



Industrial Technology Virtual Learning

CTE

May 18th, 2020



Machine Technology 2

How Heating Metal Affects its Properties

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Objective: At the conclusion of this lesson students will have objective, informative and practical information about how heating metals affects the properties of metal and the Heat treatment processes designed to alter the properties of the metal. Students will then take a Five question quiz at the end of the assignment.

Bell Ringer

Have you ever heated metal then notice that the metal changes color?

In your own words explain why you think this happens.



HOW HEATING METAL AFFECTS ITS PROPERTIES

- The electrical, magnetic and structural properties of metals can be changed through heat. As the applications of metal are varied, different environments prioritize different qualities. For example, in engineering applications, toughness is desired; in electrical applications, low electrical resistivity is important.
- There are a number of ways of heating metal which are commonly used to transform these properties. The temperature to which the metal is heated and the rate of cooling are carefully controlled to achieve the desired outcome.

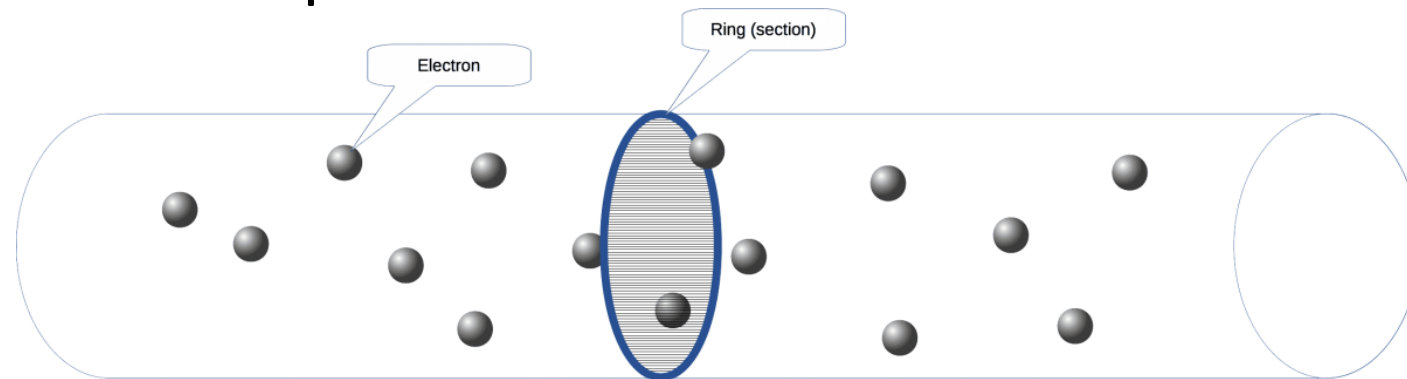
The Effect of Heat on Metal

The most important ways that metals are transformed through heat:

- Electrical Resistance
- Thermal Expansion
- Structure
- Magnetism

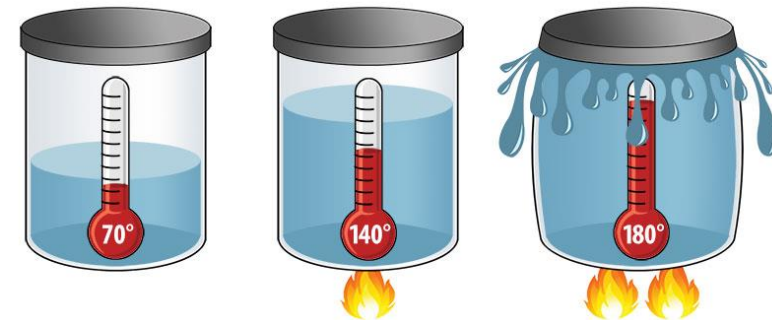
Electrical Resistance

Electrical resistance is the measure of how strongly the metal impedes the passage of electrical current. As electrons pass through the metal, they scatter as they collide with the metallic structure. When the metal is heated, the electrons absorb more energy and move faster. This leads to more scattering, thus increasing the amount of resistance. Thermometers actually use the change in electrical resistance in a piece of wire to measure temperature.



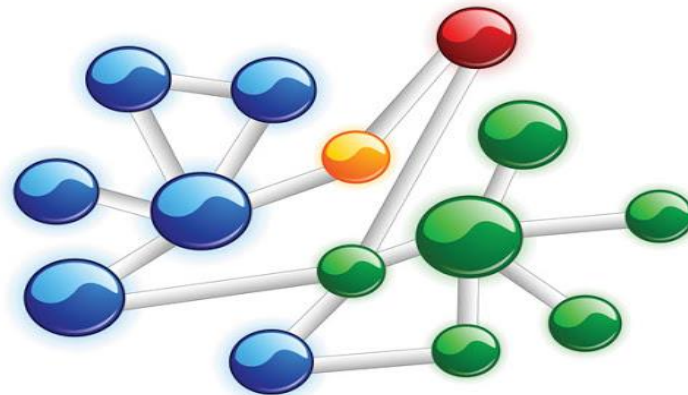
Thermal Expansion

Metal expands when heated. Length, surface area and volume will increase with temperature. The scientific term for this is thermal expansion. The degree of thermal expansion varies with different types of metal. Thermal expansion occurs because heat increases the vibrations of the atoms in the metal. Accounting for thermal expansion is essential when designing metallic structures. An everyday example would be the design of household pipes, which must accommodate expansion and contraction as the seasons change.



