Go over

3.3 Potential properties of the superficial layer

3.3.3 Physico-chemical parameters

(1) Hardness (2) Brittleness

(3) Residual stresses: Factors causing the formation of residual stresses: – mechanical, – thermal, – structural

(4) Absorption

(5) Adsorption

Types of adsorption and types of adsorption isotherms

(7) Diffusion

basic diffusion mechanisms (crystal)
other **special mechanisms: three types of difusions**

(8) Adhesion (9) Catalysis: The condition for a catalytic reaction of particles at the metal surface is their prior **chemisorption**.

3.4 Practical properties of the superficial layer

(1) **Effect of properties of superficial layer on fatigue strength**

(2) The relation of friction and wear to the superficial layer

(3)The relation of anti-corrosion property to the superficial layer

3.5 **Structure and type of the coatin**g

1 Coating - a layer of material, formed naturally or synthetically or deposited artificially on the surface of an object made of another material, with the aim of obtaining required technical or decorative properties.

2 structure of the caotings

3 Types of coatings by matrials or application

3.6 Potential properties of the coating

3.6.1 Geometrical parameters of coatings

(1) Thickness

Coating thickness is the basic parameter **on** which protective properties, decorative and technical properties significantly **depend**.

Porosity, tightness, corrosion resistance and mechanical strength all depend on the appropriate coating thickness.

In general

Protective properties of coatings increase with the rise of thickness, similarly to wear resistance.

But thickness has the opposite effect on flexibility弹性, impact strength冲击强度, and sometimes even on adhesion strength.

3.6.1Geometrical parameters of coatings

(1) Thickness

Coating thickness varies over a very broad range - from hundredths of a micrometer to several millimeters.
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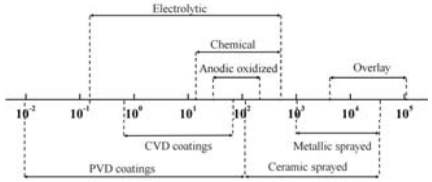


3.6.1Geometrical parameters of coatings

(2) Roughness Ra and Rz

(3) Three-dimensional structure defects

The three-dimensional structure of the coating is the result of the coating process, dependent on the **method or technique used**, on **defects** formed during the deposition and on **substrate roughness.**

Defects of the three-dimensional structure, which are simply **coating defects**, all have the same character as **those of the superficial layer**.
The most frequent defects, common to both surperficial layers and coatings, are blemishes斑瑕疵缺陷, scratches划痕, cracks裂纹裂缝and porosity.

Among the most important defects, common to all coatings, are non-uniform thickness (including object edges), delamination分层, exfoliation脱落, incomplete coverage, pits, blisters气泡, raising鼓起浮起of the coating, brittleness, chipping碎屑, and sagging松垂下垂[沉, 陷].

3.6.1Geometrical parameters of coatings

(3) Three-dimensional structure and defects

Each type of coating exhibits certain own, characteristic defects. Among the most frequently encountered are:

–for **metallic, electroplated coatings**: burns烧伤, 灼伤, streaks条纹条斑, striation条痕, 条纹状, haziness朦胧之性质或状态, roughness (here understood as major build-ups 积累,叠加; 复合; (壳型)结垢现象or surface contamination inclusions), spots 污点, decoloration去色, excessive matting无光粗糙表面 and runs条纹

–for **organic paint coatings**: bleaching漂白, browning褐变, blushing雾浊发白, spots, pinholing, uneven color, uneven luster, pock-marking麻点, orange peel桔皮漆病, crocodile skin, fading and runs;

–for **sprayed inorganic coatings**: irregularity of coating thickness (resulting from "spitting分散" by the spray gun), varying degree of melting of coating material particles

3.6.2 Geometrical – Physico-chemical parameters of coatings

Among the most important **geometric and physico-chemical parameters** are those which describe coating properties, such as:

– relating to energy, mainly **surface energy**,

–relating to radiation, mainly **reflection and emissivity**, and significantly less often (only for selected types of coatings): radiation辐射 transmittance透过系数,

–**catalytic** (dependent on degree of surface development and coating components which accelerate or retard chemical reactions),

–**thermophysical**, mainly thermal conductivity and solderability可焊性

3.6.3Physico-chemical parameters of coatings

(1) **Residual stresses**

The kind of stresses depends on **the coefficients of thermal expansion of substrate and coating layers** and on **the character of structural defects**.

Residual stresses are formed in coatings as the result of differences in thermal expansion coefficients of substrate and coating materials (stresses of the **I kind**), as well as significant defects in the structure of the coating material (stresses of the **II and III kind**)

Compressive stresses and **tensile** stresses:

If the layer contains **more atoms** in **interstitial positions than there are vacancies in the lattice**, **tensile stresses** are formed, while **the reverse situation leads to the formation of compressive stresses**

3.6.3Physico-chemical parameters of coatings

(1) **Residual stresses**

Residual stresses may be reduced by the **selection of appropriate materials and process parameters**.与材料及制备工艺有关

For examples in chrome-plated coatings, residual stresses may vary from –800 to 1000 MPa.

