Surface Engineering for Corrosion and Wear Resistance Application

Prof. Jyotsna Dutta Majumdar
Department of Metallurgical and Materials Engineering
Indian Institute of Technology, Kharagpur

Lecture – 39
Hot Dipping – I

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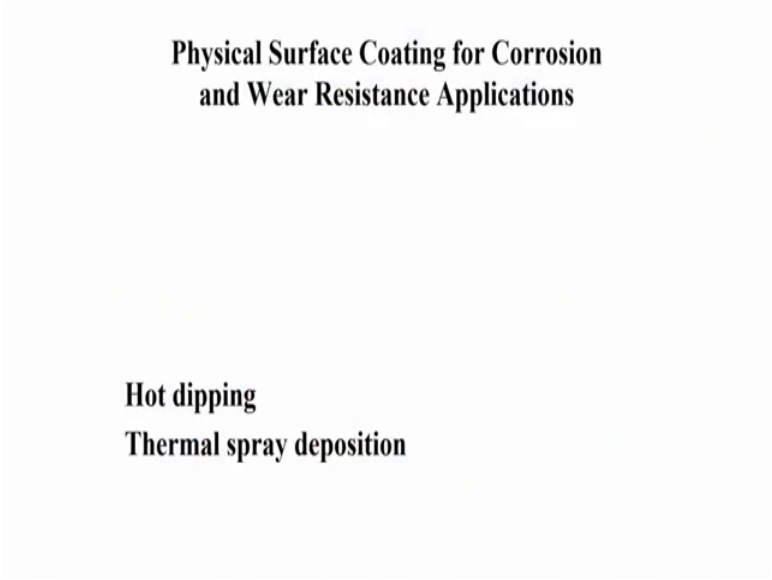

Hello, in these series of talks we will discuss about these Surface Engineering techniques for Wear and corrosion Resistance Applications which are mainly based on Hot Dipping and thermal straight position. So, this will fall under lecture number 39 to lecture number 44.

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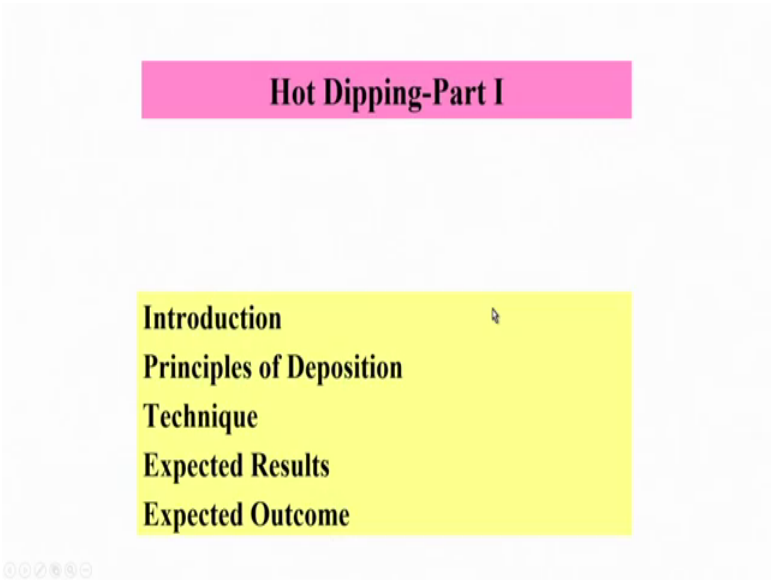

So, first going to the hot dipping process we will discuss about the little bit introduction on the hot dipping, then the principles of the deposition, the different techniques which are applied for deposition and then different outcomes which we get for different materials coated by hot dipping technique.

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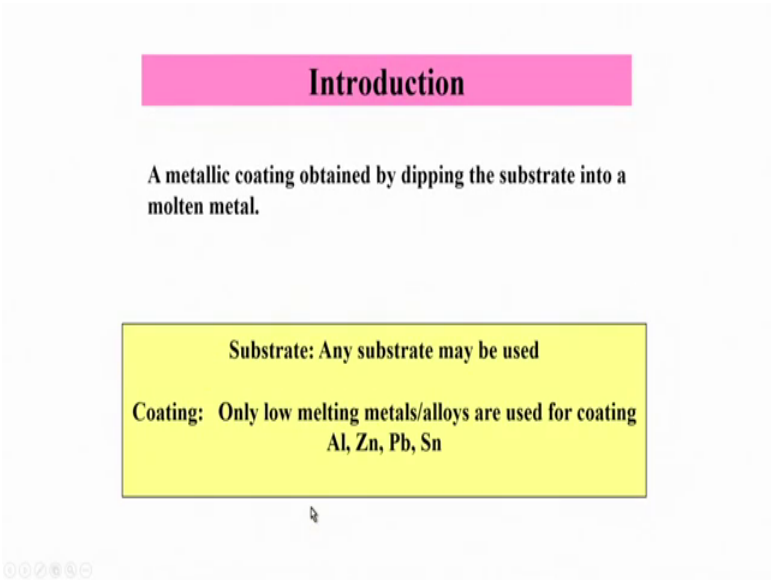

As their name implies this is here hot dipping this is nothing, but a kind of technique or may be series of techniques which are applied for development of metallic coating and obtained by dipping the substrate into the molten material which you are going to

deposit. And usually the substrate may be anything, but should have very high melting temperature and the coating should have quite low melting temperature.

And you should be aware of the fact that the melting temperature should be substrate, should be such that it should not get affected or the should not get microstructure of the substrate should not get degraded when you do coating by hot dipping technique. So, usually substrate may be steel or it may be titanium and this alloy steel or different types of steels which are available or may be that titanium and its alloys and coating may be anything like aluminum, zinc, lead, tin or their alloys which are having very low melting temperature.

So, as the alloyed or may be metal which are having low melting temperatures are low melting point they are used as coating. So, usually these hot dipping techniques are applied or this technique is specifically applied for the development of coating for either reducing the coefficient of friction or may be for corrosion resistance application, it is not really applied for hard coating which are for wear resistance applications.

So, this is the coating which is mainly applied for improving the corrosion resistance or may be the coefficient reduction of the coefficient of friction.

