Surface Engineering of Nanomaterials

Dr. Kaushik Pal
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

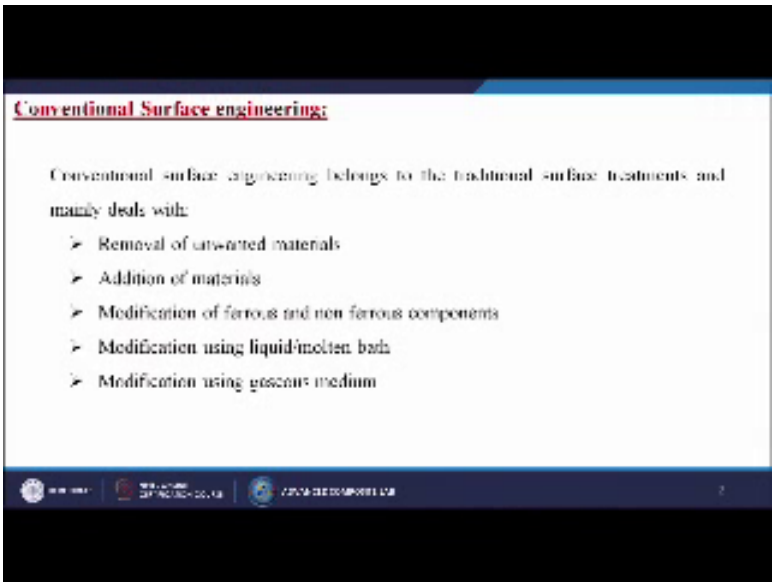
Lecture - 06
Conventional Surface Engineering

Hello, today we are going to start our next lecture which is known as the Conventional Surface Engineering. So, as I told in to the last lecture that there are two methods by which we can do the surface engineering applications or may be surface engineering process - one is called the conventional, another one is called the nonconventional. So, now, in this particular slide we are going to discuss about the conventional surface engineering

So, first we will start that what is conventional surface engineering. Actually the conventional surface engineering is the traditional process or may be you can say some kind of old method which is coming since long back and nowadays also we are following.

Next we will discuss about the nonconventional surface engineering too, which we will do by using some kind of sophisticated machines, some kind of sophisticated techniques which we cannot adopt as easily, but in this particular chapter we are going to deal with the conventional surface engineering process. So, before going to start that what is the process what is the definitions of that particular process or may be how many types are there. Before going to start first we have to know that why we are doing that conventional surface engineering process.

(Refer Slide Time: 01:39)



So, conventional surface engineering process generally we are doing to removal of some dust particles or may be some kind of contaminant or may be some kind of impurities from the metal surface. Again we can add certain kind of materials; that means, by adding some kind of materials in terms of coating or may be in terms of any kind of implantations or may be in terms of any kind of layer we can add certain materials on to the surface of the base metals.

Then we can do the modifications of the ferrous and non-ferrous components. As we know rusting which is the biggest problem for any iron material, so that iron material if I keep longer time into the environment that can react with the environmental oxygen and iron oxide can be formed which is totally a different phase then the iron and which we cannot use for longer time and that is a wastage of the material. So, by these techniques by conventional surface engineering we can make the anticorrosion materials or may be anti oxidation materials or may be top of that we can do certain kind of layers, so that the material can be shaped.

Next, modifications using liquid or molten bath - simply in the next substituent slide will see all this methods into brief, maybe will go into that depth. So, here simply we can dip our material into some bath or may be some kind of liquid medium and after that we can take out the sample, so that a coating of layer can be formed on that particular material by which we can do the surface engineering.

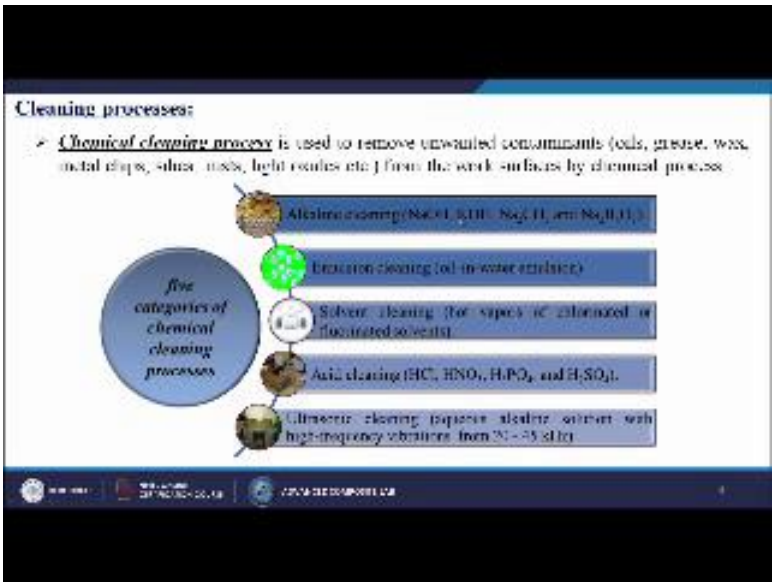
And the last one is called the modification using gaseous medium. So, simply we are putting our material into some gaseous mediums by which that gas can react at the outer surface of the particular materials and it can form any kind of coatings or maybe layers or may be barriers, so that the material will not directly come into the contact with the environment. So, by doing this kind of techniques we can do the conventional surface engineering. First we have to know what are the methods by which we can remove the unwanted materials on the surface of any material.

(Refer Slide Time: 04:10)

So, there are several methods. So, first surface engineering by removal of material it is divided into six basic types - first one is known as the cleaning, then pickling, etching, grinding, polishing and the buffing. Next slide will go each and each into detail.

So, first one is known as the cleaning. So, from the name itself we can understand that we have to clean the material, so that its outer surface can be cleaned or maybe any particles has been stick with the outer surface of that particular material or maybe can attach or maybe can deposit on to that substrate or maybe that material surface. Simply by cleaning process we can remove those unwanted particles or maybe the impurities or maybe any kind of hazardous materials too.