Brighteners, in particular, significantly affect the rise of residual stresses, mainly in nickel coatings, in which an addition of saccharin糖精 or other organic compounds of sulfur **reduces tensile stresses**.

Without the use of brighteners, tensile stresses are generated in nickel, cobalt, iron, palladium, manganese and chrome-plated coatings, while compressive stresses are generated in zinc and cadmium coatings.

3.6.3Physico-chemical parameters of coatings

(1) **Residual stresses**

Values of residual stresses vary, depending on **layer thickness**, e.g., in chrome and nickel plated coatings; stresses diminish with a rise in layer thickness and achieve a constant value when the layer thickness reaches 30 μm.

In order to reduce residual stresses of the I kind, **multi-layered coatings are deposited**, comprising a composition of layers with successively changing thermal expansion coefficients, relative to the substrate material.

3.6.3Physico-chemical parameters of coatings

(1) **Residual stresses**

Coatings with **big tensile stresses**, e.g., chrome and nickel-plated, **exert an unfavorable effect on some mechanical properties** of coated objects, especially on **fatigue strength which may decrease by 20 to 70%** as the result of coating deposition.

Compressive stresses in coatings **do not exhibit any significant effect on fatigue strength**

3.6.3Physico-chemical parameters of coatings

(2) **Adhesion**

Adherence of coatings to the substrate or of layers of multi-layer coatings to each other, described by the force necessary to detach the coating from the substrate or layers from each other, reflects the character of the dominating bond:

-**metallurgical** - consisting of **melt-mixing** of the coating and subsurface zone materials;

-**epitaxial**- consisting in the formation of coating crystals, similarly oriented relative in each other, on the crystals of the substrate, on condition that the difference in lattice parameters will not be bigger than approx 10%.取向附生的, 外延的

-**adhesive** - consisting of the utilization of adhesion of the coating to a well-cleaned substrate ;

3.6.3 Physico-chemical parameters of coatings

(2) **Adhesion**

-**diffusion** - consisting of mutual displacement, through diffusion of components of the coating and the substrate.

-**mechanical** - consisting of creation of conditions in the substrate for mechanical anchoring of coating material. This version occurs in some thermal spray techniques.

Naturally, combinations of the above types of bonding are also possible

3.6.3Physico-chemical parameters of coatings

(2) **Adhesion**

Influencing factors

1)The **condition essential for good adherence** of coatings is **high purity** of the **substrate surface** prior to deposition of coating.

Better adherence can only be achieved **2) when** the distance between the coating and the substrate is comparable to lattice parameters; **3)when** the formation of thin diffusion layers

4)Furthermore, residual stresses, degree of **surface development** (higher roughness -better adherence), as well as by differences in the ductility of surface and substrate materials.

Good adherence of coatings prevents their scaling剥落and detachment due to temperature, strong internal interaction of a mainly mechanical character and residual stresses

3.6.3Physico-chemical parameters of coatings

(3) Hardness

Hardness of coatings is one of the most often determined parameters.

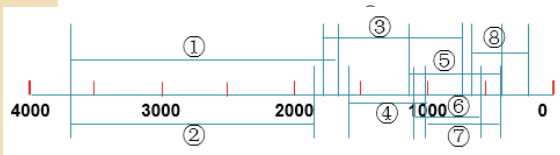
For different coatings, it obviously differs and depends on the coating material and its structure. It varies within a very broad range, from the hardness of soft rubber to that of diamond.

Similarly to superficial layers, we distinguish **macrohardness** and **microhardness** of coatings. Values obtained by both methods **are not**, as a rule, **comparable**. Usually, macrohardness constitutes a mean hardness value of a certain, quite big area; while microhardness refers to almost a point-size zone (the surface of a grain or a grain boundary)

3.6.3Physico-chemical parameters of coatings

(4) Hardness

Hardness of various coatings[HV0.005(HK0.0025)]



①PVD ②CVD ③Overlay
④Ceramin sprayed ⑤Electrolytic
⑥Chemical ⑦Metallic sprayed
⑧Anodic oxidation

3.7 Service properties of coatings

3.7.1Anti-corrosion properties

In the most general sense, **corrosion** is a process of gradual destruction of all materials, existing in all environments, as the result of chemical or electrochemical effect of the environment on these materials.

From a qualitative point of view, we distinguish the following types of corrosion:

– **Chemical** - occurring as the result of direct action on materials of dry gases, especially at elevated temperatures, or of liquid environments which do not conduct electricity;

– **Electrochemical** - caused by the action of short-circuited local corrosion sources, formed upon contact of metallic phases with an electrolyte.

3.7 Service properties of coatings

(1) Anti-corrosion properties

The same object, coated with the same type of coating, exhibits different corrosion resistance in different environments.

For that reason, a generalization of the problem of **corrosion resistance** is extremely difficult.

It depends most significantly on:

composition, structure of the coating,

three-dimensional structure of coating surface,

on defects, residual stresses, type and condition of the substrate,

on type and intensity (temperature and concentration) of the corrosive medium and time of exposure.