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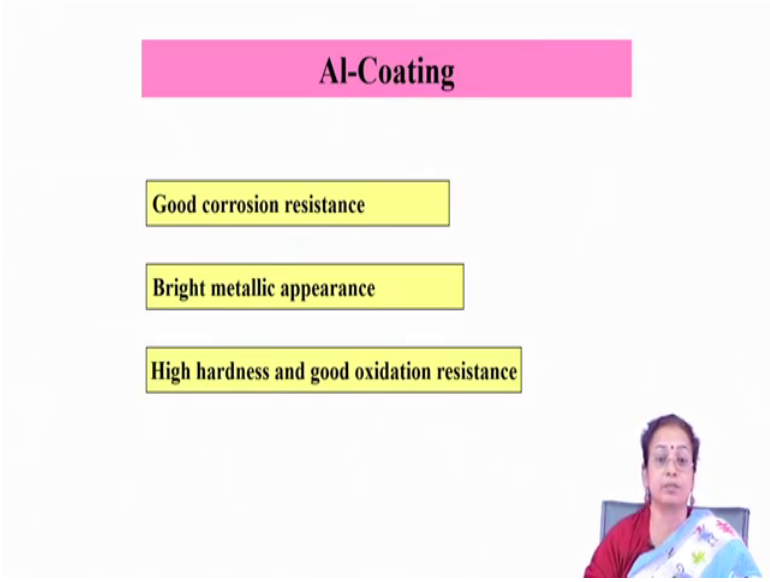

So, for we will discuss about different coatings so, as I mentioned that there are different alloys which are metal or alloys which are developed by hot dipping technique like

aluminum and its alloys zinc and its alloys lead and its alloys and tin and its alloys. So, depending on that metals are alloys those are deposited by hot dipping technique there are different names.

So, whenever you do develop the hot dipping of aluminum, then you call it as aluminizing, when you do hot dipping of zinc call it galvanizing, when you do hot dipping or plate or lead tin alloys usually pure lead is never used for hot dipping purpose because it is having very poor wettability on metallic surface. So, you use lead based alloy or lead tin alloy is different types of lead tin alloys are applied for hot dipping purpose. So, these are having different names like babbitting and depending on the alloy system which you are using.

And tin and its alloys, so tin may be tinning or tin based alloys are also used like you can call it as turn coating or may be sometimes different Babbitt alloys are also tin based for reducing the coefficient of friction. So, depending on the metal or alloys you are basically using for coating application there are different names.

So, I will discuss few of the hot dipping techniques in brief, like first one is aluminizing or aluminum coating. So, you can say it as aluminizing or hot dipping of aluminum, so basic purpose of this aluminum coating is to improve the corrosion resistance, then high temperature oxidation resistance it is having bright metallic appearance.

So, this can also be applied for improving the luster of the surface and this is also having good hardness whenever you are applying this coating on iron and steel for example, it develops very thin alumilite layer which is having high hardness. So, these alumilite can also be applied for low stress abrasion wear application and also is having very good corrosion resistance properties.

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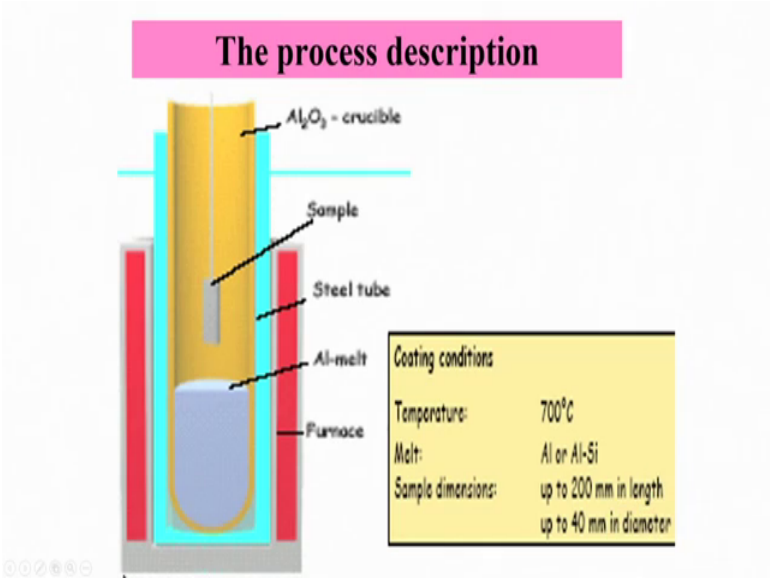

So, if you talk about hot dipping of aluminium or any hot dipping operation it is the primary requirement that your metal or substrate should be highly clean in nature. So, usually whenever you are using iron and steel as substrate, so you do different cleaning steps. For example, you may clean it by solvent degreasing technique, then by simply water rinsing you do for clearing the clean layer on the surface, if it is having lot of oxides on the surface you go for pickling operations, you can also go for sword blasting operation.

So, cleanliness is the primary requirement for the substrate. So, without cleaning you will get very poor adherence of the coating on the substrate. So, it is important that you clean i, then after the cleaning is over then you dry it properly and after that you do hot dipping operation. So, as hot dipping is carried out in normal environment and all metals and alloys which are used for hot dipping there are in molten state.

So, there is a possibilities that there are oxidation of the molten materials either when they are used for coating purpose or for in the substrate is coated by the molten material when you take it out. So, in all cases there are a lot of chances of the oxidation of the material as well as substrate. In order to avoid the oxidation problem usually people do apply fluxing.

So, fluxing can be acquired by two ways; one is you just cover the molten metal surface with chucks granules. So, usually for as fluxing you use different types of fluoride salt or

salt mixture. So, you can use it in the form of granules on the surface of the molten metal or otherwise you can also use molten flux and then coat it on the surface of the substrate, you dry it properly prior to the hot dipping operation.

So, in one case where you use the molten flux granules on the surface of the molten metal you just do the operation by one step processing, so it is called one step hot dipping or one pot hot dipping. But whenever you do apply a coating of molten salt or molten flux on the surface of the substrate cure it and then subsequently use it as substrate for hot dipping operation you call it as two step hot dipping process. So, hot dipping may be by single step or may be by two steps.

So, single step operation is easy to operate because here your molting temperature is around it depends on the molting temperature of the alloy were which alloy your using, if it is pure alloy it may be 700 to 725 degree Celsius and if it is aluminium usually little bit of silicon is used for hot dipping operation because silicon improves the fluidity. So, if you have a little bit of silicon depending on a silicon percentage your hot dip molten temperature molten metal temperature varies.

