

# 800 DEGREES

SMITHY, STEEL AND STORIES

# BLACKSMITHING

Forging is a process of plastically transforming metal. Which means to bend or compress the material into a new permanent shape.

Iron can be bent and plates can be formed without heat. For greater changes of shape, high heat and applied force are required. The heat makes the iron formable and creates almost unlimited possibilities.

In Swedish both forging and metal work without heat is referred to as smithing.

Today, there are hundreds of active blacksmiths in Sweden, but they can be difficult to find for the uninitiated. Anyone who searches for blacksmiths will mostly find companies that work with arc welding. Which differs very much from the traditional craftsmanship that blacksmithing is.



*Photo Tobias Havaas*

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# IRON & STEEL

Iron is a chemical element (Fe) that easily bonds with other elements. Iron is also the most important metal for our technical development. We have mastered the art of using iron for about 2500 years.



*Photo Jonatan Malm*

## The difference between iron and steel

Iron is an element and steel is an alloy of iron and carbon. If the carbon content is higher than 0.4%, the steel is able to be hardened, otherwise not. Among blacksmiths non-hardenable steel is called iron, even though it's technically steel. Today's steel usually contains more alloying elements that gives different properties, such as protecting against rust or making the steel tougher.

One therefore distinguishes between high and low alloy steels. High when the steel contains several different alloying elements and low, also called carbon steel, when it basically only has carbon as an alloying element.

Rust (corrosion) is formed when iron reacts with oxygen and returns to its naturally dissolved form. Rust is a scourge in many cases, but if you consider that iron is also present in our blood you can be thankful that it does not come in the form of small hard pieces.

## History

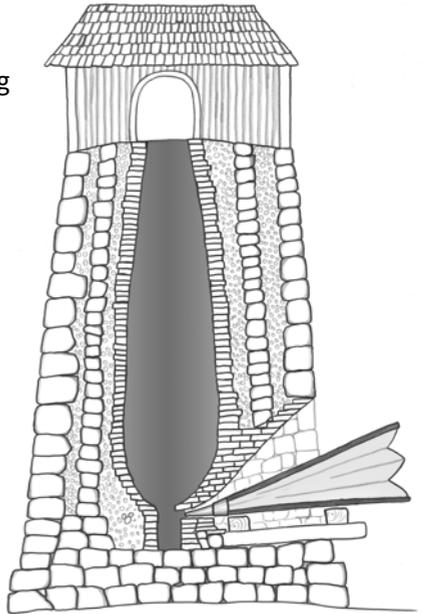
Iron is the most important metal for our technical development. The art of producing and managing iron comes from Asia and reached Scandinavia about 500 years BC.

The oldest technique for producing iron was to burn the ore in a primitive blast furnace, a simple oven with air pumped in to it. The result was an iron lump full of slag. With high heat and hammer strokes the slag was aborted and a malleable material obtained.

The standing furnaces that was developed in the Middle Ages produced a molten steel without slag and could work continuously. In this way, the production rate increased. Slightly improved it is the same principle used in iron production today.

During the 17th and 18th centuries, the Swedes became world famous for their iron production. Why? Well, Sweden had plenty of both iron ore and forest used to make charcoal for the ovens. In addition, Sweden had great help from highly qualified blacksmiths from other countries, such as Wallonia (Belgium).

The luck turned in the early 19th century when England entered the game with their coal mines and began using black coal for their ovens. They also developed new and more efficient methods for producing high-quality iron. Sweden adopted and adjusted a model of closed furnace from Lancashire which changed the whole Swedish industry. Today, this type of iron can be found in old chains, wagon wheels and such. It is very popular among blacksmiths because it is soft to work with and easy to weld and known as "Lancashire iron".



# TECHNIQUES

Iron can be shaped in the same way as clay, with the difference that iron is much harder and needs to be very hot to be shapeable.

## Temperatures

Iron can be forged when it is about 700 - 1000 degrees hot. Then it glows in a shade between red and light yellow. At lower temperatures, the iron is too stiff and can crack. If it is warmer than 1000 degrees, the carbon in the metal begins to burn and the result is a frayed surface.



