

**Metal Casting**  
**Dr. D. B. Karunakar**  
**Department of Mechanical and Industrial Engineering**  
**Indian Institute of Technology, Roorkee**

**Module – 06**  
**Finishing, Design And Environment**  
**Lecture – 01**  
**Shakeout, Fettling And Finishing**

Welcome friends, in the previous lecture, we have learnt about the solidification of molten metal inside the mould and we have also learnt; how to control the grain structure and how to overcome the problems that are likely to arise during solidification inside the mould. Now, once we pour the molten metal inside the mould, after sometime, it solidifies and we have to take the casting outside and we need to process it further so that we can get the casting which can be handed over to the customer. Now, in this process, we have to what say further process the casting.

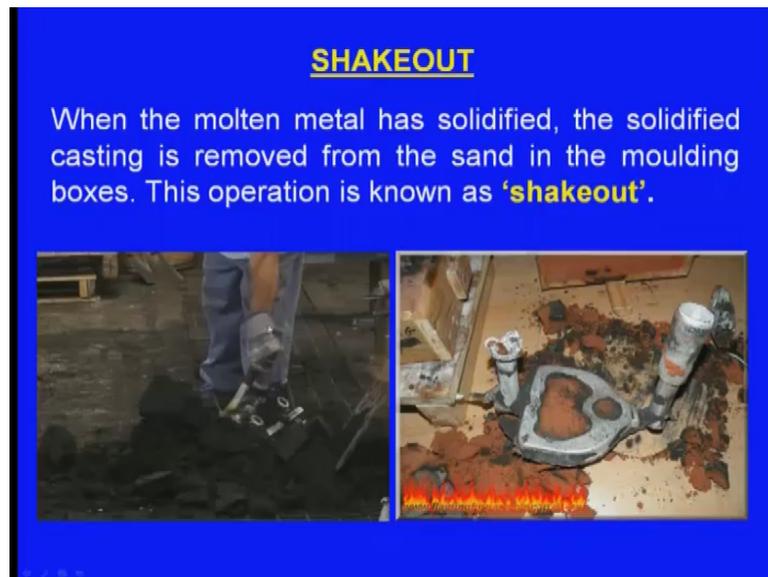
(Refer Slide Time: 01:07)



**Shakeout, Fettling  
And Finishing**

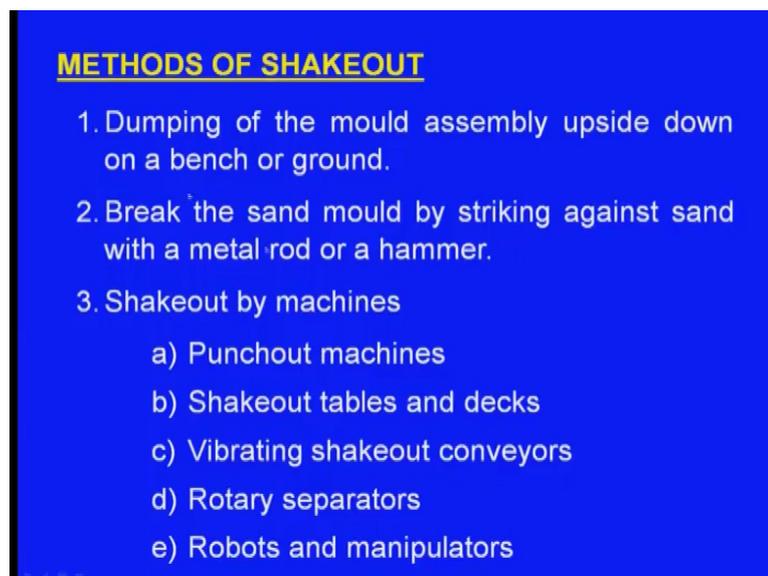
This is known as the shakeout, fettling and finishing. So, the title of this lecture will be shakeout, fettling and finishing, There are 3 parts. First, we will see the shakeout.

(Refer Slide Time: 01:20)



What is shakeout? When the molten metal has solidified, the solidified casting is removed from the sand in the moulding boxes. This operation is known as shakeout and here we can see the solidified casting is being taken out from the mould. Means, we break the mould and we take the solidified casting outside and here also we can see this is the solidified casting and surrounding the casting we can see that is the broken mould. So, breaking that mould and taking the solidified casting is known as shakeout. Now how to carry out this shakeout?

(Refer Slide Time: 02:04)



Methods of shakeout one is dumping of the mould assembly upside down on a bench or ground. Just take the mould, wash inside the solidified casting and make it upside down on a bench or a ground. The mould will be dropping down from the moulding boxes and mould also at the same time it will be breaking in to pieces. The casting can be taken outside.

Second thing is, second method is the break the sand mould by striking against sand right with a metal rod or a hammer. No need to put the what; say moulding box on a bench or no need to make upside down. Take some rod or a hammer and strike it. The mould will be broken and the casting can be taken out and this also can be achieved by using machines.

So, these are the different machines are available. One machine is the punchout machine another one is the shakeout tables and decks next one vibrating shakeout conveyers next one rotary separators next one robots and manipulators we will see this quickly punchout machines first we will see punchout machines.

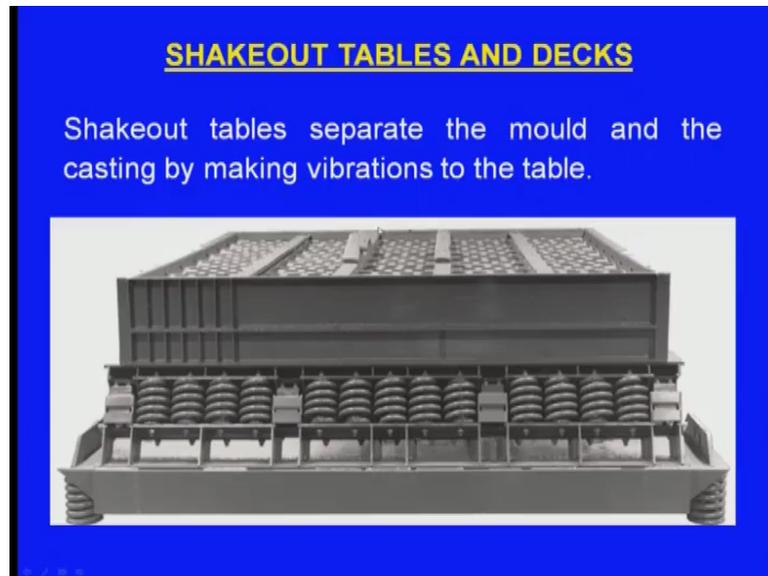
(Refer Slide Time: 03:24)



In punchout machines the entire mould and casting are ejected from the moulding box using a punch right. So, this moulding box in along with the mould and the solidified casting will be kept on this machine and there will be a punch will be there. The mould box will be held rigidly and this punch will come and push the mould. What happens?

The mould will be coming out of the moulding box at the same time, it will be broken and the casting can be taken out. So, that is the punch out machine.

(Refer Slide Time: 04:00)



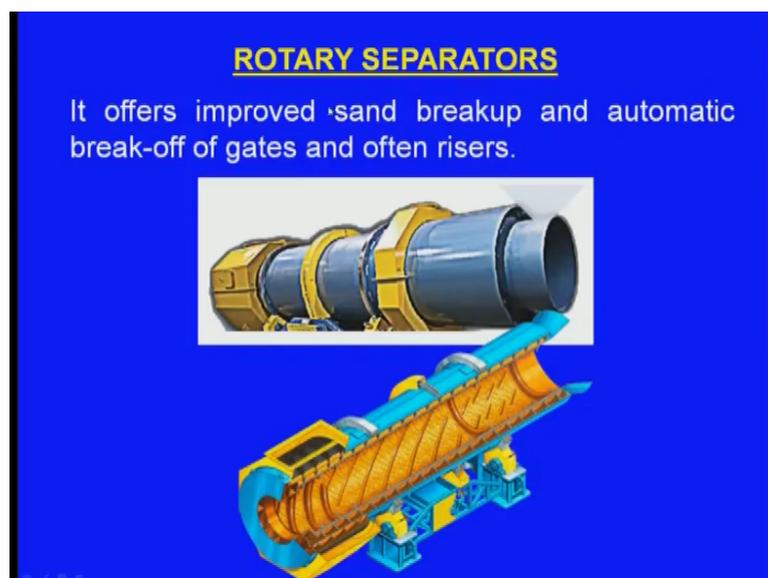
Next one is the shakeout tables and decks. Now, shakeout tables separate the mould and casting by making vibrations to the table and here we can see here is a table right. So, on this table we place the moulding box along with the mould and the casting. Now, vibrations will be given to this table, then what happens as the table is vibrating, the mould will be breaking and it will be what say coming out of the box and the casting can be taken out. So, that is the shakeout table and decks.

(Refer Slide Time: 04:43)



And the next one is the vibrating shakeout conveyers, now these are the conveyers right. So, this conveyers are available in about 100 meters long and width up to 4 meters. On this conveyers, the what; say molten box will be kept along with the solidified casting. Now, this will be vibrating as it is what say bringing mould. So, it will be vibrating and because of that the mould will be broken and the casting can be taken out.

