

**James F. Lincoln**  
**Arc Welding Foundation**

**Awards Program**

**Division VI**

**Innovative Teaching Ideas in Welding**

**Lesson Title: "Fundamentals of the Science of Heat  
Treatment"**

**Abstract:** Many students learn to weld, cut or forge but do not understand how heat affects the metal they are working with. This lesson explains how heat can cause metal to bend verses break. It can explain many instances when materials fail. In welding in helps students to understand the importance of preheating, post heating, and quenching techniques. It is not only welding though. Sharpening a chisel on a bench grinder can produce enough heat to anneal the hardness out of the tool and ruin it. This lesson is a great interactive way to integrate STEM concepts into your curriculum.

**Unit:** Metallurgy  
**Lesson Title:** Fundamentals of the Science of Heat Treatment  
**Estimated Time:** 60 minutes  
**Grade:** 9-12  
**Standard:** Agriculture, Food and Natural Resources (ANFR) Content Standard  
**Career Pathway:** Power, Structural and Technical Systems (PST)  
**Performance Indicator:** (PST.04.03)

**Need:**

It is important for students to understand the basic science of how heat effects the physical makeup and properties of steel. This is a perfect application of STEM.

For safety we immediately quench everything that is hot in the shop. This may teach students bad habits. If they do not understand how they are altering the metal by doing this, they could cause a weld, tool or part to fail when it otherwise would not.

**Objectives:**

1. Students will be able to define and characterize different physical properties of metal.
2. Students will be able to compare and contrast different methods of cooling metal.
3. Students will be able to evaluate the stresses and strengths of metals in different situations.

**Applied Academic Competencies:** (for local cross-curricular documentation)

chemistry  
physics

**Vocabulary:**

Tensile Strength- Force required to pull something until it breaks  
Compressive Strength- Force pushing on something until it deforms  
Malleable- Ability to be shaped without breaking or cracking  
Brittleness- A material that breaks instead of bends under stress  
Annealing- Heat and cool slowly to remove internal stresses  
Normalizing- Making metal softer by heating and cooling slowly  
Quenching- To cool quickly by submerging in water or other liquid  
Tempering- Increasing the hardness by heating and quenching  
Crystalline Structure- The arrangement and bonds of atoms or molecules

**Essential Equipment, Resources & Supplies:**

1. Forge, Torch or other heat source
2. Used hacksaw or reciprocating saw blades
3. Trough of water for quenching
4. Pliers, tongs and/or vise for handling hot metal

**Teaching Procedures:**

**Interest Approach:**

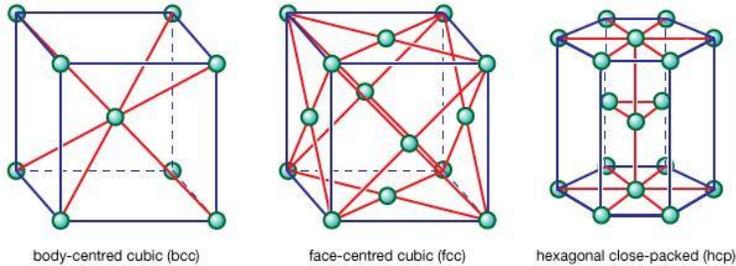
How many of you can break a piece of steel with your bare hands? Give them a piece of scrap and see if anyone can break it apart. Take a quenched hacksaw blade and break it in front of them.

**Presentation:**

Define the terms above in the vocabulary section.

Draw a simple crystalline structure of metal on the board or pull up a picture of it. Show how it can change with heat and how the properties of the material would be different in the different structures because of their bonds and their geometry of how they are connected.

**Common metallic crystal structures**



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Talk about different things students are familiar with and how they possess different types of strength. Wood, concrete, glass, rubber, steel, aluminum or cast iron are all good ones to talk about. You could also talk about high and low carbon steel, and how their properties differ, and how to identify them with a simple spark test.

**Application:**

Setup a simple demonstration in the shop. Here are the materials you will need.



Demonstration: Take a used hacksaw or reciprocating saw blade and show or allow the students to see or feel its properties when handled, flexed and moved. Steel banding will work also but the effects are not as dramatic. The metal will always spring back to its original shape.



First anneal the hacksaw blade: Heat part of it up to a bright orange color and allow it to cool slowly. Once cooled you can again show or let them handle it to see how it is now malleable and will hold the shape it is bent to.



Next temper the hacksaw blade: You can use the same blade. Heat the blade up again to a bright orange color and quickly quench it in water. Now you can take it and break it with your bare hands or hit it with a hammer and it will shatter. Now it has been tempered.



Talk through the vocabulary again.

Discuss other methods of quenching. For example burying in sand, wrapping in insulation or dipping in oil.

Discuss different situations and when each might be appropriate.

Discuss why it is important not to get cutting tools too hot when sharpening them.

**Evaluation:**

Test on vocabulary