*Photo Ian Schemper*

## Tools

The technique of forging is basically the same today as during the Iron Age.



*Photo Ian Schemper*

To get enough heat, the fire needs extra oxygen. A coal forge is a hearth with air supply from bellows or a fan. Although today it is also possible to use gas or induction heat.

Since a piece of iron can have many different shapes and a good grip is fundamental, a large set of different tongs is needed.

The Viking-age toolbox found in Mästernyr on Gotland shows that the tools look almost the same today as they did a 1000 years ago. One difference is that we have better access to iron today and therefore can have more and larger tools.

# FORGING

The glowing iron can be shaped by bending, twisting, splitting and pressing. Bending, twisting and splitting can partially be done with cold iron, while heat is needed to compress the material without it cracking. Compression also requires great force and is performed with hammer strokes or hydraulic pressure.



Fotograf Ian Schemper

example, when making the tip on a nail.

## Deforming material

By placing the iron on the anvil and beating it with a hammer, the iron is flattened slightly for each stroke. If you hit it repeatedly it becomes flat. By flipping the iron a quarter-turn between each stroke, it gets a square cross-section and becomes longer and narrower. A technique called *drawing*. It is used, for

The opposite of drawing is called *upsetting* and means that the material is packed shorter and thicker. There are also a lot of different tools that are pressed down into the iron to leave imprints. Everything from simple markings and through holes to advanced shapes that almost looks cast.

## Forge welding

It is also possible to join two or more pieces together by heating and compressing them. The iron needs to be hot enough that the surface becomes sticky and begins to melt before the pieces are compressed, usually with some well-directed strokes with the hammer.

A modern method is gas or arc welding. The function is roughly the same, but with modern welding new material is applied and fused with the surface of the metal. Almost like glue VS tape.

# WELDED STEEL

If you want to combine the different properties of two types of steel, lamination is a good method. For example, a scythe may need to have a softer core that does not crack and at the same time a hard edge that stays sharp. Then iron is used for the scythe and a piece of hardenable steel welded in for the edge. The same can be done on other cutting tools such as knives and axes.

## Pattern welding

You can combine the properties of the steel and iron by welding together a few pieces of each. Iron and various steel grades also have different luster. By turning the piece in different ways and re-joining, you can create patterns. Today, it is especially popular on knife blades but has been used mainly for weapons since the Viking era. Pattern welding is often called damast or damask after a steel making technique from Damascus.

## Damascus steel

An old technique where steel is produced in sealed casting pots and compared to the blast furnace method, it produced a slag-free steel of uniform quality, so called woots. The technology was developed in India during the Iron Age and the steel spread as a popular commodity all the way to Scandinavia. Although the techniques of damascus steel and pattern welded steel are completely different, the result is quite similar.

## How many layers can you make?

For example, seven pieces of alternating iron and steel joins together into one solid piece consisting of seven layers. By drawing and folding it in the middle, and then weld it together again doubles the number of layers. By repeating the procedure, the number of layers is increased from 7 to 14 to 28, 56, 112 and then the layers become so thin that we can no longer see any patterns. Fold two times more and get 896 layers, then 1792 etc. Historically, the blacksmith had to fold and weld the steel like the baker kneads the dough, until the quality of the steel is totally homogenized. Today we have such high quality steel that "kneading" it is unnecessary.

# HARDENING

In order for a spring to spring back when bent or a knife edge to maintain sharpness, the steel needs to be hardened.

Hardening is done by heating the steel to about 800 degrees so the molecular structure changes. Then the steel is quickly cooled in water or oil so that the structure is "locked" in that form, this maneuver is called quenching. The result is a very hard and very brittle steel. So brittle that it can break into pieces if dropped to the floor. To get the steel resilient and tough, tempering is required, which means that the steel is heated again to a lower temperature of about 150-350 degrees Celsius.



Photo Jonatan Malm

## Normalization

When deforming a piece, stresses arise in the material when it is pressed and stretched by the hammer. This can make the steel bend or even crack at the intense cooling that quenching means. In order to avoid this, before quenching, the steel should be heated to a little bit over its hardening temperature and left to cool down really slowly in order to remove the stresses. One common method is to cool the iron in heat-insulating ash.