(Refer Slide Time: 05:14)



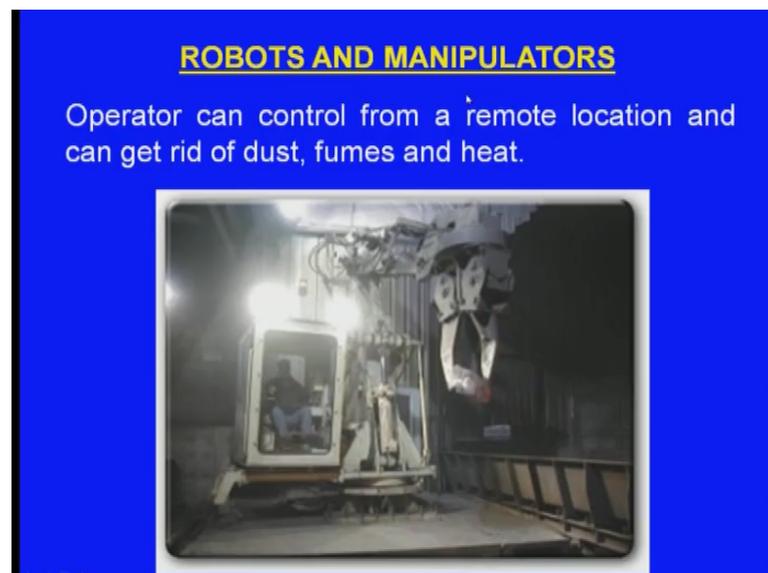
Next one is the rotary separators it offers improved sand breakup and automatic break off of gates and often risers. Now here, we can see that rotary what say separators are there.

It is a kind of cylindrical structure and it will be rotating and this moulding box generally small and medium size moulding boxes along with the mould and solidified casting can be kept inside this rotary separator. Now as this is rotating, what happens the mould inside the box will be breaking in this process the casting comes out. Not only that, not only the casting comes out what happens is the gates and often even the risers will be separated from the casting.

Now, one must remember that when we are pouring molten metal in to the mould, you should not think that the metal will be solidifying only inside the cavity. Metal will be solidifying inside the gating system means the sprue, inside the runner, inside the gates, inside the riser. Everywhere metal will be solidifying, but we do not want everything. We want only the required component. The metal that has solidified inside this sprue, the metal that solidified inside the runner, inside the ingates and inside the runner is not part of the casting that has to be removed.

Now, sometimes because of this rotary what say mechanism these extra what say elements like the sprue, gates, runner will be broken because of this rotary mechanism. So, that is additional advantage of this rotary separator. Next one.

(Refer Slide Time: 07:08)



Robots and manipulators can also be used for the shakeout purpose. Now sometimes, most what say one of the problems in the foundry is the dust problem? Sometimes if the dust is too much, the operator cannot go there. At such times, the robots and

manipulators can be used, right. So, the manipulators can be what say programmed such that it goes to the mould and it takes the mould and it breaks the mould and take the casting outside and the operator can be what say placed in a such a place that there is no dust contact between him right. In that way robot will help. So that the operator can be free from the dust. So, robots and manipulators can also be used for the shakeout purpose. So, so far we have completed.

(Refer Slide Time: 07:59)



The shakeout.

Next one is the fettling what is fettling.

(Refer Slide Time: 08:04)

## FETTLING

Fettling includes the following operations.

1. Removal of cores from the casting.
2. Removal of gates, risers, runners, etc. from the casting.
3. Removal of fins and other unwanted projections from the castings.
4. Removal of adhering sand and oxide scales from the casting.

Fettling means it includes the following operations. Removal of cores from the casting. Whenever we want to make hollow castings, we place cores. Generally these cores are made up of core sands right. So, these cores are again to be removed. When we are what doing the shakeout, these cores may not be removed. So, in the fettling operation, we will be removing the cores. Next one, removal of gates, risers, runners from the casting remember that metal will be solidifying inside this sprue, inside the runner, inside the ingates and also inside the riser. These are not part of the castings. Now, these are to be removed. Now, in the fettling operation we remove these gates risers and runners under the sprue from the casting. So, that also comes under fettling.

Next one, removal of fins and other unwanted projections from the castings. Generally sometimes fins will be what say taking place right. So, always we use generally 2 moulding boxes. The cope and the drag. Upper box is the cope and lower box is the drag. Bit way sometimes, if sand is not what say edge is not leveled properly there will be what say narrow gap between these two boxes then metal will go and solidifies there. Then what happens, a fin will be created. Now these fins are to be removed. It also comes under fettling. Next one, removal of adhering sand and oxide scales from the castings. Now during the shakeout right of course, the mould will be broken and we take the casting outside, but the casting will not be totally free from sand. Some sands will be adhering to the casting. So, this sand is to be removed. Sometimes even oxides will be adhering to the casting oxides, these are to be removed.

(Refer Slide Time: 10:12)



**FETTLING**

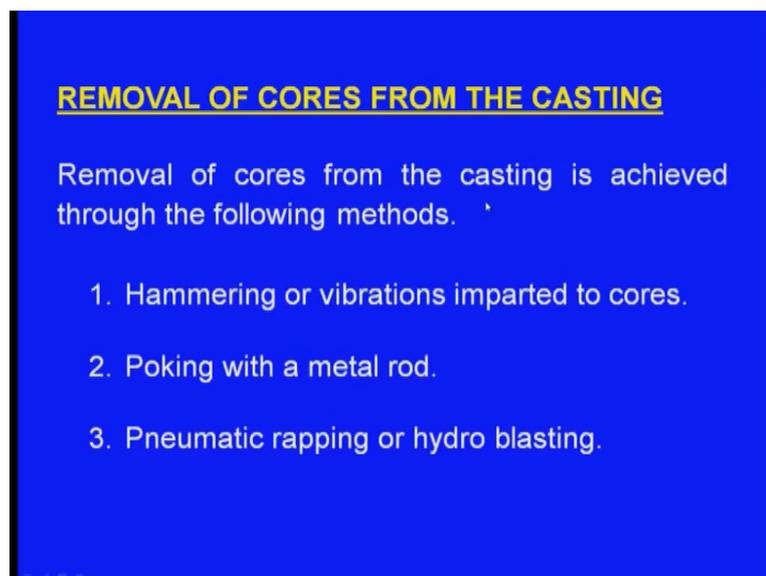
Fettling includes the following operations.

1. Removal of cores from the casting.
2. Removal of gates, risers, runners, etc. from the casting.
3. Removal of fins and other unwanted projections from the castings.
4. Removal of adhering sand and oxide scales from the casting.

So, this process is also; also comes under fettling.

So, fettling means all these processes all these activities come under fettling. Now let us see how to carry out all these fettling operations one by one. First, let us see removal of cores from the casting. How to remove the cores from the casting.

(Refer Slide Time: 10:32)



**REMOVAL OF CORES FROM THE CASTING**

Removal of cores from the casting is achieved through the following methods.

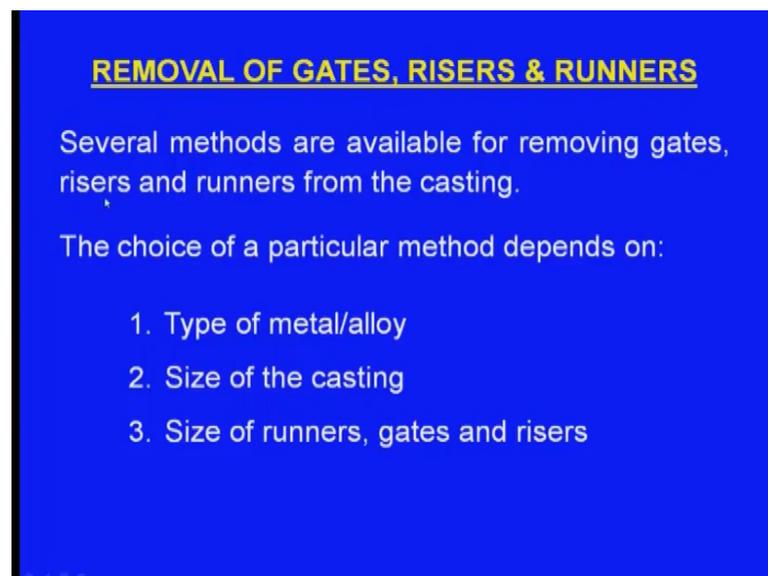
1. Hammering or vibrations imparted to cores.
2. Poking with a metal rod.
3. Pneumatic rapping or hydro blasting.

Removal of cores from the casting is achieved through the following methods. One is hammering or vibrations imparted to the cores. Second one poking with a metal rod. Third one pneumatic rapping or hydro blasting right. So, hammering and vibrations can

be imparted to the cores and cores will be removed. There will be crush and they can be removed. Next one, we can use a metallic rod and we can poke it then the what; say it will be crushed and it can be taken out. Next, pneumatic rapping or hydro blasting means pneumatic rapping means what say high pressurized air will be exposed to the place where there is a core and because of that high pressurized air the core will be broken and it will be falling down or high pressurized water that is the it will be used that is the hydro blasting.

So, any of these can be used. So, that is all about the removal of cores from the casting. Next, what say part of the fettling is removal of gates, risers, runners, from the casting? Metals solidifies inside the sprue, metal solidifies inside the runners, inside the ingates and also inside the risers. We need to remove all these elements gating elements. Now, that also is part of fettling. How to do that; right?

(Refer Slide Time: 12:00)



**REMOVAL OF GATES, RISERS & RUNNERS**

Several methods are available for removing gates, risers and runners from the casting.

The choice of a particular method depends on:

1. Type of metal/alloy
2. Size of the casting
3. Size of runners, gates and risers

Several methods are available for removing gates, risers, and runners from the casting. The choice depends upon type of metal or alloy size of the casting.

(Refer Slide Time: 12:17)

### REMOVAL OF GATES, RISERS & RUNNERS

Commonly used methods of removing gates, risers & runners are:

1. Chipping hammers
2. Flogging (Severe striking)
3. Sawing (Hacksaw, band saw)
4. Abrasive wheel slitting
5. Machining
6. Flame cutting
7. Plasma cutting

Next one, size of the runners, gates and risers commonly used methods of removing gates, risers and runners are; one is the chipping hammers, next one flogging means serious striking, next one sawing it could be hacksaw or the band saw, next one abrasive wheel slitting, next one machining, next one flame cutting, next one plasma cutting. Any of these methods can be used to remove the elements of the gating system. Means the sprue, runner, ingates and the riser.

(Refer Slide Time: 12:50)

### CHIPPING HAMMERS

They are particularly suited in case of grey iron castings and brittle materials.

The gates and risers can easily be broken by hitting the hammer.