(Refer Slide Time: 05:02)



So, cleaning there are generally five categories of cleaning process are there - first one is called the alkaline cleaning. So, simple we are putting that material into some alkaline solutions, so that there is some kind of reaction with base materials, so what will happen? Due to the chemical reaction between best solutions and substrate the surface of substrate will be modified.

Next, emulsion cleaning, so we can dip the material into some oil and water medium so that the outer surface can be cleaned. Next is called the solvent cleaning hot vapors of chlorinated or fluorinated solvents. So, first we are creating some kind of vaporization or some kind of chlorine or maybe the flouring solvents which can react with the outer surface of that particular material and it can clean the outer surface.

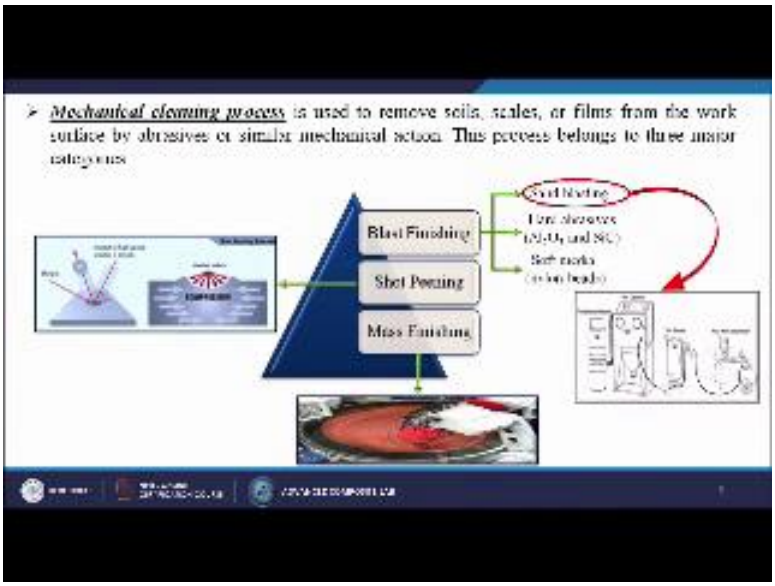
Next is called the acid cleaning. So, generally this type of cleaning, the basic example is that generally we are doing this kind of cleanings for our jewellery materials. So, suppose our any kind of jewellery materials like gold or maybe some kind of made by brass something like that if there is some (Refer Time: 06:08) after certain time its gliterness is getting reduced and its material properties is getting deteriorated and due to which the material outer surface is getting black. So, by just dipping those materials into some acids we can clean the outer surface of that particular material.

And the last one is called the ultrasonic cleaning - aqueous alkaline solutions with high frequency vibrations from 20 to 45 kilohertz. Here we are having some kind of chemical

solutions, but simply we dip our material into that chemical solutions maybe it will not react or maybe it will not be cleaned. Then what we have to do, we have to put the honed of that ultrasonic bath or maybe that ultrasonic sonicator into that solution and we have to agitate those solutions by which the chemical reaction will start in between the chemical solutions and the outer surface of that particular material by which we can do the cleaning process.

Next, we will discuss about the mechanical cleaning process. So, till now you are discussing about the chemical cleaning process by which we are using certain kind of chemical materials and we are doing the, we are allowing the material to do some chemical reactions with the solvent itself and then the reactions is taking place. But in this particular slide we are going to discuss about the mechanical cleaning; that means, we are applying any kind of energy in terms of pressure or maybe the load or maybe the any kind of elusions or may be any kind of abrasions on to the material surface; that means, by which the material outer surface is getting cleaned.

(Refer Slide Time: 07:57)



So, what are those? First one is called the blast finishing's. So, blast finishing's there are several types is called the sand blasting, hard abrasives, mainly alumina and silicon carbide and soft media like nylon beads. So, it depends upon which type of materials we are going to cleaned if your material will be softer then you have to take the soft abrasive particles and if your material will be harder then you have to go for the harder abrasive

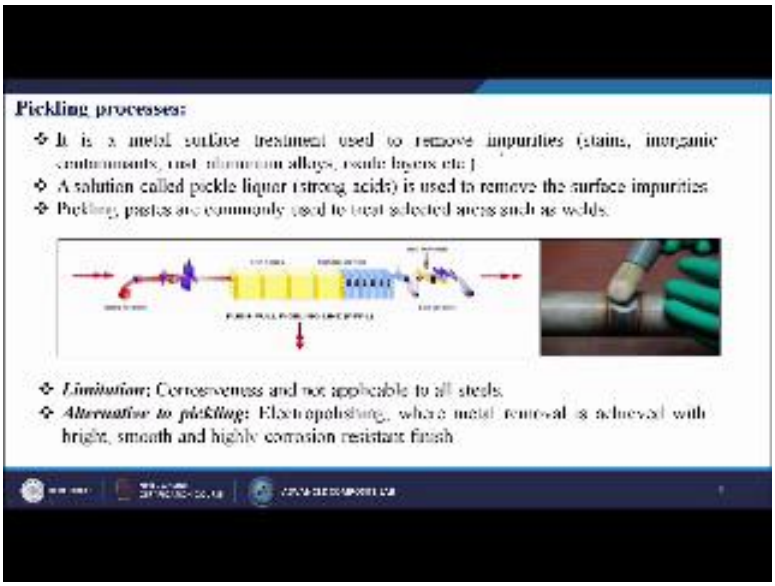
particles. What you have to do? You are having a container over there in through you are putting your abrasive particles, then one side you are having the compressor which is generating the compressed air, then your abrasive particles is mixing with the air and then with the high velocity you are throwing that particle on to your material surface by which a rubbing or maybe friction is taking place by which your material outer surface is getting cleaned that is known as the blasting.

Now, what type of abrasive you are going to take? Depends upon that, there is several nomenclatures, if you are going to take the sand as a abrasive particle it is known as the sand blasting, if you are going to take the alumina or silicon carbide these all are known as the hard abrasives that is why it is called hard blasting.

