Power Plant Engineering
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Lecture – 13
Feed Water Treatment

I welcome you all in this course on Power Plant Engineering. Today, we will discuss about the Feed Water Treatment. In all the thermal power plants where water work is used as a working fluid, the feed water treatment is very important. Ideally, pure water has to be used in a thermal power plants, but it is not possible, so minimum of hardness and impurities are maintained in the working fluid in a steam power plant or in the water.

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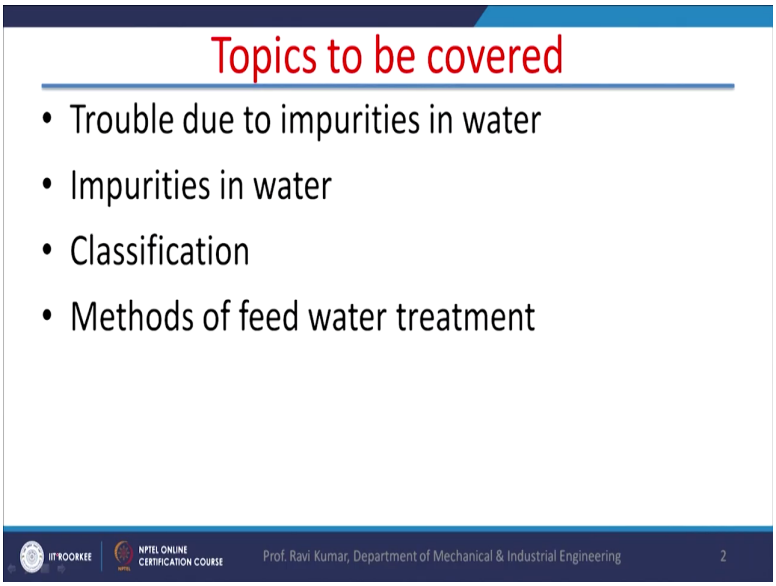

So, in today's lecture topics, we will be covering this is trouble due to impurities in water; what are the troubles which are faced in a thermal power plants when there are impurities in

water, Now, we will discuss about the impurities of water also. What are the different kind of impurities, which are there in the water, their classification and method how to treat the feed water, so it becomes usable in a thermal power plant.

Now, first of all we will discuss the troubles due to impurities in water. So, the troubles due to impurities in water first is scale formation.

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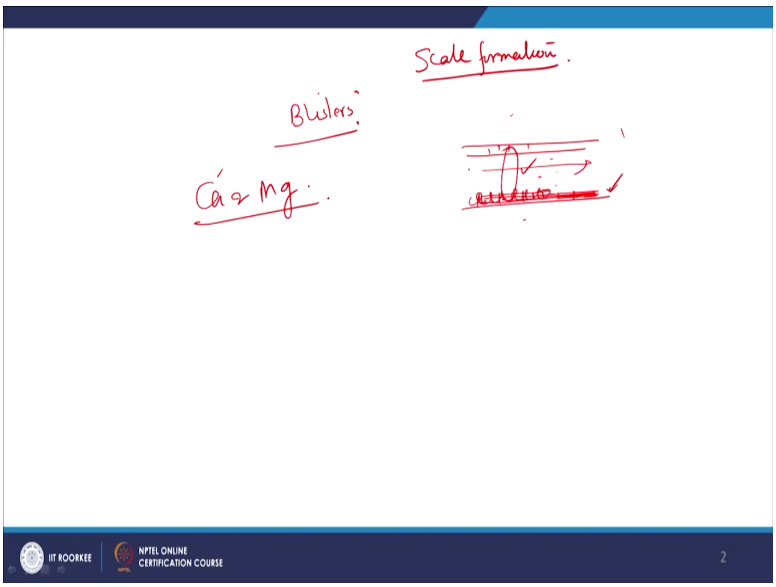

Now, you must have seen in day today's life when we use immersion heater for heating water for taking bath or for some other purpose, there is a white layer which is formed during after some duration; the white layer is formed on the surface of the immersion heater.