So, if it is for example, 0.1 to 0.2 percent, it is around 700 to 725 degree Celsius, but if it is increased to 6 to 7 percent, then it is having the lower reduce melting temperature. So, depending on the alloy you are using the melting temperature also varies, but melting temperature should be around 50 to 60 degree or may be the temperature of the hot dipped pot should be 50 to 60 degree above that of the melting temperature of the material, so that you have enough fluidity in the molten state.

So, whenever it is usually it is carried out in normal environment, so you have the possibility of you have the requirement of the covering the surface by flux granules. So, you basically take the pet furnace where you just take the molten, take the alloy in molten state cover it up with flux granules and then you dip the component.

Usually, there is a wear with the help of which you just a roller with the help of which you feed the metal in the form of concept component, final shape component or it may be if it is in the form of semi fabricated state like wear or may be pets, then if there may be the possibility of continuous feeding.

So, there you can have this particular dipping by batch processes or may be by continuous processes. So, accordingly you have to have the arrangement. So, you just dip it and then after the dipping is over you just keep it for 2 to 3 minutes and take it out and you dry it properly. Usually, you have the possibility of cooling it with the help of the air jet cooling air jet cooling arrangement.

So, you can have this arrangement in the furnace or you can take it out and then clean it outside. And then after this aluminizing is over you go for post aluminizing annealing operation.

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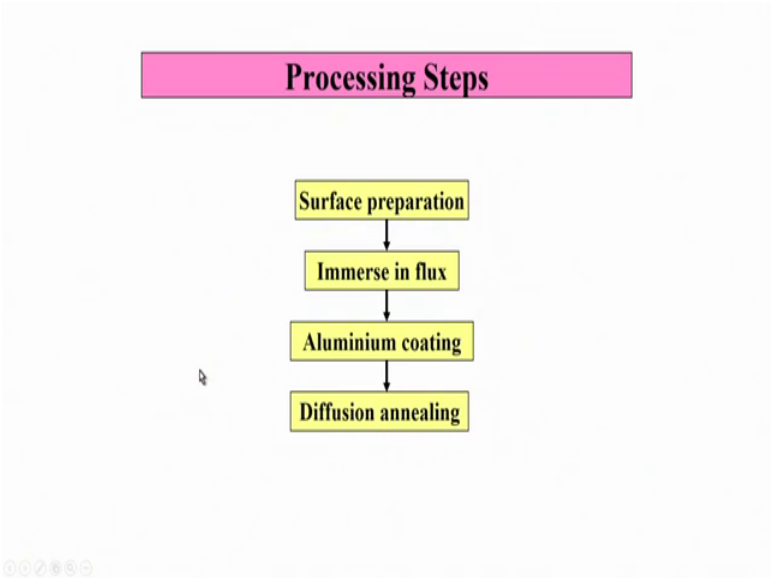

So, this is about the one step process and in two step process what you do is that you prepare the surface and then you immerse it in flux molten flux, then you go for this particular deposition dipping operation and then go for the final annealing. So, these are there two different processes. So, one step processes are having certain advantage, one step process is having several advantages like this is very quick process.

And in this process there is a no possibility of you do not need to have the flux coating operation, so you just dip it and take it out. So, when you take it out then the flux granules also acts as a kind of scavengers. So, it takes out the extra oxides or slacks which are forming on the surface and also it maintains to control the thickness of the coating which is developed onto the surface of the substrate and these are the advantages of the one step processing, over that of the two step processing.

On the other hand two step processing if you use then there is less chance of contamination because you do flux you do immerse in the flux prior to immersion in the molten metal. So, when you as soon as you immerse it in molten metal, the flux is no more on the surface it gets dispersed on the surface of the molten metal. So, when you take out again there is not much possibility of the immerse of the flux inside the coating.

So, the each and every operation is having its advantages and disadvantages. For continuous processing that this particular two step processing is superior to that of or it is having certain advantages over that of one step processing.

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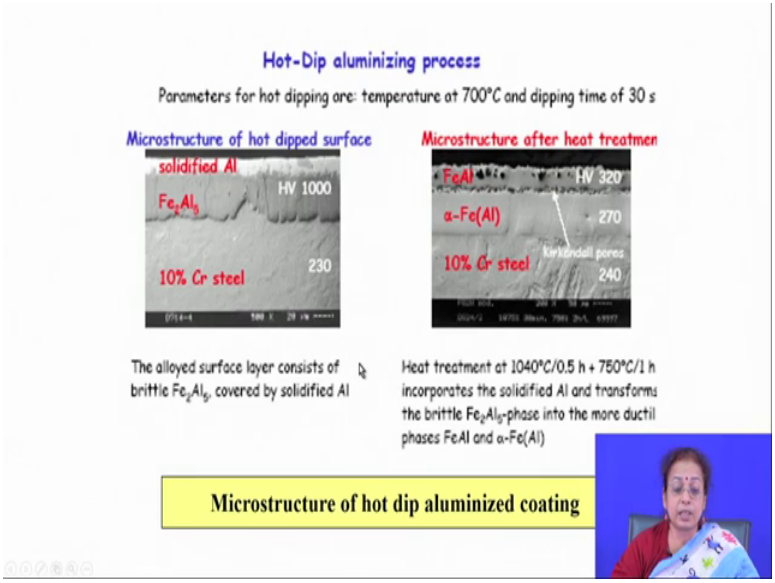

So, once you have the aluminum coating you get this kind of microstructure. So, when you talk about the coating the microstructure of the interface is very important because interface gives the overall behavior of the or from the interface only get information about the overall behavior of the coating, whenever it is subjected to any kind of environment, may be the corrosive environment or may be the mechanical environment.

So, whichever environment the component is subjected to environment plays a very important role. For example, if there are defects in the cross section plays a very defects in the cross section. So, in that case certainly you will find that whenever it is exposed to corrosive environment there will be ingress of the corrosive fluid or may be the oxygen through that defects and then there is formation of the oxide layer or corrosive layer on the surface.

So, on the other hand if you talk about different types of wear if the interface is not strong. So, in that case there is also chance or possibilities of failure of the components from the interface. So, interface plays a very important role, so whenever you talk about coating you should see the interface very carefully.

So, interfacial observation wins interface micro structure, interface composition distribution, the defect density throughout the interface from the surface towards the interface these all things play a very important role in determining the micro determining the behavior of the quoted material.

