



## Compare Hot Forming and Cold Forming Rolling Process

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### ARTICLE INFO

#### Article history:

Received: 2 January 2014;

Received in revised form:

10 May 2014;

Accepted: 20 May 2014;

#### Keywords

Hot forming,  
Cold forming,  
Metal, rolling,  
Simulation.

### ABSTRACT

In metalworking, rolling is a metal forming process in which metal stock is passed through a pair of rolls. Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature, then the process is termed as hot rolling. If the temperature of the metal is below its recrystallization temperature, the process is termed as cold rolling. In terms of usage, hot rolling processes more tonnage than any other manufacturing process, and cold rolling processes the most tonnage out of all cold working processes. This article describes the use of advanced tubing inspection NDT methods for boiler and heat exchanger equipment in the petrochemical industry to supplement major turnaround inspections. The methods presented include remote field eddy current, magnetic flux leakage, internal rotary inspection system and eddy current.

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### Introduction

Rolling is a fabricating process in which the metal, plastic, paper, glass, etc. is passed through a pair (or pairs) of rolls. There are two types of rolling process, flat and profile rolling. In flat rolling the final shape of the product is either classed as sheet (typically thickness less than 3 mm, also called "strip") or plate (typically thickness more than 3 mm).

In profile rolling, the final product may be a round rod or other shaped bar such as a structural section (beam, channel, joist etc). Rolling is also classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature then the process is termed as hot rolling. If the temperature of metal is below its recrystallization temperature the process is termed as cold rolling.

The invention of the rolling mill is attributed to Leonardo da Vinci. Earliest rolling mills were slitting mills, which were introduced from what is now Belgium to England in 1590. These passed flat bars between rolls to form a plate of iron, which was then passed between grooved rolls (slitters) to produce rods of iron. Later this began to be rerolled and tinned to make tinplate. The earlier production of plate iron in Europe had been in forges, not rolling mills (fig.1).

The slitting mill was adapted to producing hoops (for barrels) and iron with a half-round or other sections by means that were the subject of two patents of 1679 c.

A patent was granted to Thomas Blockley of England in 1759 for the polishing and rolling of metals. Another patent was granted in 1766 to Richard Ford of England for the first tandem mill. A tandem mill is one in which the metal is rolled in successive stands; Ford's tandem mill was for hot rolling of wire rods.

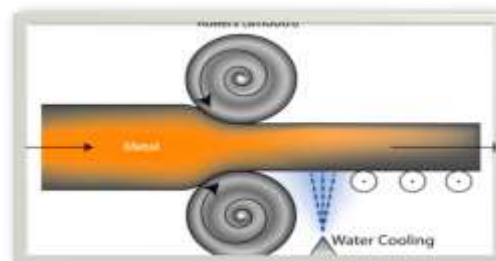


Fig 1. Rolling metal forming process

### Hot rolling

Modern rolling practice can be attributed to the pioneering efforts of Henry Cort of Funtley Iron Mills, near Fareham, England. In 1783 a patent was issued to Henry Cort for his use of grooved rolls for rolling iron bars. With this new design mills were able to produce 15 times the output per day than with a hammer. Although Cort was not the first to use grooved rolls, he was first to combine the use of many of the best features of various ironmaking and shaping processes known at the time. Thus modern writers have called him "father of modern rolling." The first rail rolling mill was established by John Birkenshaw in 1820, where he produced fish bellied wrought iron rails in lengths of 15 to 18 feet. With the advancement of technology in rolling mills the size of rolling mills grew rapidly along with the size products being rolled. Example of this was at The Great Exhibition in 1851 a plate 20 feet long, 3 1/2 feet wide, and 7/16 of inch thick, weighed 1,125 pounds was exhibited by the Consett Iron Company. Further evolution of the rolling mill came with the introduction of Three-high mills in 1853 used for rolling heavy sections (Fig.2)

Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material. After the grains deform during processing, they recrystallize, which maintains an equiaxed microstructure and prevents the metal from work hardening. The starting material is usually large pieces of metal, like semi-finished casting products, such as slabs, blooms, and billets.

If these products came from a continuous casting operation the products are usually fed directly into the rolling mills at the proper temperature. In smaller operations the material starts at room temperature and must be heated. This is done in a gas- or oil-fired soaking pit for larger workpieces and for smaller workpieces induction heating is used. As the material is worked the temperature must be monitored to make sure it remains above the recrystallization temperature. To maintain a safety factor a *finishing temperature* is defined above the recrystallization temperature; this is usually 50 to 100 °C (90 to 180 °F) above the recrystallization temperature. If the temperature does drop below this temperature the material must be re-heated before more hot rolling.