## Hardening

When steel is heated up, a chemical reaction occurs where the iron and carbon atoms at a certain temperature form a new molecular grain structure called *austenite*. If the steel is allowed to cool slowly, it regains its original and malleable structure; *ferrite*. But cooled quickly, the steel gets the formation of *martensite*.

When hardening, the steel should be heated slowly and evenly. The whole piece shall achieve hardening temperature of 800-900 degrees Celsius depending on steel grades. An easy way to know when austenite is formed is to test it with a magnet. Austenite is not magnetic, so when the magnet does not attach any longer, the steel has reached the right temperature. The transport from hearth to quenching fluid should be quick so that thin parts like the edge does not lose heat on the way. Low-alloy steels can be quenched in plain water while high-alloy steels should get a milder cooling in hot oil.

It is also possible to use a heat treat oven for more precise temperatures and heating times for both normalization and hardening.

## Tempering

When the steel is hardened, it is very hard and very brittle. In order to avoid the steel cracking, one has to take the edge of the tension that lies within the hardened steel. This is done by tempering. Since the tempering temperature is not that high, 2-300 C, it can be done in a regular household oven, but there are also special heat treat ovens for more accuracy.

If the hardened tool needs to have a flexible and a harder part, such as a knife's spine and edge, you can heat the knife's spine with an glowing piece of steel and let the heat draw towards the edge. Drawing the temper this way, the back becomes warmer while the edge reaches a lower temperature and retains more of the hardness from the hardening. Which means that the edge is hard and will stay sharp longer while the spine is a bit softer and more flexible so that the knife can take some beating without cracking.

# SURFACE TREATMENT

When the work is done, it is important to give the surface the treatment it deserves. Partly to protect against rust but also for aesthetic reasons.

## Painting

As far back as we know, people have painted forged objects. Mainly with linseed oil paint which still is a good alternative today. The linseed oil sits well and can be painted thin so that it does not hide the structure of the forged surface. But it takes a long time to cure and is not very durable for wear. There are modern paints that are more durable but which sadly kills a bit of the expression.

## Blacken

An old method that has become immensely popular in the last century. The method is quick and easy and the result is pretty good. You apply tar or oil on the object with a cloth while it is just warm. The heat causes the oil or tar to dry quickly and blacken.

## Wax and oil

One way to keep the forged steels semi-gloss look is to treat it with beeswax or linseed oil without any colour pigments.

# SMEDJENÄÄS

Otto Salomon who started and ran the sloyd education at Nääs in the late 19th century considered the metal work to be a little too dirty and demanding for children. Therefore, course participants were only trained in woodwork in the beginning. When metal work was proposed to be included in all secondary schools around 1910, the stables were converted to a smithy which was inaugurated in 1914 under the name Smedjenääs. The workshops were on the ground floor and the upper floor was used as accommodation for the students.

The education started with teaching techniques and then the students were able to make a series of models according to their own drawings and learn both hot and cold iron work. The metal education grew in popularity until Smedjenääs was too small and the education had to move to Tollerød, Alingsås and Gothenburg.



*Photos August Abrahamsson foundation*

In 1970, the house Smedjenääs was so run down that it had to be demolished because the money for a renovation was missing. Today there are thoughts and ideas about rebuilding Smedjenääs, perhaps not for just smithy but for courses and teaching in other subjects.



# EDUCATIONS



*Fotograf Ian Schemper*

Vadstena's, Vindeln's and Västerberg's folk high schools all have a combined wood and forging education of one year. Västerberg's also has an additional in-depth year.

Bäckedal's folk high school in Sveg has a one-year forging program.

HDK Steneby in Dalsland educates in metal art for 1-5 years which can result in a Candidate or Master degree. An extra year for a journeyman's certificate.

The Iron Academy in Kramfors offers a 4-year education in forging supplemented with modern workshop techniques. Fourth year, the journeyman's certificate is taken.

Sätergläntan in Insjön have an education of 1-3 years focused entirely on forging and traditional techniques. During the 3rd year a journeyman's certificate may be taken.

