Insights and Developments in Circular Saw Steel

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This presentation is directed toward those individuals who are involved in the purchase, manufacture and operation of circular, industrial carbide or stellite tipped saw blades. The Peerless Saw Company is a manufacturer of circular saw bodies, ready for tipping. Since we purchase many tons of saw steel alloy annually, I believe it will be beneficial to you to get a better understanding of how alloy steel is made, right from the blast furnace. Then, you can learn more about the heat treatment process each saw body must undergo to reach its full potential in the toughest applications. With a little more education about this process, I hope you will develop a better appreciation for the logic used when choosing the best alloy, hardness, etc. for your specific cutting application.

First, a brief introduction to my company and me is in order. The Peerless Saw Company was founded in 1931 as a manufacturer of high quality, industrial grade circular saw blades. For over 76 years, the company has grown serving saw and tool manufacturers with hardened and ground, circular saw bodies, ready for tipping. We work with Saw Shops, Saw Blade Manufacturers, Sawmills, Furniture Factories, Steel mills and many other manufacturers using specialty cutting tools. Peerless has 50 employees with an average of 13 years of service. We use four Laser Cutting machines, 15 surface grinders and our own heat treatment department where we harden and temper the saw steel alloy. We strive to supply the flattest saw body available, made from the most suitable steel. With this experience and resources, we believe our customers benefit most from learning about the alloy materials available to them. With this as our goal, we offer the following presentation.

As an overview to the presentation, I intend to tell you why you should know more about saw steel. To increase your understanding, we’ll walk through the steps of making molten steel in a Blast Furnace. After that, we’ll review the casting and hot rolling of the slab, following the process all the way to the un-coiling and shearing of the steel sheets, ready for laser cutting into saw bodies. A brief explanation showing the differences between Plain Carbon steel and Alloy will be followed with a description of the benefits of the different elements found in some Alloy steels. Finally, we’ll show what happens when the steel is heat treated to achieve hardness and toughness.

Three reasons you should know more about saw blade steel:

1. To better understand how different alloys may react to heat, stress and other factors. All saw steels are not the same.
2. To make better decisions when buying saw blades for specific uses.
3. To stay informed about material shortages or surpluses that may affect saw blade cost.

There are three key ingredients required for the production of molten steel:

1. Iron Ore - Iron ore is mined, and then ground into a granular powder, which is compressed into approximately ¾" inch diameter balls. This is the size and shape it is added to the blast furnace. Common grades of this iron ore are FE203 and FE304. Iron ore is mined around the globe and sold as a commodity. Many large steel producers also own substantial iron mines, so they can control their supply.

2. Limestone - Likewise, the Limestone is ground to powder and compressed into similar sized balls. It is mined in many places around the world and not too scarce.

3. Coke - Coke is superheated Coal, made in a furnace at temperatures above 2400 degrees Fahrenheit. The process for making Coke is not environmentally friendly, adding substantial pollution to the air, water and land around it. But many larger steel manufacturers also own coke producing plants so they can control their raw material costs more effectively.

The three ingredients are simultaneously poured into the top of the blast furnace and immediately start to interact under the intense heat. As the temperature rises toward the bottom of the furnace, the heated air blasts these three ingredients and melts them at temperatures exceeding 3450 degrees Fahrenheit.
Fahrenheit. Once melted and in a liquid form, impurities in the form of Slag are poured off and the residual molten steel is called Pig Iron.

During the Blast Furnace process, operators must take a sampling of the molten Pig Iron which is tested and within minutes approved or adjusted to reach correct chemical levels.

Once approved, the molten Pig Iron is poured off into an insulated vessel called a Torpedo Car. This vessel uses insulation similar to that used on the heat shields of the Space Shuttle. Remarkably, the Pig Iron can stay at its molten temperature of 2400 degrees F for more than two days. This vessel is constructed on a rail car, where it can be transported to the next stage of production – the Ladle Metallurgical Furnace and Steel Casting.