So, here also if you see the interface you will find that on the surface there is solidified aluminum layer below the surface there is formation of this intermetallics Fe 2 Al 5. So, these intimate lakes is very much prone to form because if you see different intermetallics in iron aluminum system the Fe 2 Al 5 is having the lowest free energy of formation. So, whenever you just deep it inside the molten metal you will find that there is dissolution of iron from the interface towards the molten aluminum and at the near interface region there is formation of Fe 2 Al 5 phase.

So, this phase is having very high hardness because this is intermetallics, but problem is that this particular phase is highly brittle in nature. So, if you keep it for a long time after this coating is over in normal environment you will find that there will be fine crack formation because of lot of stress development at the interface and also because of its high level of brittleness in nature.

So, usually what people do is that after this is over then they go for the heat treatment operation. So, the basic purpose of heat treatment is to homogenize the structure and also relieve the stress. So, the kind of heat treatment operation people do follow is nothing, but this two step heat treatment; heat treatment at 1040 degree Celsius for 0.5 hours and then at 750 degree Celsius for 1 hour.

So, if you have these kind of heat treatments, then when do you heat treatment naturally there will be that diffusion of the aluminium from the Fe 2 Al 5 towards the steel as well as from the aluminum to upper aluminium layer to the Fe 2 Al 5.

So, finally, you will find that there will be formation of three different layer the top layer consisting of Fe Al, then the intermediate layer which is nothing, but consisting of alpha

Fe with aluminium in solution and bottom layer is the nothing may be a little bit of aluminum may be they are in iron in the form of solution.

So, these are different layers and if you see the hardness distribution it is highly reduced hardness, the earlier case it was 1000 HV chain the top layer hardness and aluminium hardness will be around 660 around 30 to 36 HV chain. But on the other hand if you have this kind of microstructure, then you will have top layer hardness of 320 HV chain and then 270 HV chain which is nothing, but the hardness of iron with aluminium in solution and bottom layer is the hardness of the steel actually.

But here you will also get a lot of porosity kirkendall porosities because of the diffusion of the aluminum from Fe 2 Al 5 to solidified aluminium or iron in the from aluminum to iron Fe 2 Al 5 or may be from iron diffusion of iron from this side to the upper side because of the chemical potential difference.

So, top layer or interface between the top and middle layer will have several porosities. So, which you can discard or by machining operation, but in between you will have alpha with aluminum in solution. So, this particular phase when is formed then naturally you will find that it is no more brittle as was there earlier.

So, this particular microstructure is very much desirable because it improves the corrosion resistance particularly high temperature oxidation resistance to a large extent and basic purpose of aluminizing is to improve the high temperature oxidation resistance property.

So, whenever you expose the component in high temperatures specially when it is subjected to cyclic operation like cyclic change in temperature. So, heating and cooling in cyclic environment in thermal cyclic environment, the stress level that residual stress or may be fatigue poor fatigue property is one of the biggest trouble that the component faces or damaged due to fatigue because of thermal cycling. So, these kind of layer when is there, so even if it is subjected to thermal cycling it does not fail because it is not having so much bitterness as was there earlier for Fe 2 Al 5 case.

On the other hand because of presence of aluminium in solution whenever it is exposed to high temperature there is formation of very thin alumina layer which protects the surface from oxidation high temperature oxidation particularly. So, this is a hot dip

aluminizing process, so one step hot dipping is not adequate for the desired properties to be achieved on the surface you have to go for two step processing like first step hot dipping and then you have to go for a annealing operation. So, that you end up with a microstructure where aluminum is in the form of solution.

So, because of aluminium in the form of solution whenever it is exposed to high temperature thermal cyclic environment there this there is alumina layer formation which protects the surface from oxidation and also as this layer is not. So, brittle it does not fail in surface.

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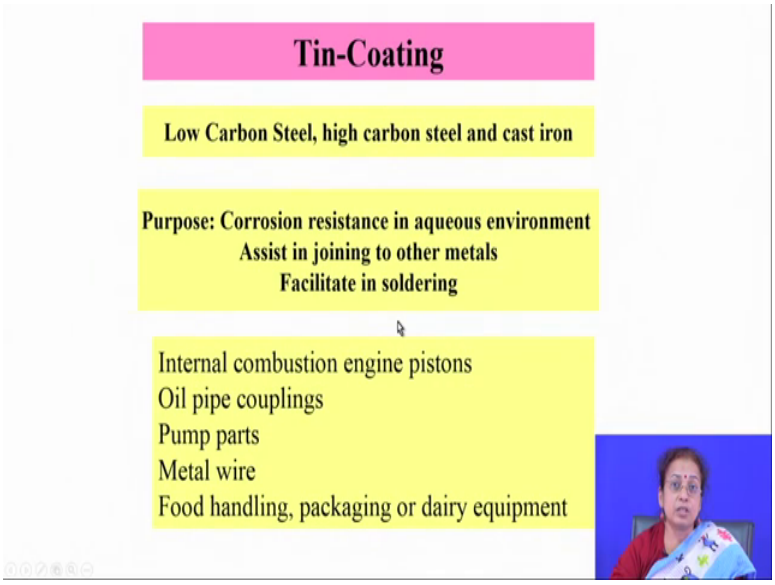

So, this is aluminizing process, so a second type of second kind of treatment which you can do also that is tin coating by hot dipping process. So, tin coating is a very important kind of coating which is having large applications particularly in food and beverage sectors, where you have lot of food cans which is which are basically coated with tin because tin is non toxic in nature and it is also having very good resistance to corrosion in aqueous environment particularly water containing environment.

So, usually low carbon steel, high carbon steel and cast iron also subjected to tin coating. Tin coating can also be applied for reducing the coefficient of friction, it can also be applied for the soldering application for as if a kind of method for soldering purpose you do tin coating and then do soldering operation.

So, naturally you need not apply tin in the form of seat or in the form of plate. So, the purposes are like corrosion resistance in aqueous environment assist in joining of two metals and facilitated soldering, it can also be used for reducing the coefficient of friction. So, usually this is applied for internal combustion engine pistons, oil pipe coupling, pump parts, metal wires and mostly when you talk about corrosion resistance application this is in food handling, packaging or dairy equipment.

