HEAT TREATING

FORMING

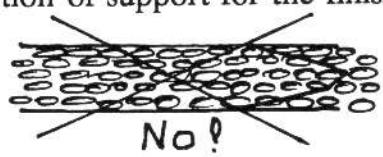
UNIT

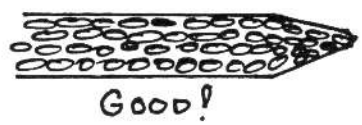
Heat Treating - Forming

Introduction

Thoughts to Remember:

- Forgings are used in situations requiring a maximum of strength and a minimum of material.
- Forging is the use of pressure (sometimes heat also) to form metal.
- Forging is done to improve the internal grain structure in metal. The grain is moved into a position of support for the desired object. Notice in the sketches below, if forging is not done, the object is formed by cutting through grain structure. In the example on the right, the grain structure is far stronger as it has been formed into a position of support for the finished product.





Definition of Terms:

- S.A.E. - Society of Automotive Engineers. This society standardizes such things used in American industry as oils, threads and threaded fasteners, and content of steel.

Hot Forming:

All steels are given a four digit (on rare occasion a five digit) identification number. In order to understand the content of steel, the breakdown of the numbering system must be understood.

Example: S.A.E. #1018

The first number (#1) indicates **the alloy** in the steel - definition of the number is as follows:

1 - Carbon - This is plain carbon steel having no alloy.
Special Note: If the four digit number starts with the #1, it will always be followed with a #0 in the second position. All other numbers must have some other number beside the #0 in the second position.

2 - Nickel
3 - Nickel/Chromium
4 - Molybdenum
5 - Chromium
6 - Chromium/Vanadium
7 - Tungsten
8 - Silicon/manganese

The second number #0 indicates the **percentage of the alloy** (the first number) that is present.

The last two numbers of the four digits is the **carbon content.** In this case it is 18. This number (18) is the points or parts of 1% carbon in the steel. This is a very small amount of carbon because if it were 20 points carbon it would be read 20/100 or approximately 1/5 of one percent carbon.

When there is, on rare occasions, a five digit number, it is read as one of the two following ways:

Example: 10120

Because the example starts with the #1, there will definitely be 0 percent alloy, and therefore, the last three numbers are grouped together indicating 1.20% (slightly more than 1%) carbon.

Example: 71360

Because the example starts with the #7, there will definitely be an alloy present and because industry has gone to the expense of introducing an alloy into the steel, the next two digits will be the percent of alloy. Therefore 71360 is read to be 13% tungsten with 60 points carbon.

Common Steels:

1018 - 1023 = Mild carbon steel - to be forged at a bright red
1045 - 1080 = Tool Steel - To be forged at a higher temperature = orange
1090 = Drill Rod - Forge at orange color.

NOTE: Failure to heat to colors indicated while forming will build up stress and result in future cracking.

Hardening:

Heat to critical range (C.R.) and quench in water or oil. When hard, only abrasives can remove material from the surface of the part. Different mediums determine how quickly (the severity) the metal will be quenched to a brittle hardness. Salt brine (sea water) is the quickest, then water, then fish oil, then motor/petroleum oil, then air (allowing certain steels to cool in an air environment will harden them. Notice the chart below and what happens to the grain structure as it is heated:

When steel is heated to critical range, the grain structure really decreases in size until it reaches critical range (cherry red - 1550 degrees F.), then the grain begins to grow in size until it reaches a liquidous state at approximately 2550 to 2650 degrees F. Note at critical range, steel becomes non-magnetic for a range of approximately 100 degrees.

Tempering:

After brittle hardening a piece of steel, it must be tempered to **remove some hardness** so that it is a tough tool that will not shatter while in use. The piece of steel must be polished bright on the surface so the temper colors can be seen. The shank or handle end of the tool is presented to intermittent heat and colors will begin to appear on the metal surface:

Pale Straw	460 degrees - leaves metal hardest of temper colors used for awls and scribes.
Brown	500 degrees - knives
Purple	530 degrees - screwdrivers, chisels
Blue	565 degrees - digging bars, bits on jack hammers
Grey	600 degrees - softest of temper colors
Black	

Annealing:

Total stress and fatigue reduction by heat.

Steel - heat to critical range (cherry red) and allow to cool extremely slow. Sometime the blacksmith even found it necessary to slow down (retard) the cooling time by embedding the part being annealed in coal dust or limestone.

Copper and its alloys - heat to black or dull red, cool in water or oil. This will not harden like steel, because there is no carbon content in a ferrous environment.

Aluminum - Heat to 635 degrees F. and allow to cool in water or air - same as copper. Ways of determining when aluminum reaches 635 are to use a pyrometer (a temperature gage), or put acetylene soot on the surface and burn off with an oxyacetylene flame, or use a piece of pine and touch the hot aluminum - if it chars, then it has reached about 635 degrees. **NOTE:** Some method must be used to determine the temperature of aluminum because it will melt before changing color as it is heated up.

Case Hardening:

Adding carbon to the outer surface of mild steel to harden just the surface. This will make the steel highly wear resistant, leaving the inner core soft for high torque (twisting force). Today the professional might use a high carbon concentrate material like "Kasenit" to impart carbon on the surface of steel. In years gone by, the old time blacksmith used bones, leather, and fruit pits to accomplish Case Hardening. Whatever the material used, the part is heated up and rolled in the carbon material, then heated and rolled again and again until the desired depth of the carbon shell has been acquired. The maximum depth is not in excess of 1/32".

Finishes:

1. Leave **heat colors** on surface of metal. This is an oxidation finish that somewhat protects the steel from further oxidation (rust).

2. **Brighten** with abrasives and keep bright with a thin film of oil.

3. **Chrome** plate - Industry uses this technique (Sears), but we don't have available in our lab.

4. **Paint** - Paint all area of tool, except the part that has been formed.

HEAT TREATING FURNACE

Gloves are recommended for this area along with safety glasses because of working with hot metal and flying heat scale. Label all metal left out "hot" with soapstone. Cool all hot forging tongs to avoid other persons being burnt. Do not remove forging tools from the forging area.

Lighting the furnace:

a. Before starting the lighting procedure, check to see carved line on top of of gas valve is ACROSS THE PIPE.

b. Start the air motor switch.

c. Light the oxyacetylene torch from a portable welder and insert the torch in the first hole inside furnace.

d. Slowly open gas valve (approximately 1/8 turn) to acquire the loudest roar possible in the furnace. This indicates maximum efficiency.

Turning the furnace off:

a. Turn the gas off first - turn gas valve the SHORTEST distance necessary to get the carved line on the gas valve ACROSS THE PIPE.

b. Turn off air motor switch.