Forging

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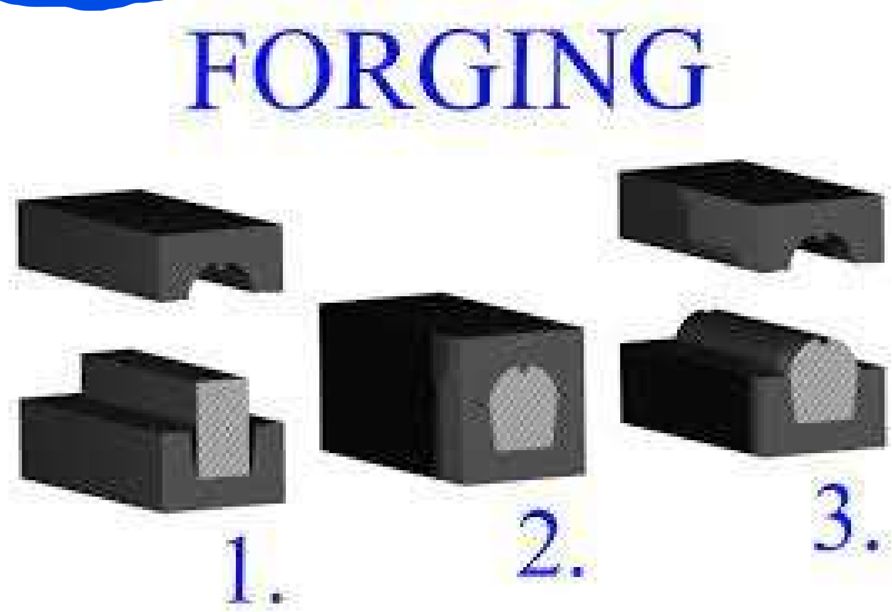
