**Electrochemical Technology in Pollution Control**

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**Lecture – 29**
**Electroplating 2**

Greetings to you. Let us continue our discussion on Electroplating. And, yesterday I talked to you about the basics of electroplating and some things about copper, zinc plating etcetera. We are discussing chromium plating.

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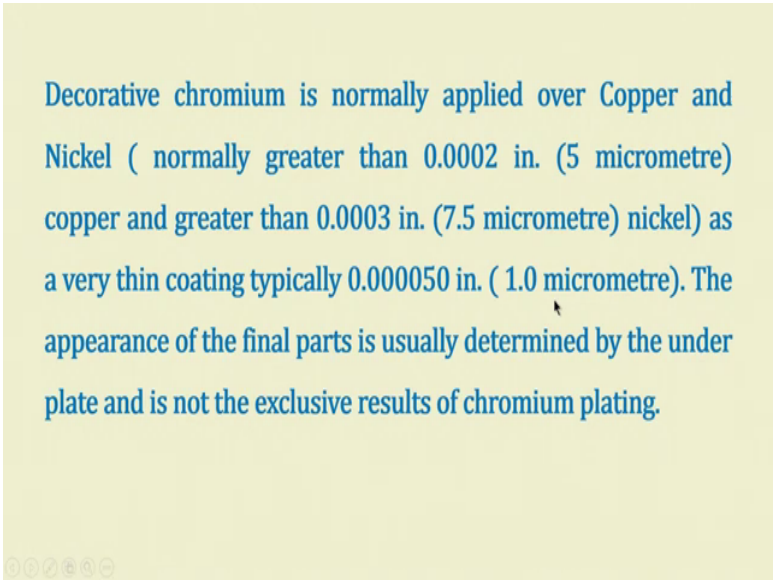


I had shown you this slide yesterday, in my not yesterday in my previous class I do not know when you will be hearing me hearing my next lecture usually.

So, decorative chromium is also applied normally over copper and nickel, copper flash is required nickel is there and I have written here 5 micron, 7.5 micron etcetera and a very thin coating typically of 1 micrometre 1 micron; micrometre and microns are same ok. So, the appearance of final parts is usually determined by the under plate and it is not exclusive results of chromium plating.

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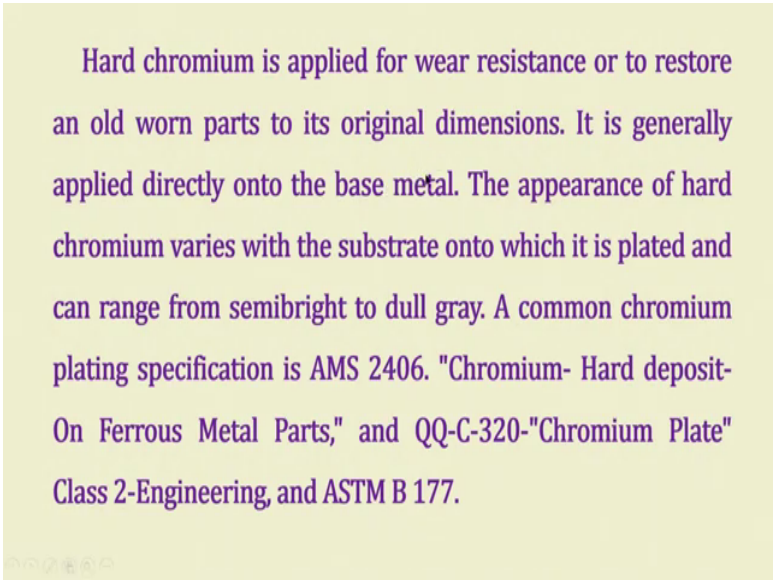


There is another type of coating, that is hard chromium coating. Hard chromium coating is required for steels, is applied for steels and iron particles iron materials for wear resistance properties. So, it is also restored to old worn parts to its original dimensions etcetera. This also I had shown you in my last class.

And, hard chromium plating I want to tell you that is something like a garage industry hard. Lot of people in small garages not exactly garages, but it is it is called garage industry; tiny

industries they are used they make hard chrome plating especially for functional resistance for wear materials etcetera, very small particles components are also required. And, the hard chromium plating usually will extend from about 15 to 30 microns that is very hard coating.

But, the material for hard coating waste is potassium dichromate only sodium dichromate; compared to sodium dichromate potassium dichromate is more soluble. So, people use potassium dichromate. And, the waste that comes out will be potash hexavalent chromium only and that is carcinogenic and toxic and all those things which we do not approve as an environmental contaminant, we do not want it.

So, chromium hard chromium plating is one has to be really careful how we manage the show spilling, spillage etcetera is very difficult. I have already talked to you about chromium plating in Bangalore lot of people since 1950s and 60s have thrown their waste in and around Peenya and now most of the underground water is contaminated with hexavalent chromium. We need special treatment to clean the aquifers containing chromium ok. So, we will discuss about it again later.

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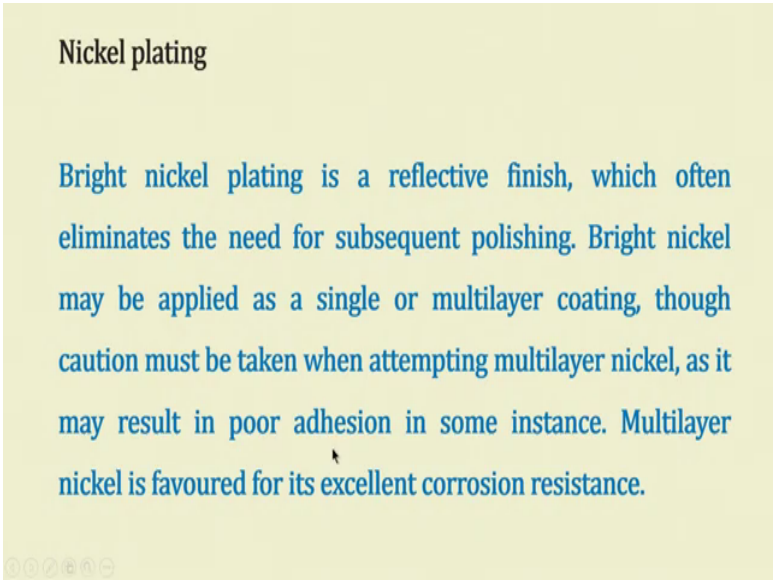


