

Forging Process Cheat Sheet

Upsetting, forging force, die types, defects and cost

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Volume constancy	$A_o h_o = A h$	Upsetting: height falls, diameter grows
True strain (upsetting)	$\epsilon = \ln(h_o / h)$	Textbook form
Open-die force (with friction)	$F = Y_f A [1 + 2\mu r / (3h)]$	Textbook form; pressure at outer radius equals flow stress Y
Closed-die force	$F = K Y_f A$	Textbook form; K covers shape complexity and friction
Typical K (textbook)	3 to 5 simple, no flash; 5 to 8 with flash; 8 to 12 complex	Not given in the post (image)
Impression-die steps	Pre-forged → block → finish → trim	Crankshaft needs about twice the steps of a connecting rod
Sand casting vs forging	Sand casting cheaper below ~20,000 pieces	Connecting-rod example in the post

Key takeaways

- Forging is nonsteady-state and has three classes: open-die (upsetting), impression-die (closed), flashless.
- Friction causes barreling in upsetting; load climbs sharply in closed-die forging once flash begins to form.
- Grain flow follows the part shape, which raises strength, toughness and fatigue resistance (crankshafts, rods, knuckles).
- Heading forms bolt and rivet heads by compressing the end in multiple directions; upsetting compresses in one direction.
- Defects: cracks, porosity, inclusions, unfilled sections, cold shut, scale pits, die shift, flakes, laps from web buckling.
- Setup and tooling cost per piece falls as quantity rises, so forging favors high volume.
- The post's force equations and K table are images; the formulas shown are the standard textbook forms, not copied from the post.