And this is chalk like powdery substance which is deposited in the and this layer is quite sufficient to prevent the heat transfer. I mean it works as a insulator. So, in that case what

happens? When we heat the water, the surface temperature of the immersion heater has to be increased in order to maintain the same amount of heat transfer, right.

And this overshooting of the temperature may damage the surface of the heater and same case happens in the boiler. When suppose boiler inside boiler there is a deposition, right now, some amount of heat has to be transmitted between the water between the flogas and the water which is inside the tube, right. Suppose it is a water tube boiler, so water is flowing inside the tube, it is surrounded by the flue gases. So, when the heat is transmitted from the flue gases to the water. The heat transmission is hampered due to presence of this layer; this layer of insula scale formation, this is scale formation and the surface of the tube inside the surface of the tube. Now, this has to be prevented.

This is nothing, but deposition of salts on the tube surface and when overheating; suppose in the boiler which is working on the high temperature, so overheating may cause blisters on the surface blisters on the tube surface and tube may also get ruptured also in due course of time. So, this is scale if there are salts of calcium and magnesium, right and silicates, they are deposited on the surface. What happens when the temperature the of the water increases due to reduced solubility of these salts in the water? The precipitation takes place and this precipitation is deposited on the surface. So, in order to avoid this precipitation, we will have to remove the salt from the water.

And second thing is when this layer becomes substantially thick; this layer, it reduces the cross section area of the tube also. When the cross section of the tube is reduced the choking of tube takes place or we can say more energy will be required to pump the water fluid tube. So, energy consumption will increase or ultimately it will hamper the performance of the system or performance of the cycle. Now, second thing which happens due to this presence of the different salts in the water that is corrosion.

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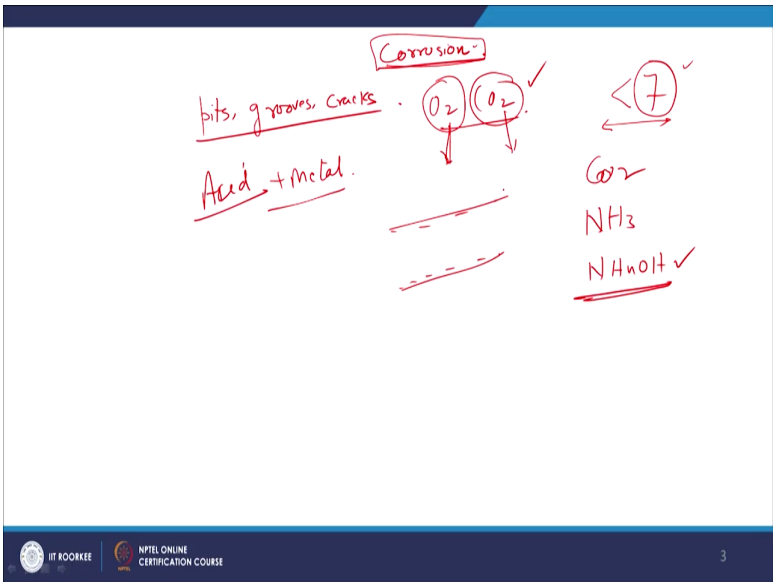

Now, what happens in corrosion? These salts this physically they eat away the material from the tube surface and this causes pits on the tube surface, grooves and cracks. Now, corrosion happens due to alkaline nature of the water. If the pH level of the water is less than 7, 7 is neutral. So, if the pH value is less than 7, the water is considered to be alkaline or it becomes alkaline.

So, alkaline nature of water which causes the corrosion of the surface, in addition to this there are dissolved gases like oxygen and carbon dioxide, ok. And carbon dioxide and oxygen in presence of the acids, it corrodes the surface of the tube. Now, how oxygen enters the water? Because in a power plant, it is a closed cycle, right. So, once the oxygen is removed from the water, it should not reappear. But what happens? In actual practice some makeup water is provided constantly because there is some leakage of water from different valves and different

joints. So, makeup water has sometimes purging of the condenser has to be done, so makeup water is provided. Through makeup water oxygen enters the cycle.