Now, we can see this is the chipping hammer right. So, we can see here. So, they are particularly suited in case of grey iron castings and brittle materials. The gates and risers can easily be broken by hitting with the hammer and we when we strike with this hammer. So, these elements of the gating systems can be broken very easily.

(Refer Slide Time: 13:14)

**FLOGGING**

Flogging involves the complete elimination of all residual moulding and core sand from the casting's surface.

A small, compressed air powered percussion tool is employed to clear the casting's hollow parts.

Next one, flogging. Flogging means striking very severely right. So, using this method also one can remove the elements of the gating systems.

(Refer Slide Time: 13:26)

**SAWING**

These saws may be hand saw and power saw type.

They are used for cutting the ferrous like steel, malleable iron and for non ferrous materials except aluminum.

Mostly the hand saws are used for small and medium castings but the power saws are used for large work.



Next one sawing right. So, these saws may be hand saw or power saw type they are used for cutting the ferrous like steel, malleable iron and for non ferrous materials except aluminum. Mostly the hand saws are used for small and medium castings, but power saws are used for the heavy castings.

(Refer Slide Time: 13:48)

**ABRASIVE WHEEL SLITTING**

These machines can work with all metals but are specially designed for hard metals which can not saw or sheared.

It is more expensive than other methods.



Next one abrasive wheel slitting. These machines can work with all metals, but are specially designed for hard materials which cannot saw or sheared and it is more expensive than other methods.

(Refer Slide Time: 14:02)

**FLAME CUTTING**

This type of method is specially used for ferrous materials of large sized castings where the risers and gates are very heavy.

In this method, the gas cutting flames and arc cutting methods may be employed .

It is not applicable for small castings.

Next one is the flame cutting. This type of method is specially used for ferrous materials and large sized castings where the risers and gates are very heavy. In this method, the gas cutting flames and arc cutting methods may be employed and it is not for small castings. Sometimes there will be heavy castings will be there right. The risers may be very big risers now, with handsaw it may not be possible for to remove that risers at such cases we use the gas cutting flames right. So, we can easily remove that and also using the arc cutting methods we can easily remove such a heavy what say elements of the gating system. Next step of the fettling is the removal of fins and other unwanted projections from the castings. How to do that?

(Refer Slide Time: 14:53)



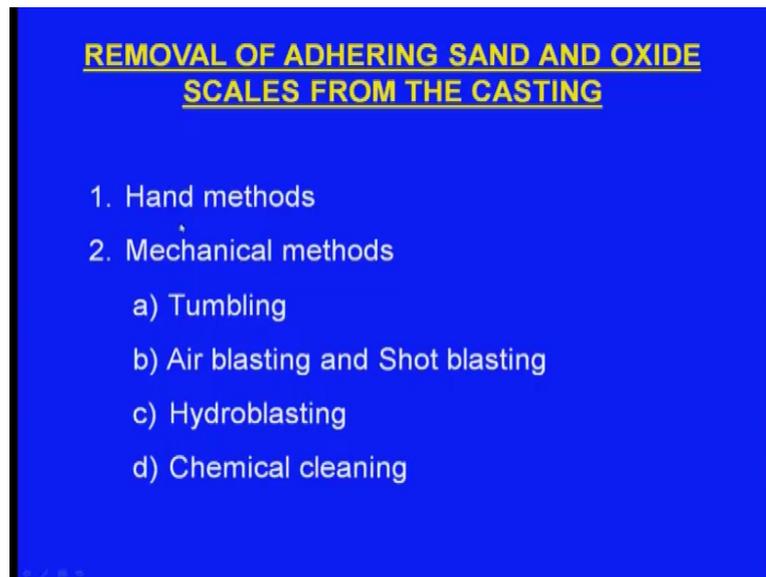
**REMOVAL OF FINS AND OTHER UNWANTED PROJECTIONS FROM THE CASTINGS**

Fins and other unwanted projections can be removed by the following methods.

1. Chipping
2. Sawing
3. Flame cutting
4. Flame scarfing
5. Grinding
6. Abrasive belt machines
7. Rotary tools
8. Trimming and sizing

Fins and other unwanted projections can be removed by the following methods- one is the chipping, second one is the sawing, third one flame cutting, fourth one flame scarfing, next one grinding, next one abrasive belt machines, next one rotary tools and finally, trimming and sizing. Any of these methods can be used for removing the unwanted fins from the castings and last the step of fettling is the removal of adherings and an oxide scale from the casting. How to do this?

(Refer Slide Time: 15:28)



One is the hand methods, second one is the mechanical methods. Under the mechanical methods, we generally four methods are there- one is the tumbling, second one is the air blasting and short blasting, third one is the hydro blasting fourth one is the chemical cleaning.

(Refer Slide Time: 15:48)



Tumbling, a horizontal barrel is filled with the castings which is then rotated. There will be horizontal barrel will be there, inside we will place the castings and usual media include water or other lubricants. It will be filled with water or lubricants. As the barrel is

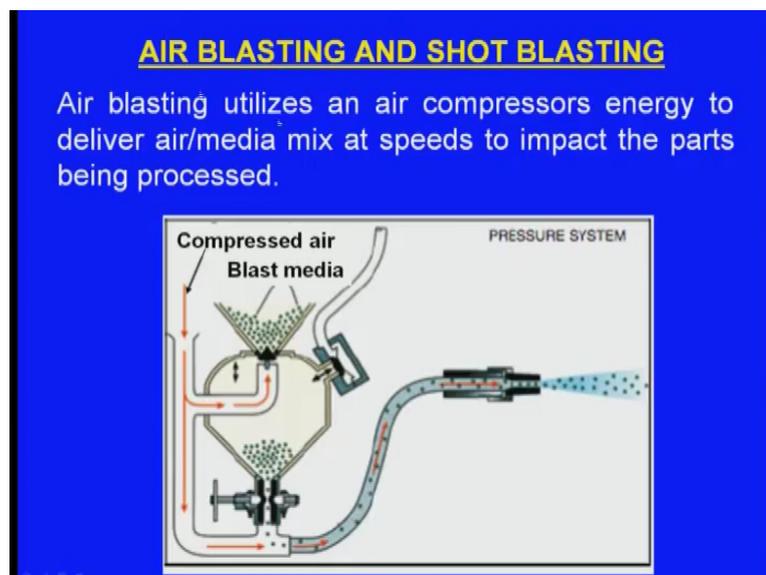
rotating, what happens, castings will go up and will go down and in this process the oxides will be removed, but this method can be used only for small and moderate size castings and here we can see.

(Refer Slide Time: 16:26)



These are the rotating barrels used in the tumbling. So, here we fill the media, may be water or the lubricating oils and we put the castings inside and the barrel will be rotating as it is rotating, the casting goes up and goes down, goes up and goes down in this process the oxides will be removed from the casting.

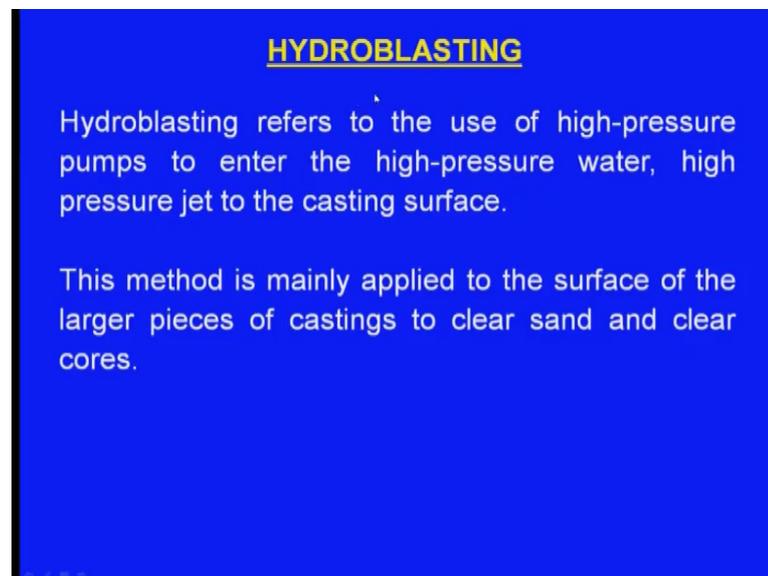
(Refer Slide Time: 16:51)



Next one air blasting and shot blasting. Air blasting utilizes an air compressors energy to deliver air and media mix at speeds to impact the parts being exposed. Now here, we use air and also certain what say abrasive materials. Now here we can see in this the compressed air will be coming like this and one stream of this compressed air will be going through the nozzle. Yes, this is the nozzle and another part of the what; say compressed air is coming and here, there is a what; say blast media what say correction is there. There, it will be opening when this compressed air is comes and it lifts the gate the what; say the abrasive what say particles will be falling down. Now these abrasives particles here, we can see they will be mixing with the compressed air. Together the mixture of the compressed air and the abrasive particles will be flowing through this nozzle and this nozzle will be exposed to that place of the casting where there are oxide

Now, when the high pressurized air along with the abrasive particles hit the place the oxides will be removed because of the kinetic energy of the abrasive particles. So, this is the air blasting and shot blasting. Next one is the hydro blasting.

(Refer Slide Time: 18:19)



It refers to the use of high pressure pumps to enter the high pressure water, high pressure jet to the casting surface. This method is mainly applied to the surface of the larger pieces of castings to clear sand and to clear the cores. So, when the casting is very big right. So, pressurized water will be exposed to that that place where there is sand is adhering and oxides are there. So, they will be removed.

(Refer Slide Time: 18:51)



So, we have completed the shakeout and the fettling.

The third part of this process is the finishing.