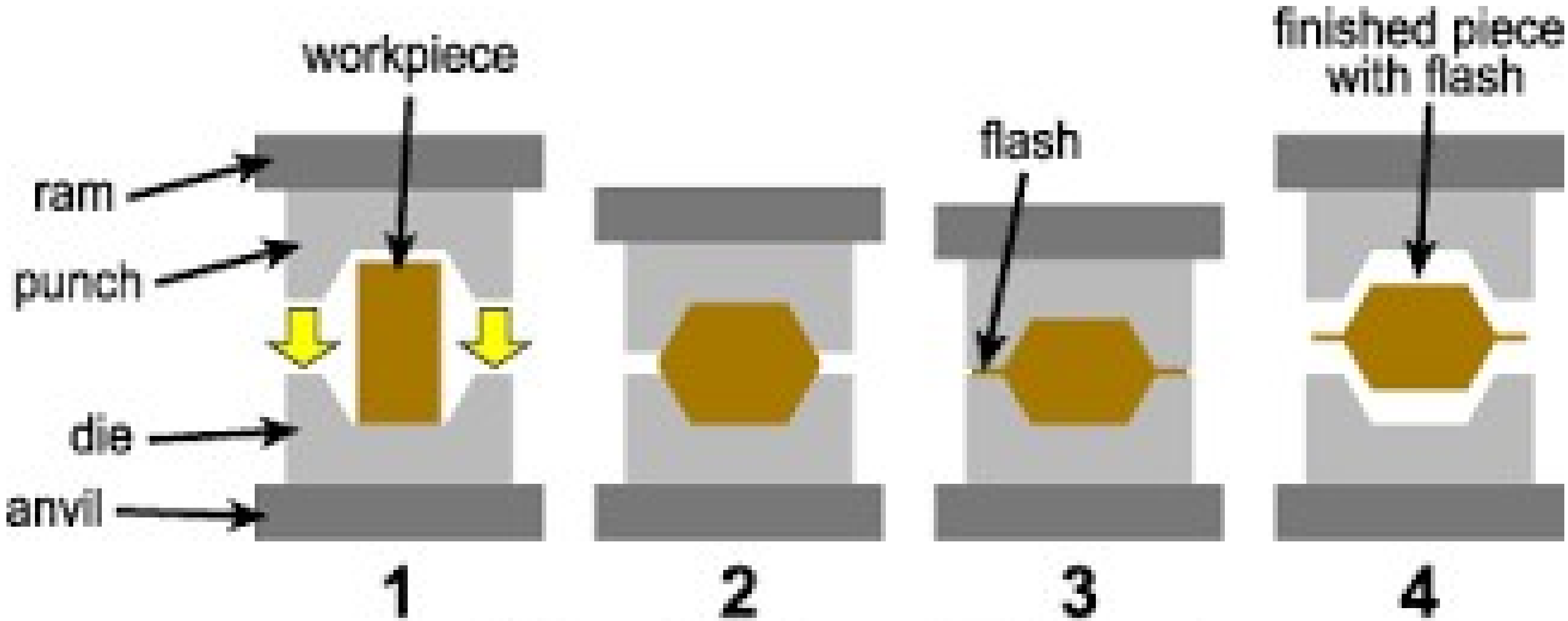
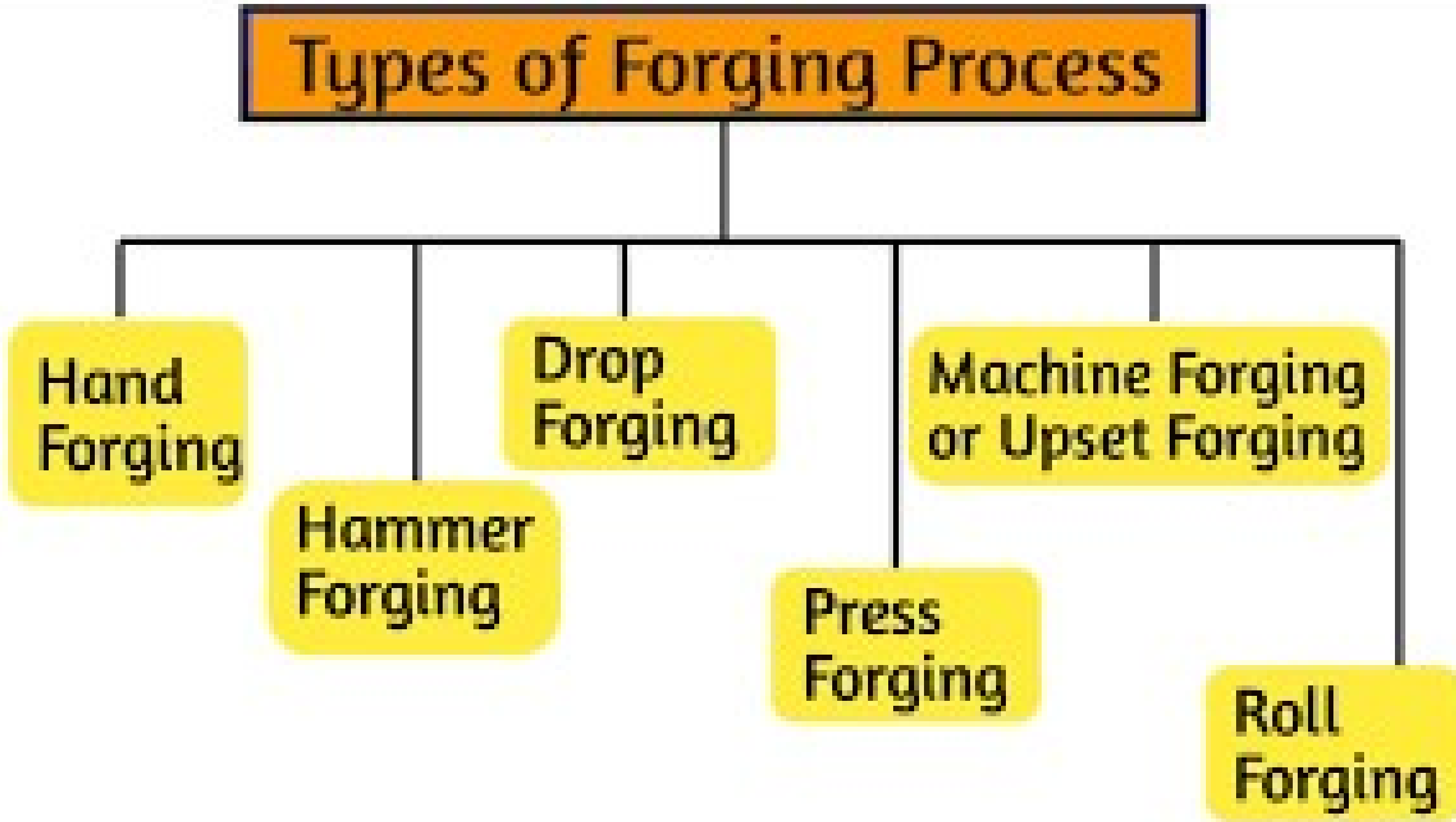
FORGING

