Where Does Cold Heading Wire & Rod Come From?

— Part 2: Hot Rolling

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In the June/July 2014 issue of this magazine, we began this three-part series tracing the origins of cold heading wire and rod. In *Part I*, we looked at the steel-making process and how the CHQ wire and rod used in North America today mostly starts out as a combination of smelted or processed iron ore and steel sources melted in electric arc furnaces, refined and continuously cast into intermediate steel products known as billets or blooms.

It is from this point that we pick up the process. In this, *Part II*, of this series, we will explore how these intermediate products are transformed from a long, usually square or rectangular section of steel, to the "round" coiled rod we associate with raw material for cold heading. An understanding of this process helps give a new appreciation for the quality expectations that have been placed in recent years on raw material suppliers. It is also intended to educate about this process and to show that it is another intermediate step in the journey towards finished wire and rod.

A rod mill, like its close cousin the coiled sheet steel mill, strikes an impressive scene to the first time visitor. Steel billets enter one end of the building and proceed through what appears to be an endless number of machines stretching as far as one can see to emerge as coiled steel rod somewhere at the other end. Although to the novice, the mill might seem like it stretches on forever, in reality the number of machines is relatively few and the amount of work at each station is relatively significant. The full extent of the transformation is simply impossible to adequately describe in words. It is best experienced in person and well worth the trip should you ever get an opportunity for a mill tour.

Much of this segment is predicated on the mill tour one would receive at **Charter Steel's** Saukville, WI, USA or Cleveland, OH, USA mills. Charter Steel is one of the leading North American producers of Cold Heading Quality (CHQ) rod and wire.

The process itself is conceptually relatively simple. The mill takes advantage of the ductile properties of heated steel to pass an approximately 40' long by 6" square billet of steel (note that sizes and shapes will vary from mill to mill since each mill has its own conventions, practices and equipment capabilities) through a series of rolling presses to produce a coiled round rod spanning several thousand feet in length and as small as 7/32" diameter.

It all begins at the front end of the rolling mill. Here billets are moved from storage and placed on a conveyor system. They are checked through several redundant systems to confirm their identity. One of the final processes of casting is to affix unique identification to each billet that identifies the heat, the casting strand number and the order of which the billet was cut from the strand. It is critical for traceability that each billet entering the system be positively identified prior to being rolled into a coil. This information will follow the coil through the entire process.

Once the billets are confirmed to match the scheduled work order, they will proceed along the conveyor until they are loaded into a reheat furnace. Each billet will spend an hour or two in the furnace until it is heated throughout to approximately 2000°F. It will emerge and immediately pass through a descaling station where any scale left over from casting or the reheat furnace is removed. This is a very important step as this scale serves no useful purpose, and in fact can reduce tool life in the rolling mill and end up creating surface problems on the rod during rolling.

Immediately after descaling, the heated billet passes through the first of approximately 10 "roughing" stands (actual quantity varies from mill to mill), which progressively reduce the billet thickness, change the shape and stretch out the length (see **Figure 1**). For example, after the billet has passed through about one half of the roughing stands, it will be reduced from about a 6" square cross section to a 3" round cross section that has gone from about 40' in length to over 150'. By the time it has completed its roughing passes, most mills will have reduced the billet to about 1-½" round diameter.

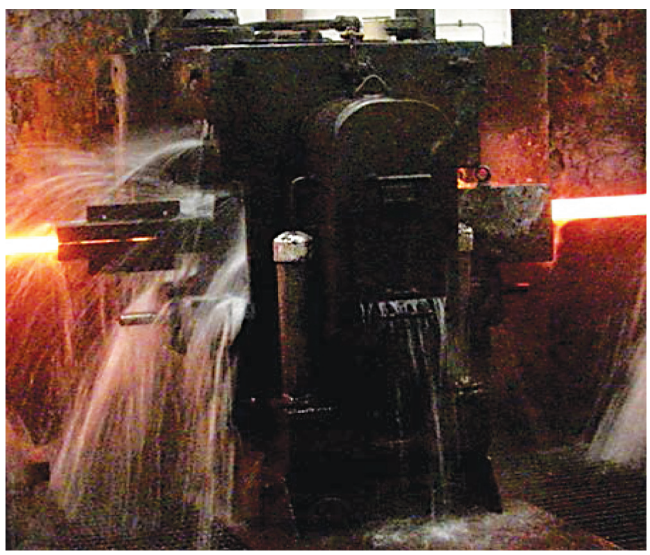

Fig. 1 — Typical breakdown mill.