Then, I am going to talk to you about nickel plating, that is bright nickel plating is a very reflective finish gives like a mirror looks like a nice mirror which often eliminates the need for subsequent polishing itself, that also is not required. Bright nickel plating may be applied as a single or multi layer coating, although caution must be taken when attempting the multilayer nickel because of the adherence properties. Its adherence properties are fairly poor that is not very good quality in some instances. Multilayer nickel; however, is favoured for corrosion resistance.

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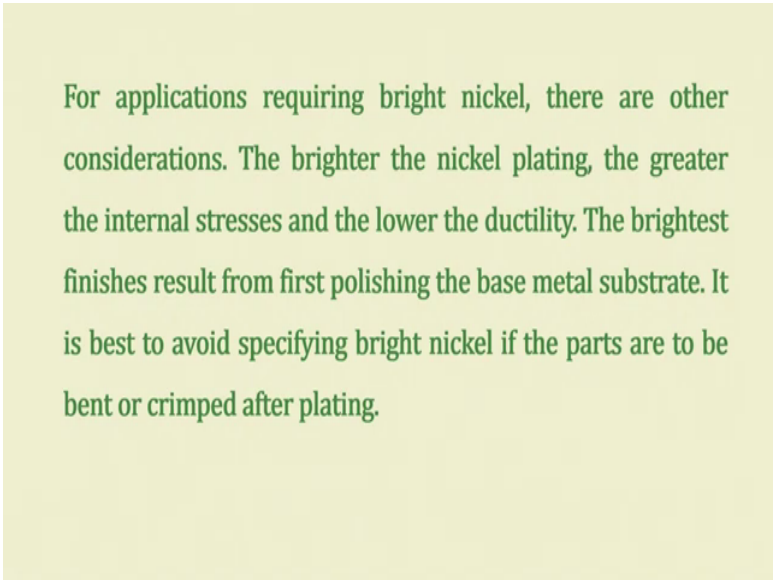


So, different kinds of nickel plating aims are there and for applications requiring bright nickel there are other considerations. For example, the brighter the nickel plating the greater would be the internal stresses, and lower would be the ductility. Why? Because the ductility and brightness they go together. If the material is very thin, it will give a beautiful finish like a mirror and if it is very thin ductility will be the problem. The metal may tear off at several places before it before it acquires the desired ductility.

So, the brightest finishes result from first polishing the base material itself; I have to take the base material keep on polishing using different kinds of chemicals as well as metal, cloth and emery and many other things until I get a almost mirror finish over that the nickel has to be plated. So, it is best to avoid specifying bright nickel, if the parts are to be bent or crimped after plating. Why? Because of this ductility problem.

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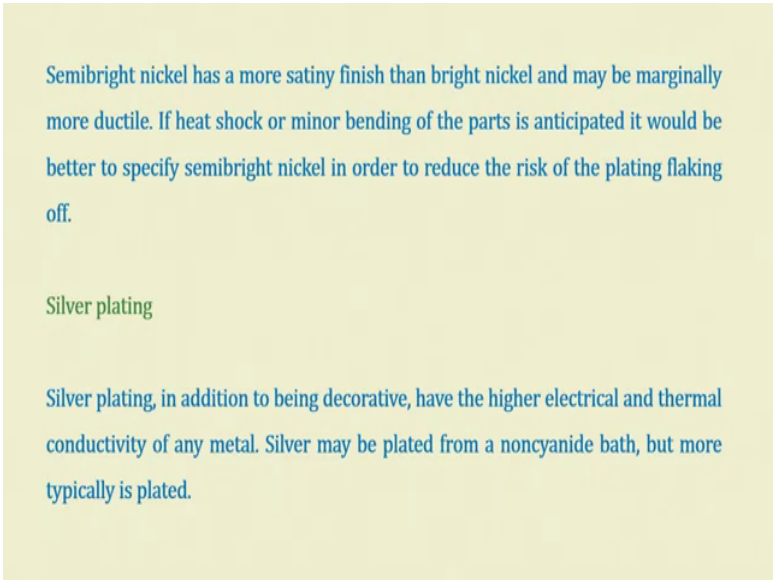


So, semi bright nickel is quite a common it has got a satiny finish, compared to bright nickel and it may be marginally more ductile because the thickness will be more. If heat shock or minor blending of the parts is anticipated, it would be better to specify semi bright nickel coating in order to reduce the risk of the plating flaking off. The if the adhesion is poor, flaking properties flaking is a real risk. You know what is flaking know? Normally, whenever I have a metal coated sometimes it peels off that is known as flaking. If the adherence is not good the peeled off material cannot be a good material at all. So, we have to really worry about flaking properties.

Now, coming back to other metals I want to talk to you a little bit about silver plating. Very important very nice and it is a decorative finish. It has higher and electrical thermal conductivity compared to many metals may be just a little bit lesser than copper and better than aluminium, but we cannot have silver conducting material in our wires etcetera. So,

aluminium and copper are preferred, but decorative purpose silver is always a first choice. So, it maybe plated from a noncyanide bath; that is a very important aspect because cyanide baths are also available, but more typically it is noncyanide bath.