And this CO 2, this carbon dioxide it comes from the bicarbonates dissolved with the water and because the metal, this acid it reacts with the metal and it makes the metal bicarbonate. And these bicarbonates they liberate the carbon dioxide in the water it is, this carbon dioxide remains dissolved in the water. So, in order to control carbon dioxide, we can mix some ammonia. Now, these are not ammonia guys, this is NH 4 OH, NH 4 OH. This should be added to the water, right. This will reduce; this will control the carbon dioxide. And oxygen has to be removed, so water has to be deaerated in order to remove the oxygen then water has to be heated up to 110 degree centigrade. I will discuss on later in this lecture how deaeration has to be done.

We can do the productive coating also on the tube surface. When the productive coating is done, then definitely the corrosion it shall be prevented.

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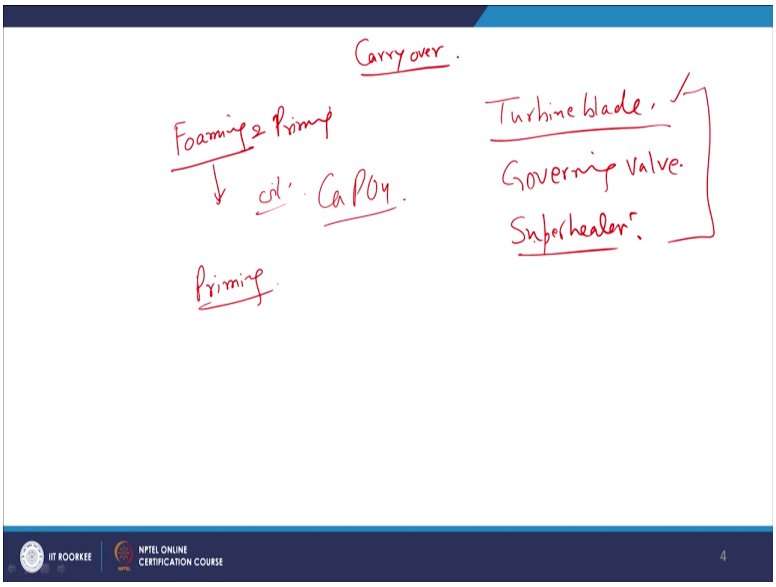

Now, next is the carry over. The carry over is a fact when this steam is taken from the drum. Sometimes what happens, solid particles along with the water they also enter in the pipeline and later on they create problem corrosion and erosion in the downstream side of the pipe. So, this solid enters the outlet pipe, this is due to foaming and priming.

Now, foaming, what is foaming? Foaming simply tiny bubbles are formed on the water surface which occupies the space which should be occupied by the water. So, the space or the volume which has to be occupied by the water is being occupied by the tiny bubbles and these bubbles are may create if there is a oil some presence of some oil in the water, right. Excessive sodium alkalinity is there in the water, in that case also the bubbles will be created or calcium phosphate is there in the water, in that case bubbles will be created and they will present in the carry over.

Second thing is priming. Priming is a sort of rigorous periodic surge in the water. If there is a rigorous periodic surge in the water; due to inertia the water will solid particle of the water will go into the steamline and they will ah cause problem. Because what happens, when these solid particles they enter into the system, they get deposited on turbine blades. And the moment they are deposited on the turbine blades, they will cause imbalance in the turbine and turbines are rotating in the very high rpm, right. So, this imbalance may damage the turbine itself.

They get deposited in the governing valve and they are deposited in super heater, because here temperature is high, right. And all these places, these depositions they have done the performance of particular component of a system. So, this carry over has to be highly avoided.

