Overview of Content for Engineers and Designers

Topics

- Designing for Manufacturability
- Controlling and Reducing Cost

Draft Angles

- Forgings made on a hammer must be designed to include draft angle to allow the parts to release from the die.
- Allowable draft angle and tolerances
  - Typical draft angle = 7 ^{o} (tolerance: +2 ^{o} / -0 ^{o})
  - Min. draft angle = 5 ^{o} (tolerance: +2 ^{o} / -0 ^{o})
  - Below 5 ^{o} (call Trenton Forging to discuss your specific needs)
- Draft design notes:
  - Typically, the deeper the impression the greater the draft angle
  - Parting line and draft consideration → where is draft taken from: top or bottom?

Die Wear

- Draft angle and wear tolerances are defined as a function of how the dies wear, i.e., the tolerances will get bigger as wear occurs
- Die wear varies according to the material that is forged and the shape of the forging. Consequently, die wear tolerances for various materials are applied in addition. Generally, carbon content and hardness of the steel define its abrasiveness; the higher the carbon content and/or hardness, the faster die wear occurs

DIE WEAR TOLERANCES

Materials	**Under 30 in. or 750 mm Factor (in./inch) (mm/millimeter)**	**Over 30 in. or 750 mm Constant**	
		in.	**mm**
Carbon, Low Alloys	0.005	0.15	3.81
Stainless	0.007	0.21	5.33
Heat Resistant Alloy	0.009	0.27	6.86

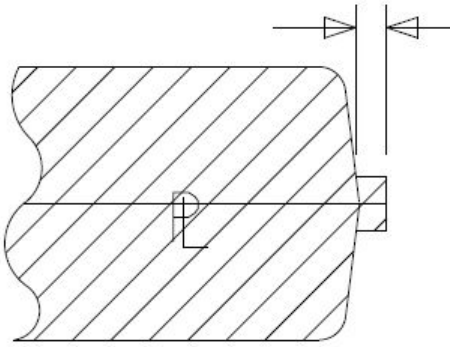
Radii

- The basic rule is: bigger is better; which is especially true with deep impressions
- Minimum radius: .060”
- Smaller radii are possible (call Trenton Forging to discuss specific needs)

Surface Finish and Surface Conditions

- The oxidation of the steel during the forging process can result in scale pits (small indentations in the surface)
    - If necessary, extra care can be taken to reduce scale pits
- The process of removing flash from the forging (or trimming) produces a surface at the parting line that is different than the as-forged surface
    - Flash extension will be .015” to .020” (see Figure 3)
        - The parting line can be hand ground or machined to reduce or remove the flash extension

Figure 3 – Flash Extention

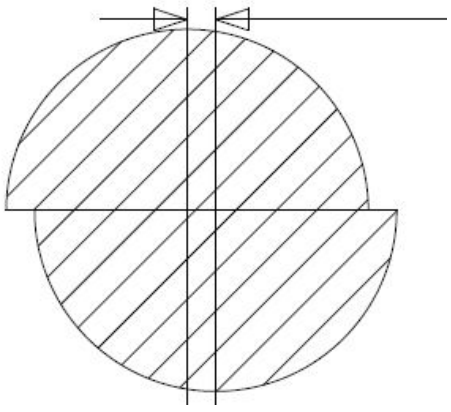


- Forged parts are tumbled and blasted with steel shot to remove scale and to improve surface finish
    - Different blast media can be used to provide a different surface finish
- Dings and dents can occur during handling; special care can be taken when necessary (call Trenton Forging to discuss specific needs)

Mismatch

- Mismatch occurs at the parting line and is caused by minor shifts between the top and bottom dies (see Figure 4)
    - Mismatch can be from side-to-side, end-to-end or can be different from side-to-side along the length which is known as twist; the reality is that there is always some variation across the parting line due to setup and slight movements between the top and bottom dies
    - Typical match tolerance: up to .030”

Figure 4 – Mismatch



- Tighter match tolerance is possible: up to .015”

Closure

- Closure is the variation in thickness of a forging (i.e., across the parting line)
  - Typical closure tolerances = +/-.030
  - Tighter closure tolerance +/- .010 with post-forging coining operation
  - Extremely tight closure tolerance is also possible: +/- .005” (call Trenton Forging to discuss)

Straightness and Flatness

- Straightness and flatness can be affected by different stages in the forging process, handling, abrasive blast and heat treat and must be preemptively curbed or corrected before shipment.
  - Straightness is a 2-D characteristic
    - Straightness tolerance: .003” per inch
  - Flatness is a 3-D characteristic
    - Flatness tolerance: .003” per inch

Cost drivers

- Raw Material Input
  - The diameter of the raw material is defined by the largest cross-section of the part and how far material must travel to fill the impressions in the die.
- Draft Angles
  - The tighter the draft angle, the more difficult it is to forge and requires more frequent die maintenance.
- Radii
  - Very tight radiuses are more difficult to forge; tight radiuses can result in cracks and premature die wear.
- Forging Size and Complexity
  - Part complexity is directly related to the deviation from the shape of the raw material to the shape of the impression, and therefore the finished part. Trenton Forging specializes in parts made from round-bar billets.
- Production Runs
  - Smaller lot sizes or shorter production runs drive cost by needing multiple setup processes.
- Heat Treatment Costs

    - Heat treating charges are based on minimum lot sizes. Small lots cost the same as large ones to process up to the minimum quantity.

Additional Resources

- Drop forge hammers -- https://www.forging.org/design/9-appendix-a
- Forging facts -- https://www.forging.org/forging-facts
- How forgings compare -- https://www.forging.org/how-forgings-compare