Surface Treatment

Method	Principles and features	Materials	Nature
Electroplating	Soak the material into the plating bath as an negative electrode to perform electrolytic deposition of metal film on the material surface by direct current.	The materials are metal and plastic (electroplating by conducting with electroless plating on the surface).	For decoration, 1 μm or below, for protection and industrial use, 1 - dozens μm or above. IN many cases, pin holes are left.
Hot-dip plating	Soak the material into dissolved metal and then pull it up for consolidation and coating of the dissolved metal.	Primary materials are iron and steel and coating metal includes Al, Zn, Sn and Pb, etc.	Thick coating is possible. Adhesion and deforming processing property depend on the nature of alloy layer formed between the coating layer and the material.
Diffusion plating	Metal elements are diffused and cemented over the material surface layer. As the processing temperature is high (around 1000˚C), post heat treatment is required.	Primary materials include iron and steel, Fe-base and Ni-base heat-resistant alloy, etc. Coating metal includes Al, Cr and Si, etc.	Alloy layer thickness is tens - hundreds μm.
Evaporation coating	Physical evaporation method: Coating by vacuum evaporation, spattering and ion plating, etc. Chemical evaporation method: Coating by decomposition of gas compound.	Materials include metal, ceramic and plastic. Coating materials are metal and ceramic.	Generally, the evaporation speed is low for the physical evaporation method. The chemical evaporation method cannot avoid high temperature processing.
Thermal spraying	Power or particles of thermal spraying materials heated to the dissolved state are sprayed onto the material surface to form coating. The material temperature during spraying is below 200˚C.	Materials include metal, ceramic and plastic, etc. Thermal spraying materials are metal, ceramic, plastic or their mixture.	The adhesion strength is relatively low. The film has air holes. The practical film thickness is about 0.6 mm or below.
Flitch	Rolled pressure welding method and explosion welding method, etc. Processing objects are simple shapes such as plates and cylinder inner face, etc.	Materials are metal and mostly iron and steel. Flitch materials are metal and alloy.	For explosion welding, the flitch material thickness is about 3 mm or below.
Anode oxidation	Materials are electrolyzed in electrolysis solution such as sulfuric acid and oxalic acid as an anode to form an oxide film on the material surface.	Primary materials are Al and Al alloy. Others include Mg, etc.	An oxide film consists of a dense layer and porous layer. Apply normal sealing processing. Good adhesion. Coloration possible.
Chemical conversion coating	Form a phosphate or chromate film on the material surface by soaking or spraying method.	Materials include iron and steel, Al and Zn, etc.	Primarily, a phosphate film applies to iron and steel materials and a chromate film to Al.
Carburizing	Carbon elements are diffused and cemented over the material surface layer. Processing temperature is 850 - 950˚C. Apply quenching after the processing.	The material is steel with C content of 0.2% or below (steels for case hardening).	The carbonizing is 0.5 - 5mm and the hardness is 700 - 850HV. Pay attention to the material deformation caused by the processing and quenching after the processing.
Nitriding	Nitride elements are diffused and cemented over the material surface layer. Processing temperature is 475 - 580℃. Heat treatment and machine processing are possible before the processing.	Materials are nitrided steel for gas nitriding (containing Cr, Mo and Al, etc.). Most steel types for ion nitriding.	The nitriding depth is 0.9mm or below. Hardness is 600 - 1150HV. Material deformation is small.
Nitrocarburizing	Perform nitriding at the same time with carbonizing. Processing temperature is 700 - 900℃. Apply quenching after the processing.	Materials are the same as those for carbonizing. The same can apply to carbon steel.	Nitrocarburizing depth is 1mm or below. Hardness is about 800HV.
Sulfurizing	Sulfur elements are diffused and cemented over the material surface layer. Processing temperature is 400 - 600℃.	Any steel material and steel type can be used.	Friction coefficient decreases from the ferric sulfide film thickness 0.2μm.
Nitrosulphurizing	Perform nitriding at the same time with sulfurizing. Processing temperature is 560 - 570℃.	Materials are the same as those for nitriding.	The nitrosulphurizing depth is 0.1 - 0.5mm.
Induction quenching	Perform quenching after rapid heating and rapid cooling by high frequency conductive current on the material surface.	Materials are iron and steel. Especially, medium carbon steel, alloy steel and cast iron, etc.	Hardened layer thickness is 0.4 - 5mm. Working time is short. Material deformation is small.
Flame hardening	Perform quenching after rapid heating and rapid cooling by oxygen-fuel flame on the material surface.	The same as above	Hardened layer thickness is 1 - several mm.
Other surface quenching	Perform quenching after rapid heating and rapid cooling by laser beam and electric beam, etc.	Any materials can be used as long as they have a quenching property.	The hardened layer is extremely thin. Local hardening is possible.
Plastic lining	Coat the material surface by the sheet lining method, thermal spraying method or application method, etc.	The coating materials are polyethylene, vinyl chloride, fluorine resin and rubber, etc.	Thick coating is possible. It may be 1mm or above in some cases.
Ceramic coating	Coat the material surface by the evaporation method, thermal spraying method or quenching method, etc.	Coating material is glassy ceramic (enamel). Various ceramic.	Less adhesive. Repeated heating and cooling may cause cracks on the film.

Source: Manufacturing and Machine Tool Technology in JSME's Mechanical Engineers' Handbook