very closely.
2. Pre-Form 2 does fill the dies completely. Again, the simulation predicted the material flow very well.
   The shop floor trials showed a slightly a-symmetric result, and one side of the part showed a very slight under-fill. Either an off-center billet positioning, or an uneven die temperature distribution might have caused this a-symmetric behavior.
3. Apart from the under-fill, both pre-forms did not show any other defects, which was consistent with the simulation results.

All simulations ran from beginning to end without manual user intervention. This is a very important aspect of being able to use a simulation tool during the design process. The turn-around time has to be short enough to make an impact.

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