Forging

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Training Objective

After watching this video and reviewing the printed material, the student/trainee will become familiar with the principles of forging and its place in manufacturing.

- The basics of forging technology are explained.
- Open and closed die forging methods are detailed.
- Hot die technology is discussed.
- The use of computers in forging is presented.

Forging is the controlled deformation of metal into a specific shape by compressive forces. The forging process goes back to 8000 B.C. and evolved from the manual art of simple blacksmithing. Then as now, a series of compressive hammer blows performs the shaping or forging of the part. Modern forging uses machine driven impact hammers or presses which deform the workpiece by controlled pressure.

The forging process is superior to casting in that the parts formed have denser microstructures, more defined grain patterns, and less porosity, making such parts much stronger than a casting. All metals and alloys are forgeable, but each will have a forgeability rating from high to low or poor. The factors involved are the material's composition, crystal structure and mechanical properties all considered within a temperature range. The wider the temperature range, the higher the forgeability rating. Most forging is done on heated workpieces. "Cold forging" can occur at room temperatures. The most forgeable materials are aluminum, copper, and magnesium. Lower ratings are applied to the various steels, nickel, and titanium alloys. Hot forging temperatures range from 93^{o} C (200^{o} F) to 1650^{o} C (3000^{o} F) for refractory metals.

Types of Forging

The two basic types are open-die forging and impression or closed die forming. Additional variations include seamless ring forging, hot-die forging, and isothermal forging. Open-die forging is performed on ingots, billets, or a pre-formed shape. There is little restriction to metal flow and as the repeated hammer blows reduce the cross section of the workpiece, its length can increase. Upsetting and bulging are other results in open die forging. Bulging will of course reduce the piece's length. Lengthening and upsetting are done as the piece is incrementally rotated on its longitudinal axis and advanced lengthwise through the die. There is basically no limit to the size of a forging made with the open-die method. However, most work will require extensive machining to achieve their shape or net shape. Open forge die shapes are usually flat, V-shape, or semi-rounds. Die accessories include saddles, blocks, rings, mandrels, and punches. All these are commonly made of hot-work tool steels or medium carbon steels. During forging graphite based lubricants are used.

As the work done in open forging is usually large and cumbersome, heavy duty and often mechanically powered material handling equipment is needed such as cranes, fork lifts, and various rotating devices.

Closed die or impression forging is done in one or in a series of die impressions or die cavities. These dies are often heated to maintain proper forging temperatures. This type of forging is often done in heavy presses as well as with hammers.

Workpieces may be round or rectangular in cross section, or flat discs. Simple shapes may be forged in a single stroke while more complicated pieces may pass through several strokes and die cavities before achieving their final form. During the final forging, a thin layer of metal, called the “flash” will flow out between the dies. This flash is subsequently removed manually or by special trimming dies. With a carefully controlled pre-form size and shape, flashless forging is possible. As in open die forging, graphite lubricants are used. Water or oil based, such lubricants enhance metal flow, minimize die wear, retard heat loss, and aid in releasing the work from the die. The final forged part is much closer to net shape than with open-die forging and is of higher quality, both dimensionally and metallurgically.

Seamless ring forging is the circumferential expansion and cross section of a centrally pierced, disk shaped workpiece. Both exterior and interior profiles can be obtained on the ring rolling machine which consists of a mandrel or undriven wheel and a driven outer wheel. As the distance between the rollers and mandrel closes, the forging action takes place. Products produced include gear blanks, bearing races, valve bodies, wheels, and turbine components.

Hot die and isothermal forging utilize heated dies to maintain forging temperatures in the workpiece. While hot die forging maintains temperatures below the workpiece’s forging temperatures, isothermal forging maintains temperatures at actual forging heat. These types of forging are used on aluminum and copper alloys and others with a narrow forging temperature range. Products produced are more precise in dimension and geometry, can be more complex in design, and have a smoother surface finish.

Computers have become critically important in forging operations. Die designs can be quickly devised. The computer is used to arrive at optimum forging sequences based on size and part geometry. Computer controlled forging systems are virtually fully automatic, thus reducing labor costs and scrap, while increasing productivity and quality.

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Review Questions

1. Forging as a process is closely related to:
   a. welding
   b. machining
   c. casting
   d. blacksmithing

2. While cold forging is done at room temperatures, hot forging occurs at:
   a. 100 to 500 degrees
   b. 500 to 1000 degrees
   c. 1000 to 2000 degrees
   d. 200 to 3000 degrees

3. Metal flow in open-die forging is:
   a. limited
   b. practically unlimited
   c. harder to achieve
   d. done without any lubrication

4 Another name for closed die forging is:
   a. impression forging
   b. drop forging
   c. cast forging
   d. hammering

5. “Flash” refers to:
   a. the closing of the dies
   b. excess metal flowing out of a die
   c. fuming of the lubricant
   d. part ejection

6. Forging lubricants are:
   a. oil based
   b. water based
   c. lead based
   d. graphite based

7. The primary difference between hot die forging and isothermal forging is:
   a. the temperature of the workpiece
   b. the temperature of the dies
   c. the materials forged
   d. workpiece finishing.

8. Hot die and isothermal forging is used on:
   a. ferrous materials only
   b. non-ferrous material only
   c. materials with narrow forging ranges
   d. only very ductile materials

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Answer Key

1. d
2. d
3. b
4. a
5. b
6. d
7. a
8. c