Next is called a shot peening, if you remember that in my last lecture I have already discussed about the shot peening. Shot peening is nothing that you are going to use certain balls which is made by some ceramics or maybe some kind of hard particles, then from this particular height you are relieving those balls and directly those balls is coming to the surface and while it is coming it is gaining some kinetic energy, due to that kinetic energy it is getting a depressions or maybe giving a depressions onto your material surface. So, material surface is going to be modified or maybe there is some kind of impurities or some kind of dust particles which maybe can be vanished at the impact of that particular ball on that particular surface.

Third one is called the mass finishing. Mass finishing is nothing but the simple grinding process. So, here we are having some kind of grinding wheels or maybe some kind of finishing process like honeying, lapping, grinding then there are so many unconventional methods are also there by which you can put your material onto some abrasive particles and then abrasive particles which rubbed its surface and you could do the surface engineering by this methods. So, that is why it is known as the mechanical cleaning process.

(Refer Slide Time: 10:44)



Next we will start with the pickling process. So, for the name itself you can understand that pickling process is something like that, that we are going to put certain material on top of the surface then either it will dry or maybe it can be doing some kind of chemical reactions after that we have to wash that surface and due to that your surface modifications can be done. It is also one type of things that when our face is getting dirty then we can use certain kind of face wash or maybe some kind of soaps. So, first we are cleaning that face then while we are washing that soap particularly it is taking out the dust particles with it. So, in simple Hudson's that is none other than the pickling process.

So, here it is a metal surface treatment used to remove impurities generally stains, inorganic contaminants, rust, aluminum alloys, oxide layers etcetera. A solution called pickle liquor strong acids is used to remove the surface impurities. So, here this pickle liquor is acting as soap, so just it will clean your material surface. Pickling pastes are commonly used to treat selected areas such as welds. So, from this particular figure you can understand that you have done some kind of welding, then after that we are putting that pickling liquor which is acting as some solvent over there, then after certain time you will wash it and whatever the dust particles or maybe rusting has been formed it will come out with your pickling liquor.

Here this is also another process generally which we have seen as industrial process or maybe generally we are adopting this process when we are doing the continuous

manufacturing of some parts of industry. So, here this is the entry sections where we are putting on materials then that material is going through acid tanks which is nothing but the pickle liquor, then through that the time can be controlled by us that how much time it will be in the acid treatment. Then again it will come to the some rinsing sections where you are washing those materials, so that pickle liquor can get out or maybe can be removed then it is going through the exit sections and exit sections you can put certain entry like that it will wash, then it will wipe or maybe it will clean, then it will test and if it is then it can go for the assembly purpose.

There are certain limitations of these particular techniques too. What are these? One is called the corrosiveness and not applicable to all steels because you are using certain kind of acids, if you are materially soft or maybe it does not have that acid innateness may be it can react with the pickling liquor.

Alternative to pickling: electropolishing, where metal removal is achieved with bright, smooth and highly corrosion resistance finish. So, simply there will be some kind of chemical reactions in between the potential difference which I will come into the next slide. So, there you can do certain kind of chemical reactions by which your rusting or maybe dust particle can directly come out from your base metal.

Next method is called the etching, etching is nothing if you want to remember I can tell you one example that etching is nothing just make some scratch on to the metal surface. So, simple I am having that surface and I want to scratch it like this, this is also a one kind of etching process. So, by etching also we can clean the material surface.

(Refer Slide Time: 14:43)

So, there are several types of etching - one is called the wet etching, then dry etching, nontoxic etching and photo etching, so one by one will go into the detail.

What is called the wet etching? First one it is called the chemical process because wet you are using some kind of liquid or maybe solvent which is into the liquid form, so that is why it is called the wet etching. So, it is a chemical process isotropic process that uses liquid chemicals or etchants to remove materials from a wafer cheaper than dry etching, but very difficult to start and stop, because unless and until reaction will be finished you cannot stop this. And you have to put the etchant onto a surface or by any brass or maybe by any other means or maybe you can dip your materials into some etchant, so that the chemical reactions will be taking place.

Next one is called the dry etching, from the name itself we can understand that we are not going to put our material into some liquid form or maybe into some wet gel or something like. So, here we are doing it into the dry medium. So, physical or chemical process or physical chemical process, anisotropic techniques include plasma enhanced, reactive ion etcetera; removal of material by exposing the material to a bombardment of ions. So, here just we are using certain kind of electron gun or maybe some kind of bombardment of ion implantation type of things where the ion is directly coming, it is giving or maybe getting a reactions onto the surface of that particular material by that

some portions of the material can be go out, so that you are getting a virgin surface or maybe the newer surface.

Next is called that nontoxic etching. So, generally ferric chloride used as a etching solution and does not produce a corrosive gas as acids too, that because nowadays every people is talking about the environmental concerns, that we should not make any kind of gases which will be toxic which can come to the environment, so that there will be some problem for exhaling and inhaling and maybe it can cause certain kind of problems to the eyes or maybe our skins. So, the nontoxic etching means when you are doing this kind of reactions because maximum reactions is exothermic reaction they are generating certain kind of fumes, gas or maybe some kind of heat. So, what about the nontoxic case, that it is not creating any kind of toxic gases which is harmful to the operator as well as to the environment itself.