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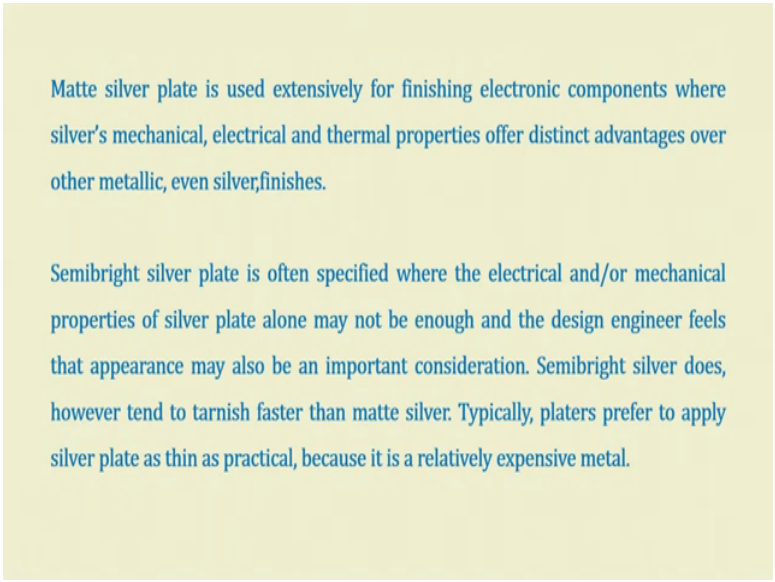


So, matte silver finish plate; nowadays lot of people use them as on ornaments and jewellery. Is used extensively for finishing electronic components also where silver's mechanical, electrical and thermal properties offer distinct advantages over other metallic properties; even silver finish also. Semi bright silver plate is often specified where electrical and mechanical properties are need to be considered. And sometimes the design engineers will specify that appearance may also be an important consideration.

So, in such cases we should go for semi bright silver plate and the problem is it tarnishes much faster than matte silver. Most of the silver plating usually when exposed to atmosphere they

react with the sulphide in fact, in the atmosphere and they form silver sulphide. So, it is one of the practical difficulties of main maintenance of silver coated materials; especially if it is functional, then it is much more difficult to manage.

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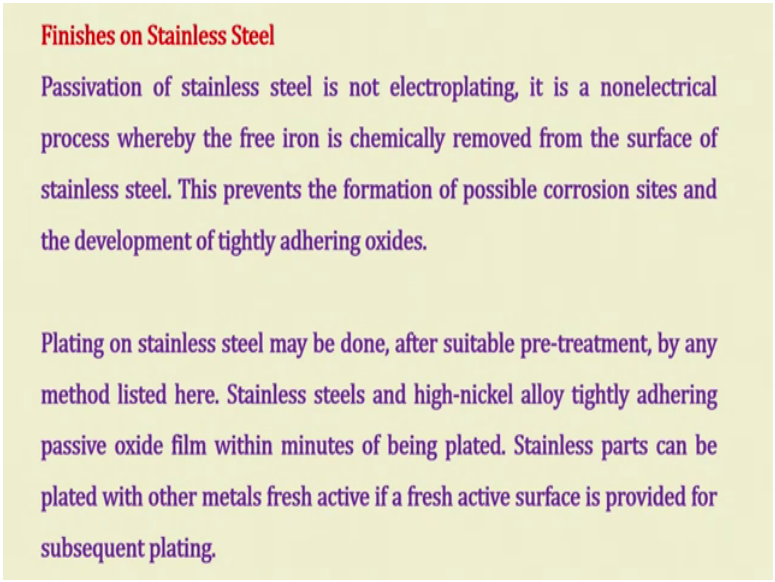


Then, let us talk about finishes on the stainless steel. Why do we need stainless steel at all? So, stainless steel normally is a an alloy of iron, nickel and manganese ok. So, passivation of stainless steel quite often we require, but passivation is not electroplating. What is passivation? Passivation is to treat the metals with acids and give a protective layer of the oxide on the silver plates. So, a quite often passivation is employed for materials with zinc with yeah, you can say zinc passivation etcetera and that gives you somewhat yellowish or greenish colour at the steel, but passivation of stainless steel is not normally practiced and it is not electroplating either.

It is a non-electrical process whereby the free iron is chemically removed from the surface of the stainless steel. We do not want free iron; free iron means it is open for oxidation, corrosion and mechanical, irritation etcetera. So, the passivation of stainless steel is mainly carried out for chemical removal from the stainless steel of the iron only free iron that is not alloyed. This prevents the formation of possible corrosion sites from where the corrosion will start. And then the development of tightly adhering oxides etcetera is quite possible; sometimes we passivate iron with phosphate. So, iron phosphate compound is formed on the surface which is not really that dangerous like an oxide because oxide means corrosion less life.

So, plating on stainless steel may be done however, because after suitable pre treatment now we can coat it with many other things. So, stainless steels are coated with high nickel material alloy tightly adhering passive oxide film can be formed within minutes of plating and oxide films are very difficult to remove. So, the adhesion of an oxide film on a metal is always preferable. Most of the metals stainless steels are usually passivated with sulphuric acid or nitric acid. Stainless steel parts can be plated with other metals also and a fresh active surface has to be provided for subsequent plating.

So, before I take a stainless steel for plating quite often when I buy the stainless steel for other purposes they are all passivated and then kept and served to you and supplied to you in the passivated form only. So, passivation form is only a temporary measure to safeguard the metal until it is taken up for further coating or plating.

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So, now let us talk about tin plating. Tin is a very fairly easy material to plate and it is approved for a variety of industrial applications, it is approved for food containers etcetera many of the Coco-Cola and other things we used to use tin containers and wherever there is food contact tin applications are used.

Many of you may remember that, in most of most of the vessels in villages about 30 – 35 years before brass vessels used to be coated with thin tin because tin melts at very low temperature. And the you just melt the tin and coat the brass vessel inside and it becomes safe because brass you cannot put sour things like curds and other things in brass and copper vessels because again the food will get contaminated it will spoil faster because of the acidity. Brass will also dissolve copper will dissolve because of the acidity the life will be gone.

