DEFORM™ Application #121

# Hot Forged Weld Yoke

## Background:

American Axle & Manufacturing (AAM) is a premier Tier One manufacturer of driveline systems, including forged products, for trucks, busses, sport-utility vehicles and passenger cars. AAM uses DEFORM-2D and DEFORM-3D for process development for a wide range of hot, warm, and cold forgings.

## Weld Yoke Production:

AAM manufactures weld yokes at its Tonawanda Forge facility. A typical yoke, used in this case study, is forged in a three part platter. The single hit forging is produced on a mechanical press, followed by flash trim. The annual production for this part is 200,000 pieces, requiring 1.25 million pounds of steel.

Short lead times are a common theme in the forging industry. The lead time on these parts is eight weeks after receipt of the order. One critical element in this lead time is the raw material. For economical production, the proper size and quantity of steel must be ordered in advance of the first production trials.

Design Environment for FORMing

The hot forged yoke is shown prior to trimming the flash.

## Design Metrics:

A number of metrics can be used to evaluate the billet geometry. These include:

1. The die cavity should be completely filled. Underfills are likely to deviate from the dimensional forging requirements.

2. Flash should be produced around the entire flash land. Inadequate flash is generally an indicator of a process that will not be robust. When slight process variations occur, the inadequate flash will become an underfill.

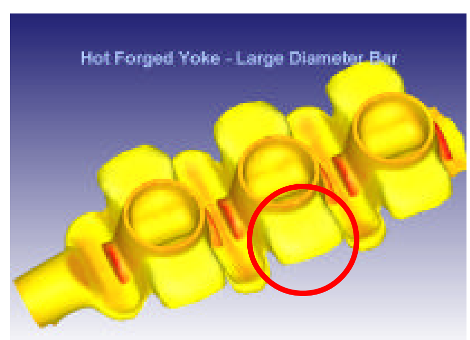
3. Excessive or premature flash result in lower yields, which lowers margins. Excessive flash also increases die wear. In any case, profit margins will decline.

4. Defect formation is to be avoided. Laps, shear bands or other defects will result in scrap or rework.

Since this part is manually transferred, additional material is required at the 'front' of the forging for the operator to grip the bar with tongs.

## Oversized Billet:

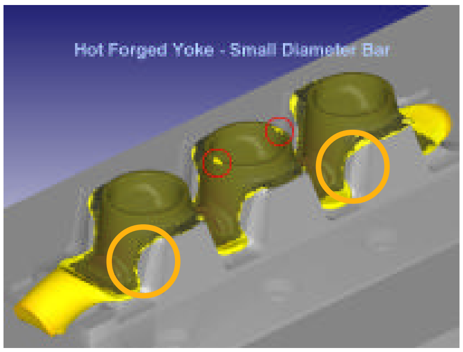
The simulation of a large diameter bar is shown. While the die cavity is filled, excessive flash is observed. This wasted material erodes profit margins through lower material yield and typically leads to reduced tooling life.




The large diameter bar fills the die cavity, but produces excessive flash, as shown (red circle).

## Undersized Billet:

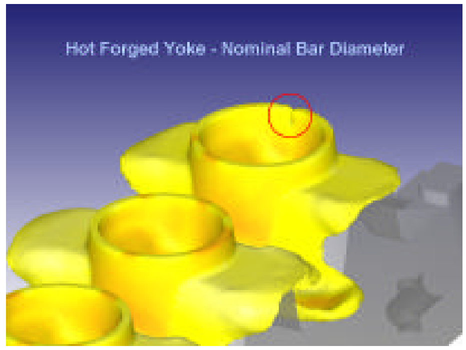
A slight die underfill is the result of forging a smaller than optimum bar diameter. Additionally, there is very little flash in the vertical flash land. These are indicators of a process that will not be robust and potential problems during trimming.




The small diameter bar doesn't completely fill the die cavity, as shown with the red circles. The orange circles represent an area of inadequate flash.

## Short Billet:

In addition to proper diameter, the cut length and location of the billet should

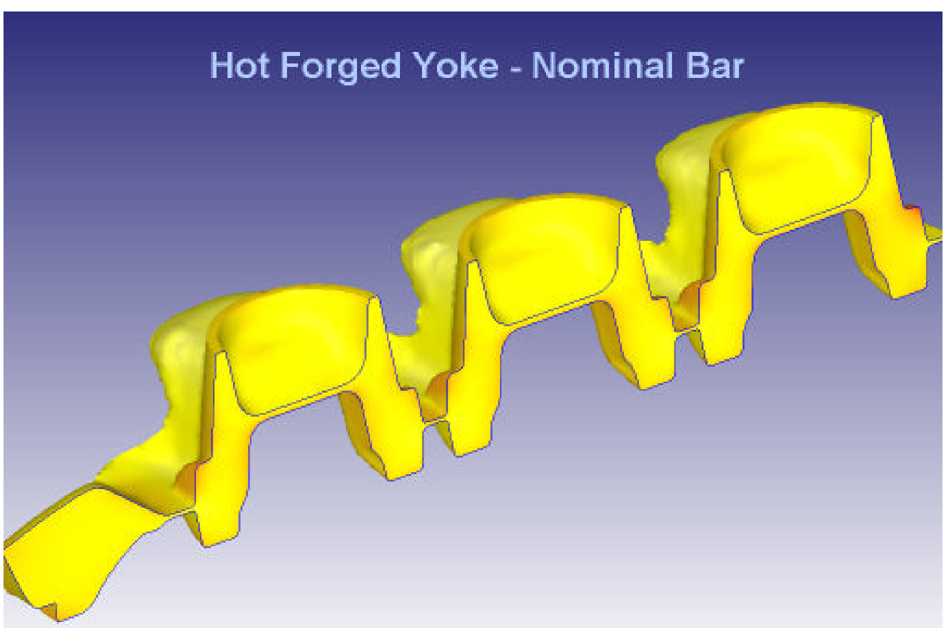



An optimum diameter bar can still result in a defect if the bar is short or located towards the operator. The red circle shows a closed forging lap.

be determined in advance. A bar that is too short or positioned towards the operator can result in an underfill or forging lap. In this case, the defect was observed on the back of the forging (away from the operator).

## Nominal Billet:

The fourth simulation shows a reasonable bar size, location and length. The die cavity is filled without defects. The flash is adequate for trimming and robustness, without being excessive.




The nominal diameter bar fills the die cavity without defects.
The flash pattern is in line with expectations. The model was sliced for clarity.

## Conclusions:

The contributions of process simulation in the development of multiple cavity forgings have been well documented. This case study illustrates how DEFORM contributes to controlling cost in a tight lead time environment for a simpler process.

Tight schedules are the order of the day. Very few manufacturers have the luxury of an increased selling price to compensate for added costs associated with conservative material sizing, recutting dies or shop trials. With profit margins as tight as schedules, it is critical to optimize the process prior to committing cash to the production trials. DEFORM-3D is a valuable tool to provide feedback to the forging designer early in the process. Even more important, when defects that would result in scrap are observed, they can be avoided completely.

## Acknowledgement:

This die geometry and process conditions were supplied by American Axle & Manufacturing in Tonawanda, New York by Mr. Eric Burger.

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