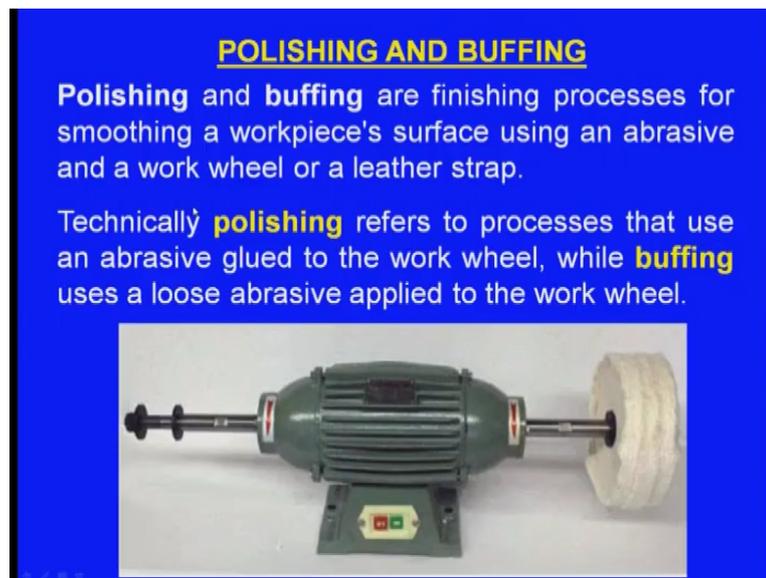
(Refer Slide Time: 19:00)



Finishing of the casting it is the last stage in cleaning of the castings it includes grinding, for better surface finish. Next one rotary filing that is also for better surface finish. Next one for machining means, if there is any dimensional deviation we do the machining. Next one chemical treatment to achieve the required what say surface finish and also to achieve the required geometrical accuracy. Next one polishing and buffing surface

treatment and finally, painting. So, all these come under the finishing operations now these are well known grinding, rotary filing, machining, and chemical treatment. So, I will be what say explaining the polishing and buffing and the surface treatment. So first, let us see this polishing and buffing.

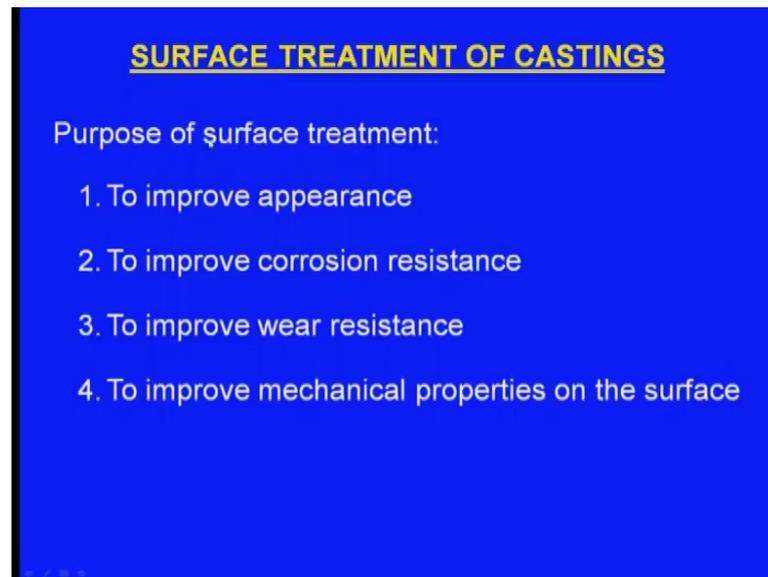
(Refer Slide Time: 19:58)



Polishing and buffing are finishing process for smoothing a work pieces surface using an abrasive and a work wheel or a leather strap right. So, here we can see.

So, this is a polishing wheel right. So, technically polishing refers to process that use abrasive glued to the work wheel right, you we can see this is the leather wheel and abrasives are glued to this weather wheel. Now this will be used to polish the casting. While buffing uses a loose abrasives applied to the work wheel. So, extremely small material is removed from the work piece the main aim of polishing and buffing is not to remove the material not to achieve geometrical accuracy, but to achieve extreme surface finish.

(Refer Slide Time: 20:59)



Now, the purpose of surface treatment. Next one let us see the surface treatment of castings. Purpose of surface treatment- one is to improve the appearance, second one is to improve corrosion resistance, next one objective of surface treatment is to improve wear resistance next objective is to improve mechanical properties on the surface.

So, when we do the surface treatment any or all of this could be the objectives.

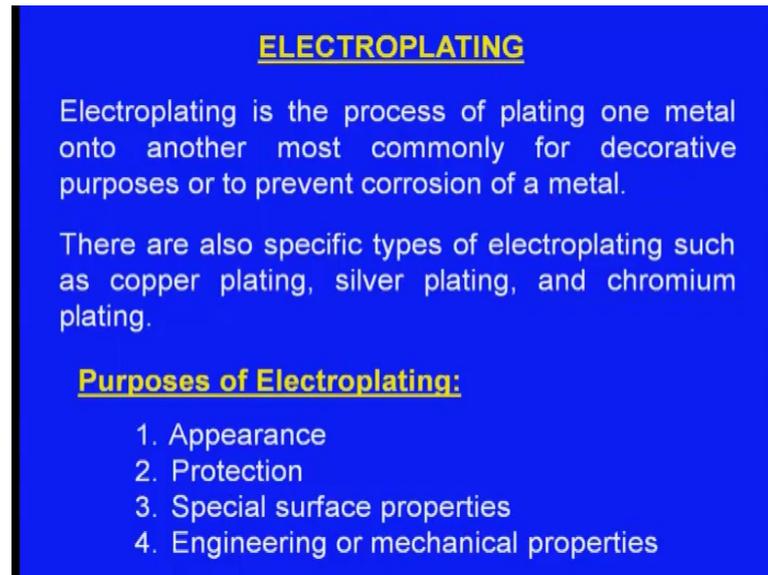
(Refer Slide Time: 21:32)



Now, methods of surface treatment- one is electroplating, second one is the tinning and galvanizing, third one is the anodizing, fourth one pickling, fifth one carburizing, sixth

one nitriding and nitrocarburizing, seventh one flame and induction hardening, eighth one hard facing. Now let us see all this one by one. Electroplating: electroplating is the process of plating one metal onto another metal right mostly for decorative purpose or to prevent corrosion. There are also specific types of electroplating such as copper plating, silver plating right and chromium plating

(Refer Slide Time: 22:22)



**ELECTROPLATING**

Electroplating is the process of plating one metal onto another most commonly for decorative purposes or to prevent corrosion of a metal.

There are also specific types of electroplating such as copper plating, silver plating, and chromium plating.

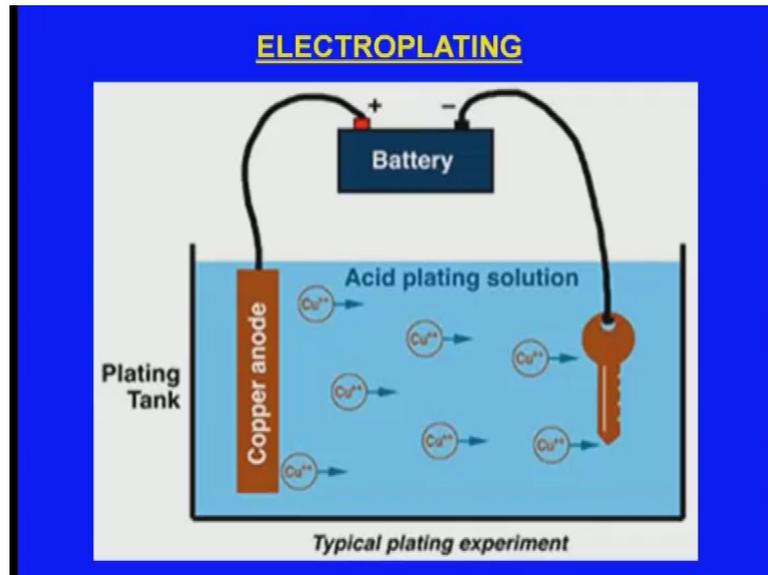
**Purposes of Electroplating:**

1. Appearance
2. Protection
3. Special surface properties
4. Engineering or mechanical properties

Now what is the purpose of electroplating? One is to improve the appearance, second one is for protection, means, protection from corrosion protection from wear, next one to achieve special surface properties may be. Surface may be soft we want hard surface inside we do not want hard. So, in such case we go for the electroplating.

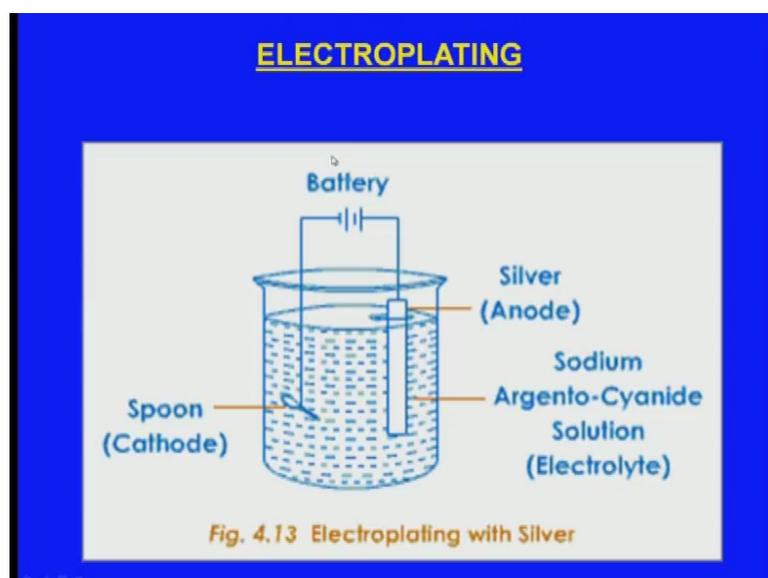
Next one engineering: to improve engineering or mechanical properties of the casting. In such case, we can go for electroplating and here, we can see this is the principle of electroplating right. So, it depends what say on the principle of the electrochemical what say decomposition.

(Refer Slide Time: 23:07)



Now, here is an anode and here is the cathode and a e m f is applied. Then what happens? An electrolyte is present in this tank. Then what will happen material will be removed from the anode and it will be deposited on the cathode. The same principle will be applied in this electroplating. Means, the casting will be made as the cathode and the material with which we want to give a coating will be made as the anode and these two will be kept inside the electrolyte and e m f will be applied. Then what will happen? Material will be removed from the that material which we are using as the coating and it will be deposited on the casting and same ah.