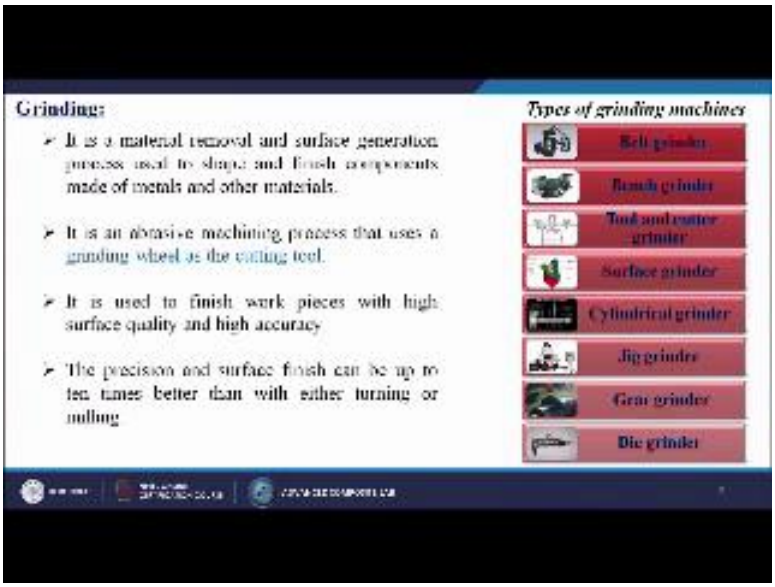
Next one is called the photo etching. So, chemical milling process used to fabricate sheet metal components used on any commercially available metal or alloy mainly aluminum, brass, copper and steel. So, this is also another kind of modified versions of the etching process. Right hand side you can see that there are two types of etching - one is called the dry etching, it is called the vertical sidewalls; another one is called the wet etching. So, here you are having the for a polysilicon methods, here you are using certain kind of mask over there are, so that your etchant is going and it is doing the reactions with the surface of that particular material.

Next there are two types of etching you can do - one is isotropic, another one is called the anisotropic. So, isotropic etches equally in all directions when you want to do the etching of all surfaces you have to dip that material into some solutions, so that chemical reactions can be taken place all around, so that is why it is called the isotropic etching process. And anisotropic etches at different rates in different directions then either you have to dip your material only a one side or maybe you can put the coating of that etchant material on a single side, so that you can restrict the reactions in different ways.

Next one is called the grinding. So, grinding in a mechanical term is simply it is called the one kind of fishing methods. So, when you are making any kind of material by casting, forming the final portions is called the grinding. So, in grinding here generally we are using some kind of abrasive particles which can rub your materials or maybe the

surfaces or maybe metal surface or maybe any kind of surface and by which it can be smooth. So, what is the method? The method is that you have to use certain kind of wheel generally which is known as the grinding wheel, then we can attach certain kind of abrasives over there it depends upon what type of materials you are going to grind, if you are going to grind the softer materials your abrasive particles will be little bit harder than the softer particles or maybe your materials will be harder then you have to go for maybe alumina, silicon carbide, carborundum or cubic boron nitride. So, these all are the different materials as abrasive particles you can use.

(Refer Slide Time: 19:57)



So, it is the material removal and surface generation process used to shape and finish components made of metals and other materials. It is an abrasive machining process that uses a grinding wheel as the cutting wheel. It is used to finish work piece with high surface quality and high accuracy. The precision and surface finish can be up to 10 times better than with either turning or milling operations.

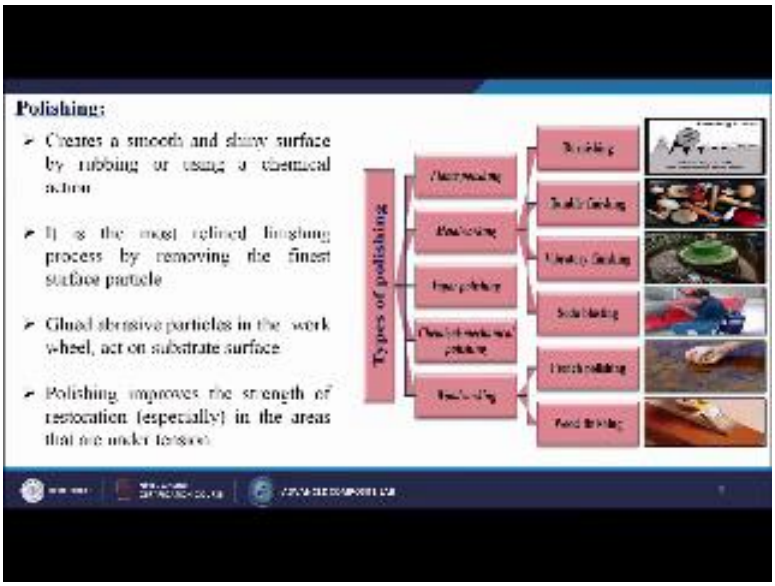
Turning and milling also one kind of conventional machining process like lathe, by lathe machines you can do the turning operations, we are having the milling machines by which you can do the meaning operations or may be by shaper you can do the shaping operations, but these all are the conventional machining process. But when you are talking about the grinding depending upon the size of the abrasive particles, if it is very smaller you will get the better surface finish over there, if the particles will be bigger or

maybe the coarse particle you are going to use then only you can get some kind of a rough surface. So, depending upon that whether you can go for a harder material or maybe we can go for a software material you have to choose different types of abrasive particles over there.

There are several types of grinding machines are available - one is called the belt grinder where your belt is acting as a grinding wheel or maybe the grinding medium, then bench grinder, tool and cutter grinder, surface grinder, cylindrical grinder, gig grinder, gear grinder, die grinder. So, depending upon how you are going to grind your material, how you can hold your material, so that you can place your grind abrasive particles nearer to the material or may be closer to the material, so that it can grind any complex shapes or maybe any kind of positions where the normal persons cannot go or may be cannot reach. So, it depends upon, we are having several types of grinding mechanism.

Next one is called the polishing. So, simple term polishing or may be policing is nothing but just we are likely rubbing the material by which we are enhancing the material properties in terms of maybe its color or maybe shape and size or maybe whatever is there, any rust or may be oxide formation so we can clean it over there.

