SNS COLLEGE OF TECHNOLOGY
Vazhiampalayam, Coimbatore-35
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Heat treatment of steel

DR. C SONIA AP/CHEMISTRY

Heat treatment of steel

Heat treatment is a critical process in metallurgy, widely used in industries such as automotive, aerospace, and tool manufacturing to enhance the mechanical properties of steel

Heat treatment of steel

Annealing: This process involves heating steel and then slowly cooling it to refine its structure and make it softer. Annealing helps relieve internal stresses and improve machinability

Heat treatment of steel

Low-Temperature Annealing:

Temperature Range: Typically between 260 °C (500 °F) and 760 °C (1400 °F).

Suitable for low-carbon steel.

Process: The material is heated just below the lower critical temperature of steel and then cooled slowly in still air.

Purpose: Softens the metal, making it more workable for shaping, stamping, or forming1

Heat treatment of steel

High-Temperature Annealing:
Temperature Range: Above 760 °C (1400 °F).
Applicable to various alloys.
Process: Material is heated to a higher temperature and then cooled.
Purpose: Adjusts material properties, such as ductility and hardness, based on the specific alloy and desired outcome

Heat treatment of steel

Quenching:

Process: Rapidly cooling hot steel by submerging it in water or oil.

Result: Changes the molecular structure from ferrite to martensite, increasing hardness and wear resistance.

Advantages: Reduced brittleness and easier workability due to the hardened surface layer.

Heat treatment of steel

Hardening:

Process: Slow cooling in an oven or furnace over hours or days.

Result: Homogeneous material hardened throughout its entire structure, not just the surface.

Advantages: Increased durability, corrosion resistance, and overall hardness

Low-alloy steels are best for quenching, while high-alloy steels suit hardening due to their alloy content1

Heat treatment of steel

Tempering is performed after hardening processes.
Components are heated to a specific temperature below the critical point.
The material is then cooled in still air.
It alters mechanical properties, including hardness, ductility, and toughness.
Purpose:
Toughness: Tempering increases toughness by reducing excess hardness obtained during hardening.
Ductility: It restores ductility while maintaining an acceptable level of hardness.
Brittleness Reduction: Helps strike a balance between hardness and flexibility1.

Heat treatment of steel

Application:

Commonly used for carbon steel.

Also beneficial for reducing hardness in recently welded components.

Immediate tempering after quench-hardening prevents excessive brittleness.

Heat treatment of steel

Regularizes the grain structure, resulting in smaller and more uniform grains throughout the material.

Purpose

Enhances ductility, toughness, and overall material performance.

Widely used in automotive, aerospace, construction, and manufacturing industries1

Heat treatment of steel

Carburizing: By adding carbon to the surface of steel through heat and carbon-rich substances, carburizing creates a hard outer layer while keeping the center relatively soft

Process:

During carburizing, the metal is heated in the presence of a carbon-bearing material, such as charcoal or carbon monoxide.

The goal is to increase hardness and make the metal more wear-resistant

Heat treatment of steel

Nitriding is a heat treatment process that enhances the surface of steel objects by introducing nitrogen into the material.

Process:

Nitriding involves diffusing nitrogen into the surface of steel.

The donor medium can be ammonia (NH_3) or a nitrogen-containing salt.

Common temperature range: 500 to 550°C.

Alloying elements (e.g., chromium, molybdenum) combine with nitrogen to form hard metallic nitrides.