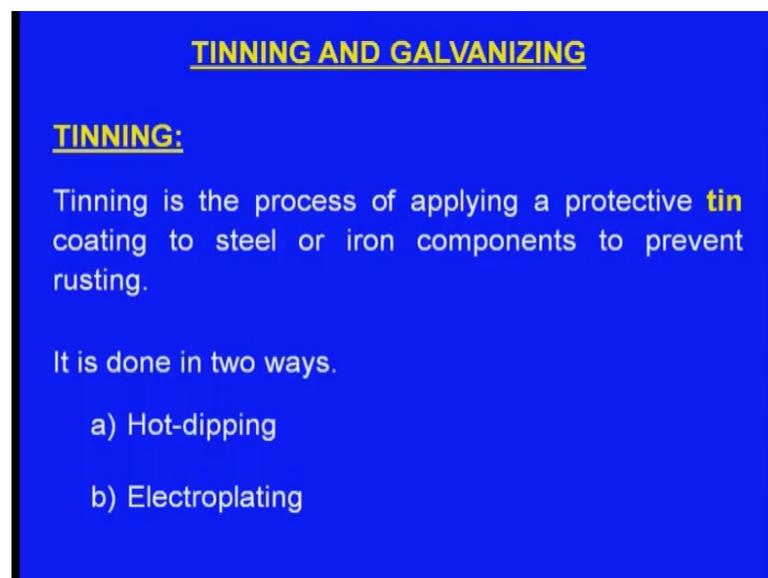
(Refer Slide Time: 23:56)



Here also, we can see this is the silver electroplating. So, silver here it is used as the anode and maybe for example, there is a spoon right then what will happen, when we pass the electricity material be removed from the silver and it will be deposited on the spoon which is the cathode. Next one is the tinning and galvanizing. What is tinning and galvanizing? Tinning is the process of applying a protective tin coating to steel or iron components to prevent rusting.

So, to prevent rusting or to what say achieve corrosion resistance we do this tinning.

(Refer Slide Time: 24:41)



**TINNING AND GALVANIZING**

**TINNING:**

Tinning is the process of applying a protective **tin** coating to steel or iron components to prevent rusting.

It is done in two ways.

- a) Hot-dipping
- b) Electroplating

It is done in two ways. One is the hot dipping, second one is the electroplating. In the case of the hot dipping we melt the tin in a container and the casting will be taken and it will be dipped inside the molten tin and it will be taken out. Then what will happen, a thin layer of tin will be applied on the casting surface. So, that is the tinning. Next one is the using electroplating also we can give use do the tinning. Means, electrolyte will be made as the anode and the casting will be made as the cathode. Now, an e m f will be applied and they will be kept inside an electrolyte; then what will happen material will be removed from the what; say tin and it will be deposited on the casting.

So, that is how we can do the tinning using electroplating operation also.

(Refer Slide Time: 25:36)

**GALVANIZING PROCESS**

Galvanization is the process of applying a protective **zinc** coating to steel or iron components to prevent rusting.

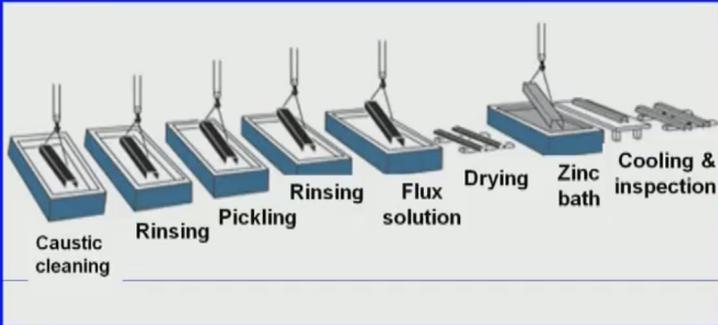
Galvanizing process consists of four fundamental steps:

- Surface preparation
- Prefluxing
- Galvanizing
- Finishing

Next one is the galvanizing process. Galvanization is the process of applying a again protective zinc coating in the previously it was a tin coating now it is the zinc coating to steel or iron components to prevent rusting. Again our objective is to improve the corrosion resistance. This galvanizing process consists of four fundamental steps: one is the surface preparation, next one prefluxing, next one galvanizing, next one finishing. So, these four steps one has to follow when he is doing galvanizing.

(Refer Slide Time: 26:13)

**GALVANIZING PROCESS**



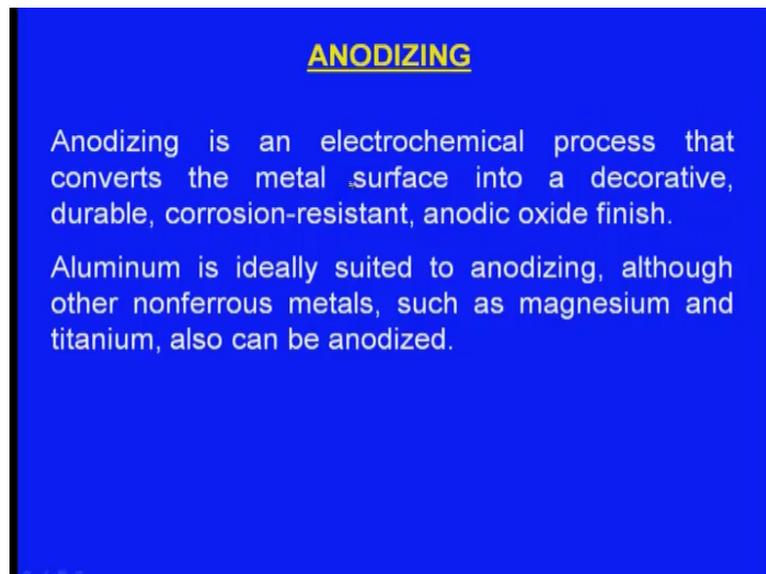
Sequence followed in galvanizing process

Now, here we can see different steps involved in galvanizing process can be seen. First one is the;

So, this is the component. This is the component, first step is the caustic leaning means with an alkali. It should be cleaned thoroughly, next one after cleaning it should be removed. Next step is the pickling. Pickling means if any unwanted material is there unwanted scales are there. So, those will be removed in a chemical or a mild acid. Next one after that, again rinsing because that acid has to be removed, if that acid layer is present on the casting what will happen, it keeps on reacting with the casting. So, that must be removed. So, we are doing rinsing. Next one flux solution. After that it will be dried out. Next one, here we can see here is a zinc bath. Means molten zinc is inside a container. Now that casting will be taken and it will be dipped inside the zinc bath then it will be taken out and it will be dried out.

Next, it will be cooled down and then it will be inspected whether the zinc is applied all around or not like that it will be inspected. So, this is these are the sequence followed in the galvanizing process. So, galvanizing means applying a thin coating of zinc around the casting, our next process for the surface treatment is the anodizing.

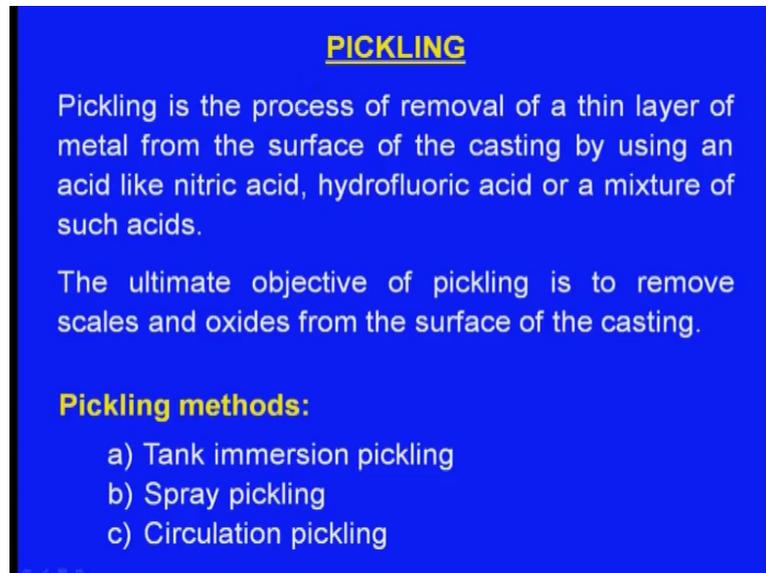
(Refer Slide Time: 27:46)



Anodizing is again an electrochemical process that converts the metal surface into a decorative durable corrosion resistant and anodic oxide finish right. Aluminum is ideally suited for anodizing; although other non ferrous metal such as magnesium and titaniums

can also be used. Our next step, next method in the surface treatment process is pickling. Pickling, what is pickling?

(Refer Slide Time: 28:16)



**PICKLING**

Pickling is the process of removal of a thin layer of metal from the surface of the casting by using an acid like nitric acid, hydrofluoric acid or a mixture of such acids.

The ultimate objective of pickling is to remove scales and oxides from the surface of the casting.