In addition, there are plenty of shorter weekend, weekly and summer courses around the country. The nearest weekend course is arranged by Slöjd & Byggnadsvård in Tollerred.

*Links to the schools above and the weekend courses in Tollerred can be found at [www.slojdochbyggnadsvard.se](http://www.slojdochbyggnadsvard.se)*

# SMITHY

The image of the smithy is often dark, rough, cold and old-fashioned. This is often true when most smithys are old and smeared by the smoke from the forge. But many blacksmiths also work in more modern industrial premises with concrete floors and light walls.



*Fotograf Ian Schemper*

For simpler work, a gas forge or mobile coal forge in your backyard or in an open garage is fully sufficient. Provided that the hammering does not disturb the neighbours. What is needed to get started in addition to the forge is an anvil, a hammer, a tong, a cut hardy and a metal bucket.

Start with a relatively light hammer about 900-1000g and a pair of tongs with so-called wolf jaws, it can grab most objects. Supplement it with a small tong with a good nip for small pieces. Get forging tongs or at least pliers that are straight from shaft to head and do not use, for example, a polygrip as the curved shape makes it difficult to handle.

A cut hardy is a sharp tool you put in the anvil and uses to cut hot peices of steel. As a substitute you can use a chisel or cool the object and cut it with a hack saw or angle grinder.

Anvils can be difficult and expensive to obtain. For hobby level, it is fine to work on a piece of rail, robust T-beam or a large piece of steel.

A vice is very good to attach tools in if you do not have an anvil with holes, but also to hold your piece when you are turning or bending it.

# FORGING DICTIONARY

Steel	Our most common metal, an alloy of iron and carbon.
Alloy steel	More alloying elements than carbon for specific properties
Carbon steel	Steel with hardly any other alloying elements than carbon.
Iron or Mild steel	Plain, non-hardenable steel with low carbon.
Whole steel	A blade or head entirely all made of steel and not a laminate.
Laminate steel	When a harder steel is inserted into the edge of a tool.
Lancashire hearth	Early 19th century method for producing iron in closed furnaces which spread to Sweden and changed the industri.
Edge	The cutting part of a tool, such as a knife.
Edge steel	A harder steel that is welded in to the blade to form the edge.
Forge	A kind of hearth where the blacksmith heats the iron.
Firepot	The heat-resistant pit in the forge.
Slack tub	Container of water or oil used to quench hot metal.
Nail header	Tool for forging the head on a nail.
Cut hardy	Tool to put in the anvil to cut off hot pieces of steel.
Welding	Method to join pieces of metal by heating and pressing them together.
Arc welding	Method to join metal by using electricity to melt a small surface area.

# TALES & STORIES

When it comes to blacksmithing there are plenty of superstition from the old days and small myths or misunderstandings from today. Therefore, let's shed some light over some of the delusions that enthusiasts might come across.

**The Devil takes a cold forging blacksmith a year** is a widely spread expression that has worked and still serves as a reminder not continuing to forge when the steel has lost its heat.

**If you leave your hammer on the anvil the Devil will come to forge.** . Probably an example of moral superstition about keeping the workshop clean

**Pee in the slack tub.** Peeing in the quenching water was considered to result in better hardening and the pee from a virgin or a red-haired boy was considered to be best. But because salt affects the boiling point of water, a small difference in the hardening property is not unreasonable. Or at least it would have been convenient to have a "toilet" close to hand.

**Hard steel means sharp steel.** An edge gets sharp from grinding. The hardness of the steel decides how well it will keep sharp and moderation is best. Hard steel can more easily get small cracks.

**Old steel is the best.** Today we know more about metallurgy than we did before and have more specialized steel of more uniform quality than before. But for forge welding antique steel is actually better, because much of today's steel is made for arc welding and cold processing.

**Real blacksmith from back then.** Almost all blacksmiths have met elderly men who proclaimed that sometime in their youth there was "a real blacksmith" who could harden or even weld. These techniques were certainly loaded with mystery in earlier years and still seems to be perceived in that way too many people. But both hardening and welding are given elements in most forging courses and are mastered by many blacksmiths today.



*Photo Tobias Havaas*

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Located at Slöjd & Byggnadsvård  
(Sloyd & Building preservation)