(Refer Slide Time: 22:22)



So, it is not as much as like grinding because grinding the material removal rate is higher than the polishing. Polishing is a light work, by which simply we can rub and we can do it, but your rusting and everything is into the deeper to the material surface that time we

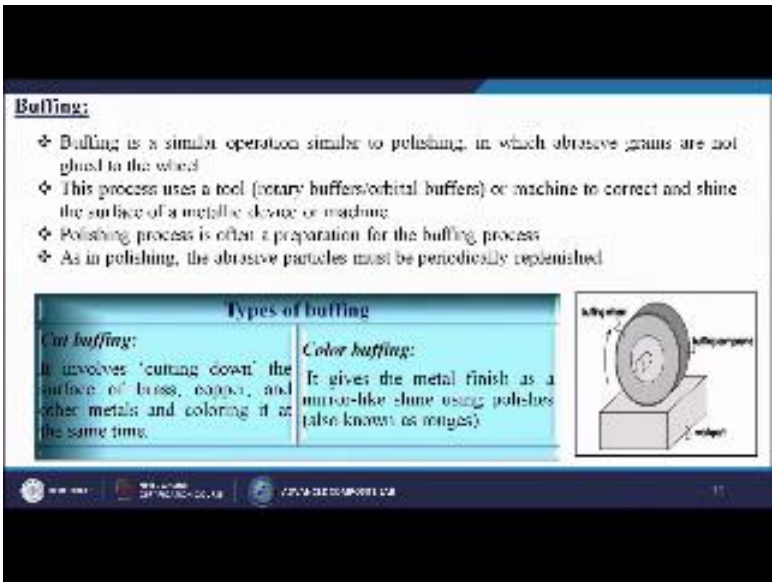
have to go for the grinding we cannot do it by the polishing. So, creates a smooth and shiny surface by rubbing or using chemical actions, it is the most refined finishing process by removing the finest surface particles. So, as I told already if few layer only can be removed by this polishing, we cannot go for the deeper thickness of the particular material.

Glued abrasive particle in the work wheel, act on the substrate surface. Polishing improves the strength of restoration especially in the areas that are under tension. So, there are several types of polishing you can see over here - one is call the flame polishing, here we are using certain kind of heat by which we are doing the polishing process. Then metalworking, which is also divided into four parts, one is called the burnishing, tumble finishing, vibratory finishing, soda blasting. So, from this particular figure you can understand that we are using the burnishing over there, so it is also one kind of coatings. If there is any cracks or small pores, so by burnish we can fill up this area and, so that you can get the smooth surface.

Then next is called the tumble finishing, vibratory finishing by using the vibrations of the particular machines we are rubbing the outer surface of that material, so that it can be smooth or maybe its affected area can be removed. Next is called the soda blasting, the best example is that till in our house or may be home our grandmother or maybe grandfather they used to say that if we are having some gold ornaments or something like that we are putting it into some soda solutions then we are a little bit heating, so that it glitters can once again it will comes back. So, by doing this one also that is also polishing methods. So, by doing this methods also we can do the surface finishing or maybe we can remove any kind of acids on maybe toxicity on the materials too.

Next one is called the vapor polishing by which we are creating the polishing by vapor, then chemical mechanical polishing. And last one is called the woodworking, it is also divided into two parts - one is called the French polishing and called the Wood finishing. So, wood finishing means we are using certain kind of oil or maybe certain kind of emulsions by which we are going to use the polishing methods.

(Refer Slide Time: 25:16)



Next one is called the buffing. So, buffing is also like polishing methods in which abrasive grains are not glued on the wheel. Here one wheel is there and surface is there just we are putting the abrasive particles in between these two. So, the abrasive particles are free here. So, by these methods we can do the surface engineering process and that is known as the buffing.

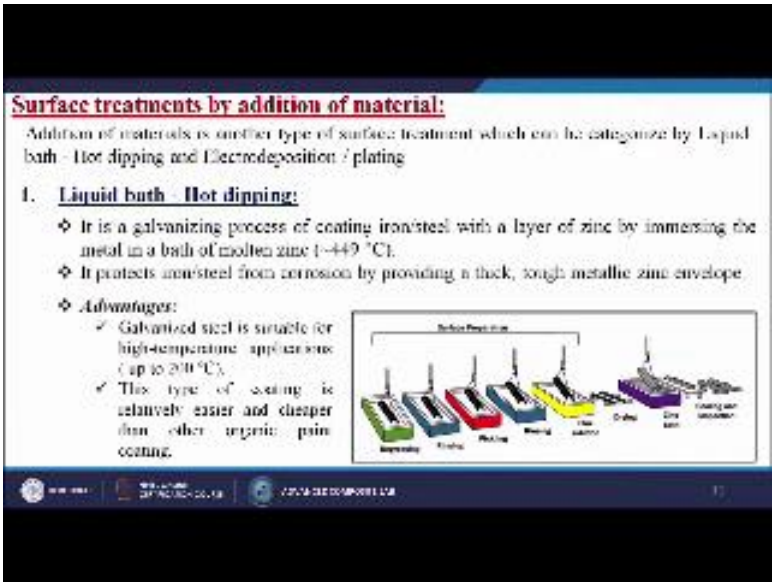
So, this process uses a tool that is rotary buffers or orbital buffers here this is the tool it is rotating and there is having some work peace and in between these two we are putting the abrasive particles as a free, so that is known as the buffing process. So, polishing process is often a preparation for the buffing process as in polishing the abrasive particles must be periodically changed or may be replenished, why? Because your wheel is giving a pressure on to your metal due to this gravity or may be wet, so whatever the abrasive particles I am using over here with constant rubbing and a normal load is acting always it will became, it means it will break into small-small pieces so after certain time all the projection area will be blunt. So, what you have to do? We have to put the newer particle, so that we can get the newer projection idea which can rub easily onto the material surface.

So, there are two types of buffing one is called the cut buffing and another one is called the color buffing. So, cut buffing, it involves cutting down the surface of brass, copper and other metals and coloring it at the same time, and what is called the color buffing? It

gives the metal finish as a mirror like shine using polishes as known as the rouges. So, it depends upon what type of particles you are going to use, how much load you are giving, so that you can get the shiny surface or maybe you can get the dull surface too.

Next is called the liquid treatment by additions of materials. So, here we are doing this surface engineering by additions of any materials. So, first one is called the liquid bath hot dipping. So, it is a galvanizing process of coating iron and steel with a layer of zinc by immersing the metal in a bath of molten zinc.