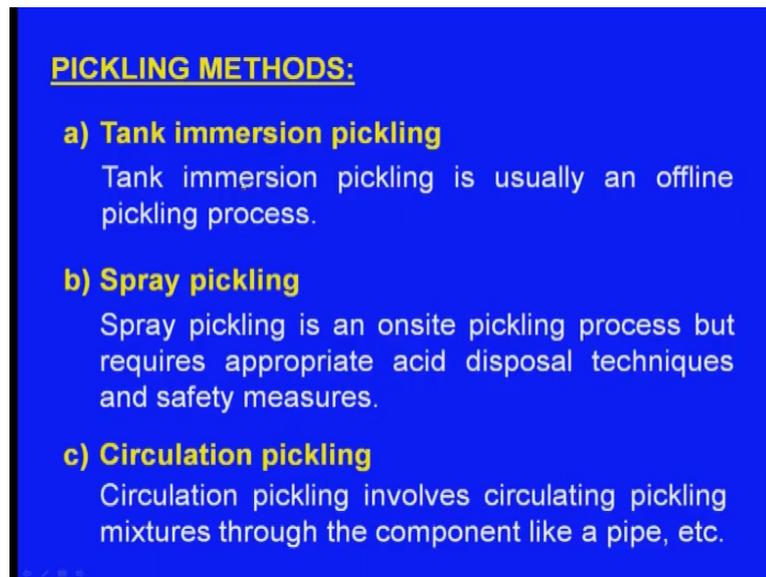
**Pickling methods:**

- a) Tank immersion pickling
- b) Spray pickling
- c) Circulation pickling

Pickling is the process of removal of a thin layer of metal from the surface of the casting by using an acid like nitric acid, hydrofluoric acid or a mixture of such acids. The ultimate objective of pickling is to remove scales and oxides from the surface of the casting right. Sometimes, oxides will be there scales will be there it is very difficult to remove using the hydro blasting or pneumatic blasting. At such times, we use the pickling. So, what is there in pickling? There will be a tank will be there. In the tank then acid will be there like nitric acid or hydrofluoric acid. The casting will be kept inside this container for a pre determined time. Then what will happen? The acid will be reacting with a thin layer of the casting and that layer will be removed. In this process even the scales will be removed from the casting now, the casting will be free from the castings oxides. It will be free from the rough surface finally, we get a casting with a better surface finish.

Now, there are three pickling methods are there. One is tank immersion pickling, next one is this spray pickling third one is the circulation pickling.

(Refer Slide Time: 29:43)



**PICKLING METHODS:**

**a) Tank immersion pickling**  
Tank immersion pickling is usually an offline pickling process.

**b) Spray pickling**  
Spray pickling is an onsite pickling process but requires appropriate acid disposal techniques and safety measures.

**c) Circulation pickling**  
Circulation pickling involves circulating pickling mixtures through the component like a pipe, etc.

In the tank immersion pickling what happens, there will be tank and inside that tank there will be acid, the casting will be kept inside that tank for a pre determined time and the acid will be reacting all around the casting. There are scales. Scales will be removed. If there is a rough surface, that rough surface will be reacting and finally, a free surface fine surface will be created on the casting that is the tank immersion pickling. Next one spray pickling. So this is used for the it is an onsite pickling process, but requires appropriate acid disposal techniques and safety measures.

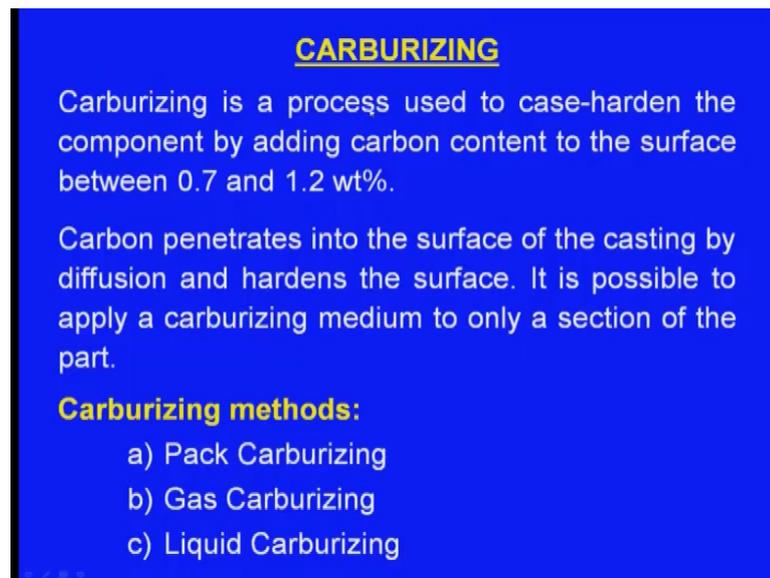
What is this? If the casting is small casting or a medium size casting we can put it inside a the tank. If that casting is a heavy casting, how can we put it inside the tank? It is not possible. At such times, we go for the spray pickling means, yes we take the big casting and wherever there are scales there we what say sprinkle acid right. So, that acid will be reacting with the scales and those scales will be removed; but we need to wash it after the spray pickling is over and also appropriate measures have to be taken so that these acids will be disposed very safely.

Next one is the circulation pickling. What is this? In this the circulation pickling involves circulating pickling mixtures through the component like a pipe. Suppose, if the casting is a big cylindrical pipe and it cannot be kept inside a tank and also certainly, the spray pickling will not do, then what to do? Certainly, we have to go for the circulation

pickling. What happens? Inside the circulation pickling the acid will be flowing through this cylindrical casting inside.

So, the inner surface will be finished. The inner surface it will be improved. The scales that are present inside the inner surface will be removed. So, that is the purpose and objective of circulation pickling. Next one is the carburizing.

(Refer Slide Time: 32:03)



**CARBURIZING**

Carburizing is a process used to case-harden the component by adding carbon content to the surface between 0.7 and 1.2 wt%.

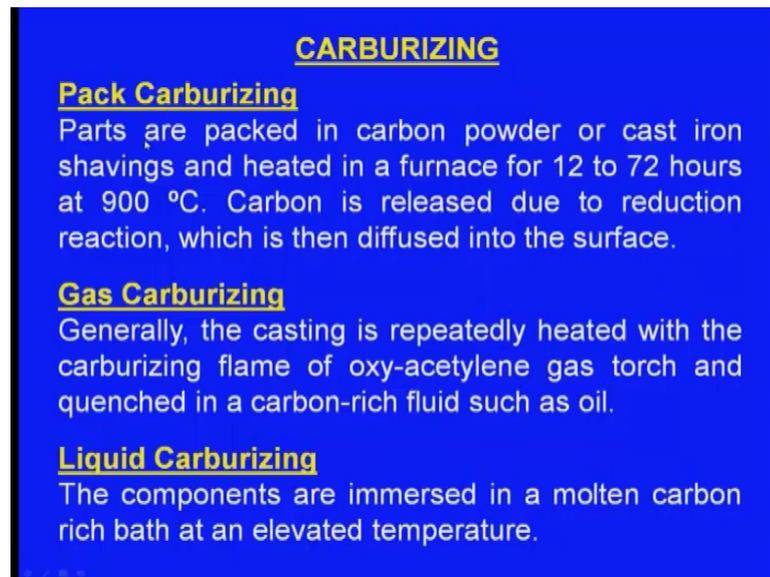
Carbon penetrates into the surface of the casting by diffusion and hardens the surface. It is possible to apply a carburizing medium to only a section of the part.

**Carburizing methods:**

- a) Pack Carburizing
- b) Gas Carburizing
- c) Liquid Carburizing

Carburizing is a process used to case harden the component by adding carbon content to the surface between 0.0, 0.7 to 1.2 percent weight percentage. The objective is to case harden. Means, we want to harden the surface not the entire casting. The carbon penetrates into the surface of the casting by diffusion and hardens the surface. It is possible to apply carburizing medium to only a section of the part. Sometimes, the entire surface of the casting need not be what say hardened by carburizing method. Only at a what say particular place we want to harden the surface. That is also possible. Now, carburizing methods, there are three methods. One is the pack carburizing, second one is the gas carburizing third one is the liquid carburizing in the pack carburizing.

(Refer Slide Time: 33:01)



**CARBURIZING**

**Pack Carburizing**  
Parts are packed in carbon powder or cast iron shavings and heated in a furnace for 12 to 72 hours at 900 °C. Carbon is released due to reduction reaction, which is then diffused into the surface.

**Gas Carburizing**  
Generally, the casting is repeatedly heated with the carburizing flame of oxy-acetylene gas torch and quenched in a carbon-rich fluid such as oil.

**Liquid Carburizing**  
The components are immersed in a molten carbon rich bath at an elevated temperature.

Parts are packed in a carbon powder or cast iron shavings and heated in a furnace for 12 to 72 hours at about 900 degree centigrade, then what happens, the component is packed inside the carbon powder or cast iron shavings. Carbon is released due to reduction reaction right yes, then that carbon diffuses into the surface then it hardens the surface.

So, that is the pack carburizing. Next one, gas carburizing generally, the casting is repeatedly heated with the carburizing flame of oxy acetylene gas torch and quenched in a carbon rich fluid such as oil now we use the gas welding right. So, we use the oxy acetylene gas acetylene and oxygen then again in this what say flame there will be three types of flames will be there. One is the carburizing flame, neutral flame and the oxidizing flame. We use the carburizing flame means the proportion of acetylene will be more. Means, they the flame contains rich carbon. Now with this flame, with this carburizing flame, we heat the surface of the casting then what happens; the carbon that is present in this carburizing flame will be diffusing into the surface of the casting. Then surface of the casting will be hardened and then it will be quenched in a oil.

So, that is the gas carburizing. Next one liquid carburizing, what is this? The components are immersed in a molten carbon rich bath at an elevated temperature right. So, the there will be a bath which contains a molten carbon and it will be at an at an elevated temperature and their component will be immersed in that bath then what will happen, the carbon from the what; say this rich carbon bath will be diffusing into the surface of

the casting and the surface of the casting will be hardened. So, carburizing is for hardening the surface of the casting maybe, the entire surface or a part of the surface. The next process of the surface treatment is nitriding and nitro carburizing.

(Refer Slide Time: 35:32)



**NITRIDING AND NITROCARBURIZING**

Both nitriding and nitrocarburizing are low temperature treatments that produce thin and hard layers on the surface of a steel casting to improve its wear resistance.

Both treatments diffuse nitrogen into the surface of the components to form a thin layer.

Ordinary nitrogen is inert at the treatment temperatures. Ammonia acts as a source of nascent nitrogen as it cracks on the component.