The Pig Iron is now poured from the Torpedo Car into an electric arc furnace called the Ladle Metallurgical Furnace (LMF) where electrodes keep the Pig Iron in a molten form. Here, it is De-oxidized and Alloyed, meaning other elements are added to the Pig Iron. It is here that the Pig Iron now turns into a Plain Carbon or Alloy Steel.

Steel Casting and Hot Rolling

From the LMF, the molten steel must now be solidified in one of two methods:

Ingots Casting: At this time, the Ingot process is mostly outdated in modern steel manufacturing systems. The ingot casting involved pouring the molten steel into molds, letting them cool, then re-heating, separating from the molds, scarfing or removing the impure surface and rolling into a finished slab. This method was so slow and costly that it has been abandoned by modern, efficient mills.

Continuous Casting: This method receives the molten steel in a collector, called a Tundish, which serves as a funnel that directs the liquid into a mold which starts to form the liquid into its solid dimension by the use of roll segments which produce a cast slab. Frequently, the slab is now about 10” thick or more. However, when the steel is known to be rolled into thin coils, the slabs are thinner, closer to 4” in thickness.

Hot Rolling: Now solid, but still red hot, the slab begins its journey through the Hot-Roll Strip mill where it is run through large rollers that reduce the thickness all the way to the finished size. The slab is run back and forth through this series
of rollers, cooled by water spray, with its temperature monitored closely by
sensors along the way. Once finished thickness is achieved, the strip is now
rolled into coils for further processing.

In order to achieve a smooth, scale free surface on the steel, the steel must
be un-coiled and run through a bath of hydrochloric acid which erodes the
surface and produces a smooth surface which will laser cut more cleanly. After
the acid bath, the steel is washed, rinsed, dried and re-coiled.

The next step is called Annealing, which stabilizes the material in
preparation for future heat treatment operations. The coils are stacked in a
furnace and heated to 1300 degrees F., which may take days for the
temperature to evenly soak throughout all the steel, before the process is
completed.

In some cases, the coils may be further reduced in thickness in Cold Mills,
where they are Cold Rolled. However, in most cases, this operation is not
necessary and only adds to the costs of the material. The key is having a high
quality Hot Rolling operation where thickness integrity is held close.

Even in the best Hot Rolling mills, the edges of the coils have a tendency to
be rolled slightly thinner. So, to prevent having thick and thin spots on the saw
bodies, the Slitting Process is employed.
The Slitting Process

Master coils have their edges trimmed or are cut (slit) to various widths by means of passing material through a tooling set-up called an arbor. The arbor sets the width of the material with precision hard-tooling spacers. Rubber stripper rings keep the strip flat and level. The material is “cut” with high carbon alloy slitting knives which are offset between the top & bottom arbors, using a scissors action to cut the steel. This operation produces clean edges at precise dimensions. Commonly, the steel is also oiled to prevent rust following the slitting, before re-coiling.

Cut-To-Length (CTL) Line

The final operation is the conversion of the coil to sheets, ready for laser cutting. Again, the coil is un-coiled, leveled between heavy rollers, and then sheared to exact length. Different thicknesses may be sheared to different lengths in order to make the most efficient use of the diameters of saw bodies that will come from that thickness.

Grade Identification

Now that you have a better understanding of how steel is made, it’s a good idea to learn more about different grades of steel. Industrial Saw Steel Alloys vary in their content of different elements. If no alloying elements were added at the LMF electrical arc furnace, the steel will be considered Plain Carbon Steel. This family of steels is designated with four numbers: The first two digits represent the family; in this case “10” refers to the Plain Carbon family. The second two digits refer to the Carbon Content, which relates to the maximum achievable hardness the steel can reach. A low carbon content, such as 10, 20, and 30 will not produce much hardness. However a higher carbon content, like 50, 60, 75, etc. will produce higher harnesses, up to say, 60 Rc. Industrial Saw blades are not made from Plain Carbon Steels.

