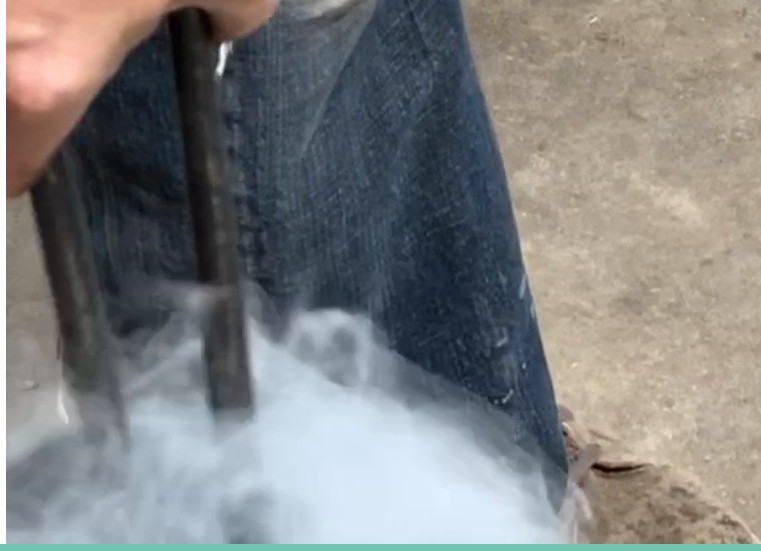
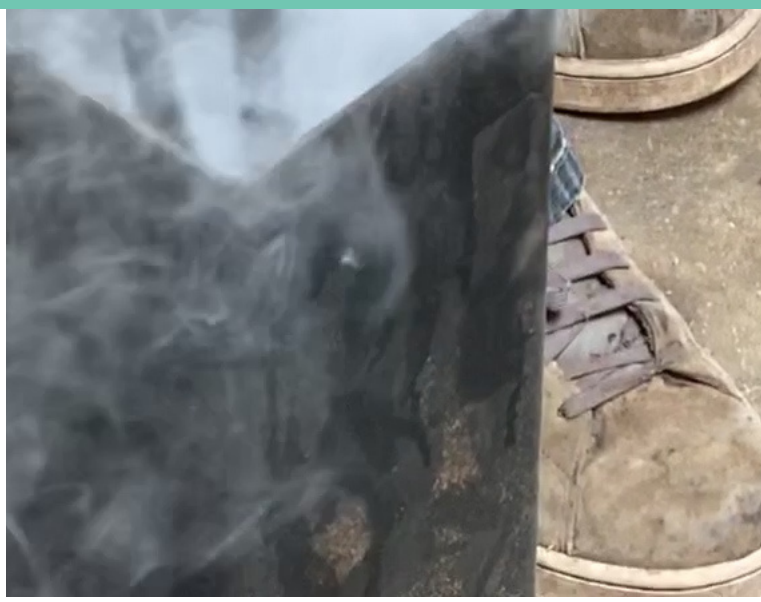
SCHOOL OF VISUAL PHILOSOPHY

RUNNING COLORS

INSTRUCTED BY YORI SEEGER

BASICS OF HARDENING OF STEEL





Steel is an iron alloy. The main ingrediant is iron. Not all steel is created equal and there are thousands of alloys which are given the name. In order for a material to properly carry the name steel it must contain iron and carbon.

Table of contents

WHAT'S IN A NAME

Iron is the fourth most abundant element by weight. The symbol on the periodic table is Fe for Ferrous, which is derived from the Latin word Ferrum meaning iron. The earliest known iron smelters are either the Hettites or the Kasakans of the Caucaus mountains. By 1400 BC the Hettites were making iron tools and weponry.

Steel is created by adding carbon into iron, making it an iron alloy. The percent of carbon added into the iron effects the strength and ductility of the metal. Mild steel contains .05 to .3 percent carbon. Medium carbon steels are classified with .25 to .45 percent carbon. High cabon steel contains .45 to 1.5 percent carbon.

STRUCTURAL CHANGES CAUSED BY HEAT

Steel changes drastically when heat treated. Understanding these effects and the type of steel that you are working with will help you to make the correct alteration to your metal and suit the needs of the tool you intend to create. The basic terms in the heat treating process are known as **Normalizing**, **Annealing**, **Quenching** and **Tempering**. The basic catagories of steel are **Air Hardening**, **Oil Hardening** and **Water Hardening**. It is important to understand which steel you are working with and how each of the heat treatment porcesses will effect your alloy of choice. The following heat treatment process does not include air ardening steels. **Normalizing** is a process which will relax the steel after it has been transformed during the forging process. Relieving stress from the worked steel is important and eliviates the porbablity of warping and cracking during the quench. To normalize most steels, heat it up to anorange heat (1700-2000 F) and allow to air cool. This process may need to be repeated depending on the steel and the tool being created. **Annealing** is a process that will soften steel and is often used prior to hand filing, chiseling and other cold work. To anneal most steel you will want to heat to an orange tempurature and burry it in an insulating material such as ash, vermiculite or perlite. The slower it cools the more effective the annealing process.

Quenching is rapid coolingof Austenite wich creates Martensite by trapping displaced carbon atoms. The quenching process does not allow the carbon time to difuse as it normally would through a slower cooling process. Too much martensite in an allow will result in a brittle material while to little will result in a ductile material unable to maintan a hard edge. It is easy to create martesnite with quenching but often creates more than we need for our tools. **Tempering** is the process of reheating quenched steel allowing some of the carbon atoms to diffuse, lowering the amount of martensite within the steel. Each alloy will have specific and individual needs for tempering in order to create the correct percentage of martensite needed.

Running Colors

RUnning colors is a method of tempering. it is often used when we want part of the tool to be soft and ductile and another part to be hard. A good example of this is a chisel. We do not want to strike hardened steel as the tool will be brittle and it can become dangerous for the user. In this case we want the striking end of the chisel to be ductile and soft while the working or cutting end is hard and tempered. In this case like to run colors by placing the striking en in the forge and allowing it to gain an orane heat. It is important to polish the portion you wish to be tempered so that you can easlily see the colors as they run. Heat from the striking end will extend toward the cutting en and becomes visible as the steel changes colors from straw yellow, to blue, and then to purple. When the desired color reaches the portion of the tool you wish to temper simply requench in the appropriate solution.

2000°F	Bright yellow	1093°C
1900°F	Dark yellow	1038°C
1800°F	Orange yellow	982°C
1700°F	Orange	927°C
1600°F	Orange red	871°C
1500°F	Bright red	816°C
1400°F	Red	760°C
1300°F	Medium red	704°C
1200°F	Dull red	649°C
1100°F	Slight red	593°C
1000°F	Very slight red, mostly grey	538°C
0800°F	Dark grey	427°C
0575°F	Blue	302°C
0540°F	Dark Purple	282°C
0520°F	Purple	271°C
0500°F	Brown/Purple	260°C
0480°F	Brown	249°C
0465°F	Dark Straw	241°C
0445°F	Light Straw	229°C
0390°F	Faint Straw	199°C