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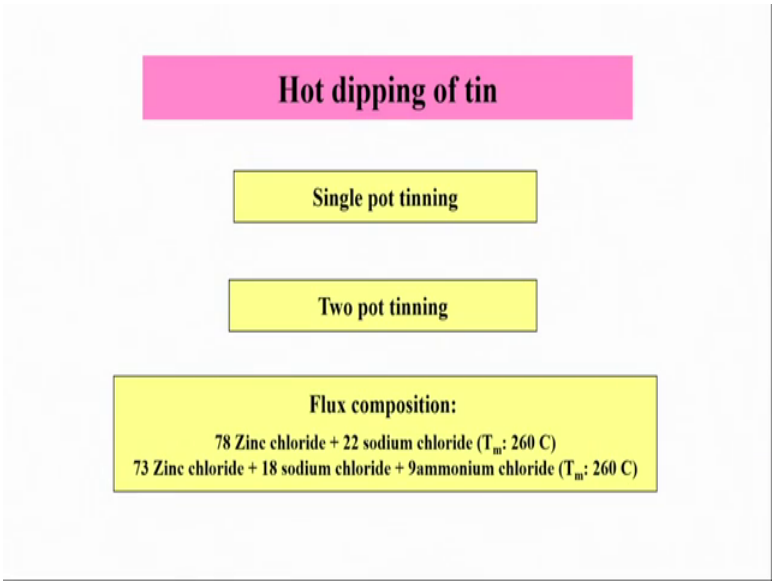

So, like in aluminum that tin coating can also be applied by two way; one is single pot tinning another one is two pot tinning. So, when you do apply tin coating, so there is not much intermetallic phase formation, so tin is there as pure form on the surface. So, usually there is no need for any further heat treatment operation. So, usually again flux whereas, a flux you use zinc chloride sodium chloride mixture it is having the melting temperature of 260degree Celsius. So, you can also add a little bit of ammonium chloride.

So, these two fluxes are mostly applied for all hot dipping operation because they are having very low melting temperature and they are easy to handle and you can do kind of you can use those pellets on the surface of molten metal as well as you can coat the surface of the component with these particular fluxes. So, now whenever you talk about the hot dipping process there are also several other parallel techniques which you should know.

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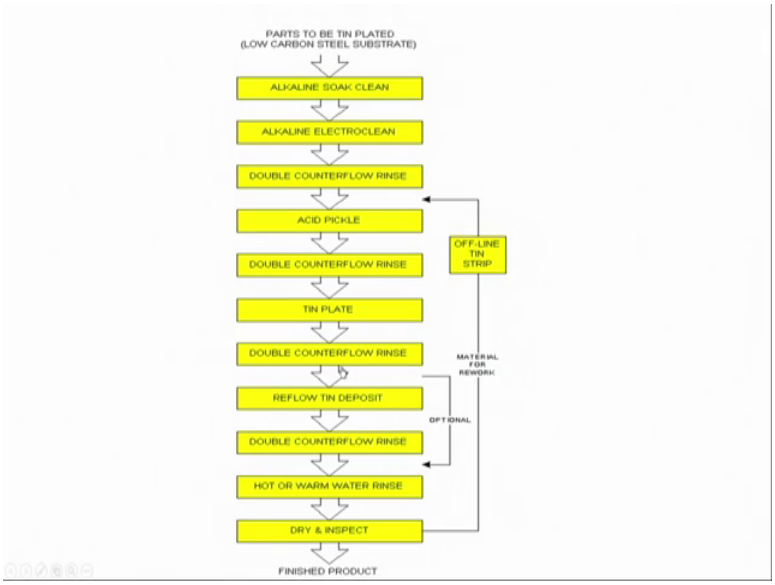

So, similarly tin coating also if you talk about parallel techniques; parallel techniques are for example, electro deposition of tin. So, electro deposition is also often applied and prefer to hot dipping process because after hot dipping you have to go for machining operation as they are hot dip layer is basically the molten and cast layer more melt and cast layer. So, this is having lot of a roughness surface finish is not so good, so you have to go for the finishing operation.

On the other hand if you go for electro deposition process you get highly mirror polished surface and naturally the thickness can be as low as you wish. So, for particularly for corrosion resistance application the electro deposition is the preferred technique to this typical hot dipping operation. So, here also as I mentioned in the case of aluminizing in tinning also it is very important that whichever technique you use either hot dipping or electro deposition you go for cleaning operation very nicely.

So, usually there are several steps of cleaning you do alkaline soak cleaning and then you just you can go for electro cleaning by using it as anode and then you can use that double counter low that rinsing operation, then if you there are a lot of surface oxide layer you can go for acid pickling and then you go for plating operation.

So, then again you go on rinsing and then you take out go for that hot or warm water rinsing and finally, in as I mentioned you that in electro deposition in hot dipping process you do not need to go for further heat treatment, but if you talk about electro deposition

you need to go for subsequent heat treatment because in all electro deposition process there is chance of hydrogen pickup from the solution.

So, you have to take out the hydrogen or moisture content which are there on the surface by typical baking operation, see usually 200 to 250 degree Celsius temperature heating is done. So, at this temperature you take out the water from the environment from the surface and make it completely hydrogen free if at all there is any chance of ingress of hydrogen.

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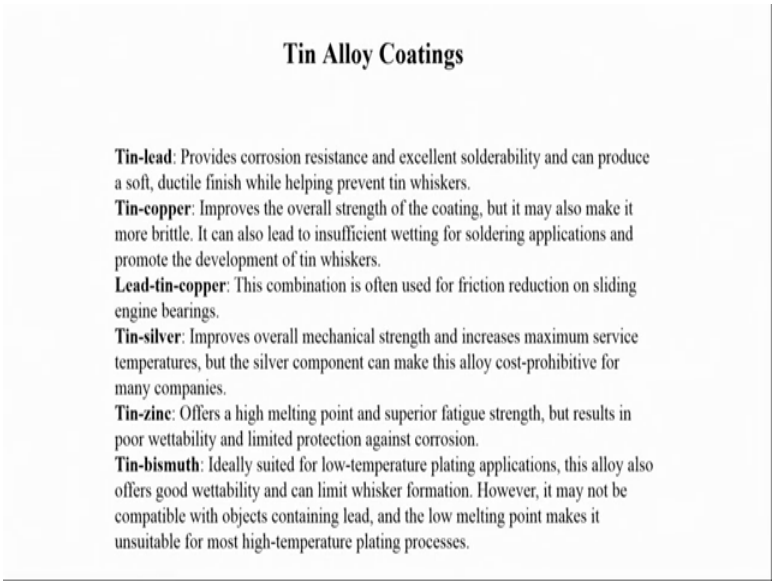

So, apart from this tin is used in pure form for different applications as I mentioned you can be used for corrosion resistance aqueous corrosion resistance application as cans and cans for food and beverages, can also be used for anti friction property enhancement, it can also be used for typical soldering as a base for soldering application.