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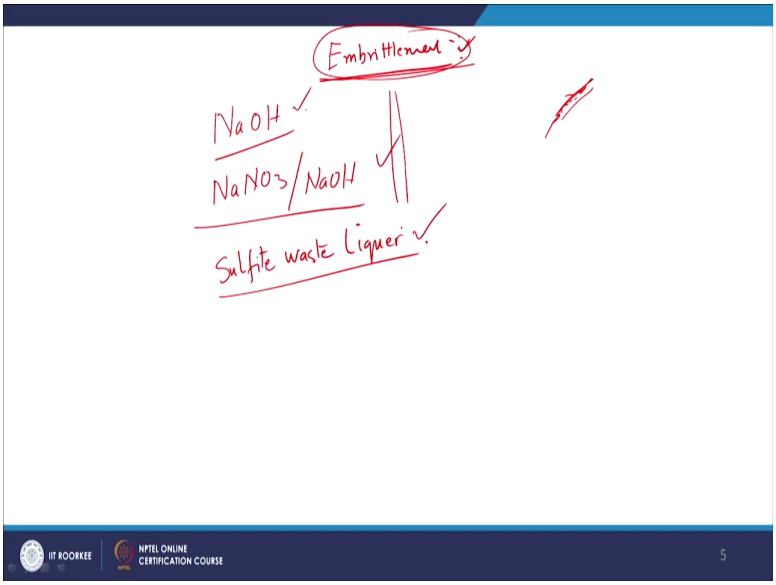

But in addition to carry over, embrittlement also takes place; embrittlement of ah the tube valve. What happens, when the alkaline water it enter because tube though the tube surface is smooth, right, but still there may be some cracks on the tube surface. Now, in these cracks this alkaline water enters, it gets heated and evaporated and leaves the salt behind, right. And this process continues and concentration of the salt salts keep on increasing in these cavities of the grooves or the pits and subsequently, it will lead to the embrittlement of the tube and the tube will get ruptured during the operation.

So, in order to prevent this embrittlement first of all sodium hydroxide should not be there in the water, right. So, the water or the feed water should be free from the sodium hydroxide. So, what happens? It we cannot be completely free from sodium hydroxide. So, sodium nitrate and sodium hydroxide a definite ratio has to be maintained between these two, so that the embrittlement of the tube surface is prevented. Sulfite waste liquer, this sulfite waste liquer we get from the pulp industry. It has, it is basic in nature. So, we can mix this sulfite waste liquer in the feed water and this problem, this problem related with this can be minimized. So, this is one of the solution for the embrittlement of the tubes in a power plant.

Now, we will go for the different classes of impurities in the water.

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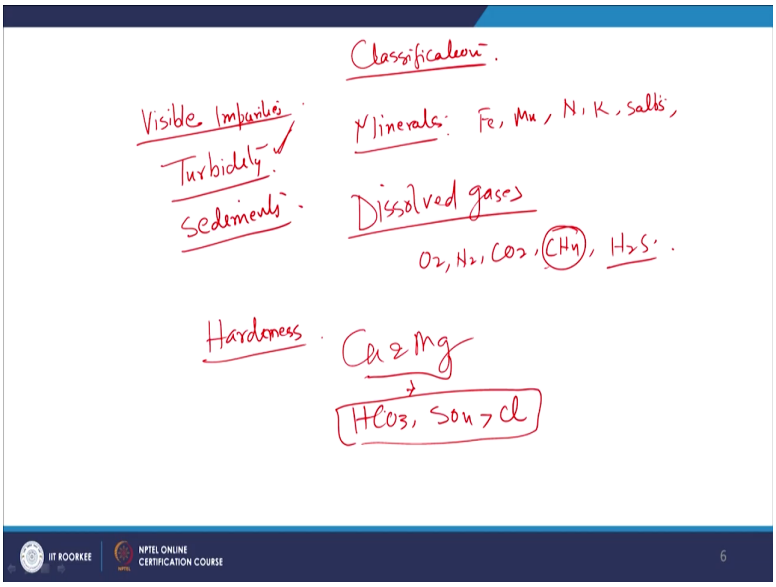

So, first of all we will do the classification. Some are visible impurities. If you take tap water or any other water because the water which comes for the thermal power plant, the water comes from the river or from the sea, not sea water it comes from the river, normally or from a large water body. So, there are certain visible impurities. Now, what are the visible impurities? There are some micro biological impurities some plants, some tiny plants or the roots of the plants will be there which can be easily filtered out, but they have to be removed because otherwise they will block the passage, right.