Both nitriding and nitro carburizing are low temperature treatments that produce thin and hard layers on the surface of a steel casting to improve its wear resistance. The purpose of carburizing is to harden the surface whereas; the purpose of nitriding is to improve the wear resistance of the surface. Both in, in both the treatments right diffuse nitrogen into the surface of the components to form thin layer nitrogen will be diffused

In the previous case, it was carbon, now it is nitrogen right. Ordinary nitrogen is inert at the treatment temperatures whereas, ammonia acts as a source of nascent nitrogen as it cracks on the component right. So, we need the nascent nitrogen for that purpose, we use ammonia.

(Refer Slide Time: 36:31)

### NITRIDING

In nitriding, this nascent nitrogen diffuses into the component and forms a thin layer.

The treatment temperature is low and no need for quenching. Hence, there will be less distortion.

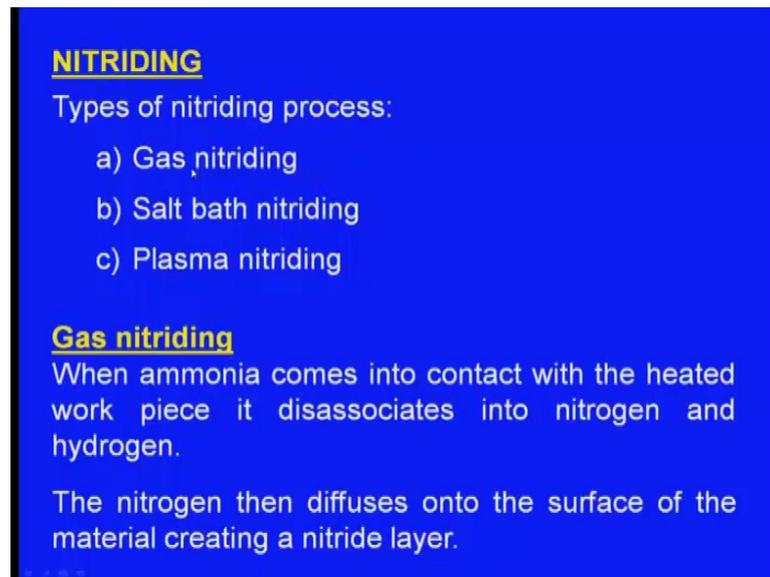
The layer produced by nitriding is harder than that from carburizing.

However, its typical heat treatment time is 60 hours as against 12 hours for carburizing.

Now, let us see the nitriding in nitriding the nascent nitrogen diffuses into the component and forms a thin layer. The treatment temperature is low and no need for quenching hence, there will be less distortion. In the case of the carburizing what happens, after the carburization is over after the diffusion of the carbon is over we use to quench. So, in the process of quenching there will be distortion of the casting means, there will be irregular deviations of the geometry. Here, no such distortion takes place. The layer produced by nitriding is harder than the layer produced by carburizing. As far as the hardness is concerned, nitriding produces better hardness compared to the carburizing.

Next one; however, its typical heat treatment time is 60 hours as against 12 hours for carburizing. Carburizing right, it requires only 12 hours whereas, nitriding requires 60 hours.

(Refer Slide Time: 37:34)



**NITRIDING**  
Types of nitriding process:

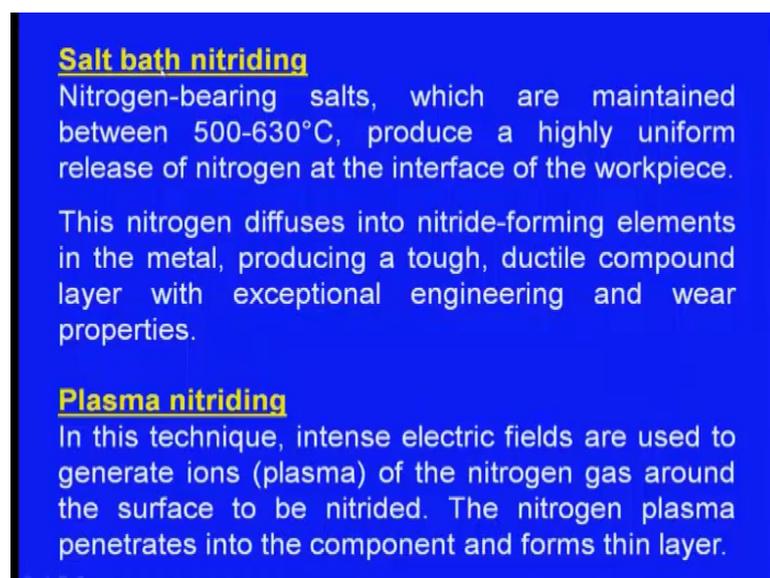
- a) Gas nitriding
- b) Salt bath nitriding
- c) Plasma nitriding

**Gas nitriding**  
When ammonia comes into contact with the heated work piece it disassociates into nitrogen and hydrogen.

The nitrogen then diffuses onto the surface of the material creating a nitride layer.

Now, there are three types of nitriding process. One is the gas nitriding, second one is the salt bath nitriding third one is the plasma nitriding. In the gas nitriding right, when ammonia comes in contact with the heated work piece it disassociates into nitrogen and hydrogen. This nitrogen diffuses into the surface of the casting and forms a nitrate layer. So, this is the gas nitriding.

(Refer Slide Time: 38:05)



**Salt bath nitriding**  
Nitrogen-bearing salts, which are maintained between 500-630°C, produce a highly uniform release of nitrogen at the interface of the workpiece.

This nitrogen diffuses into nitride-forming elements in the metal, producing a tough, ductile compound layer with exceptional engineering and wear properties.

**Plasma nitriding**  
In this technique, intense electric fields are used to generate ions (plasma) of the nitrogen gas around the surface to be nitrided. The nitrogen plasma penetrates into the component and forms thin layer.

Now, what about the salt bath nitriding? Nitrogen bearing salts which are maintained between 500 to 630 degree centigrade produce a highly uniform release of nitrogen at the

interface of the work piece right. So, when the hydrogen bearing salts are heated at about to 500 to 600 degree centigrade nascent nitrogen is released. So, when we place the work piece inside this bath then what will happen, this nitrogen will be diffusing into the surface of the casting. Then what will happen, it will be what say hardening the surface of the casting.

Next one is the plasma nitriding. In this technique intense electric fields are used to generate ions or the plasma of the nitrogen gas around the surface to be nitride. Then what will happen, the nitrogen plasma penetrates into the compound component and forms a thin layer which is very hard. So, that is the plasma nitriding.

(Refer Slide Time: 39:13)

### Nitrocarburizing

Nitrocarburizing is a shallow case variation of the nitriding process.

It is a thermochemical diffusion process where nitrogen, carbon, and to a very small degree, oxygen atoms diffuse into the surface of the steel part, forming a compound layer at the surface, and a diffusion layer.

In addition to wear resistance, nitrocarburizing provides corrosion resistance and aesthetically pleasing black finish on the component. It also improves fatigue resistance.

Next one is the nitro carburizing. It is little different from the nitriding process right. It is a thermo chemical diffusion process where nitrogen and also carbon and a very small degree of oxygen will be diffusing into the surface of the steel part forming a compound layer at the surface and a diffusion layer. Now what is the one should know the difference between nitriding and nitro carburizing. Nitriding means we are only sending the nascent nitrogen inside the surface of the casting whereas, in the case of the nitro carburizing we are sending nitrogen carbon and an extremely small amount of oxygen also. All these three will be going together, they will be diffusing into the surface of the casting and they harden the surface.

In addition to the wear resistance the; so, you see the basic purpose of nitrogen nitriding is to improve the wear resistance right in addition to wear resistance nitro carburizing provides corrosion resistance and aesthetically pleasing black finish on the component apart from improving the wear resistance it also improves the corrosion resistance this nitro carburizing and also it gives an aesthetical pleasing look to thee casting and also it also improves the fatigue resistance. So, that is all about the nitro carburizing. Next one is the flame and induction hardening. So, this is the next method in the surface treatment process, flame and induction hardening.

## FLAME & INDUCTION HARDENING

### FLAME HARDENING

Flame hardening is a surface hardening method used for steel components.

The steel component to be hardened is heated using an oxy- acetylene (or similar gas) above the transformation temperature. Then it is quenched in a spray of water.

The thickness of the surface layer hardened by this method will range from 1 mm to 10 mm.

(Refer Slide Time: 40:54)

Flame hardening is a surface hardening method used for steel components. The steel component to be hardened is heated using oxy acetylene gas above the transformation temperature. Then it will be quenched in a spray of water. The thickness of the surface layer hardened by this method will range from 1 mm to 10 mm.

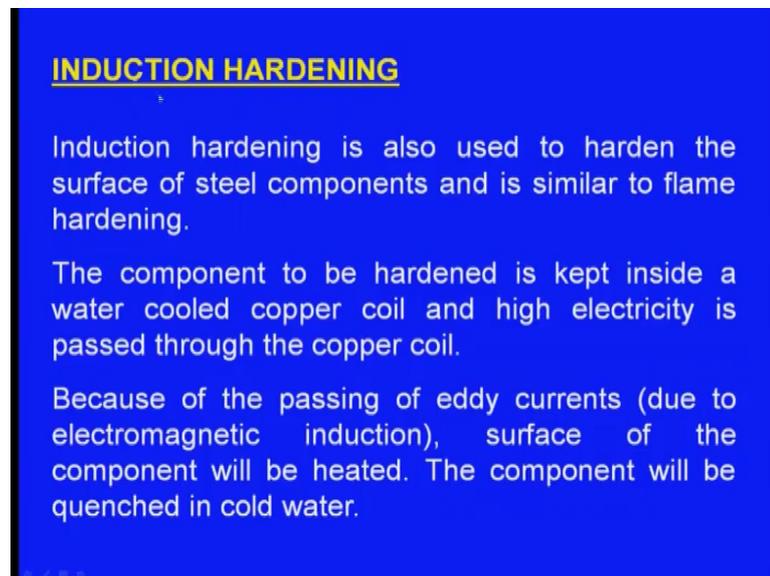
So, this is the flame hardening means we will be heating the cast component using the oxy acetylene flame and suddenly it will be quenched with a spray of water. So, this is the flame hardening.