So, apart from tin there are also different other alloys tin based alloys which are used for coating like tin lead alloy it provides corrosion resistance and excellent solderability and can produce a soft ductile and finish layer which basically helps preventing the tin whisker. One of the biggest for development of tin coating by electro deposition is by whisker is tin whisker formation.

So, what happens is that if there is surface roughness, so in their rougher point there is charge accumulation and as a result of which you will find that gradually the amount of

coating which is deposited in that particular point is much higher than that of other points and as a result of which there is a very thin whisker formation.

And that whisker goes on developing as the coating processes or coating progresses. So, two tin whisker is one of the biggest problems associated with electro deposition of tin. So, usually you have to go for machining operation to get rid of the tin whiskers, but if you have tin lead alloy then naturally there is less chance of whisker formation.

Tin copper is an alloy which improves the strength actually, but it can be brittle as well and it can also lead to insufficient waiting for soldering application and promote the development of the tin whisker. Lead tin copper alloy this combination is often used for friction reduction on sliding engine bearings. Tin silver improves the overall mechanical strength and increases the maximum service temperature, but silver component can make the alloy cost prohibitive for many components.

Tin zinc is another kind of coating which offers high melting point and superior fatigue strength, but is having poor wettability again and limited protection against corrosion. Tin bismuth is another alloy this is for low temperature plating application is very much suitable alloy and it can improve that it can have better wettability and can limit whisker formation, but it may not be compatible with objects containing lead and low melting point makes it unsuitable for most high temperature plating processes.

So, these are different tin based alloys which are also subjected to hot dipping operation and also by electro deposition, but hot dipping is refer to electro deposition because in hot dipping if you do, then you can directly get the alloy (Refer Time: 27:01) tin and subsequently go the deposition. But on the other hand if it is electro deposition, you have to go for optimization of parameters in order to get the desired stoichiometry of the alloy on their surface.

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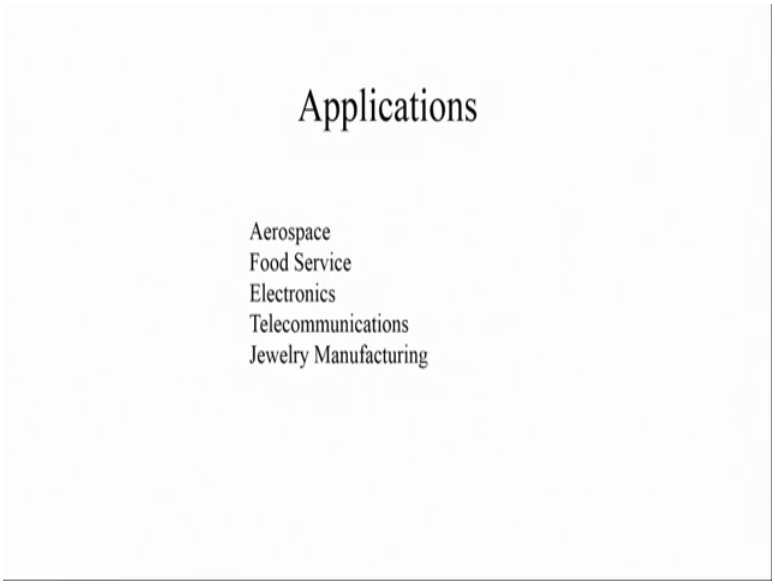

So, as I mentioned tin fitting is having several applications in aerospace, food services, electronics, telecommunications and for jewelry manufacturing.

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These are some of the applications where thin coating has been applied for that typical food containers which is where you will find that the coating looks coating surface looks highly glazy and back appearance, you can also have the screws and then big beverage containers coated with tin.

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And then you can also have the steel coils that coils of the steel made of the wires of the steel made of the tin coating, so the screws made of tin coating.

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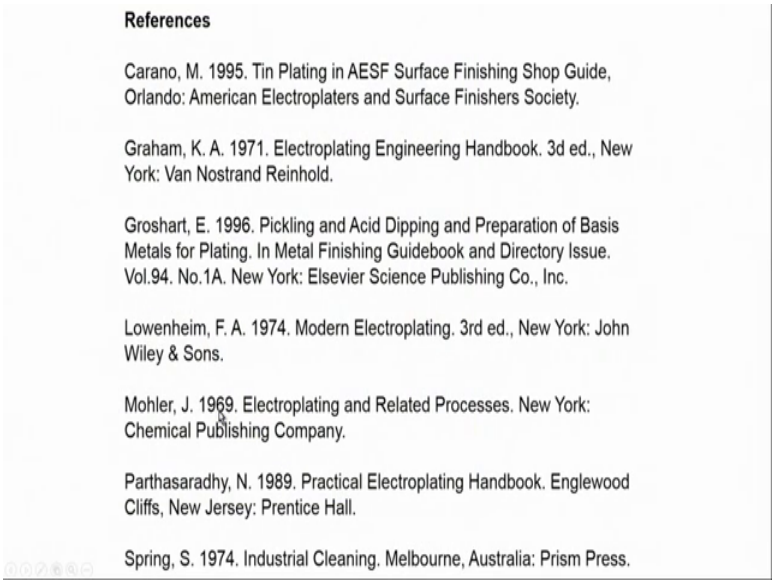

References

Carano, M. 1995. Tin Plating in AESF Surface Finishing Shop Guide, Orlando: American Electroplaters and Surface Finishers Society.

Graham, K. A. 1971. Electroplating Engineering Handbook. 3d ed., New York: Van Nostrand Reinhold.

Groshart, E. 1996. Pickling and Acid Dipping and Preparation of Basis Metals for Plating. In Metal Finishing Guidebook and Directory Issue. Vol.94. No.1A. New York: Elsevier Science Publishing Co., Inc.

Lowenheim, F. A. 1974. Modern Electroplating. 3rd ed., New York: John Wiley & Sons.