Turbidity might be there. Turbidity is some suspended in soluble matter which is present in the water that causes turbidity and turbidity has to be minimized. So, the sediments are there, but the beauty of the sediments is the water is still it is not moving; in that case sediments, they get automatically settled during due course of time. There are minerals in the water and the minerals are iron, manganese, sodium, potassium, other salts, fluorides, silica. So, these are the

minerals which are normally dissolved in the water. Mineral acids are there like H 2 SO 4, H Cl and the nitric acid; they may be present in the water.

Dissolved gases: now, dissolved gases is we have already discussed oxygen. So, as (Refer Time: 14:44) oxygen, nitrogen is also there. Carbon dioxide we have discussed. Ammonia can be there, because ammonia comes from the plants. So, ammonia, not ammonia this methane; the methane comes from the plants. So, methane can also be there, hydrogen sulfite can also be there. So, this is a possibility of presence of these gases in the water and the hardness of the water, which is most threatening because it causes the deposition on the surface and that is insulating layer and which hampers the performance of the plant. So, the hardness is normally calcium and magnesium, bicarbonate, sulfate and chlorides. Bicarbonate, sulfate and chlorides of calcium and magnesium, they causes hardness in they cause hardness in feed water.

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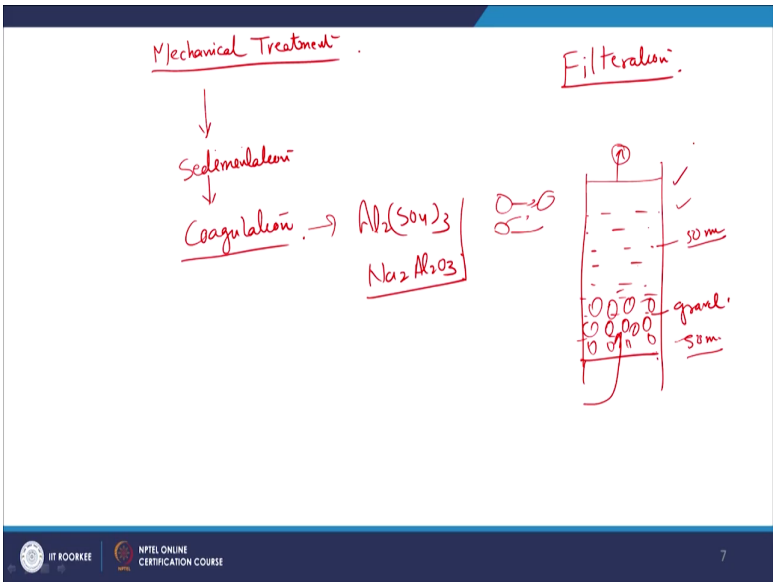

Now, the next is how to treat the feed water. How to make the feed water usable for the thermal power plant? So, one method is mechanical treatment, mechanical treatment. In mechanical treatment, what we can do, we can take the water sedimentation I mean what I am going to explain is sedimentation. So, we can take water in a large vessel, leave it there for some, due to gravity the vertical particles will be sedimentated in the water and they can be subsequently removed. So, this is mechanical treatment. But it cannot remove many of the impurities in the water, but some of the impurities in the water for example, some micro biological substance are there, I mean some roots of the plant or some leaves of the plant they will be settled and they can be removed from the water.

Now, another is coagulation. Water has is a is a colloidal suspension, water also has some colloidal suspension which can be removed by coagulation. So, what we do it for coagulation, alumina, alum sorry not alumina, alum is added to the water. Well, alum is like added to the water or a chemical like aluminium sulphate or chemical like Na 2 Al 2 O 3. Now, if we add this chemical to the water, so they need gelatinous substance and there is very good cohesiveness between gelatinous material and the particle start adhering to each other. They start esting to each other and the lumps are made, and the lumps later all the lumps can be filtered out from the water and this is another way of purification of the water.