So, most of the brass materials used to be coated with thin tin layer about 30 – 40 years before, nowadays that practice has been stopped and the there used to be village professionals who used to go from house to house or town to town for coating tin coating ok. Nowadays, we have melamine coating and several other types of coatings or stainless steel direct use, where there is no need for such tin because tin is also an environmentally dangerous material. So, that practice has been stopped.

There are known common tin salts that are extremely toxic or carcinogenic. This was one of the reason why food components foods were stored in tin containers, but tin does not tarnish easily also making it a good choice as a low cost decorative finish. Malaysia is one of the best one of the countries which produces tin in large quantities including Indonesia also.

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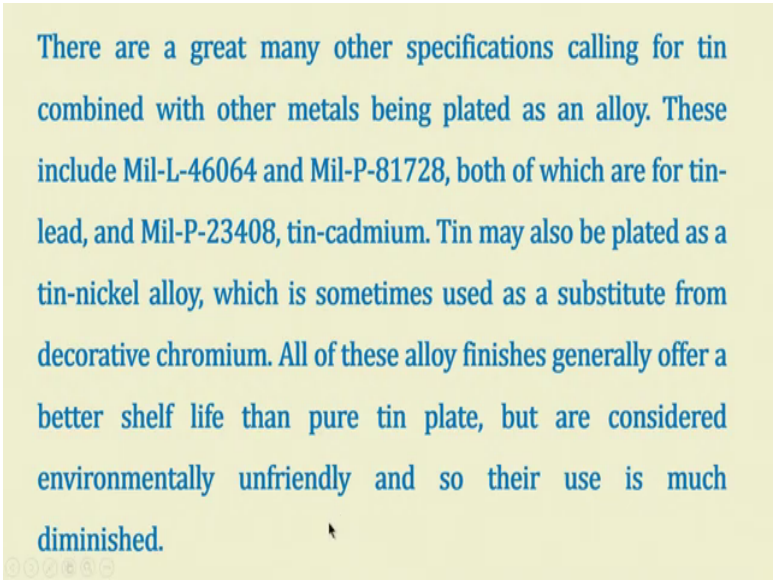

There are great many applications calling for tin combined with other metals being plated as an alloy. These include these numbers Mil-L-46064, Mil-P-81728 both of which are for tin lead and for Mil-P-23408 for tin cadmium. Tin also may be plated as a tin nickel alloy, which is sometimes used as a substitute for decorative chromium. Even now the from Indonesia quite a few articles are tin finished.

All these alloy finishes generally offer better shelf life than pure tin plate, but are considered to be environment unfriendly in the light of new evidence that is usually toxic; most of the tin compounds are toxic.

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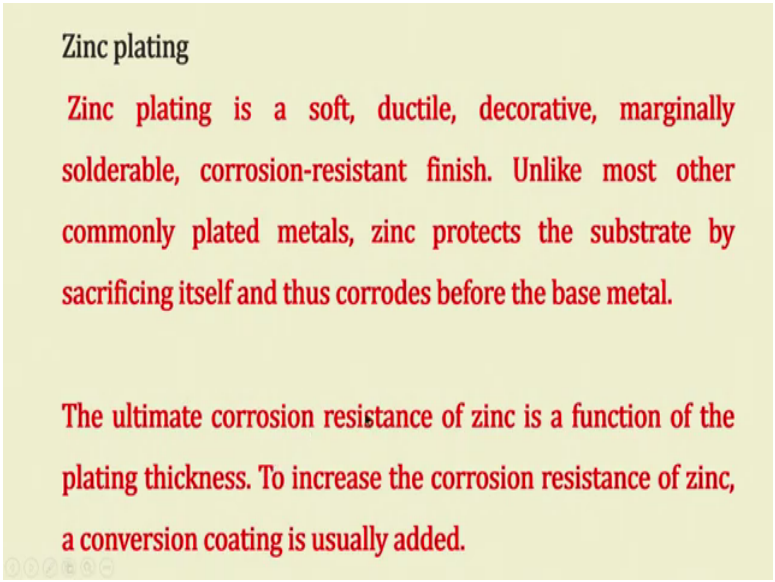


So, zinc plating very important plating. Zinc itself is a provides a soft ductile decorative coating and it is marginally solderable, it gives a corrosion resistant finish. Unlike most other commonly plated metals zinc protects the substrate by sacrificing itself. It is a very reactive

material and people do not mind sacrificing zinc because it is cost effective. And, it is as a sacrificing material if you quote anything with zinc corrodes before the base metals then one can write it again later.

So, the ultimate corrosion resistance of zinc is a function of plating thickness to increase the corrosion resistance of zinc a conversion coating is usually added. You have to look up the definitions of conversion coating etcetera for further information.

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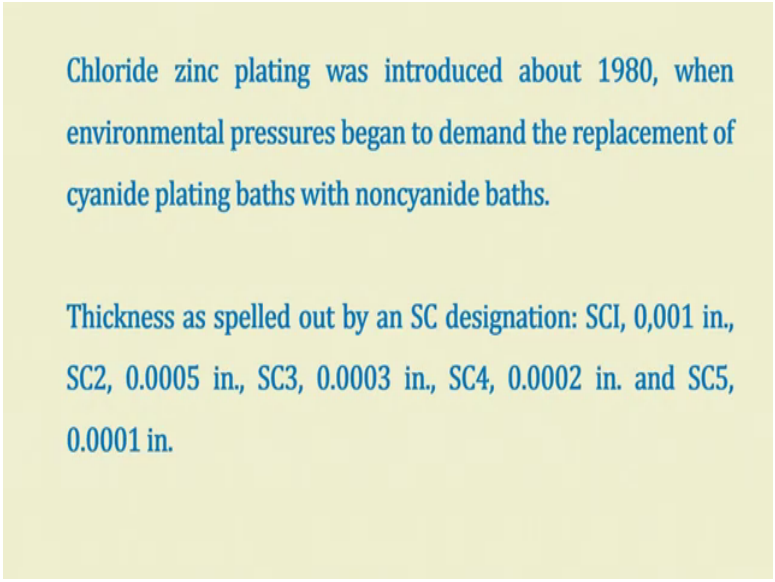


Usually people used to quote zinc with as a cyanide again environmental considerations normally do not permit cyanide coating cyanide plating. So, nowadays there are processes which you use zinc chloride as an electrolyte and somewhere introduced since 1980 only. And, when environmental pressure began to mount you know replacement of cyanide became necessary in most of the in most of the countries. And, non-cyanide baths have been developed

since last 20 – 30 years very good material for base plate coating for as a sacrificial metal as well as passivation.