(Refer Slide Time: 27:32)



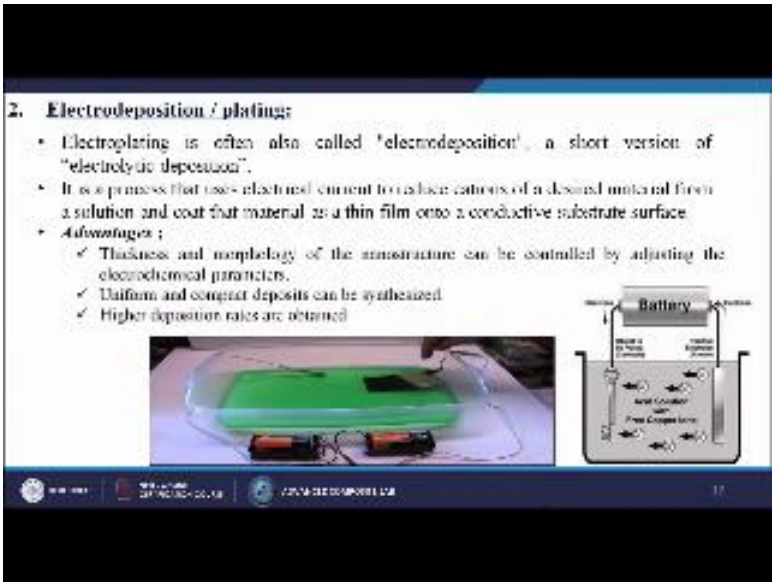
So, as we know the zinc with melting temperature is around 440 to 450 degree centigrade. So, we are having one bath of molten zinc simply we are taking over material first we are cleaning it, then we are dipping this into the zinc solvent, then after certain time where taking out the sample we are allowing that sample to be cold then when it will be cooled we are using it for our purposes. So, that is why it is called the liquid bath hot dipping process.

What are the advantages? First one is called the galvanized steel is suitable for high temperature applications of 200 degree centigrade. This type of coating is relativity easier cheaper than other galvanic paint coating. So, from this particular figure you can understand first we are doing the degreasing then rinsing; that means, any grease or may be oily surfaces attached with the surface, if we dip that simple into some solutions may be the zinc will not stick with the material.

So, first we have to clean the materials outer surface, so that the additions will be more then we can deep this into the zinc solutions then after that we can do that drying, then again if we can put into some solutions zinc solutions. So, several times either if you want to increase the coating thickness we can dip our material several times in the zinc bath or maybe a single time. Then after that you have to do the cooling operations and inspections weather the coating is inform or not.

Next one is called the electrodeposition or may be plating. So, from the name itself we can understand that we are having one cathode and anode terminal then we are putting those materials into some electro light, then we are using some voltage potential difference over there, then due to that the one material it is releasing some irons and that and irons is coming into the molecules form and then that molecule is depositing to the another material.

(Refer Slide Time: 29:34)



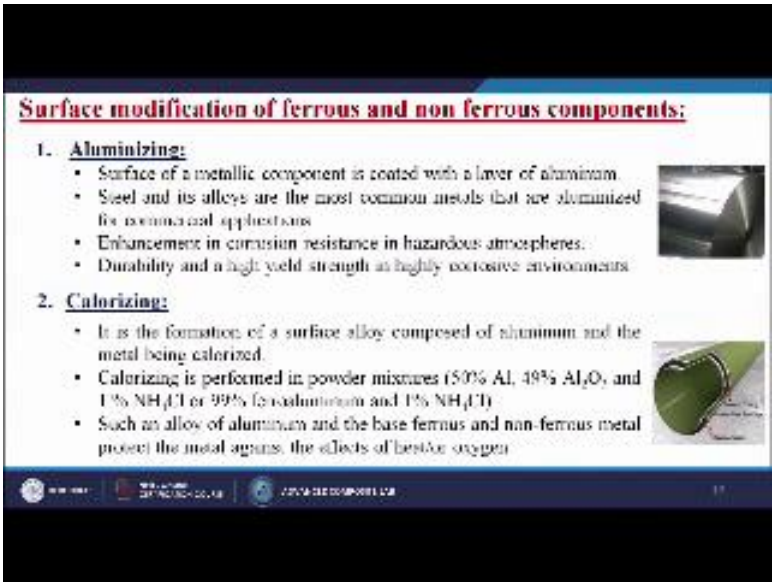
So, here from this particular figure you can understand that we are using some copper as anode materials and whom another material on which we are going to use the copper coating over there. So, we are putting that material into the cathode then through battery we are generating the high potential difference in between these two, so that this copper iron it is going and it is depositing on the outer surface of your coating material.

So, electroplating is often also called as electro depositions, a short version of electrolytic deposition. It is process that use electrical current to reduce cations of the

desired material form solutions and coat that material as a thin film onto a conductive substrate. There are some advantages too, inform and compounder produce can be synthesized because you can control the time, by controlling the time you can increase or decrease the thickness of that particular coating. Also high depositions rates are obtained if you go for a longer time.

Next, surface modifications of ferrous and non-ferrous compounds; here we can see certain kind of unconventional methods or maybe conventional methods.