Hot rolled metals generally have little directionality in their mechanical properties and deformation induced residual stresses. However, in certain instances non-metallic inclusions will impart some directionality and workpieces less than 20 mm (0.79 in) thick often have some directional properties. Also, non-uniform cooling will induce a lot of residual stresses, which usually occurs in shapes that have a non-uniform cross-section, such as I-beams. While the finished product is of good quality, the surface is covered in mill scale, which is an oxide that forms at high-temperatures. It is usually removed via pickling or the smooth clean surface process, which reveals a smooth surface. Dimensional tolerances are usually 2 to 5% of the overall dimension.

Hot rolled mild steel seems to have a wider tolerance for amount of included carbon than cold rolled, making it a bit more problematic to use as a blacksmith. Also for similar metals, hot rolled seems to typically be less costly.

Hot rolling is used mainly to produce sheet metal or simple cross sections, such as rail tracks.

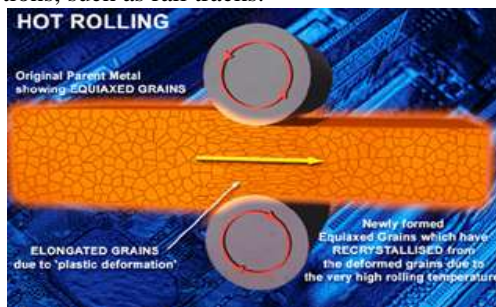


Fig.2. Hot rolling process

## COLD ROLLING

Cold rolling occurs with the metal below its recrystallization temperature (usually at room temperature), which increases the strength via strain hardening up to 20%. It also improves the surface finish and holds tighter tolerances. Commonly cold-rolled products include sheets, strips, bars, and rods; these products are usually smaller than the same products that are hot rolled. Because of the smaller size of the workpieces and their greater strength, as compared to hot rolled stock, four-high or cluster mills are used. Cold rolling cannot reduce the thickness of a workpiece as much as hot rolling in a single pass.

Cold-rolled sheets and strips come in various conditions: *full-hard*, *half-hard*, *quarter-hard*, and *skin-rolled*. Full-hard rolling reduces the thickness by 50%, while the others involve less of a reduction. Skin-rolling, also known as a *skin-pass*, involves the least amount of reduction: 0.5-1%. It is used to produce a smooth surface, a uniform thickness, and reduce the yield point phenomenon (by preventing Lüders bands from forming in later processing). It locks dislocations at the surface and thereby reduces the possibility of formation of Lüders bands. To avoid the formation of Lüders bands it is necessary to

create substantial density of unpinned dislocations in ferrite matrix. It is also used to breakup the spangles in galvanized steel. Skin-rolled stock is usually used in subsequent cold-working processes where good ductility is required.

Other shapes can be cold-rolled if the cross-section is relatively uniform and the transverse dimension is relatively small. Cold rolling shapes requires a series of shaping operations, usually along the lines of sizing, breakdown, roughing, semi-roughing, semi-finishing, and finishing. If processed by a blacksmith, the smoother, more consistent, and lower levels of carbon encapsulated in the steel makes it easier to process, but at the cost of being more expensive (fig.3).

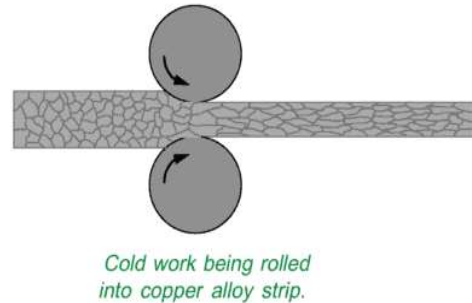


Fig.3. Cold forming process

## CONCLUSION

### The advantages of cold working are:

- A better surface finish may be achieved
- Dimensional accuracy can be excellent because the work is not hot so it doesn't shrink on cooling; also the low temperatures mean the tools such as dies and rollers can last a long time without wearing out.
- Usually there is no problem with oxidative effects such as scale formation. In fact, cold rolling (for example) can make such scale come off the surface of a previously hot-worked object.
- Controlled amounts of cold work may be introduced.

### The advantages of hot working are:

- Lower working forces to produce a given shape, which means the machines involved don't have to be as strong, which means they can be built more cheaply;
- The possibility of producing a very dramatic shape change in a single working step, without causing large amounts of internal stress, cracks or cold working;
- Sometimes hot working can be combined with a casting process so that metal is cast and then immediately hot worked. This saves money because we don't have to pay for the energy to reheat the metal.
- Hot working tends to break up large crystals in the metal and can produce a favourable alignment of elongated crystals
- Hot working can remove some kinds of defects that occur in cast metals. It can close gas pockets (bubbles) or voids in a cast billet; and it may also break up non-metallic slag which can sometimes get caught in the melt (inclusions).

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