At this stage, the next steps are somewhat dependent on the mill. Any finished size rod above about ¾" diameter must be coiled in one fashion, while smaller diameters can be coiled in a different fashion. Therefore, depending on the layout and capabilities of the mill, this 1-½" diameter rod may proceed to be formed into rod (material less than ¾" diameter) or into bar (material greater than ¾" diameter). Until coiling though, the process is pretty much the same. The rod passes through additional roller stands to reduce the diameter to the prescribed size in the work order. Obviously the closer the diameter is to 1-½", the fewer additional roller stands are required. Conversely, the smaller the diameter, the more roller stands that are required prior to coiling.

On the larger bar material, once it has reached the end of the line it is coiled in what is known as a "reform tub". This is nothing more than coiling the material around a slowly turning mandrel. It is analogous to winding thread on a spool. Once the entire strand is coiled, the coil is detached and placed on a conveyor to cool off (see **Figure 2**).

Fig. 2 — Coiled bar from the reform tub.

Coiling of the smaller rod is far more impressive. As the rod leaves the last of the stands, it is moving very fast. It enters the coiling unit where it passes through a spinning, curved pipe known as a "laying head". The rod takes the curvature of this pipe producing nice uniform loops that overlap one another as they emerge from the laying head (see **Figure 3**). These drop onto a conveyor that blows air across the loops cooling them down. This is all accomplished at high speed. It is truly an impressive sight to see several thousand feet of rod coiled so rapidly. The rod moves along the conveyor until it drops off the end onto a mandrel forming the actual coil.

At this stage, the material is inspected. The last 10 or so loops on each end of the coil, which are not as uniform as the interior loops, are removed and set aside for recycling, and the coil is compacted and banded. Each coil gets a final once over and is given a label with all the pertinent identification information for that coil of steel. The coil is then moved to storage or sold to a wire processor for the final stages of conditioning the material before it is available to manufacture into finished product.

Fig. 3 — Coiled rod exiting the laying head.

As with any process that is moving at this speed and employing hot metal, it is impossible to guarantee that the product is without any flaws. However, the mills take great care to limit the incidence of hot rolling defects. To this end, many mills have added in-line laser micrometers and eddy-current units to detect flaws during processing. These help to keep the process controlled and alert the mill to any potential or developing problems. Additionally, the mill samples each coil to confirm mechanical performance and combines this data with composition information from the melt to generate the mill certification.

A number of quality issues can be attributed to the hot rolling process. The one most commonly associated with hot rolling is seams. A seam is when either a surface anomaly formed during steel solidification is stretched out and becomes part of the rod surface or a scratch or crack that opens up during hot rolling and is subsequently rolled shut. Seams can be problematic in that they provide a "weak spot" that may open up in an all-out head crack when the parts are upset in cold forming or create an unwanted surface condition on a part that has stringent application requirements such as fatigue-critical fasteners. However, it is important to remember that not all head cracks are the result of seams. In fact, many are the result of other factors. Unfortunately, the current state-of-the-art is not yet advanced enough to completely eliminate seams from the product. Therefore, a wire supplier will likely accept returns of wire or rod containing seams, but be unable to guarantee that without additional surface conditioning that a coil is completely free of seams.

Other problems that can occur during hot rolling include laps in the wire, scratches and decarburization. In the same way that they are vigilant for seams, the mill watches for the causes of these issues and takes every step to avoid them.

Hot rolling is the second major step in the process of converting raw steel into cold heading quality wire and rod. However, like casting the billet at the end of melting (as described in *Part I*), hot rolled rod is not the end of the line. Although at this stage it looks a lot like the material that manufacturers feed into the header, nothing could be further from the truth. Therefore, in the last part of this series we will explore how hot rolled rod is conditioned to make it practically useful to the cold header. *www.NNITraining.com* **FTI**