(Refer Slide Time: 30:44)



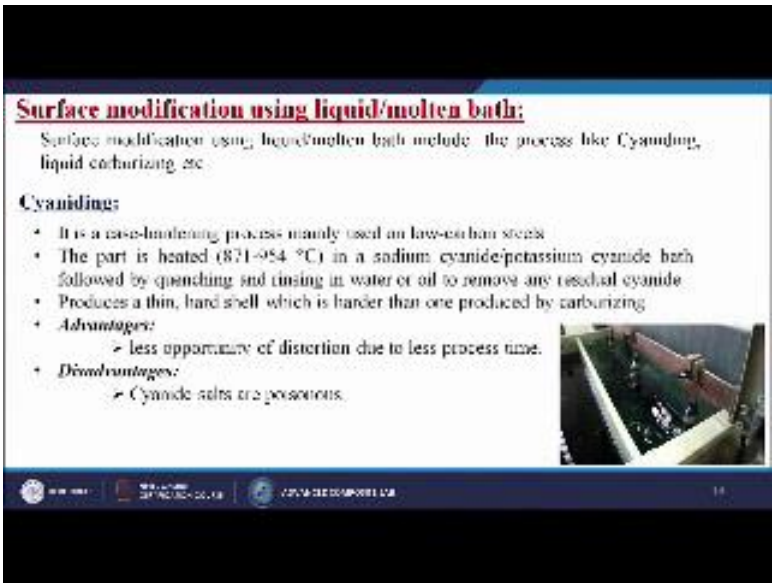
Under this one is called aluminizing, from the name itself you can understand that we are going to do the coating of aluminum onto your material into some environment. So, surface of metallic component is coated with layer of aluminum. Steel and its alloys are most common metals that are aluminized for commercial applications. Enhancement in corrosion resistance in hazardous atmospheres. Durability and high yield strength is highly corrosive environment. So, we are doing a coating of aluminum onto the material surface.

Next one is called the calorizing. Calorizing also one kind of aluminum coating, but here also we are adding some kind of best material on which you are going to do the coating. So, it is a formation of surface alloy composed of aluminum and the metal being calorized. Calorizing is performed in a powder mixture, generally 50 percent aluminum, and 49 percent alumina and 1 percentage ammonium chloride or 99 percent

ferroaluminum and 1 percent ammonium chloride mixture. Such an alloy of aluminum and the base ferrous and non-ferrous metal protect the metal against the effects of heat or oxygen.

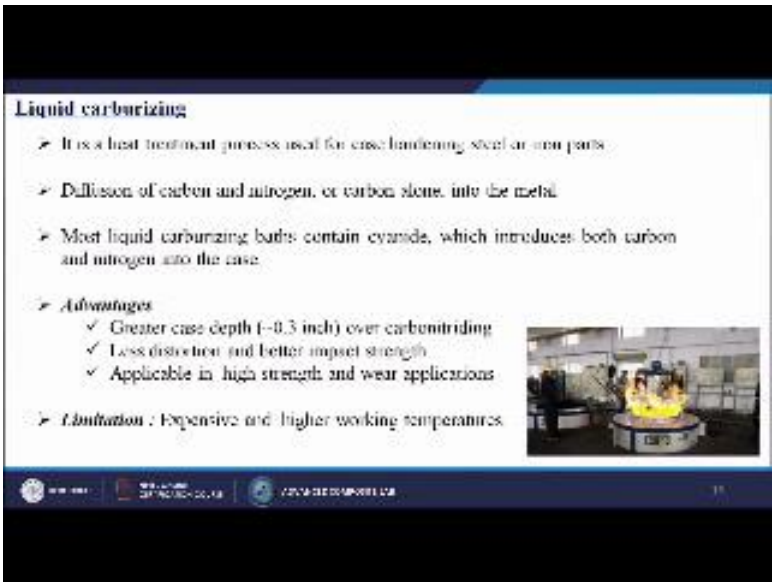
Next is called the cyaniding. Cyaniding means we are putting our material into some cyanide, means potassium cyanide or maybe the sodium cyanide environment by which that same group generally that is known as a cyanide group that can attach with the material outer surface and can do some kind of coatings or maybe the surface modifications.

(Refer Slide Time: 32:19)



So, it is a case hardening process mainly used on low carbon steels. This part is heated around 871 to 954 degree centigrade in a sodium cyanide, potassium cyanide bath followed by quenching and rinsing in water or oil to remove any residual cyanide. Produces a thin, hard cells which is harder than one produced by carburizing. Advantages: less opportunity of destruction due to less process time. Disadvantages: cyanide salts are poisonous. We know that Madam Curie, she has invented the cyanide as a poison and this is very poisonous to our body also.

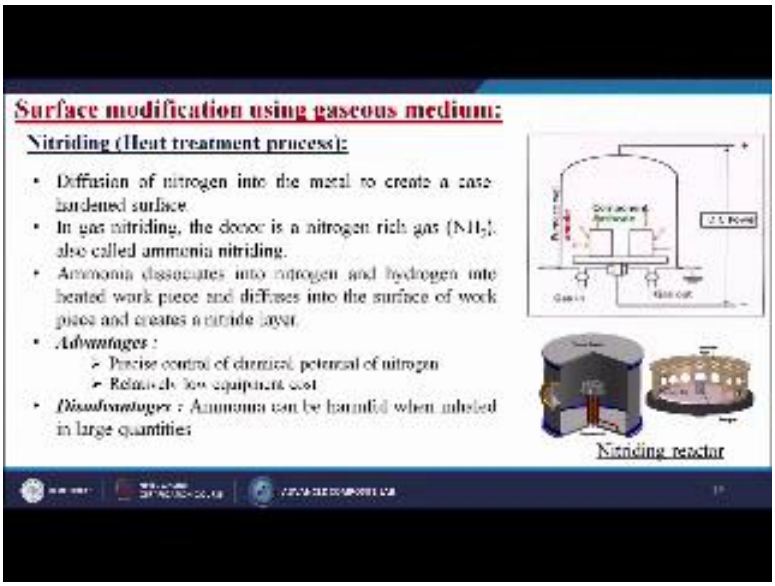
(Refer Slide Time: 32:58)



Next is called the liquid carburizing. So, it is the heat treatment process used for case earning steel or iron part. Diffusion of carbon and nitrogen or carbon alone in to the metal, so here the first case when we are talking about the carburizing we are putting the material into some carbon environment, but here that carbon environment in to the liquid stage, we have dip power material into that liquid carbon solution, carbon dioxide solution and we can do the liquid carburizing. Greater case depth over carbonitriding, less distortion and better impact strength, applicable in high strength and wear applications; there are certain limitations also expensive and higher working temperature is required. So, that is why generally these methods we are using in to the industrial purpose.