Now, after coagulation we can do the filteration also, filteration. Now, in filteration the water gets filtered and it is a very unmysterious technique. There is a tank, in the tank at the bottom, there is a gravel substance which is placed in the gravels, so the gravels are here and fine soil is placed at the top. Thickness is around we can make around 50 mm and here, you can take in this also you can take 50 mm, right and not 50 mm, yes 50 mm and then water is made to flow from bottom to top, right and the water, slow, very slow water it has to be maintained and we can get filtered water from the top.

So, these are I am just giving you the state schematic arrangement and ah through this technique the filteration can be done. There are many other techniques also for filteration, but this is a very simple technique which can be done ah at the site.

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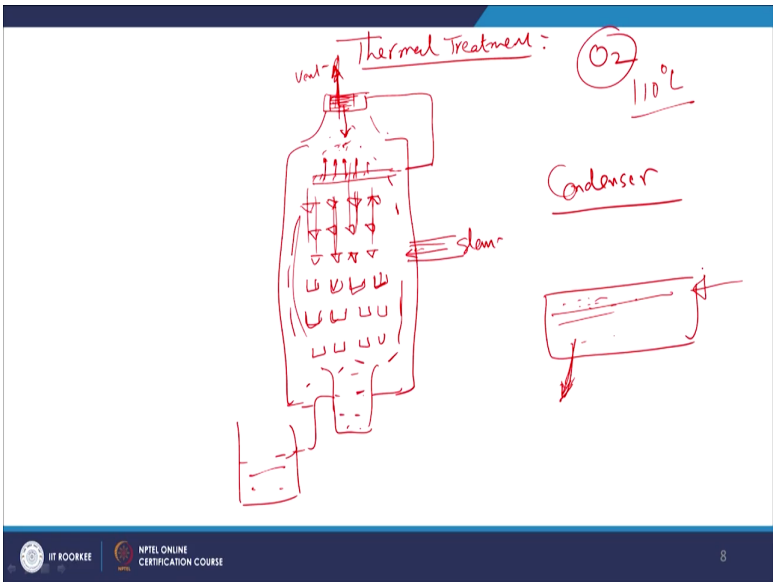

The next is thermal treatment of the water. Now, thermal treatment of water is mainly done to remove oxygen or this is also known as deareation of the water. Now, for deaeration of the water, there is a separate arrangement for the in the thermal power plant deaeration of water. So, for deaeration there is a big tank and at the top of the tank. There is a sort of condenser which is connected here for venting, this is vent, ok.

And there is an arrangement for the spray because water coming from the vent will enter here spray will be made in vertical direction. And just below the spray, there is there are heating tyres, there is an array of heating tyres and below the array of heating tyres. There is air separation tray, the tray, the number of trays. In these trays, through these trays air separation takes place because air does not remain in these trays it comes out of the tray and here the

collection of condenser takes place and from here it can go to some other place or some other pit for collection.

The steam enters from this side, steam enters from this side and it fills the entire area. It get mix with the water, the steam is at high temperature I mean because the deaeration suppose we say at 110 degree centigrade the steam has to be higher than this, may be 120, 125 or 130 degrees centigrade. So, steam heats the entire area. Entire volume is heated with the help of steam and steam is when steam is filling the entire area then it gets mixed with the water spray also and when it gets mixed it gets mixed with the watering spray part of the steam gets condensed also and this condensing it travels over these heated trays.

Now, these heated trays, it travels over the heated trays and subsequently it gets condensed, it gets collected, the condenser it gets collected in the trays and air remains outside, it gets up and this mixture of steam and air, sorry steam and oxygen or steam and air. It comes here near vent where there is a condenser again the water is condensed, water vapor is condensed and air is removed from here. So, basically what we do? We heat the water, basically we heat the water with the help of the steam, we take the temperature of the water to temperature around 110 degree centigrade and then the water is condensed, right. And so, the mixture of water and the steam is passed through a condenser, steam is converted into the water, it gets removed and remaining air it is sent to the atmosphere.

