Bolt Progression Load Optimization

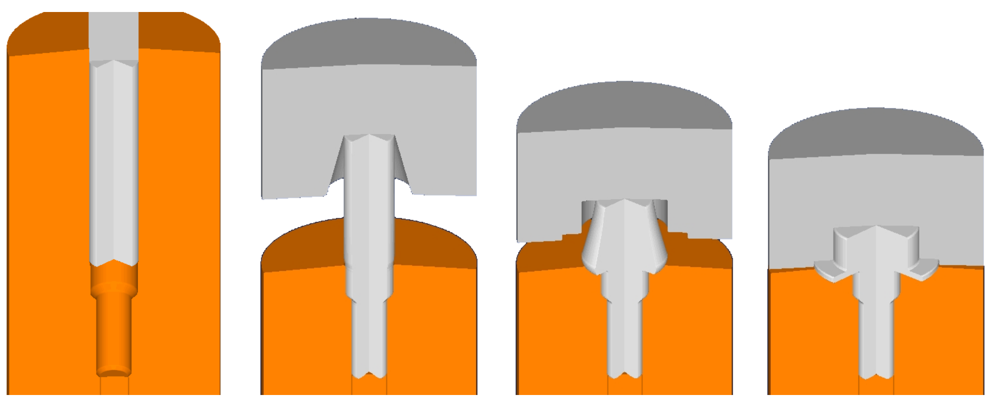
There is a common misconception that the manufacture of traditional components on common machinery doesn't offer the opportunities to optimize processes. The majority of manufacturers in metal forming tend to develop processes that seem to be reasonable, without making the investment in optimizing the process. Optimum processes are those that will generally be more robust and tolerant of day-to-day fluctuations in temperature, material, operators, lubricants and other conditions. Optimum processes will have longer tool and die life - dollars that go straight to the bottom line. These processes will generally consume less energy and be easier on the equipment relative to the average process that is just OK.

Bolt Progression

A study was conducted on the manufacture of a flanged shoulder bolt blank on a two die – three blow header. The method of manufacture is a common one that includes trap extrusion of the initial wire, a cone upset and final forming of the head without the use of sliding dies.

In this case, the wire diameter was varried from .325" diameter thru .425" diameter, with the subsequent processes adjusted to accommodate this variation. The highest loads were not in the extrusion, but the cone upset and heading operation. As one would expect, the extrusion load increases along with the extrusion ratio. In other words, the larger wire results in a higher load for the first operation. On the other hand, the following operations were improved significantly with the larger wire diameter.

To briefly summarize the results, the benefits of smaller wire size are a lower extrusion load and smaller wire diameter. On the other hand, the larger wire diameter resulted in a lower total load, less energy to produce each part, less risk of eccentricity, a more balanced load between stations, shorter dies and a product with a more uniform hardness distribution (the subject of another discussion). Imagine this much opportunity to improve even a very simple process.



This process is conducted in stages as shown from left to right. The first operation is a trap extrusion (shown on left), a cone upset and heading operation (far right) are performed in the same (bottom) die.