Next one is called and nitriding. Probably in the last slides also I have discussed about the nitriding, but that time only I said only one line that we are doing the modifications into some nitrogen atmosphere. How you are creating the nitrogen atmosphere? Either we are using some kind of ammonia gases on which we are keeping our materials then the nitrogen can act on the material surface and do the surface engineering.

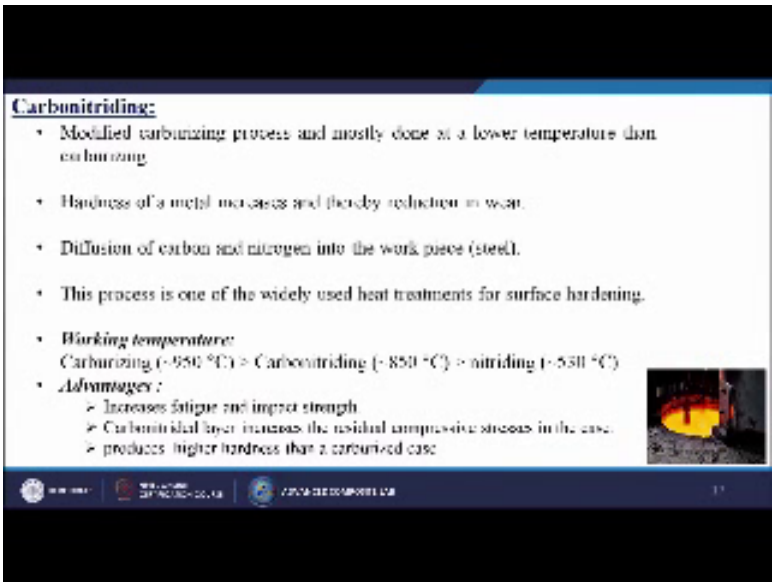
(Refer Slide Time: 34:15)



So, diffusion of nitrogen into the metal to create a case-hardened surface, in gas nitriding the donor is nitrogen rich gas ammonia and also called the ammonia nitriding, ammonia dissociates into nitrogen and hydrogen into heated work piece and diffuses into the surface of work piece and creates a nitride layer over there. Advantages: precise control chemical potential of nitrogen, relatively low equipment cost. Disadvantage: ammonia can be harmful when inhaled in large quantities. So, we have to take that precaution too.

So, here this is the material, this is the total schematic diagram where the gas is inside and then another side the gas is coming out. You are having two terminals - one is call the cathode and anode, then your ammonia is dividing into two parts - one is called and nitrogen and another one is called the hydrogen; hydrogen is coming out and nitrogen it is creating a reaction with the surface and it is forming the nitride layer on top of the surface.

(Refer Slide Time: 35:22)



Then next one is called the carbonitriding. Modified carburizing process and mostly done at lower temperature than carburizing, hardness of metal increases and thereby reduction in wear, diffusion of carbon and nitrogen in the work piece. So, this is also one kind of we can say the modified versions of the nitriding process.

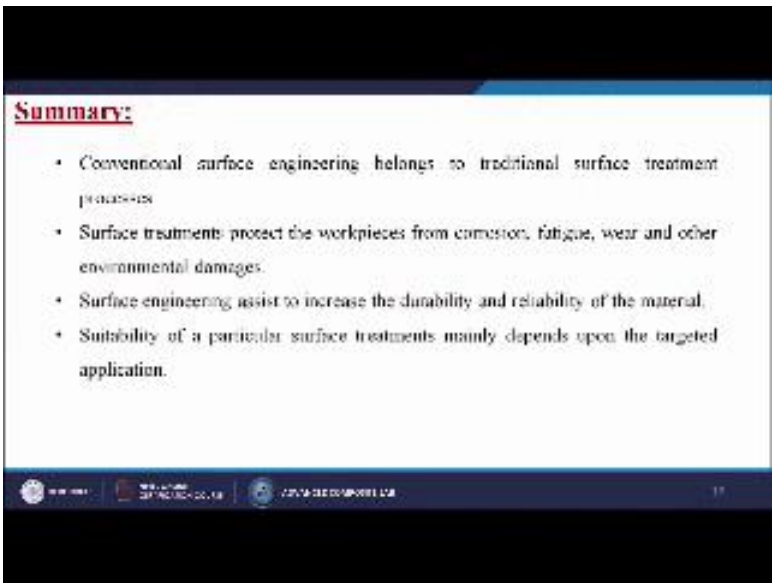
So, from this you can understand that for carburizing we use the temperature around 950 degree centigrade, for carbonnitriding we are using the temperature around 850 degree centigrade and for nitriding we are going the temperature up to 530 degree centigrade. So, it depends upon the what is the melting temperature of that particular material and if your melting temperature is low then you can go for the nitriding, on carbonitriding; if your melting temperature of your materials is high then you can go for the carburizing too.

Advantages: increase factor can impact strength, carbonitrided layer increases the residual compressive stresses in that case, produces higher hardness than a carburized case. Then these are the applications generally by which we are doing the surface engineering. Here I have given very minimum examples, but there are n numbers of examples present over there.

(Refer Slide Time: 36:37)

So, first one is called the automobile motive applications, aerospace applications, biomedical applications, machine tools, textile industry, electronic device, we can do the surface engineering. So, here we have seen that mobile nowadays we are making which is the water resistant that means we can dip the mobile into some water and the water will not interact with the material by which the mobile has been prepared.

(Refer Slide Time: 37:08)



Next slide we can summarize our whole lecture. So, first is called the conventional surface engineering belongs to traditional surface treatment process. Surface treatments

protect the workpieces from corrosion, fatigue, wear and other environmental damage. Simply from the outer attack the surface engineering will prevent our material properties.

Surface engineering assist to increase the durability and reliability of the material; that means, it will increase the life of your particular material. Suitability of particular surface treatments mainly depends upon the targeted application, it depends upon the applications by which you can adapt, there are several surface engineering process I have explained. So, it depends upon which type of applications you are going to do and best on that you have to choose different types of surface engineering process.

Thank you.