Processing of Metals: Hot Working

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Introduction

Modern forging processes account for a large part of basic metalworking. Often a forged or rolled shape is subjected to a secondary process of metalworking, such as stamping or machining.

To many the term hot working means that the metal is deformed or worked at an elevated temperature; however, hot working technically means that the metal is worked at a high enough temperature that no plastic deformation, strain hardening, or cold working takes place. One way to check for hot working is to measure the hardness or strength of the metal before and after the working process; if no strengthening occurs, it is hot working. Another way to think of true hot working is that before the metal cools, the temperature is high enough that it anneals the metal and removes the cold work that would otherwise have occurred.

http://www.youtube.com/watch?v=JfJn3r_-HuE&feature=related

Hot Rolling

The process of shaping steel begins by teeming or pouring molten steel into ingot molds. The molds are then moved to the stripper where, after the metal solidifies, the ingot is removed. Before the ingot can be rolled, it must be heated uniformly to about 2200°F (1204°C) throughout in order to allow uniform flow of material during the rolling operation. The soaking is done in soaking pits.

During the ingot casting process the steel cools from its surfaces toward the center, forming large, columnar, dendritic grains; that is, the grains grow parallel to the direction of heat that flows through the walls of the mold, and then more equiaxed grains form in the center of the ingot where more of the heat has escaped through the top of the ingot. These large grains are characterized by low strength and high elongation, which in most cases is considered undesirable. In addition, internal voids can be created owing to shrinkage of the material. The shrinkage voids result in reduced cross-sectional area, and even more importantly, they act as stress risers, which significantly reduce the strength of the structure. These undesirable grains and internal shrinkage voids can be removed or altered by the process of hot working: rolling, drawing, extruding, or forging.
Hot Rolling

FIGURE 9.2
A representation of large dendritic crystals forming in a solidifying metal in a mold. These large grains will be re-formed into smaller uniform grains by the rolling, or other hot-working processes.

http://www.youtube.com/watch?v=6xnKmt_qsLs

Strand Casting

FIGURE 9.12
Diagram of continuous (strand) casting (American Iron & Steel Institute).
Recrystallization

Figure 9.15

Forging Processes

http://www.youtube.com/watch?v=PXVWiGqelM&feature=related

http://www.youtube.com/watch?v=XTU0Z-FkhtU&NR=1
Forging Dies

http://www.microtect.com/technicalbulletin.htm

Upset Forging

step 1  step 2  step 3

http://www.ebcind.com/images/subpages/capabilities/image-upsetForge.jpg

Swaging

Swaging is normally done by rotating a spindle between a set of cylindrical rollers mounted in a ring around the spindle. In the end of the spindle is a slot into which is fitted a die holder, with backers, and a set of dies. The diametrical distance between the rollers is a little less than the diameter of the tool set (dies and backers) so that as the spindle rotates the dies are forced together with great force as they encounter each opposing pair of rollers; the blows delivered by this process are quite rapid — 1800 to 4000 per minute. A workpiece, usually cylindrical, is fed into tapered dies that gradually work the metal down to the finish size of the dies. In a modification of this process, called radial forging, the striking rolls rotate, and the dies and backers remain fixed. The workpiece is then rotated in the dies, but the result is essentially the same.

http://mascotttools.com/products/art50.jpg

Hot Extrusion

Extrusion is a process of forcing metal through a die, similar to squeezing toothpaste out of a tube. The very soft nonferrous metals (lead, tin, zinc) may be extruded cold or warm, whereas the stronger nonferrous metals, for example, aluminum, copper, brass, magnesium, and ferrous metals usually need to be at a forging temperature to make them plastic enough to be extruded. Square and round tubular products, structural shapes, and round, square, or hexagonal solid shapes are some examples of extruded pieces. There is almost no limit to the kinds of intricate cross-sectional shapes that can be made by this process. Extrusion produces surfaces that are clean and smooth with accurate shapes that can be held within close tolerances. The great advantage of the extrusion process is that it allows manufacture of intricate shapes. For example, inexpensive bronze gears of various size and shapes can be extruded in lengths of 20 to 40 ft, and later cut off to desired lengths; however, in cases where a product can be rolled instead of extruded, the choice should be a rolled product if large amounts are needed, because rolling is a less expensive method for shaping large quantities of metal. For short runs, extrusions may be more economical, since tooling costs are much lower.

http://www.youtube.com/watch?v=7qD5J54uRc&feature=related
Hot Drawing

Drawing is a process in which the cross section of a bar, rod, or wire is reduced by pulling it through a die opening. (A mandrel pushes on the work piece and thus pulls the work through the die) The process is similar to extrusion, except that in this process the material is pulled through a die, whereas in extrusion the material is pushed through. Cold drawing, covered in the next chapter, uses relatively thin metal and changes its thickness only slightly, whereas hot drawing deforms the metal to a very great extent. Hot drawing is used to make thick-walled parts of simple cylindrical shapes. Heavy-duty hydraulic cylinders, artillery shells, and oxygen tanks are made by the hot drawing process.

Hot Spinning

Although most metal spinning operations are carried out on cold metal, very large, tough metals are spun while hot. Domed heads for pressure vessels are often made by hot spinning. This process consists of shaping flat or preformed metal disks over a rotating form. Pressure applied by the spinning tool causes the hot metal to flow over the form. Because simple tooling is needed for spinning, it is a less expensive method of forming circular and cylindrical shapes than using drawing or stamping dies.

http://www.youtube.com/watch?v=EzVogfVxXPc&feature=related
Seamless Tubing

Seamless tube is hot formed by the Mannesmann process of roll piercing. A heated, cylindrical billet is passed through rotating conical rolls whose axes are in different planes. This action creates high tensile stresses that form a crack at the center of the billet that flows over a conical mandrel that shapes and sizes the thick-walled tube. A following operation in a rolling mill with grooved rolls and a mandrel further elongates the tube and reduces its wall thickness. Seamless tube is often cold drawn as a finishing operation.

http://www.youtube.com/watch?v=5O2OL5t10fI&feature=related

Pipe Welding (Roll Forming)

Hot-formed pipe is made of skelp, a low-carbon semi finished steel strip. Essentially, the hot strip is drawn through a series of rolls that gradually curl the flat strip into a cylinder. As the pipe is formed the edges are forced together, and at a white heat they make a weld bond. This process is called butt welding. Since the skelp is unwound from a continuous coil, the pipe must be cut to lengths with a flying saw, one that follows the moving pipe as it cuts it to length. Small diameter pipe, up to 3 in., is butt welded. For larger diameters it is lap welded to give it greater strength. Hot-formed pressure-welded pipe is much less expensive than seamless tubing and is widely used for underground water systems, household plumbing, and for many industrial uses; however, because it is pressure welded (butt welded), it is not acceptable for high-pressure applications such as in hydraulic machinery, where seamless pipe is used.
References


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