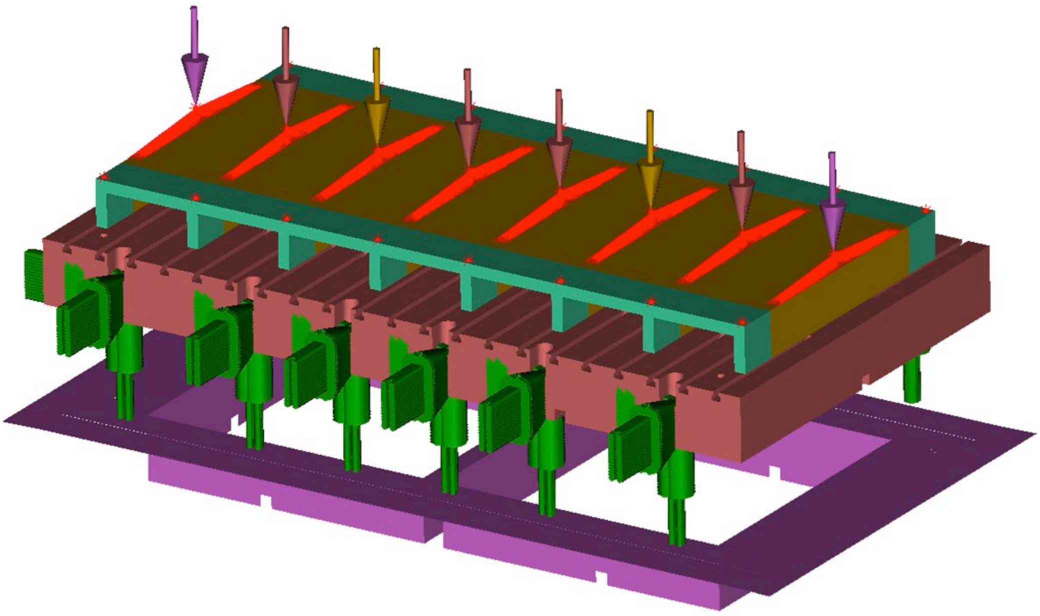
Case study

Tower international

Automotive supplier uses Marc to improve design of stamping tools



Introduction

Stamping operations used to form metallic automotive components can generate forces of thousands of tons. The tools (die components) that form these products must be able to withstand this cyclic loading environment for the life of the vehicle program. At the same time, it is important to optimize the tool design in order to be competitive.

The evolution of higher strength materials also adds to the challenge. The large loads involved in forming these components increase the challenge of designing robust tools. Both linear and non-linear analysis must be used to support the tool design process.

Background

In one case, Tower International engineers were challenged to determine whether an existing die bolster used to form automotive frame components could be used in an application with much greater loads. The die bolster is a plate attached to the press bed that locates and holds the die shoe. The die shoe, in turn,

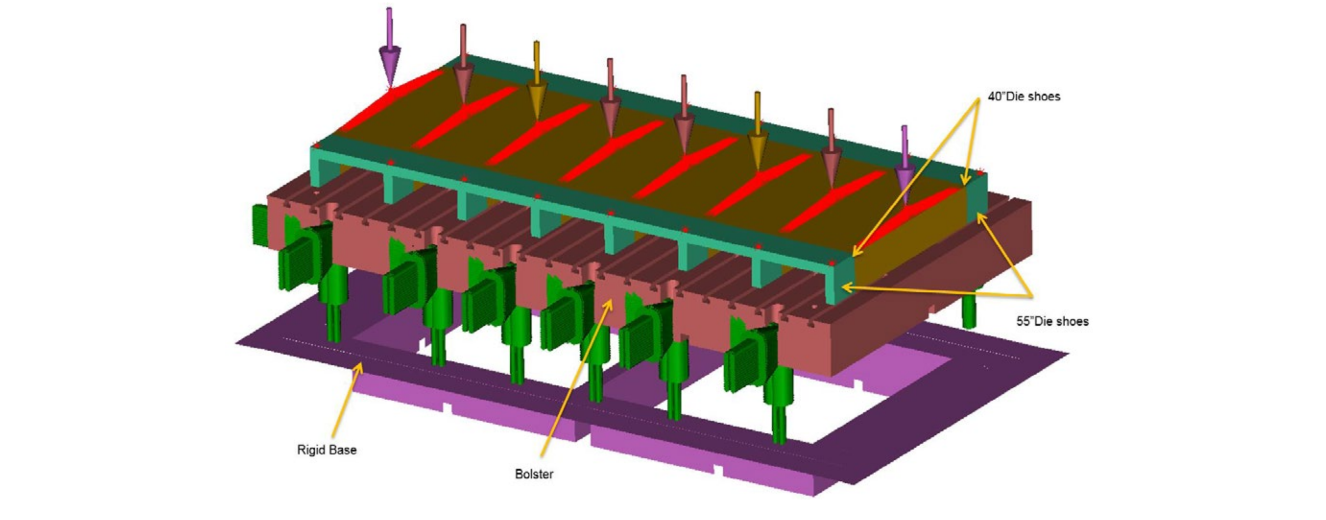


Figure 1: 1000-ton press die bolster model

supports the die retainer that contains the cavities that shape the part as the punch descends. Tower engineers had to evaluate the deflection of the die bolster (Figure 1) with a 1000-ton load using both 40 and 55 inch die shoes. Excessive deflection in the bolster could affect the dimensions of the stamped part and the fatigue life of the bolster over time.