- Forging is a metal working process that manipulates, shapes, deforms, and compresses metal to achieve a desired form, configuration, or appearance outlined by a metal processing design or diagram. Depending on the type of metal and the requirements of the design, the forging process can be completed using either hot or cold forging processes.



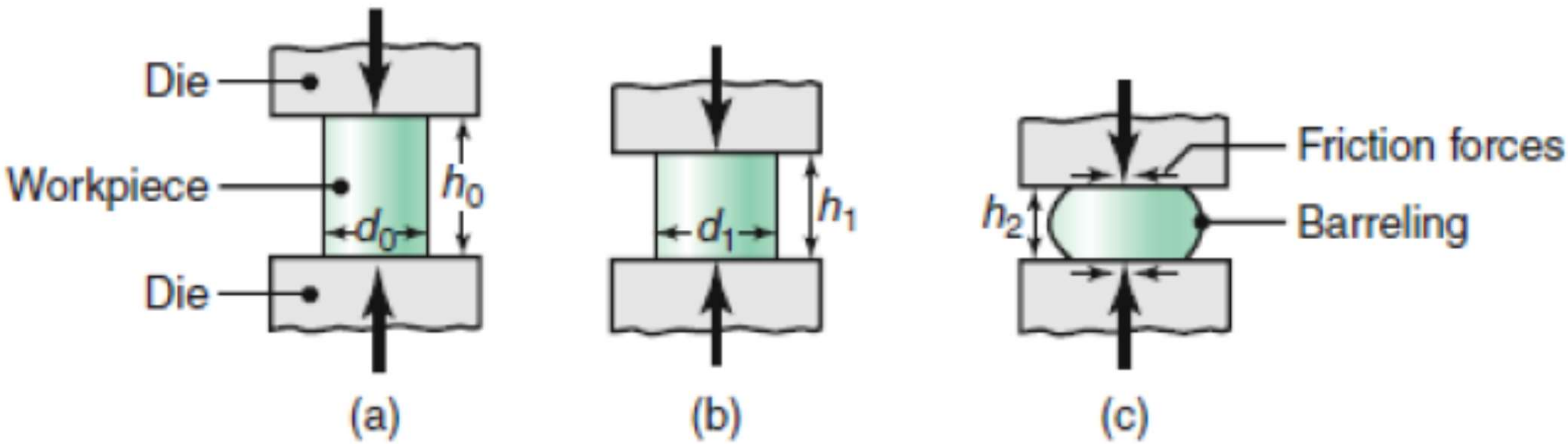


workpiece
ram
punch
die
anvil
flash
finished piece
with flash
1
2
3
4


Types of Forging Process
Hand Forging
Hammer Forging
Drop Forging
Press Forging
Machine Forging or Upset Forging
Roll Forging

OPEN-DIE FORGING

Open-die forging is a hot forging process in which metal is shaped by hammering or pressing between flat or simple contoured dies. In open die forging the dies do not completely cover the workpiece. Instead, there are open spaces that allow various aspects of the workpiece to move from direct hot die contact, and to cooler open areas. In this type of forging, metals are worked above their recrystallization temperatures. Because the process requires repeated changes in workpiece positioning. The workpiece cools during open die forging below its hot-working or recrystallization temperature. It must be reheated before forging can continue.



Operations performed on open die presses

1. Drawing out or reducing the cross-section of an ingot or billet to lengthen it.
2. Upsetting or reducing the length of an ingot or billet to a larger diameter.
3. Upsetting, drawing out, and piercing-processes sometimes combined with forging over a mandrel for forging rough-contoured rings. Practically all forgeable ferrous and non-ferrous alloys can be open-die forged, including some exotic materials like age-hardening super alloys and corrosion-resistant refractory alloys.

Applications

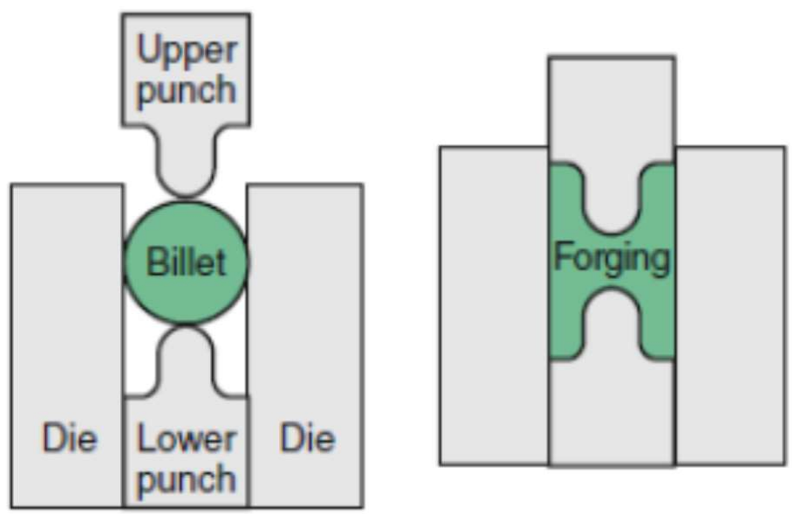
Open-die processes can produce:

1. Step shafts, solid shafts (spindles or rotors) whose diameter increases or decreases at multiple locations along the longitudinal axis.
2. Hollow cylindrical shapes, usually with length much greater than the diameter of the part Length, wall thickness, internal and outer diameter can be varied as needed.
3. Contour-formed metal shells like pressure vessels, which may incorporate extruded nozzles and other design features.

CLOSED-DIE FORGING

In closed-Die Forging, no flash is formed and the workpiece is completely surrounded by the dies. In this process, a billet with carefully controlled volume is deformed (hot or cold) by a punch in order to fill a die cavity without any loss of material. Therefore, proper control of the volume of material is essential to obtain a forging of desired dimensions.

Undersized blanks in closed-die forging prevent the complete filling of the die, while oversized blanks may cause premature die failure or jamming of the dies.