Alloy steels use similar designations, where the first two digits refer to family characteristics and the next two digits refer to Carbon Content. For instance, in # 8670, the 86 refers to an alloy that contains Nickel (.70 – 1.00%), Chrome (.30 - .50%) & Molybdenum (.05-.10%). The 70 refers to .70 of one percent Carbon Content. This steel can reach a hardness of approximately 63 Rc, when quenched in a heat treat system.
A very popular European saw steel alloy is called 75 Cr1, whose analysis is very close to a # 1075 Plain Carbon Steel, with Chromium (.30-.60%) added. The .75% Carbon Content means it can reach a hardness similar to the # 8670. The Chromium makes it an Alloy, though not one with a lot of elements added. So, why add the Nickel, and Moly to the #8670 Alloy?

We’ve already covered the need for the Carbon. Almost all of the additional alloying elements are included to help control consistent harden-ability, while providing toughness, wear resistance and durability to the tools made from these steels. The more alloys added normally increases the value and the cost of the steel. However, it’s believed that higher alloy steels bring more performance to the job.

- Carbon - Allows for Harden-ability
- Nickel – Toughness, Harden-ability
- Chromium - Wear Resistance, Hardness
- Molybdenum – Toughness, Hardness
- Manganese – Durability, Harden-ability
- Silicon – Durability & Harden-ability

**Heat Treatment to Reach Proper Steel Hardness**

**Hardening**

- Alloy steels must be hardened in order to meet the demands of circular saw blades.
- In our industry, hardness is measured on the Rockwell C scale.
- The higher the number, the greater the hardness. (We’ll look at some ranges)
- Hardening steel is a difficult process that requires a large investment in human capital and equipment. We estimate the cost of installing a complete heat treat system to be between $1 - 2,000,000, US. That’s why most saw manufacturers don’t harden their own steel. The hardening can be done by Heat Treatment Contractors or the steel can be purchased in hardened sheets, in some, but not all alloys.
- Traditional methods of heat treatment are Oil Quench, Salt Bath or in Peerless’ case, Water Cooled Platens.

Regardless of the method, these alloys must be fully heated to above 1550 degrees F., and then quickly quenched, which means having their temperature reduced to less than 100 degrees within 10 seconds. When successfully quenched, the alloy steel should measure near max hardness about 60-62 Rc.

**Tempering**

The heat treatment job is only half done. 60 Rc is far too brittle and must be tempered (drawn or annealed) to the optimum hardness, which in the case of # 8670 alloy is between 40 – 50 Rc, pending specific application.
tempering takes place inside furnaces, usually with the saw steel stacked between thick, steel platens under pressure throughout the 8 – 12 hour heating cycle. Once the temperature is maintained for at least one hour throughout all the steel, the hardness is tempered to the 40-50 Rc range desired. For instance, Guided Edger saw bodies will be tempered at 750 degrees Fahrenheit for at least eight hours to reach a 46-48 Rc hardness. Trim Saw bodies don’t normally require as high a hardness, so they would be tempered at 875 degrees to reach a 38-42 Rc hardness. It’s important to note that companies who quench their steel under pressure achieve a flatter saw body. Likewise, all tempering should be done under pressure, as very good flattening action takes place when hardness is reduced during tempering.

A very wise option that improves flatness is to temper the saw bodies, under pressure an additional time, after surface grinding. Though the surface is oxidized leaving a burned, gray-blue-yellow appearance, the resulting flatness is generally the best available. It might not look shiny and new, but better flatness interprets into better cut quality and longer life of your saw body.

Here are some typical hardness ranges:

- Guided Saws are in the 44 – 48 Rc range
- Trim Saws are normally near 40 Rc
- Secondary: normally near 40 Rc as well.
- Steel tooth saw blades: Set = 44 Rc

Summary

- Circular saw blade steel is a specialized material. These are hard to make alloys and only a few mills worldwide will accept orders. Total consumption is estimated at well under 3% of the steel used in the world. Steel mills require minimum “Heat” quantities of 300 Metric Tons (600,000 #) per order.
- All Saw Steel is not the same. Knowledgeable consumers will ask what kind of alloy is provided in their saw blades and tools.
- Consider the benefits of higher alloy steels, understanding the characteristics that different elements bring to the job.
- Proper hardening of the material is crucial to making a flat circular saw and effects all other operations of saw plate manufacturing.
- Understand where the heat treatment takes place and what options may be available to increase flatness quality.