DEFORM™ Application #115

Progressive Die Stamping

Problem Background:

In a progressive die forming process, a component is formed as a strip of stock moves through a series of punch and die stations. Each station performs a discrete forming operation. The final component is progressively formed as the strip moves through each station. A schematic of the process is illustrated in Figure 1. A progressive die process sequence has traditionally been determined based on designer's experience and the performance of similar components at a company. The major challenges have been to determine the fewest number of stations to form the component without defects and the punch / die geometry for each station. This methodology has often proven inconsistant, with some processes requiring multiple development iterations. This is both time consuming and expensive.

Process Simulation:

An alternative development process was developed at the Ohio State University - Engineering Research Center (OSU/ERC) on a progressive die forming process initially developed by Pax Machine Works. The DEFORM™-2D system was used to analyze a typical round, cupped part as shown in Figure 2. The OSU/ERC staff used DEFORM™-2D to determine the required number of forming stations. The diameters of the punch, die and starting blank, corner radii, drawing depth and blank holder force at each station were considered in the analysis.

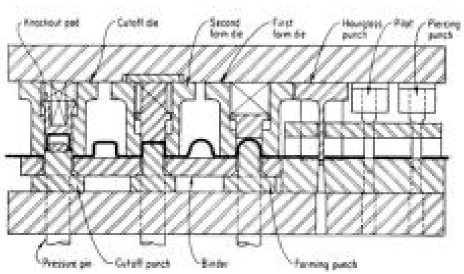

Figure 1: A schematic of a progressive die forming process is shown. The strip stock moves from right to left.

Methodology

The OSU/ERC team was supplied with the alloy type, blank thickness and blank diameter from Pax Machine Works, Celena, OH. The only constraint applied by Pax Machine Works was that the accumulative wall thinning over the process was limited to 10%.

LDR values of 1.55, 1.60 and 1.65 (from Lange) were used for this AISI-1008 steel material, to determine the probable or "initial guess" punch and die diameters, which were established as 97mm and 101.5mm respectively. Following this, the probable punch and die corner radii were established as 19.5 and 21.5mm respectively (also from Lange) and the blank holder force was calculated as 50kN.

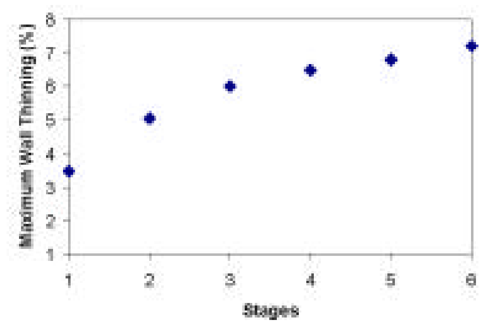

Figure 3: Wall thinning by station is shown in this progressive die sequence.

For the first station, the OSU/ERC team set the maximum wall thinning to 4%. This was based on the previous experience. The highest thinning typically occurrs in the initial stations of the die progression, as shown in Figure 3. DEFORM™ simulations were carried out in an iterative manner, varying only the punch and die diameters, until the part wall thinning was just less than 4%. Using this optimum set of punch and die diameters, the corner radii were determined in a similar iterative manner (also limiting thinning to 4%). Punch and die geometries for subsequent stations were determined in the same way, with the OSU/ERC team applying reduced wall thinning limits in each progressive die station.

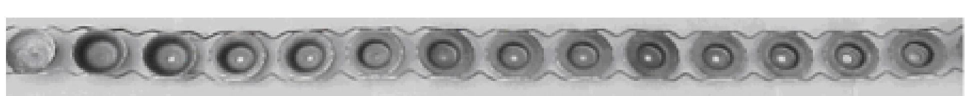

Figure 2: The cupped part sequence is shown courtesy of OSU/ERC & Pax Machine Works.