(Refer Slide Time: 41:35)



So, here we can see yes the component is being heated by the what; say flame then it will be quenched.

(Refer Slide Time: 41:42)



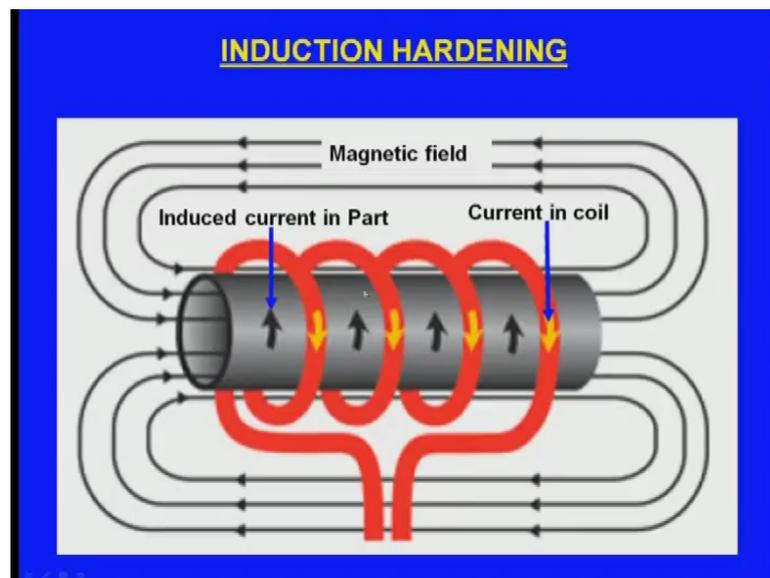
Next one is the induction hardening. Induction hardening is also used to harden the surface of the steel components and it is similar to flame hardening. Now the component to be hardened is kept inside a water cold copper coil and high electricity is passed through the copper coil. Means, if we want to what say induction harden a component that component will be kept inside a copper cooled copper right, water cooled copper

coil right. The component will be inside this coil and high electricity will be passing through that coil and inside that coil there is the component.

Now, what happens and because of the passing of the what; say because of the electromagnetic induction eddy currents will be developed inside the what; say component. Now as the eddy currents are passing through the component what happens a the components offers resistance to the eddy current then what happens if it offers the resistance right that too these eddy currents will be passing around the surface of the casting then what will happen, but the surface of the casting is offering resistance to the flow of eddy currents then what will happen heat will be generated now then the component will be heated up. Then at such times, it will be suddenly quenched with water that then what will happen the surface of the casting will be hardened.

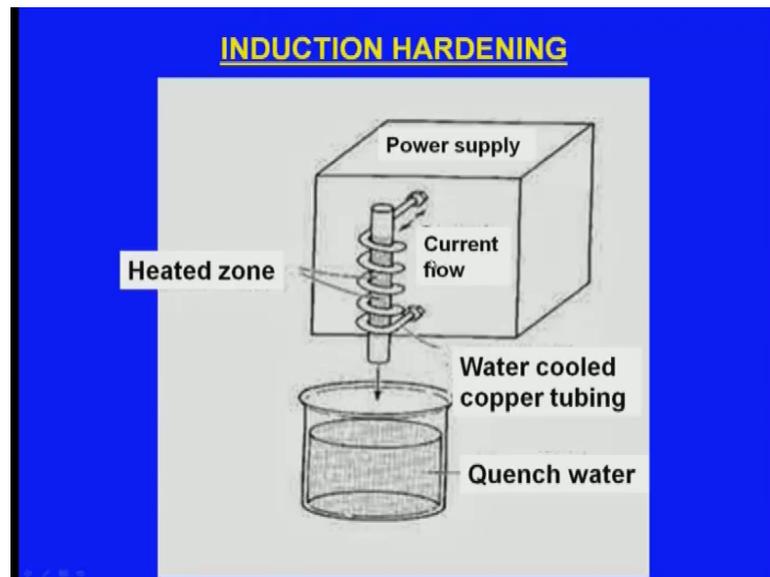
So, this is the induction hardening.

(Refer Slide Time: 43:21)



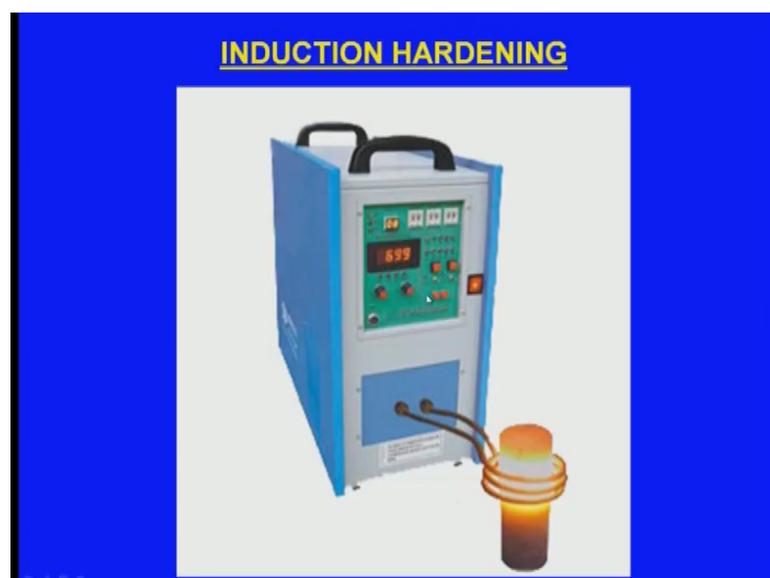
And here we can see yes, this is the magnetic field right. So, this is the copper coil this is the copper coil right and this is the component and we are passing the current through this coil then what happens on the surface of the casting there is induced current in the part this induced current are the eddy current is due to electromagnetic induction as the what; say eddy current is passing through the component the surface will be heated up then it will be quenched.

(Refer Slide Time: 43:54)



And the maybe the setup may look like this right. So, this is the power supply and this is the coil. This is the coil and right, this is the component and here we can see this is the quench water next quench water next this is the water cooled this is the copper tubing and then what happens when we pass the electricity eddy currents will be developed and the surface will be heated up and suddenly it will be quenched.

(Refer Slide Time: 44:24)

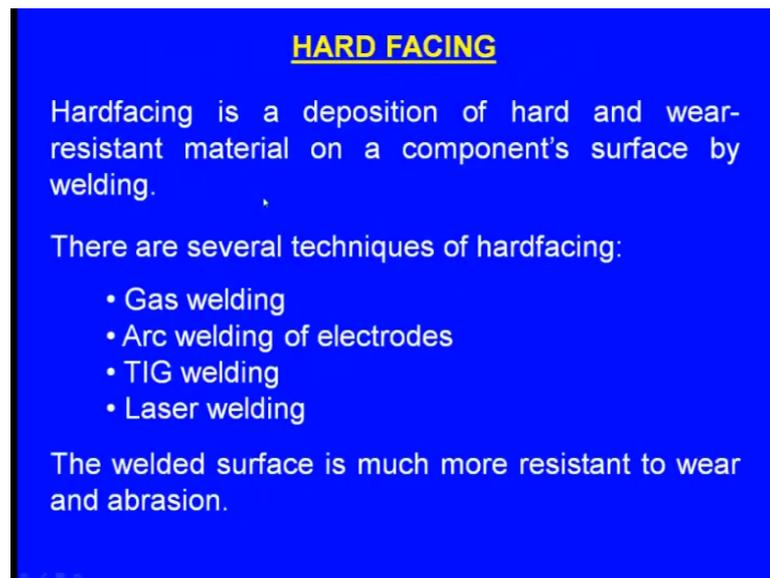


The machine looks like this induction hardening machine yes this is the coil and this is the coil and this is the casting and you see as we pass the what; say main current primary

current through the coil because of the electromagnetic induction, the surface of the casting will be heated up like this, then it will be taken out and it will be quenched inside the water.

Next, we will see the hard facing under the methods of surface treatment. Now, the question is what is this hard facing?

(Refer Slide Time: 44:59)



**HARD FACING**

Hardfacing is a deposition of hard and wear-resistant material on a component's surface by welding.

There are several techniques of hardfacing:

- Gas welding
- Arc welding of electrodes
- TIG welding
- Laser welding

The welded surface is much more resistant to wear and abrasion.

Hard facing is a deposition of hard and wear resistant material on a components surface by welding right. So, we take hard and wear resistant material and that will be taken in the form of an electrode. Then, it will be deposited on the what; say components surface by welding. There are several techniques of hard facing, one is the gas welding, next one is the arc welding, TIG welding and laser welding. In all this cases the hard and wear resistant material will be melted and a thin layer of this material will be deposited on the components surface. The welded surface is much more resistant to wear and abrasion. Now what is happening, the material the component may not be so hard in the beginning and it may not have so much of wear resistance in the beginning.

Now, we are taking a material which has got which is very hard and which has got highest wear resistance. Now, this material we are taking and we are depositing a thin layer around that component then what will happen the welded surface is much more resistant to wear and abrasion. So, we are hardening the component on the surface and

also we are enhancing the wear resistance of the component at the surface. So, that is the principle of hard facing.

(Refer Slide Time: 46:32)



Now, this it is how this hard facing is carried out. So, this is the component now this is the gas torch and as the gas torch is progressing around the work piece the component will be the material, the hard face material will be taken in the form of a filler rod and that will be melted and that will be deposited around the surface. So, not only by using gas torch there are other ways. Just now we have seen it. It can be done using arc welding, it can also be done by TIG welding or it can also be done using laser welding. In any of this process or using all of this process this hard facing can be carried out. Friends in this lecture, we have learnt about the surface treatment of the castings under that we have seen different methods of the surface treatment.

One method is the electroplating another method is tinning and galvanizing and another method is anodizing another method pickling another method is carburizing another method nitriding and nitro carburizing and another method flame and induction hardening and the last method is the hard facing. So, with this we are completing the surface treatment of the castings and we will meet in the next lecture until then bye

Thank you.