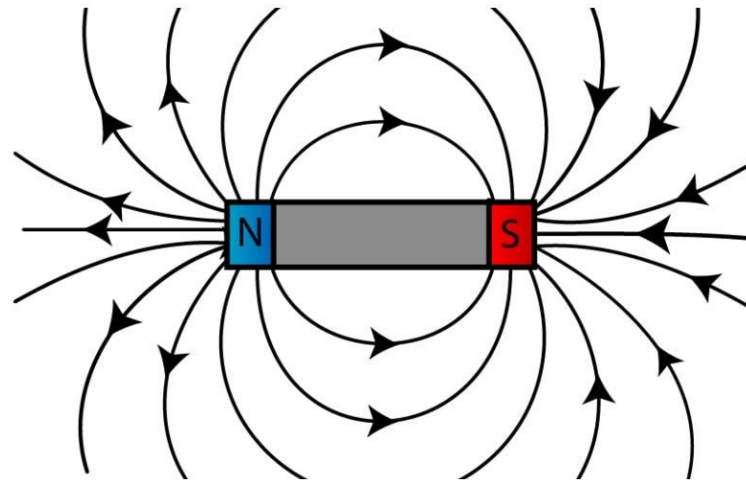
Structure

Metals are comprised of a symmetrical structure of atoms known as an allotrope. Heating the metal will displace atoms from their position and the displaced atoms form a new structure. This process is known as allotropic phase transformation. Allotropic phase transformation alters the hardness, strength and ductility of the metal. When iron is heated past 1,674 degrees Fahrenheit it is able to absorb more carbon, which is an ingredient that will increase the hardness of any steel product.



Magnetism

There are three metals with magnetic properties: iron, nickel and cobalt. They are known as ferromagnetic metals. Heating these metals will reduce their magnetization to the point where magnetism is completely eradicated. The temperature at which this occurs is known as the Curie temperature. For nickel, this temperature is 626 degrees Fahrenheit; for cobalt it is 2,012 degrees Fahrenheit; and for Iron it is 1,418 degrees Fahrenheit.



Heat Treatment

Heat treatment is a process designed to alter the properties of the metal to better suit its intended use. The main types of heat treatment are:

- Annealing
- Normalizing
- Hardening
- Tempering

Annealing

Annealing is frequently used to soften metals including iron, steel, copper, brass and silver. The process involves heating the metal to a specific temperature then allowing it to cool slowly at a controlled rate. Annealing alters the physical and chemical properties of the metal to increase [ductility](#) and reduce [hardness](#). This facilitates shaping, stamping or forming processes, and allows the metal to be cut more easily. Annealing also enhances electrical conductivity.



Normalizing

Normalizing (commonly referred to as normalized) is applied to alloys to provide uniformity in grain size and composition. The metal is heated to a predefined temperature then cooled by air. The resulting metal is free of undesirable impurities and exhibits greater strength and hardness.

Normalizing is often used to produce a harder and stronger steel, albeit one that is less ductile than that produced by annealing. Typically, the normalizing process is performed on materials that will be subjected to machining, because the process has improved this attribute.



Hardening

Hardening is applied to steel and other alloys to improve their mechanical properties. During hardening, the metal is heated at a high temperature and this temperature is maintained until a proportion of carbon has been dissolved. Next the metal is quenched, which involves rapidly cooling it in oil or water. Hardening will produce an alloy which has high strength and wear resistance.



Tempering

Tempering is applied to steel where ductility is desired. Untempered steel is very hard but too brittle for most practical applications. Tempering is a low temperature heat treatment process normally performed after hardening in order to reach a desired hardness/toughness ratio. The process involves heating steel to a lower temperature to reduce some of the excess hardness. The metal is then allowed to cool in still air which results in a tougher and less brittle steel.



References

- <https://www.metalsupermarkets.com/how-heating-metal-affects-its-properties/>
- <https://www.thoughtco.com/what-happens-when-metals-undergo-heat-treatment-2340016>
- <https://sciencing.com/list-ferromagnetic-metals-8479101.html>

Quiz

Question #One

#1. What Three properties of metal that can be changes by heat?

- A. Magnetic, Physical, Regional.
- B. Structure, Physical, Regional.
- C. Cellulare, Structure, Physical.
- D. Electrical, Magnetic, and Structure.

Answer

D. Electrical, Magnetic, and Structure.

Question #Two

#2 What are Four ways to Heat Treat metals?

- A. Tempering, Hardening, Annealing, Normalizing.
- B. Hardening, Hammering, Forging, Manipulating.
- C. Annealing, Forging, Magnifying, Manipulating.
- D. Normalizing, Tempering, Tampering, Hammering.

Answer

A. Tempering, Hardening, Annealing, Normalizing.

Question #Three

#3. The process designed to alter the properties of metal?

- A. Tempering.
- B. Heat Treatment.
- C. Hardening.
- D. Forging.

Answer

B. Heat Treatment.

Question #Four

- #4. What is it called when a metal is heated then quenched with water/oil to cool it quickly?
- A. Tempering.
 - B. Forging.
 - C. Hardening.
 - D. Electrical.

Answer

C. Hardening.

Question Five

#5. The process involving heating steel to a lower temperature to reduce excess hardness.

- A. Tempering.
- B. Forging.
- C. Hardening.
- D. Electrical.

Answer

A. Tempering.