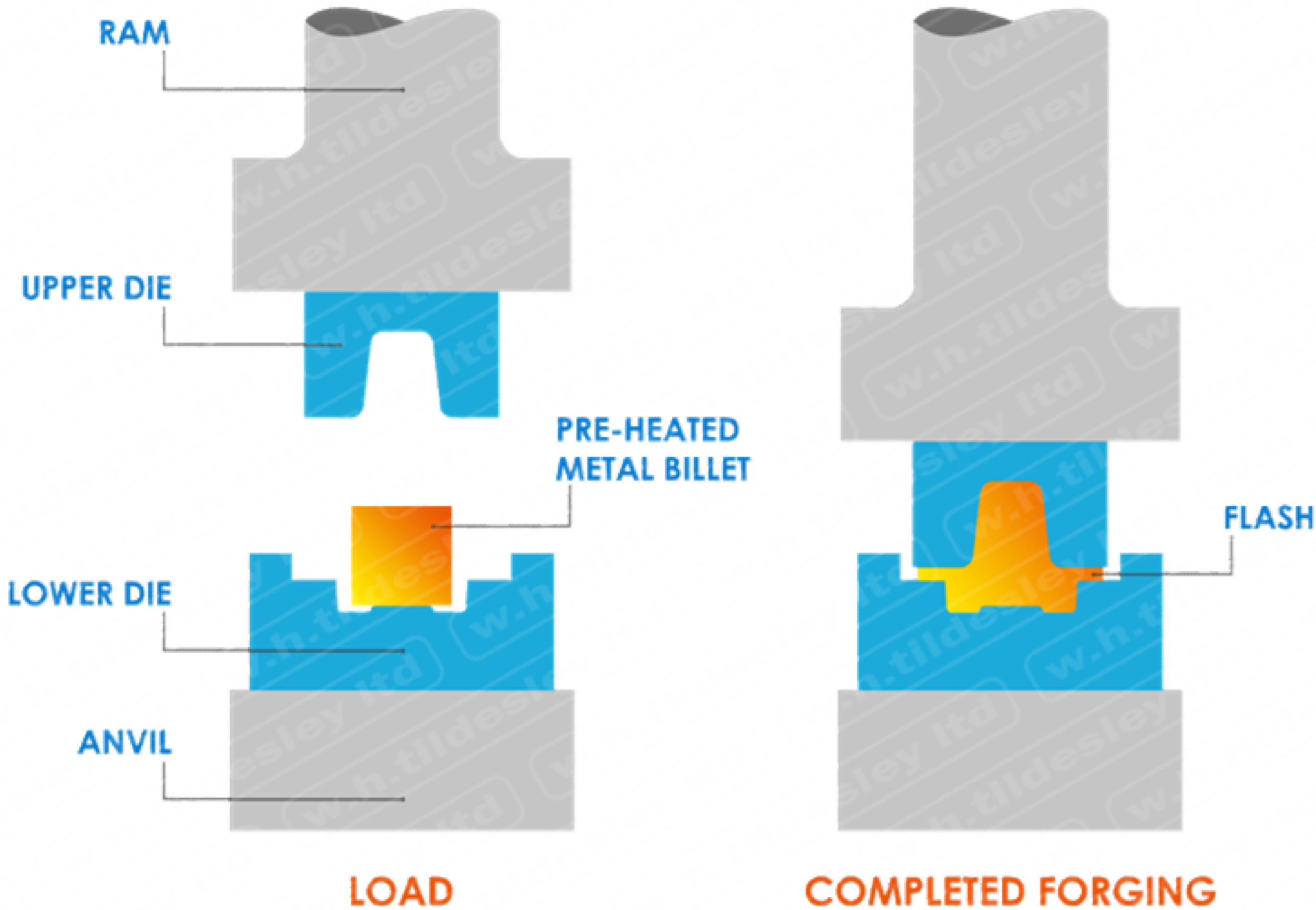


1. Start of stroke

2. End of stroke

Drop Forging

- Drop forging is a metal forming process.
- A workpiece is inserted into a die and then hammered until it has assumed the shape of the die.
- The lower die is a stationary part, while the upper part is a moving hammer dropped onto the workpiece in order to deform it.
- Drop forging can be performed both at high or ambient temperature.
- This manufacturing process has a long tradition in the metal shaping industry and it has been used for hundreds of years.
- The mechanics of the process are still the same, but all involved machinery has greatly advanced to turn drop forging into a high-precision manufacturing process.
- Similar to all other forging techniques, drop forging enhances the material properties of the final piece.