DEFORM™

Design Environment for FORMing

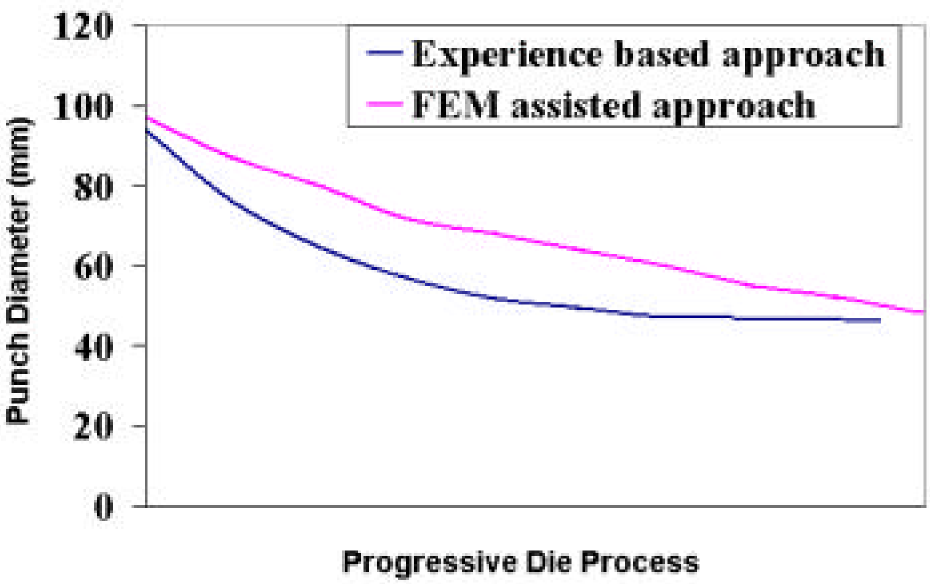

Figure 4: A comparison between the FEM-based design and that of the experienced designers at Pax Machine Works is shown.

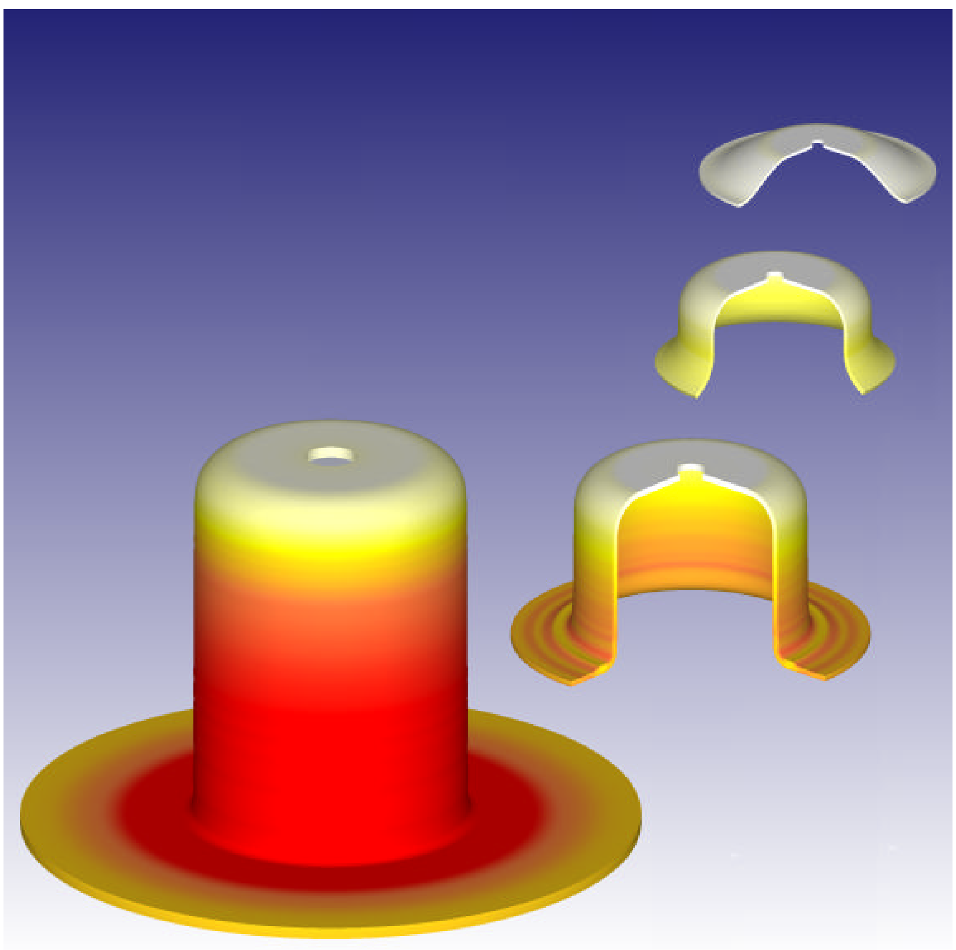

Figure 5: The DEFORM™ predictions of deformation at selected die stations is shown with contours of effective plastic strain (red is higher).

Solution:

Using DEFORM™, the OSU/ERC team was able to design a progressive die sequence to make the cupped part in 10 stations. While an extra station was required in this example, the methodology was shown to be sound. Using this methodology with experienced designers should result in fewer operations. Figure 4 shows the comparison between the emperical design and the design conducted using FEM. It can be noted that the FEM designed progression exhibits reductions that are more consistent from one station to the next. More aggressive wall thinning limits in the early stations could have been used. This example illustrates how DEFORM™ is capable of optimizing a progressive die sequence.

Acknowledgements:

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