Mohler, J. 1969. Electroplating and Related Processes. New York: Chemical Publishing Company.

Parthasaradhy, N. 1989. Practical Electroplating Handbook. Englewood Cliffs, New Jersey: Prentice Hall.

Spring, S. 1974. Industrial Cleaning. Melbourne, Australia: Prism Press.

So, these are different applications of the tin coatings and these are the different references where details on tin plating's are also given.

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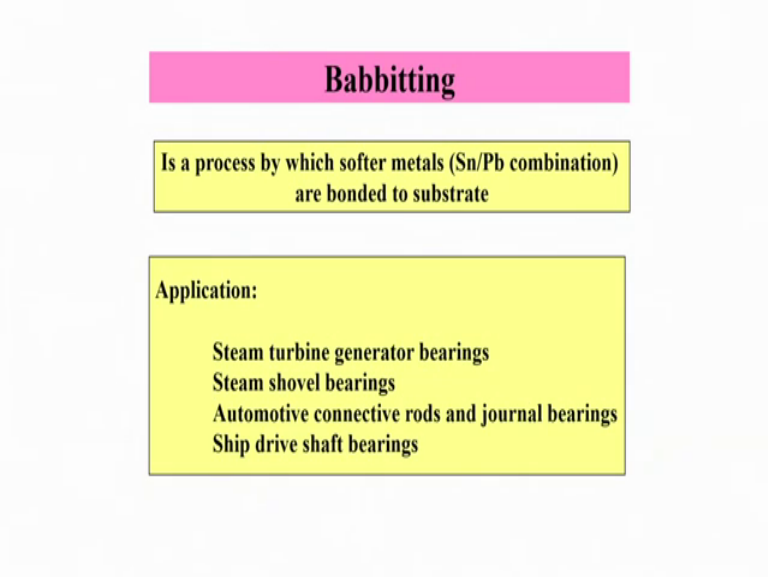

So, next I will discuss about babbitting technique which is nothing, but again tin based alloy. So, there are different babbitting alloys which are applied, but the basic purpose of babbitting is that not really to improve the corrosion resistance because usually you use lead in this tin alloy and when lead present naturally it is not really non toxic as pure tin and its corrosion resistance also decreases to a little extent.

So, it is means mostly applied for improving the anti friction property or to deduce their coefficient of friction. So, the typical applications include steam turbine generator bearings, then shovel bearings, automotive connecting rods and journal bearings and ship drive shaft bearing.

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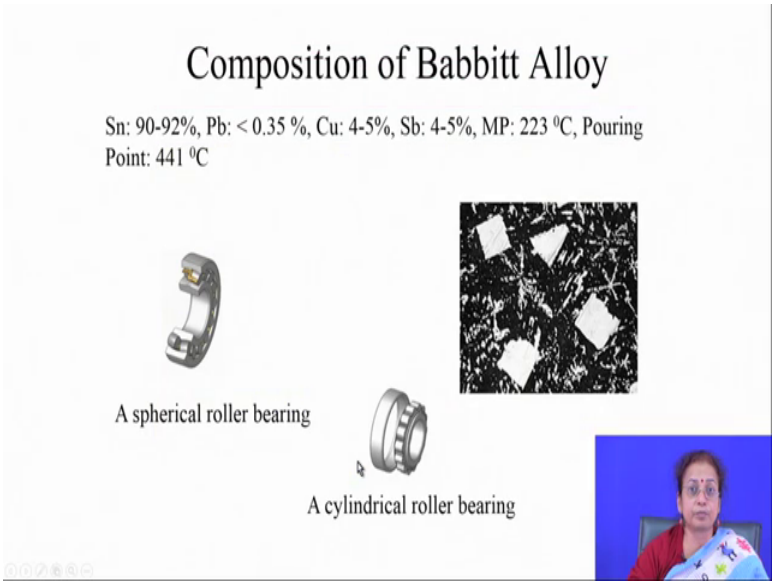

So, these are different bearings coated with thin lead alloy that difficulty babbitting babbitt alloys. So, as I mentioned you that typical compositions have a little bit of plate, so this is typical 90 to 92 percent tin less than 0.35 percent lead, copper 4 to 5 percent, antimony 4 to 5 percent, melting point is quite low 225 degree Celsius and pouring point naturally 441 degrees Celsius much higher than that of melting point.

So, in the microstructure you get different intermetallics of the lead tin alloy and the structure is quite good and defect free when you do hot dipping operation and this is typical solidified structure. So, you get lot of dendrites in the microstructure so, but interface is quite strong there is no problem in the interface.

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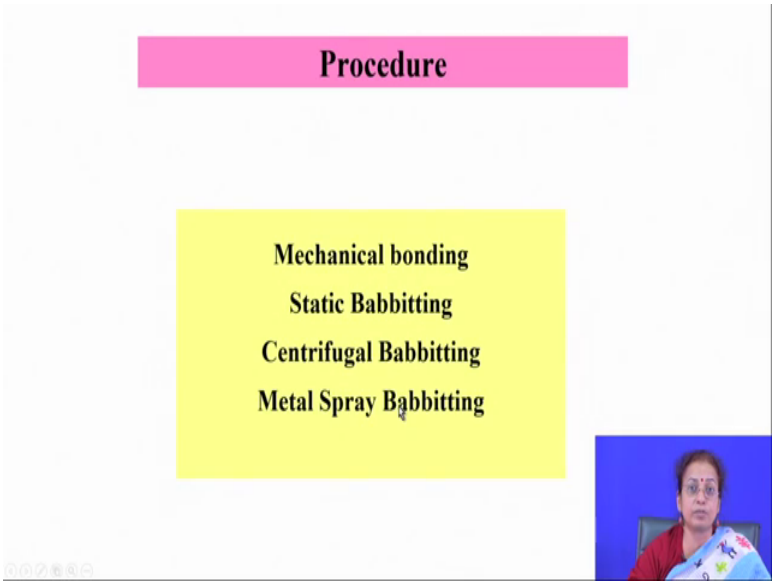

If you talk about the parallel processing of the babbitting, then there are several ways by which you can do babbitting as it is alloy, so people do not prefer to go for electro deposition, but they go for mechanical bonding, then static babbitting, then centrifugal babbitting, then metal spray babbitting these are their different parallel processes which people do apply.