RAM
UPPER DIE
PRE-HEATED
METAL BILLET
LOWER DIE
ANVIL
LOAD
FLASH
COMPLETED FORGING

Benefits of Drop Forging

- Good surface finish
- Enhanced mechanical properties
- Recyclable flash
- Improved metal strength by aligning the grain along the lines of potential stress

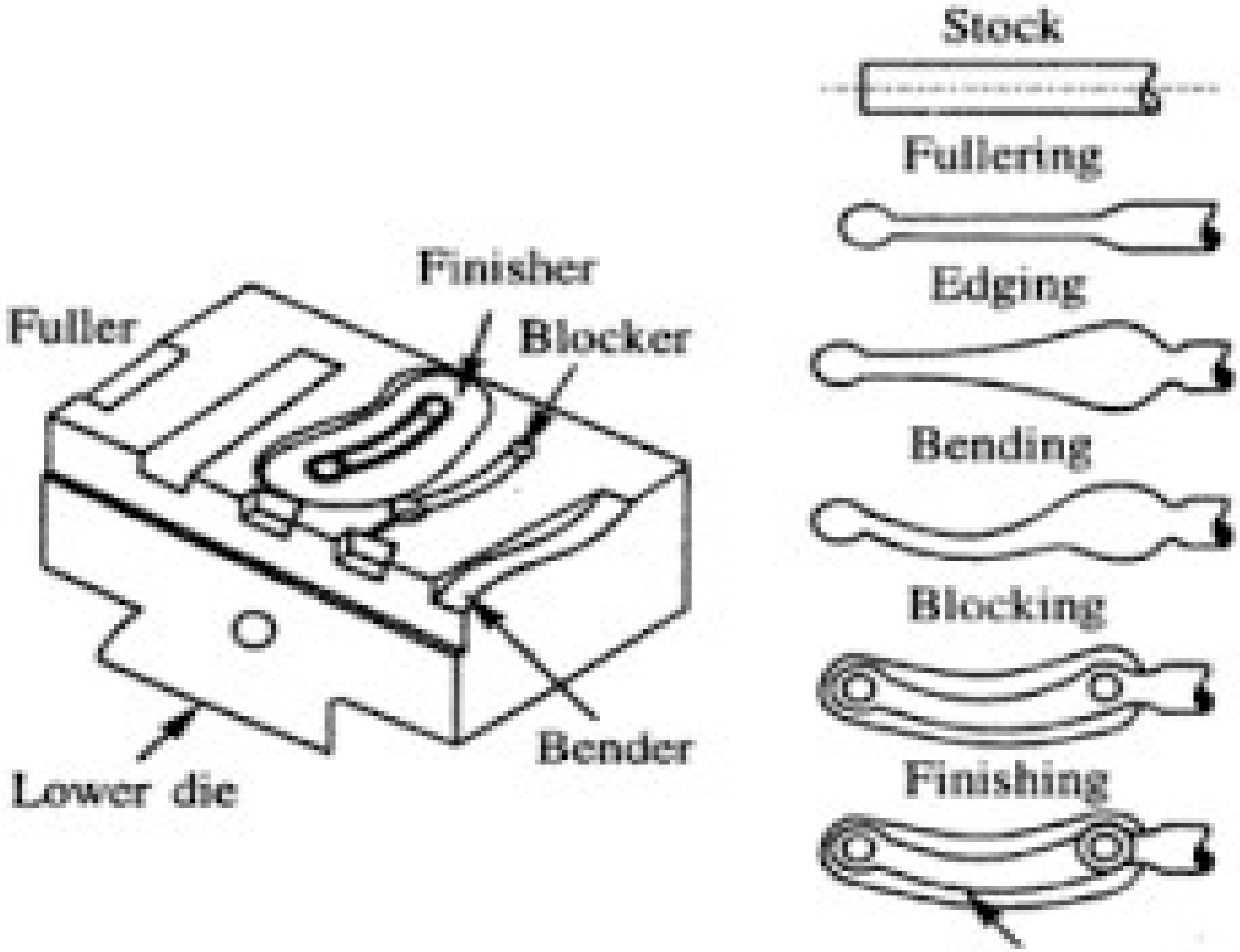
Typical Drop Forged Components

- Railroads
- Crankshafts
- Levers
- Gears
- Connecting rods
- Spanners
- Pedal cranks
- Gear blanks