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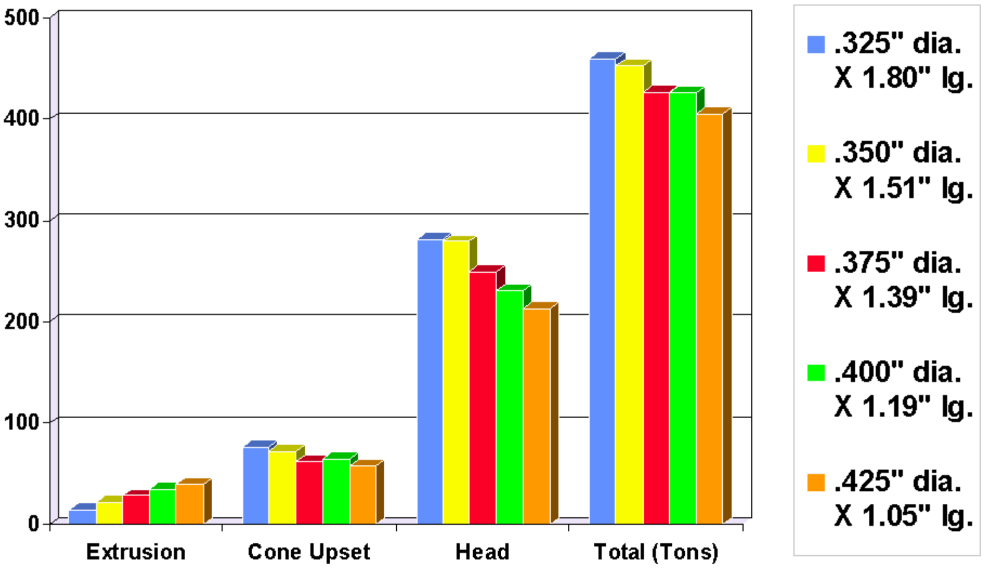
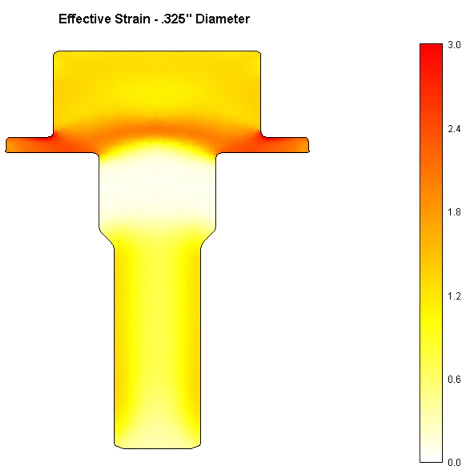
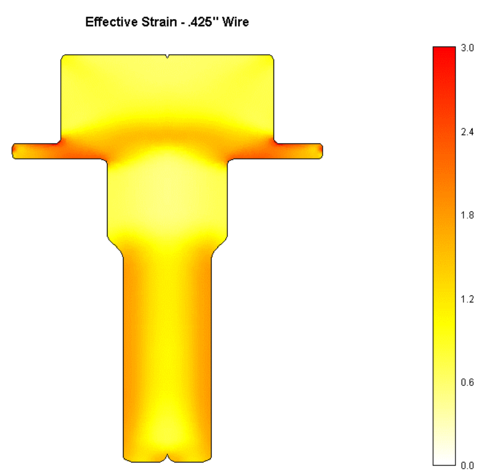


The chart shown includes load calculations based on five different process designs. The load (in tons) is shown at each stage of the progression for each process design. On the right, the total load for each process is shown. The smallest diameter wire studied is .325" and is shown in blue. The largest diameter is .425", which is shown in orange. Below, the figures show contours of effective strain (cold work) for the .325" wire (left) and the .425" wire (right). Additional information about each process is included.





.325" diameter wire

- higher total load
- less load balance between stages

- longer extrusion die length
- greater risk of buckling
- weaker shoulder region due to low strain (less work hardening)
- higher risk of internal transverse head fracture at shear band (shown in red) at head/shoulder intersection
- smaller wire to shear

.425" diameter wire

- lower total load
- improved load balance between stages
- shorter extrusion die length
- less risk of buckling
- stronger shoulder region due to work hardening
- less risk of internal transverse head fracture at head/shoulder intersection

- larger wire to shear

Opportunities

Each decision about a process or design has a cost associated with it. When establishing one parameter such as wire size, it influences many others. For example, the wire diameter essentially controls the extrusion ratio in this case. On the other hand, there are other variables that also offer opportunities for cost reduction or improved processes. These include the extrusion die angle, cone design, extrusion die land and reliefs, to name a few.

Common processes that appear to be simple on the surface are not without significant opportunities for improvement. Process simulation is used in conjunction with creative engineering to understand and optimize a wide range of processes.

Of course, most process designs involve compromise. If a company is limited to a maximum wire size or press tonnage, it may dictate which progression to use. Unfortunately, all too often, compromises are made without the designer having the information required to make the best decision for the company.

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