So, thickness 0.001 inch, 0.0005, 0.0003 inches there are specifications SC4 and SC5 corresponds to 0.0001 inch. Many of such come coatings coated materials are used in aircraft industries ok.

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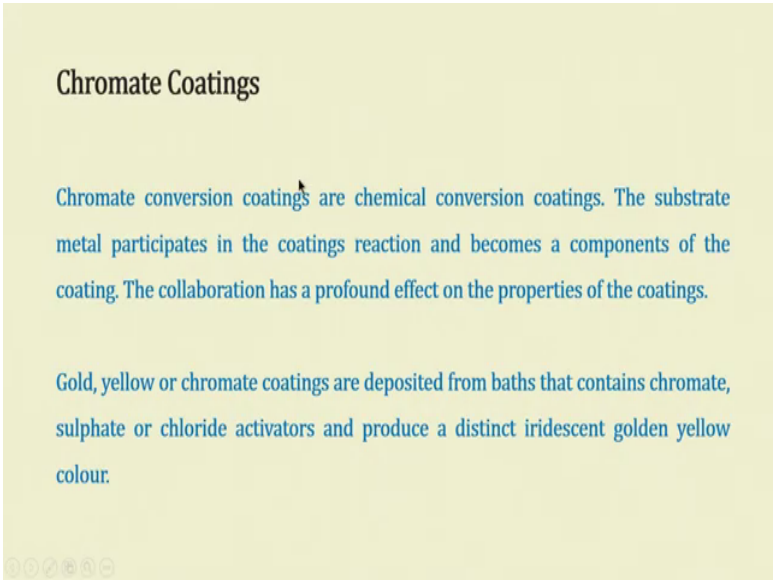


Now, chromate coatings I want to talk to you, because chromate coating is different from chromate plating ok. So, chromate coating is just a conversion chemical conversion. So, the substrate metal participates in the coatings reaction and become say component of the coating; zinc chromate for example, is a chromate coating it is not chromate plating. So, this kind of combination has a profound effect on the properties of coatings also. Actually zinc chromate looks blackish it does not look decorative and it does not look bright also.

But, there are several coatings which are coloured – gold, yellow, chromate coatings are possible from baths that contain chromate sulphate for that we have to add sulphate and chloride activators and then produce a iridescent golden yellow colour.

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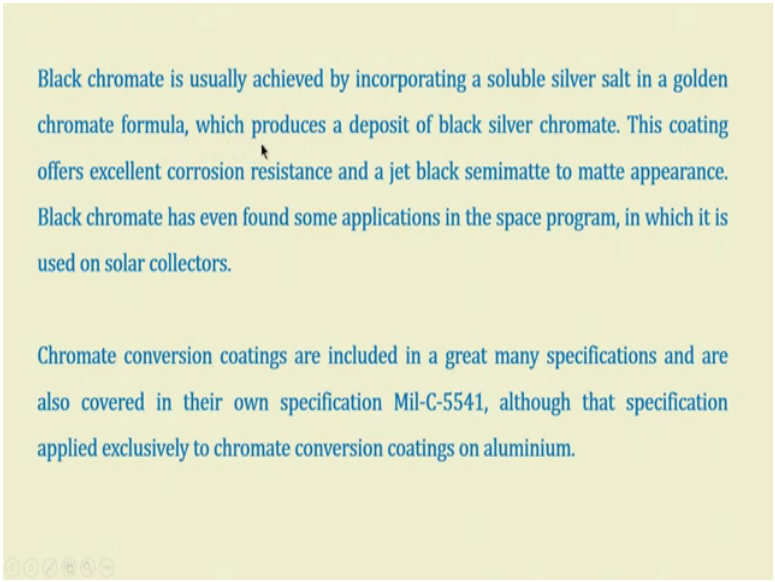


So, black chromate is usually achieved by incorporating a soluble silver salt in a golden chromate formula. These formulas what I am talking about are available in almost all plating handbooks. You see the any one professional enough to undertake electroplating would be buying the anodes, cathodes and electroplating baths and then electrolytes sometimes they will even purchase rectifiers and other things required for coating.

Now, lot of people sell readymade solutions for specific finishes that is readymade electrolytes. And the coatings there the specialization comes from adding a little bit of new other indifferent chemicals, but providing specific properties. So, all you have to do if you want to do a coating

is buy the required kind of chemicals from the suppliers and they all become proprietary chemicals.

But, some of the proprietary chemical compositions are well known and there are plating people, plating professionals, companies which who produce electro who produce electrolytes cathodes anodes etcetera they also produce handbooks for you to give you a certain information about the quality control quality plating and all those things and such informations are available in handbooks. These handbooks are also sold across the table, across the shelf. You can order your handbook and then start planning your industry also.

So, the black silver coating is produced from a golden coating formula by introducing a little bit of silver. So, this type of coating offers excellent corrosion resistance and jet black semi-matte to matte finish. So, black chromate has even found some applications in space programs which are used on solar collectors very important; because in the in the stellar space the only source of energy would be sunlight.

Chromate conversion coatings are included in great many specifications and also covered in our own specification of Mil-C-5541 although that specification applied exclusively to chromate conversion coatings on aluminium. Aluminium also can be coated given a coating of chromium.