So, in mechanical bonding they just have the seat of the tin lead that babbitt alloy and they just wrap the component surface with this seat and then apply mechanical loading. So, you will find at the interface very strong bonding is forming which is nothing, but typically of mechanical interlocking in nature. In static babbitting you simply do hot dipping operation do just dip it in babbitt alloy take it out.

In centrifugal babbitting you can basically control the thickness of the babbitt layer you have where you have the centrifugal rotation in the of the component or may be of the alloy which is in molten state, usually component is having the if its always better prefer to have the centrifugal motion in the component. So, you have that advantage of this thing and metal spray babbitting is another kind of babbitting where you can do babbitting by spraying it.

So, what do you do is that you have that usually there are different ways why you do by which you can do spraying, one of the important way by which you can do spraying is by

thermal spraying. So, in thermal spraying you can go for their different ways by which you can do thermal spraying.

So, one of the biggest we will be discussing these are thermal spraying techniques in details later, but you go for frame spraying operation for babbitting purpose which is very important to a very easy way of spraying by babbitting.

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And so these are the parallel techniques, so another alloy which is basically used for a hot dipping operation is nothing, but terne coating that is again lead alloy with 2 to 25 percent tin. So, this is lead based alloy, so and this is lead based alloys, so basic purposes mainly for improving the anti friction property and tin is quite high. So, tin has to be used because the otherwise lead is having very poor wettability.

So, this is mainly lead base, but you use 2 to 25 percent tin, this is used for in transportation industry, electrical appliance industry, then building industry like gasoline tanks, trucks and tractors, then radiated parts, valve covers and oil filters, oil filter cans, then chassis for radios, television and tape recorders and roofing, siding, flashing the fire doors these all there all you have the possibility of application of the this particular terne coating.

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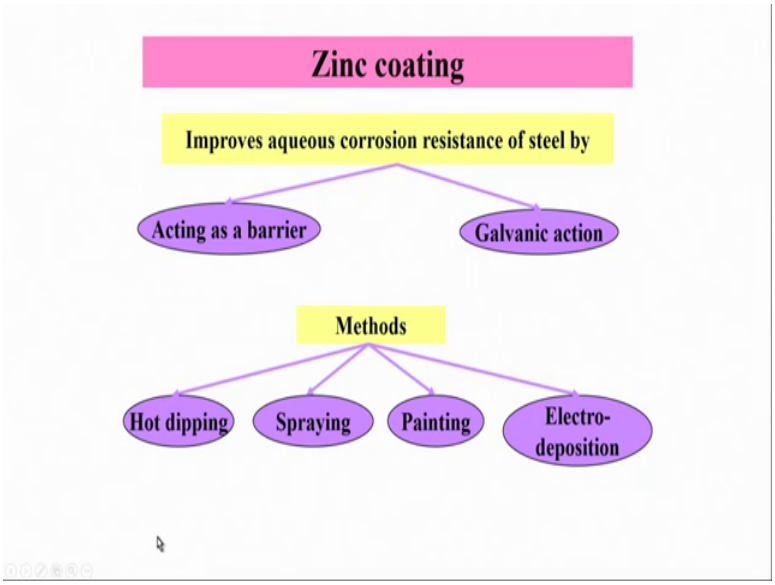

And finally, the biggest industry of hot dipping is for zinc coating, so you got to tell it as hot dip galvanizing. So, zinc coating basically zinc coating is very much applied for protecting against the corrosion resistance.

So, here zinc coating when you do apply zinc offers corrosion resistance properties by two ways; one is by barrier coating by acting as barrier coating whenever there is a very thin zinc layer on the surface of steel, usually it acts as a barrier to corrosion and also it saves the component surface by sacrificial action or by galvanic action when there is any defects in the coated layer.

So, zinc coating is preferred to tin coating for that purpose because it saves the component surface by two ways, but tin only saves the surface by acting as barrier coating. So, zinc coating whenever you talk about the zinc coating that you will find mostly they do apply hot dip galvanizing or hot dipping operation for zinc coating. So, now, if you talk about the parallel techniques; parallel techniques are electro deposition, spraying, painting these are all parallel techniques.

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So, we will discuss about these all techniques in the next talk, but before that I would like to say some of the typical applications of the galvanizing like this is the typical long pipe lines which are galvanized by zinc coating. Similarly, railway trucks they are also kept in the environment after zinc cutting zinc coatings. So, you will find that they are quite they are non corroded as there is no signature of the corrosion.

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It can be you can laid down in the environment for a long period of time. Then this is valuable iron fittings, they are also that pipeline assembly then they are also zinc coated

quite often and again these are cylindrical components made of zinc coating and then seamless pipes they are zinc coated.

So, zinc coating offers the corrosion resistance property particularly when you are looking for the general corrosion resistance property in normal environment where there is not much humidities or temperature is also not really so high and on top of that you can also have a very thin painting layer. So, that it offers further resistance to oxidation.

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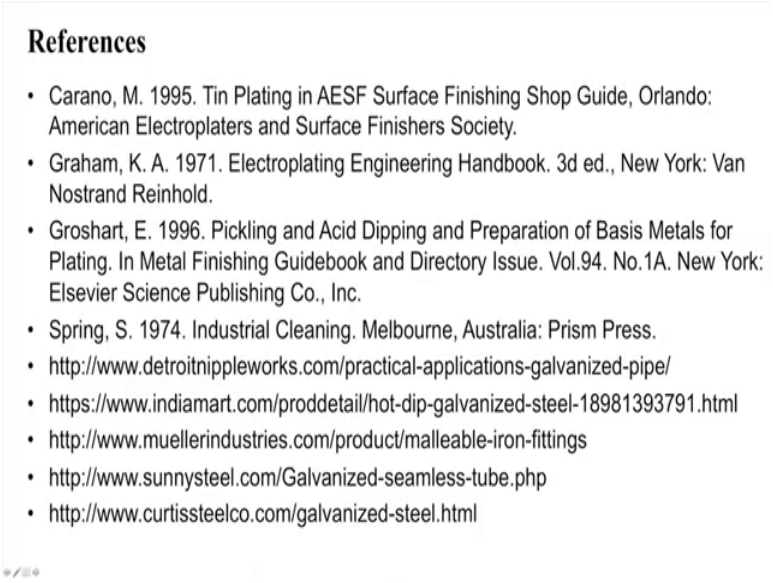

Thank you very much.