Carburizing and carbonitriding

Description

Image

Image caption

(1) Nitriding and Carburizing © S zillayali at Wikimedia Commons (CC BY 3.0) (2) Camillus tanto folder with "Titanium Carbonitride" coated VG10 blade. © Slideordies14 at Wikimedia Commons (CC BY 3.0)

The process

In CARBURISING, additional carbon is diffused into the surface of a low-carbon steel to give a high-carbon surface layer. When this is quenched, the layer transforms to a hard, brittle, martensite, which can subsequently be tempered to obtain the required balance of hardness and toughness. There are three broad classes of carburizing equipment; all require temperatures of about 900 C. The first uses a powder pack that releases carbon monoxide (CO); this decomposes on the surface of the steel to give atomic carbon and CO2. It is best for small parts. The second uses a fused salt bath containing sodium cyanide (NaCN>25%), barium chloride, sodium chloride and accelerators; it is very versatile and has a low capital cost. The last uses gas - methane, butane or pentane - as the source of carbon in a special muffle furnace that allows the gas to flow freely round the parts to be carburized; it lends itself to large-quantity production.

CARBO-NITRIDING is a variant of gas carburizing in which ammonia (NH3) is added to the carburizing gas. Nitrogen, released from the ammonia, and carbon from the carburizing gas, diffuse into the component at the same time, precipitating nitrides as well as increasing the surface carbon content. It generally requires a lower temperature and shorter time than plain carburizing. The process produces a thinner layer, but one that retains its hardness to higher temperatures.

Both processes give components with hard, wear resistant surfaces on a tough, ductile core. Carburizing gives better impact resistance than carbo-nitriding, but it causes more distortion and is slower, making it more expensive.

Process schematic

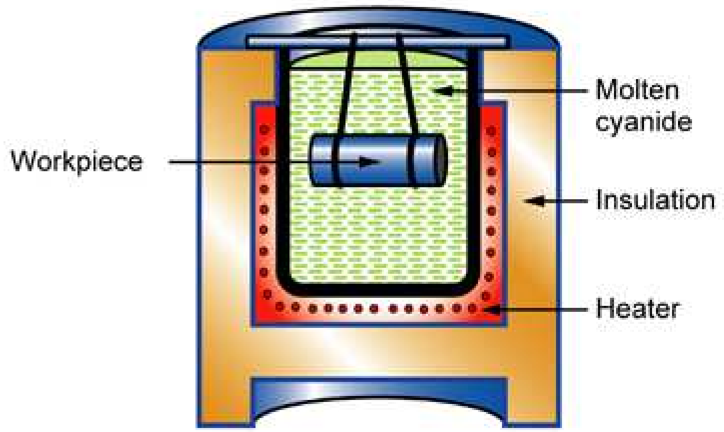

Figure caption

A salt-bath carburizing furnace

Material compatibility

Metals - ferrous	✓

Function of treatment

Hardness	✓
Wear resistance	✓
Fatigue resistance	✓
Friction control	✓

Economic compatibility

Relative tooling cost	low
Relative equipment cost	medium
Labor intensity	medium

Physical and quality attributes

Surface roughness (A=v. smooth)	A			
Curved surface coverage	Very good			
Coating thickness	75	-	1.5e3	µm
Surface hardness	600	-	1.2e3	Vickers
Processing temperature	815	-	1.09e3	°C

Process characteristics

Discrete	✓

Supporting information

Design guidelines

Carburizing, nitriding and carbonitriding all achieve the same thing: the creation of a hard, wear-resistant surface on a tough, cheap steel body. Before treatment, the steel is easily worked and machined. After treatment it can only be finished by grinding or polishing. All three processes are very widely used in mechanical design.

Technical notes

Steels for carburizing and carbonitriding are cheap and easily worked, typically low carbon (< 0.45% C) plain or low alloy grades such as AISI 1020, 1022, 1024, 3310, 4037, 4320 or 8620.

Typical uses

Both processes are widely used in automotive, mechanical and aeronautical engineering. They are applied to near-finished components ranging from mild steel pressings to heavy-duty alloy-steel transmission components. As a general rule: Light cases (up to 0.5 mm) are applied to water pump, shafts, sockets and small gears. Moderate cases (0.5 - 1.0 mm) are applied to valve rocker arms, bushes and gear. Heavy cases (1.0 - 1.5 mm) are applied to transmission gears and king-pins. Extra heavy cases (1.5 mm and over) are applied to camshafts.

The economics

Both processes are of immense economic significance. The equipment can be expensive, but tooling costs are generally low, and many parts can be treated simultaneously, keeping labor cost low.

The environment

The word 'cyanide', mentioned above, is sufficient warning that these processes require stringent safety precautions, and that disposal of spent baths must follow proper procedures. Both are energy-intensive, but the ability to enhance the performance of cheap, low-energy, recyclable steels more than compensates.

Links

MaterialUniverse

Reference