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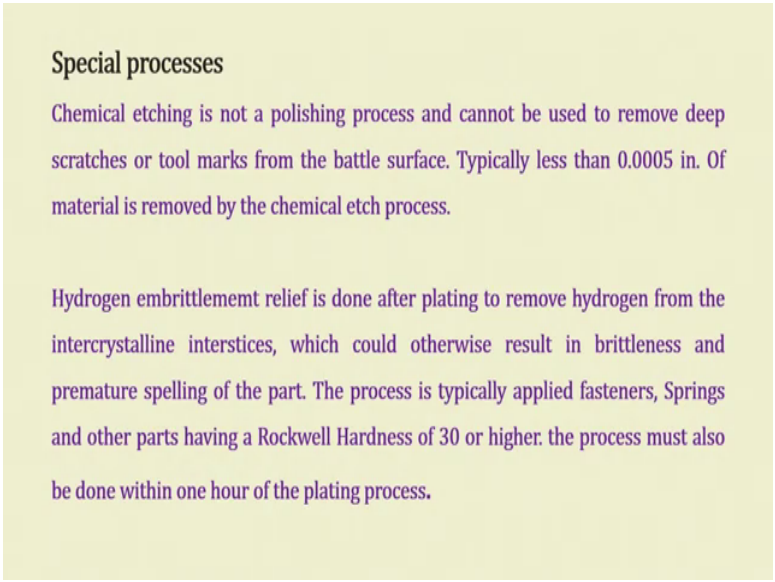


So, then there are special processes and these are known as you know by their own names; for example, chemical etching. Chemical etching is not a polishing process, it cannot be used to remove deep scratches or anything like that, but it is a coating all the way all the same. So, typically less than 0.0005 inch of material is removed by chemical etching process and then that can be coated or painted or do whatever you wish to give the finish.

Sometimes the knobs on the instrument, they are all bright yellow finish or bright aluminium finish, but with black marking. They are all in spectrophotometers etcetera the electron; the wavelength can be marked written on those slits etcetera. So, if you see a bright aluminium finish with marking, black marking they are all chemically etched materials. So, chemical etching is also a process which is part of electroplating system and typically less than 0.0005 inch of the material is removed before it is painted or coated.

So, hydrogen embrittlememt relief – so, quite often again whenever you are using whenever you are doing electroplating acids will upon reaction with the metal, they generate hydrogen. This hydrogen gets into the metal matrix metal plates either cathode or anode. So, the hydrogen going inside the metal causes the metal to become brittle that is known as hydrogen embrittlement. A very well known process lot of research work has gone into the study of environment hydrogen embrittlement.

And, it is that is done after plating to remove hydrogen. So, we have to do hydrogen embrittlement relief operations to remove hydrogen from the intercrystalline interstices that could otherwise result in brittleness this I already told you. So, the process is typically applied to fasteners, springs and other parts having a Rockwell hardness of 30 or higher. So, this Rockwell hardness I am not going to explain to you except that materials are measured quality of the materials are measured in terms of the hardness also has one factor ah.

There are different kinds of hardness that is Brinell hardness, Rockwell hardness etcetera and the process must be done within 1 hour of the plating process. Which process? The process of hydrogen embrittlememt relief, that process is to be done within 1 hour of the plating process.

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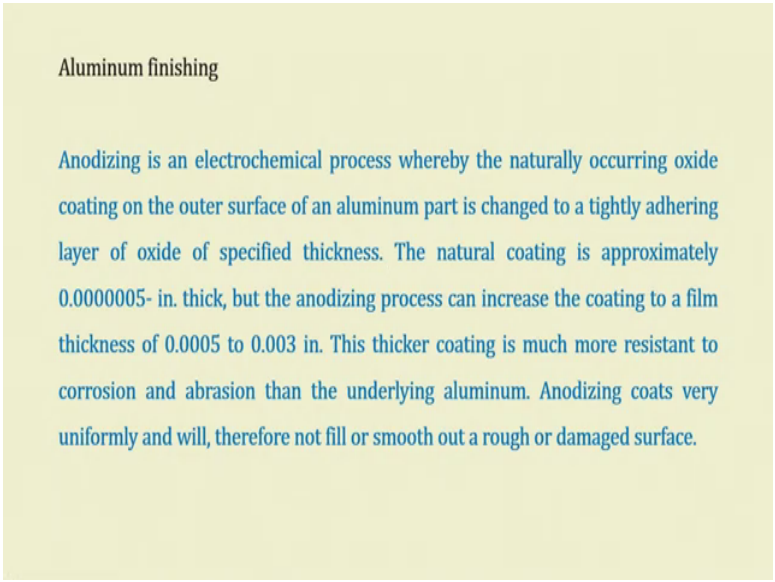


So, now let us talk a little about aluminium finishing. Anodizing is an electrochemical process whereby naturally occurring oxide coating on the outer surface of aluminium part is changed to slightly adhering layer of the oxide of specified thickness. Now, it is a very funny thing. Usually, whenever aluminium is produced know, the when you store the aluminium anywhere open to atmosphere a thin coating of aluminium oxide forms on all aluminium material ok. So, same thing is true with silver also. Wherever whenever you use a silver room item a thin coating of silver oxide is there on silver metal similarly, with aluminium. The problem is aluminium coating is fairly hard whereas, silver coating is not that hard ok.

Now, the aluminium coating can be easily damaged due to specific conditions. So, what we want to do is we want to increase the thickness of the aluminium oxide coating. Most of the time the coatings on metals are of the oxide type only. So, this oxide coating if I want to

increase a its thickness slightly more, then it is something like a coating that makes it functionally more attractive, more resistant to changes more resistant to the environment.

So, natural coating is approximately 0.000 6 0s 5 inches you can see here. This is the natural coating of aluminium inch, thick so much inch thick, but the anodizing process can increase it to 0.0005 to 0.003 inches. So, from 6 0 5 thickness to 003 is almost 1000 or 10000 times thickness. This thicker coating is much more resistant to corrosion. Very simple to imagine and abrasion that are also resistant to abrasion than the underlying aluminium that is why aluminium materials always need to be anodized or coated.