Stock

Stock material to Lever by Drop forging

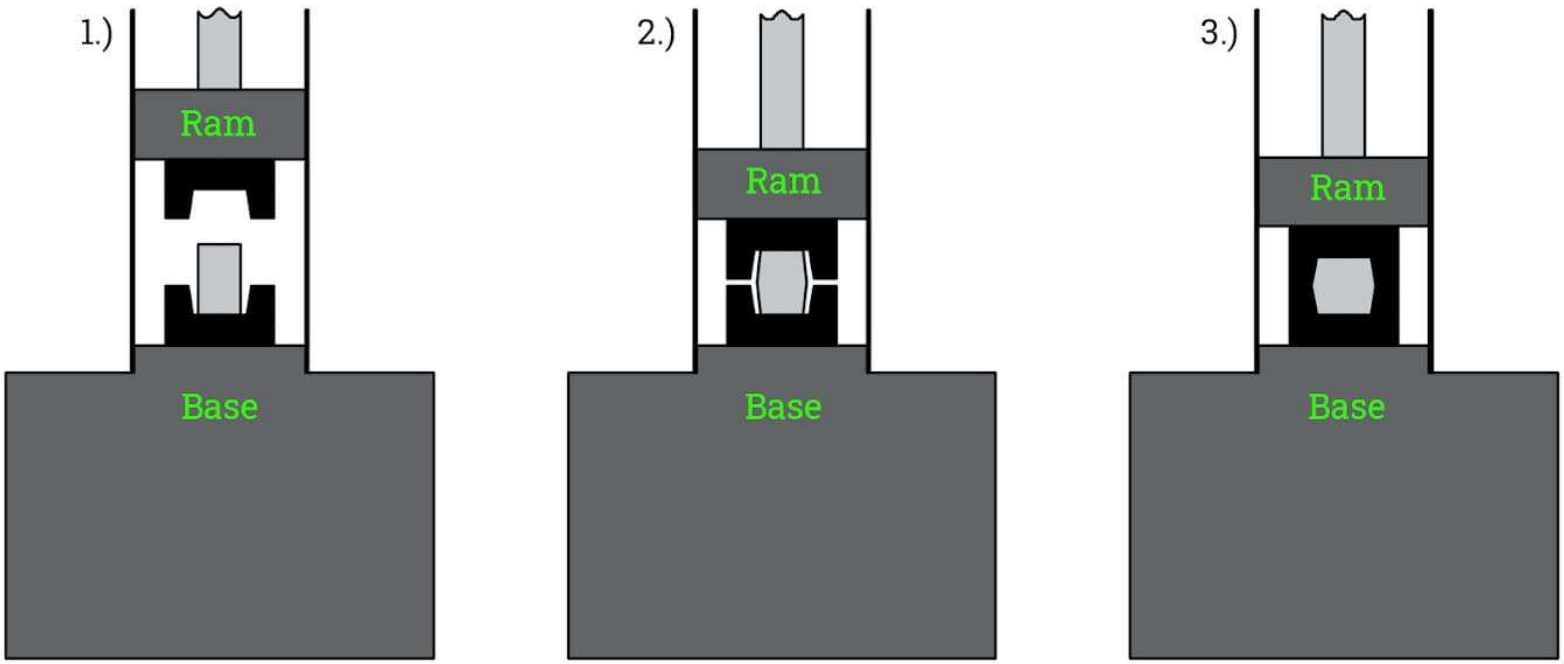
Finishing


Fuller
Finisher
Blocker
Bender
Lower die
Stock
Fullering
Edging
Bending
Blocking
Finishing

Press Forging

- A forging press uses a vertical ram to apply gradual, controlled pressure to a die holding a workpiece.
- It is a similar process to drop forging, but it uses slow pressure instead of a series of blows.
- The slow movement of the ram penetrates deeper into the workpiece so that the workpiece undergoes uniform plastic deformation.
- Press forging dies can be open or closed. In open die forging, the die does not completely enclose the work-piece.
- In the closed die method, also known as impression die forging, the die completely surrounds the workpiece.

Forging Press Process



Force Moves The Upper Die Toward The Billet

The Downward Pressure Deforms The Billet

The Mold Closes Over The Billet To Complete The Forging Process

Types of Forging Presses

The three main types of forging presses used for press forging are listed below:

- Mechanical Press – converts the rotation of the motor into linear motion of the ram.
- Hydraulic Press – hydraulic motion of the piston moves the ram.
- Screw press – screw mechanism actuates the ram movement.

Advantages of Press Forging

- Deforms the work piece completely
- Compression rate of the work piece can be controlled
- More economical for high volume productions
- Any size and shape can be created
- Requires less draft and produces lesser scrap.