In another case, a die shoe (used in a stamping press) made of gray cast iron had experienced cracking under cyclic loading of 1100 tons of press force. The gray cast iron used was a relatively brittle material with an elongation of only 1.71%. Tower International engineers studied the effect of switching to a ductile iron with an elongation of 12%. They needed to determine whether the expected material change would solve the cracking problem and also whether or not it would affect the dimensions of the finished parts.

Case 1

Taking advantage of the structural symmetry, Cheng addressed the die bolster application by modeling half of the bolster and die shoe using solid elements. Appropriate contact body interactions are defined between various components. The material used for the bolster and die shoe is SAE 1008 hot rolled low carbon steel. She used symmetric boundary conditions and distributed 500 tons of force over half of the 40 and 55-inch die shoes.

The bottom of the bolster is supported by the base which was modeled as a rigid surface in the simulations. The simulation results (Figure 2) show that the maximum deflection of the die bolster with the 40-inch die shoe was 0.4 mm on the top and 0.32 mm on the bottom while the die shoe was displaced 0.52 to 0.59 mm. The maximum deflection with the 55 inch die shoe was 0.4 mm on the top and 0.34 mm on the bottom and the die shoe displaced 0.58 to 0.64 mm. The bolster satisfied the design criteria in the new application by deflecting less than the die shoe.

Case 2

In this case, Cheng evaluated the strength of both gray cast iron and ductile iron die shoes in the production press environment. The press force was applied through the die pad which was modeled as a rigid surface. A load of 690, 1100, 1320 and 1800 tons was applied to the die shoe in separate simulations. The simulation results included the total equivalent plastic strain mapped over the die shoe.

The baseline analysis with the existing gray cast iron material showed high amounts of plastic strain above 0.2% in several areas of the die shoe. These hot spots matched up very well with the areas where cracks appeared in the actual die shoe (Figure 3). On the other hand, the simulation of the ductile cast iron die shoe did not show any elevated plastic strain. The simulation results showed that the die shoe made of gray cast iron has the potential to crack at a press force above 690 tons while the die shoe made of ductile cast iron will not crack even at 1800 tons of press force (Figure 4).

Key highlights:
Product: Marc
Industry: Automotive
Benefits:
Accurate simulations help reduce risk of downtime and lost revenues, by predicting regions of potential failure
Get the design right the first time with computer models and deliver reliable performance

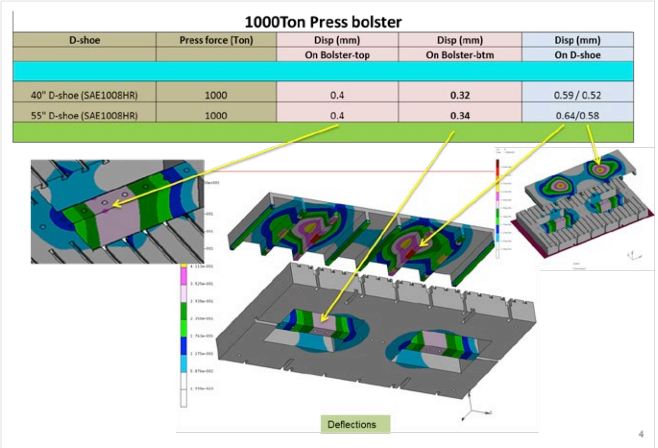


Figure 2: Results of the die bolster study show that the die bolster deflection is less than the die shoe

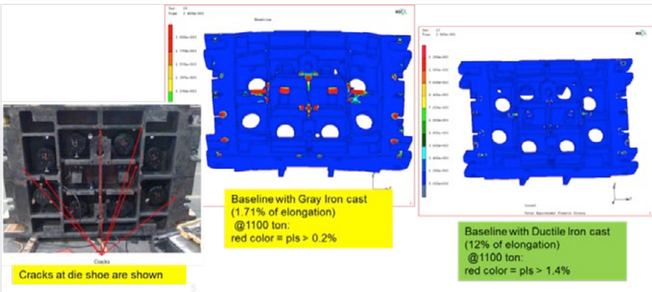


Figure 3: Total equivalent plastic strain plot of gray cast iron die shoe matches cracks seen in the physical die shoe while simulation of the ductile cast iron shoe indicates that cracking will not occur.

Results from FEA:

A. Total Equivalent Plastic Strain (pls)

Press load	690 Ton	1100 Ton	1320 Ton	1800Ton	
Base line	1.37%	3.28%	4.70%	10.14%	(Gray Iron elongation 1.71%)
Ductile Iron	0.82%	1.63%	2.34%	3.77%	(Ductile Iron elongation 12%)

B. Max. Principal Plastic Strain (pls)

Press load	690 Ton	1100 Ton	1320 Ton	1800Ton	
Base line	0.70%	1.50%	2.14%	4.56%	(Gray Iron elongation 1.71%)
Ductile Iron	0.51%	0.90%	1.14%	1.78%	(Ductile Iron elongation 12%)

Figure 4: Results from this simulation show that the baseline die shoe with gray cast iron may crack at a press force greater than 690 tons while the die shoe with ductile cast iron will not crack even at 1800 tons.

Remarks

"A die shoe that cracks under press loads requires a substantial investment to build a replacement shoe and also runs the risk of downtime and lost revenues," Cheng said. "Marc software enables us to accurately predict the performance of these and other die components. The analysis results enable us to get the design right the first time and to have the die components deliver reliable performance that enables us to meet our commitments to our customers."

About Tower International

Tower International is a leading global manufacturer of engineered automotive structural metal components and assemblies. The company supplies body-structure stampings, frames and other chassis structures and complex welded assemblies for small and large cars, crossovers, pickups, and sport utility vehicles. Tower's 27 manufacturing facilities are located near its customers in North America, Europe, Brazil and China.

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Yueming Cheng,
CAE Engineer, Tower International

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