So, anodizing coats very uniformly and will therefore, not fill or smooth out a rough surface. So, this last sentence is very important for you to understand because many people have a misconception that anodizing coats are it will take care of all the problems know. Anodizing coat cannot remove a scratch it just gives a coating over that scratch also. So, it is many people think that I will get the part anodized scratch will go, scratch will not go.

So, it would not fill out smoothen out rough patch, for that we have to use mechanical smoothening operations. You can do buffing, you can do milling, you can do many other sand finishing, emery finishing and very fined finishing buffing all those things and then use the anodized anodization to give a smooth finish or a functional finish.

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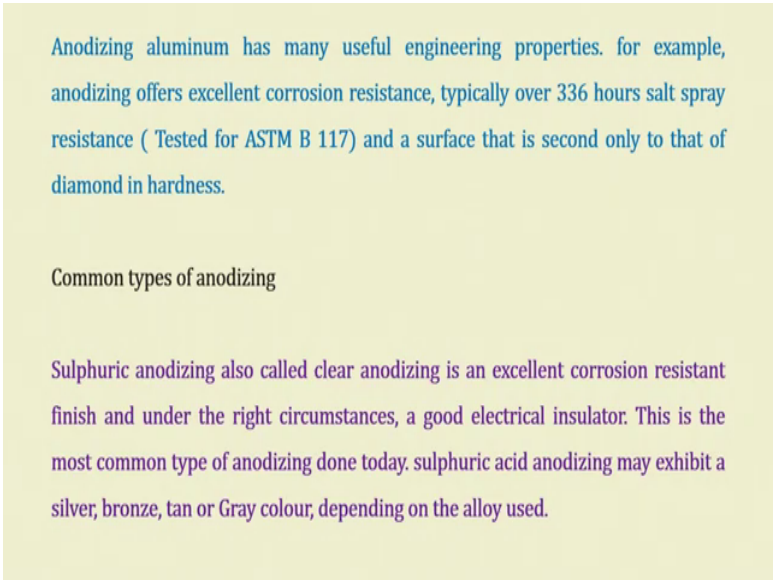


So, anodizing aluminium has many many engineering applications. They have properties related to corrosion resistance typically how do we test a substance is corrosion resistant or not. So, there are what people normally do is you take the material put it in a chamber and after you put it in a chamber, you spray the material with sodium chloride. 1 percent sodium chloride or 3 percent sodium chloride or 5 percent depending upon the specification this it is known as salt spray.

Salt spray testing there are number of standards available for salt spray testing which gives you something like an advance information on the strength of the coating. So, typically people conduct 336 hours 4 days spray or 5 days spray continuously on the coated surface to see whether any poke marks, then any corrosion points start from the sprayed material. So, those

standards one of them is ASTM B 117 and surface that is coated only to that of diamond in hardness.

So, anodizing there are common types of anodizing are there. Sulphuric acid anodizing is one part that is called as clear anodizing. It is an excellent corrosion resistant finish under right circumstances and it is a good electrical insulator most of the oxide coatings are good insulators. So, this is the most common type of anodizing done today and it is it can exhibit silvery finish, bronze finish, tan finish or gray colour depending upon the alloy you use ok.

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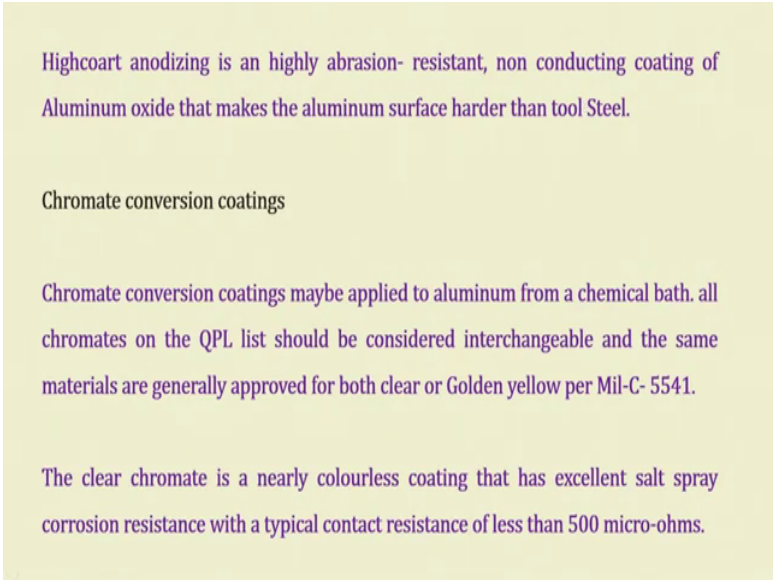


So, highcoart anodizing is again a highly abrasion resistant coating non-conducting that is always aluminium oxide only that makes the aluminium surface harder than tool steel. What is the tool steel? I do not know how many of you know about the tools. The sometimes the screw drivers and other mechanical tools which we use in our day to day life the tip is a tool

special tool and remaining metal is ordinary stay steel. So, the tip is harder than the material handle and then support material etcetera.

So, the tip is always braced or fixed to the tool so that the tip is harder and it can withstand more mechanical pressure. So, coming back to this non-coating aluminium oxide makes a the aluminium surface harder than tool steel.

Then chromate conversion coatings we had already discussed a little bit and that also can be applied to aluminium from a chemical bath. All chromates on the QPL list should be considered interchangeable and the same materials are generally approved for both clear and golden yellow colour finish corresponding to Mil-C-5541 standard.

So, clear chromate is also there it is a nearly colourless coating that has excellent salt spray corrosion resistance which is a typical contact resistance of less than 500 micro-ohms.