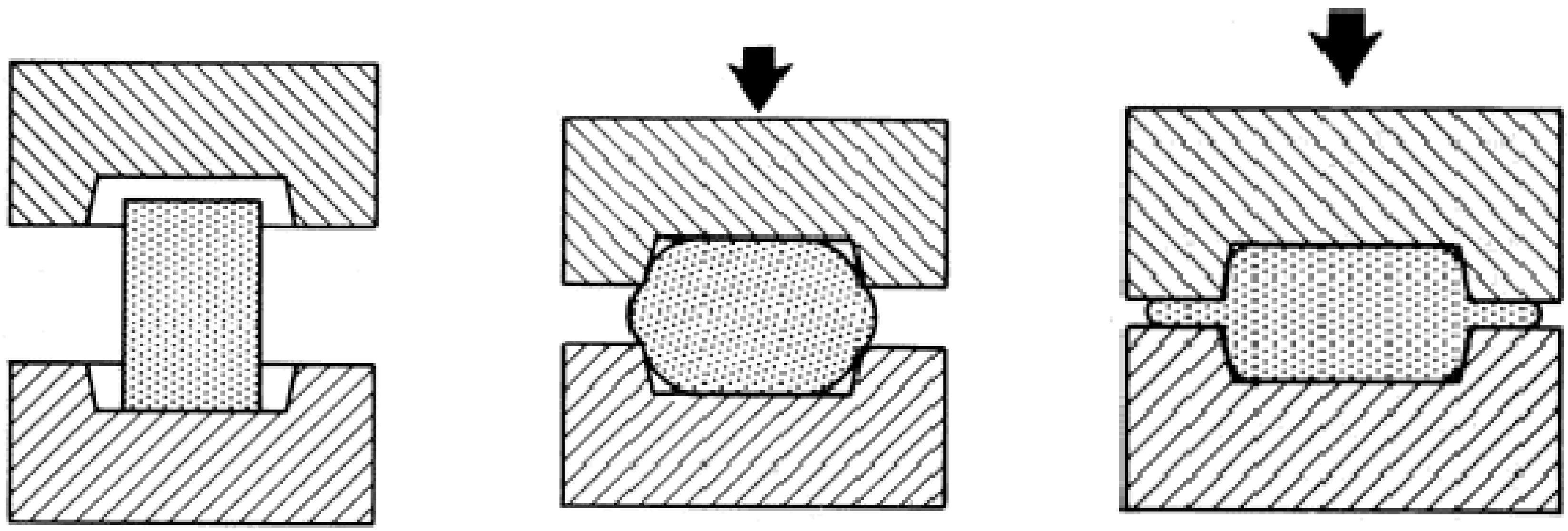
Industrial Applications

- Making of coins and silver articles
- Automatic forging.

Impression Die Forging

- Impression die forging is a metal deformation technique in which a billet is compressed between two sets of die to form a complex part.
- “Impression” refers to the pre-cut profile of the dies used during the forging process, which are customized based on the part that is being produced.
- During the impression die forging process, a pre-cut billet that’s been heated to a pre-determined temperature is placed between two sets of custom dies/tooling.
- As previously mentioned, each die contains a pre-cut profile (or cavity) that resembles what the final product will look like.
- The billet then undergoes controlled deformation as it is compressed between the two dies.
- Depending on the forging being made, there may be more than one set of dies involved in the process.
- While the billet is being compressed, excess metal (flash) will flow and cause pressure to build up within the die.
- Since flash cools down more quickly than the metal inside the die, it blocks more hot metal from escaping and turning into more flash.
- This also ensures that the remaining hot metal fills up the die and creates a more uniform product.
- Once this forging process is complete, the flash is removed, and the final product is left to cool.
- Once the forging has cooled, it’s cleaned off and inspected.