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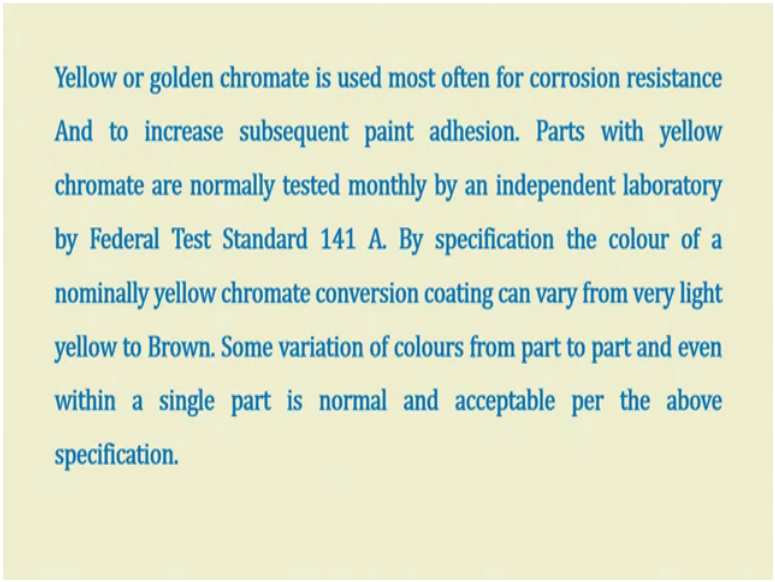


Yellow or golden chromate is most often used for corrosion resistance and it is used to increase subsequent paint adhesion. Suppose, we want to corrosion resistance of natural metal followed by if I want to paint it; paint also will adhere. Again, it will it will safeguard the metal from corrosion. So, parts with yellow chromate are normally tested monthly by independent laboratories and the Federal Test corresponding to that is 141 A. Again, you do not have to remember these numbers they have no meaning, but whenever you need something you can work on that, you can get the details.

By specification the colour of a normally nominally yellow chromate conversion coating can vary from very light yellow to brown finish. Some variation of colours happens from part to part and even within a single part there will be changes according to this standard 141 A, but they are all acceptable if the colour colours are getting mixed.

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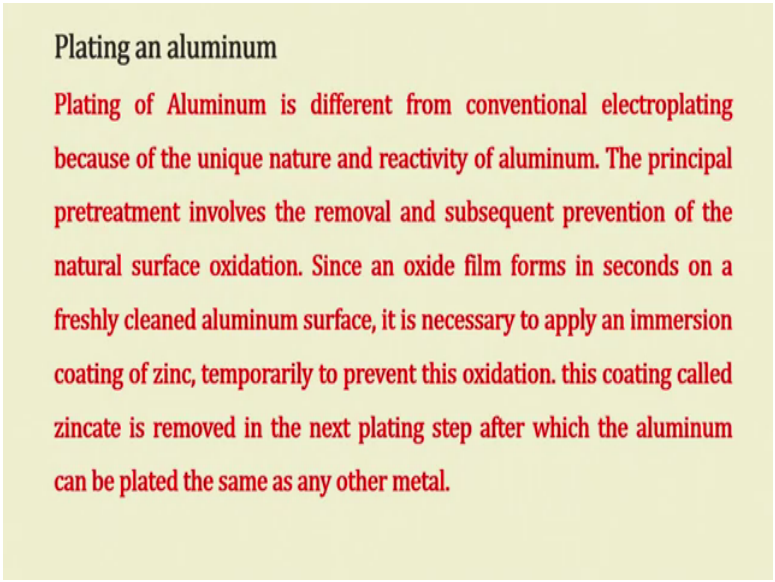


So, now we talk of plating on aluminium; not coatings, not anodization – plating. So, plating of aluminium is different from conventional electroplating because of the unique nature and reactivity of aluminium. The principle pre-treatment removes the removal and subsequent prevention of the natural surface oxidation.

Oxide film normally forms in within seconds on a freshly cleaned aluminium surface. So, it is necessary to apply immersion coating of zinc, temporarily to prevent this oxidation. It is called a zincate – sodium zincate, aluminium zincate and that is removed in the next plating step after which aluminium can be plated like any other material.

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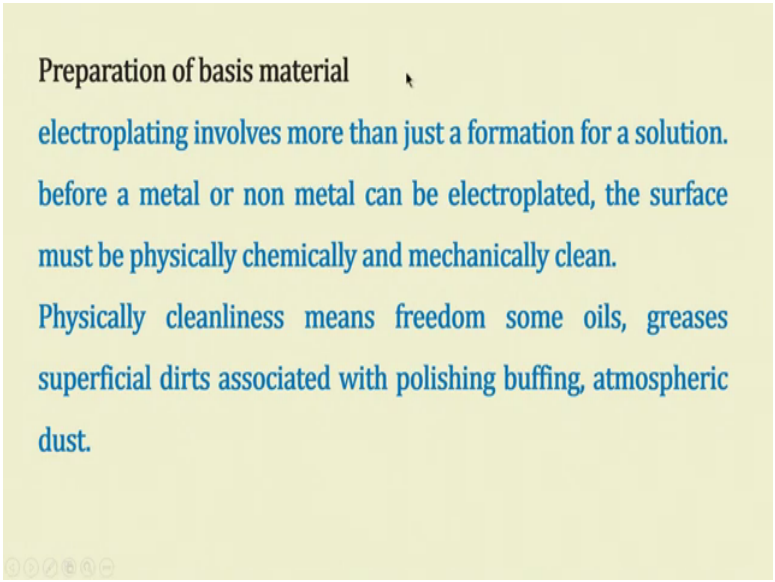


So, we will discuss about this plating aluminium plating a little more and then we will move on to other topics. I would suggest that you look up the electroplating processes in detail to get an idea of what kind of wastes are generated. For example, in most of the aluminium coatings you would always come across chromate as a contaminant. Now, many people would be wondering why chromate comes as a contaminant at all that comes from the coatings.

And now we are discussing about the plating. So, please look up all these plating processes in general. Many of them are textbook topics. Those things I have specified in the course in the beginning itself. Some of the reference books what I have already mentioned will deal with these topics.

Thank you very much. We will meet again.