Impression Die Forging process

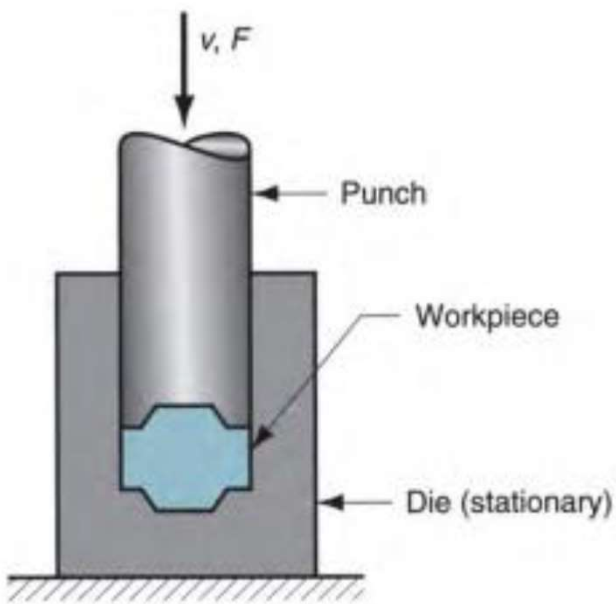


Advantages

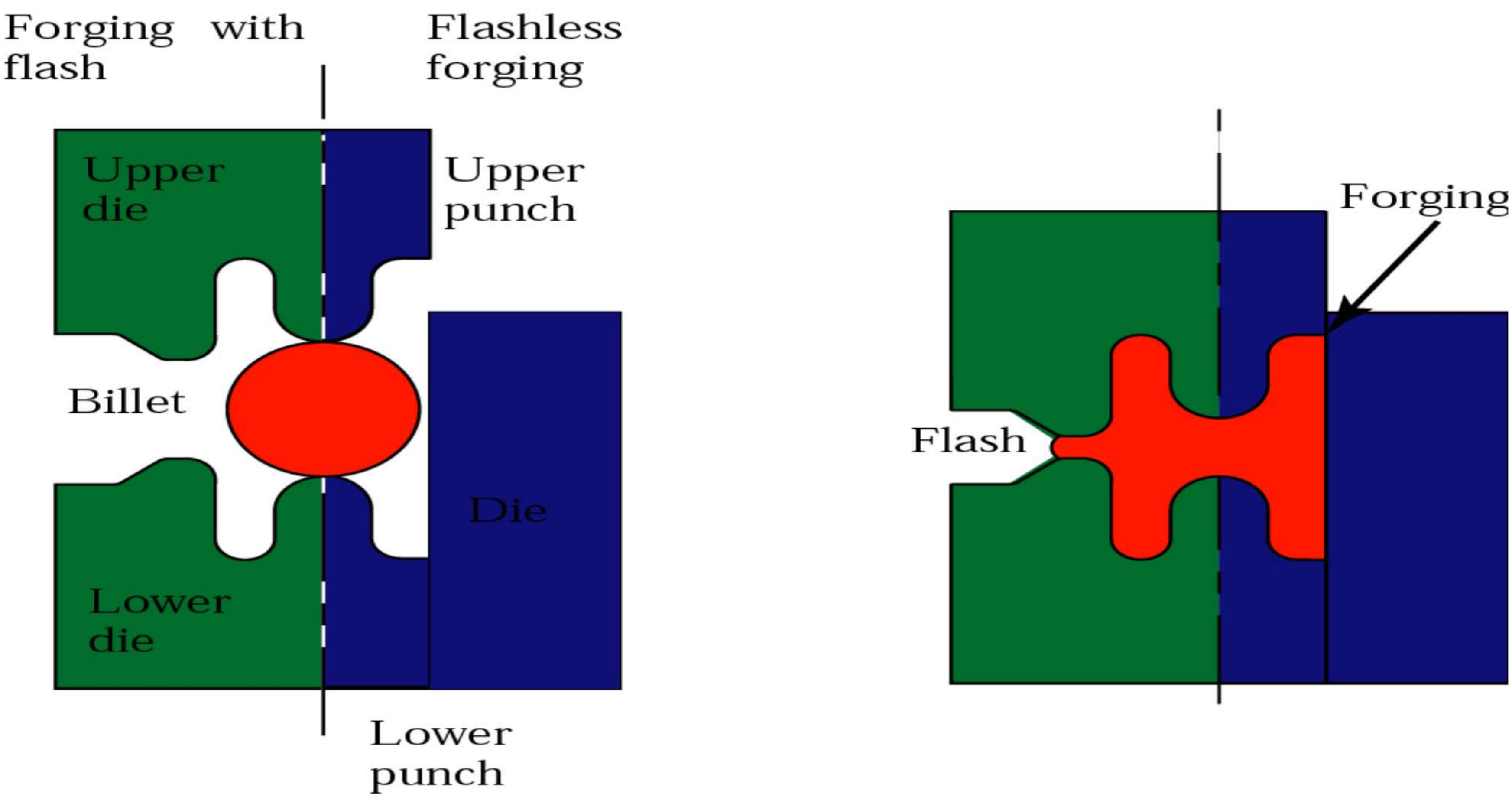
- Impression die forging is very effective for shaping aluminum, steel, titanium, and a wide range of metal alloys.
- By enclosing the hot metal inside sets of dies, many kinds of complex three-dimensional shapes can be produced.
- This includes simple forms such as cubes, disks and spheres, but it can also be applied to multi-section parts that incorporate thin delicate webs and long, spindly shapes.
- Impression die forging is also useful for parts with holes, pockets and protrusions, and even asymmetrical parts can be produced through this process.
- Thanks to this forging process, high-quality components can be manufactured at a relatively reasonable cost.
- The resulting parts resist both fatigue and impact, are very durable and have higher strength-to-weight ratios.
- Sometimes, these parts are up to 20% stronger than those produced by other forging methods.
- Impression die forging also generates less wasted metal, and this refined method is capable of higher production rates than other techniques.

Precision Forging

- Precision forging is an innovative manufacturing process for the flashless, near-net shape production of high-performance components.
- Outstanding material characteristics as well as a reduced process chain and a high material efficiency are the essential advantages of precision forging.
- Precision forging is worked in a close to final shape or close-tolerance forging way.
- It is a refinement forging techniques compare to traditional closed die forging technology.
- When you need a product with near net shape or net shape, precision forging is the right choice to source, such forging technic will refine the product to little or no machining.



Conventional vs Precision Forging



(a) Start of stroke

(b) End of stroke

Advantages

- High material utilization. As there is no flash in precision forging, according to the designed processes, material will be forged into desired shape after plastic deformation.
- Good working performance. Parts produced by precision forging, the metal fiber is evenly distributed along the contour shape, dense and continuous.
- For precision forgings without flash, there will not exist leakage of metal fiber that caused by removing flash, this will be good for improving stress corrosion resistance and fatigue resistance of products.
- Complicated shape parts are available in precision forging.
- High precision. After precision forging, we will get net or near net shape products, such high precision will require just very little or even no machining job.

Grain Flow


CASTING
No grain flow
BAR STOCK
Grain flow broken
by machining
FORGING
True grain flow

- A casted component does not have uniform grain structure, grain flow, or directional strength.
- During the casting process, slurry is poured into a mold, and as this slurry cools, dendrites form, which eventually turn into grains.
- These grains are not uniform, as some may be small, large, coarse, and/or fine, which results in grain boundary voids.
- When that billet is machined, it often means that the unidirectional grain flow pattern has been cut, and its contour has changed.
- Machining exposes the grain ends and makes the material more prone to sensitive stress, corrosion cracks, and fatigue.
- Forging produces components in which the grains are deliberately aligned in the direction of maximum strength, resulting in exceptional fatigue and impact resistance.
- During the forging process, the metal then undergoes controlled deformation under (typically) elevated temperatures.
- The benefit of forging, when compared to other manufacturing processes, is that grain flow can be controlled.