So, this is a nowadays this is deaeration has to be done frequently in a thermal power plant in order to remove oxygen or air from the system because air is also a desired gas in a thermal power plant because what happens in a thermal power plants it gets accumulated in the low pressure zone and the low pressure zone is the condenser.

So, inside the condenser, the pressure inside the condenser the pressure inside the concerned condenser is 0.1 bar, 100 kilopascal sorry 10 kilopascal or 7 kilopascal in that range. So, that this is I am talking about the absolute pressure the condenser works at the vacuum. So, at this pressure it the non-condensables they get accumulated near the condenser tubes. So, frequently the mixture of steam and gas, non-condensables has to be ejected from the condenser, right. And since this ejection takes place, we have to provide the make of water

and through make of water the this air enters this again enters the system, right. So, it is a constant process in a in a thermal power plant.

Now, we can do dissolution also where the requirement is less than 4 per cent, dissolution can also be done ah to in order to get rid of all the impurities in the water and chemical treatment is also done. Through another method of chemical treatment of the feed water, this is chemical treatment.

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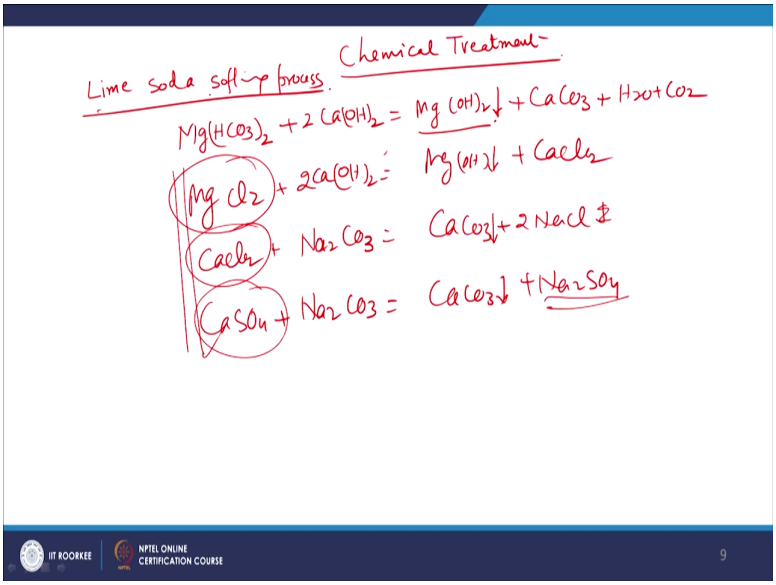

Now, for chemical treatment, first method is lime soda method softening process. Now, lime soda softening process, I will express these in terms of chemical reactions like magnesium hydro carbonate, magnesium hydro carbonate, calcium hydroxide, ok. This is lime, soda is sodaish, sodaish is sodium carbonate. So, calcium hydroxide it works it reacts with this and it causes Mg OH 2 which is precipitated.

The philosophy is through reactions the salts will get precipitated in water and this precipitation precipitated salt will be subsequently removed. So, and plus CaCO 3 plus H 2 O plus CO 2. Now, this is what reaction magnesium hydroxide is precipitated. For example, for removal of magnesium chloride 2 Ca OH 2, here also magnesium hydroxide take takes place plus CaCl 2.

Now, CaCl 2 again has to be removed for this sodaish is used. We get CaCO 3 plus 2 NaCl. NaCl is soluble, NaCl does not precipitate, CaCO 3 gets precipitated. Now, calcium sulphate, it has to be removed then Na 2 CO 3, CaCO 3, again it will get precipitated plus Na 2 SO 4. It will remain dissolved in the; because dissolved salt do not erode the tubes, but they are also dissolved they are they are less harmful than the undissolved salts. This permanent hardness because this causes scale formation; Na 2 SO 4 does not cause scale formation, but this will cause scale formation on the tube surface. So, this is how we get rid off these the hardness with help of lime soda softening process.

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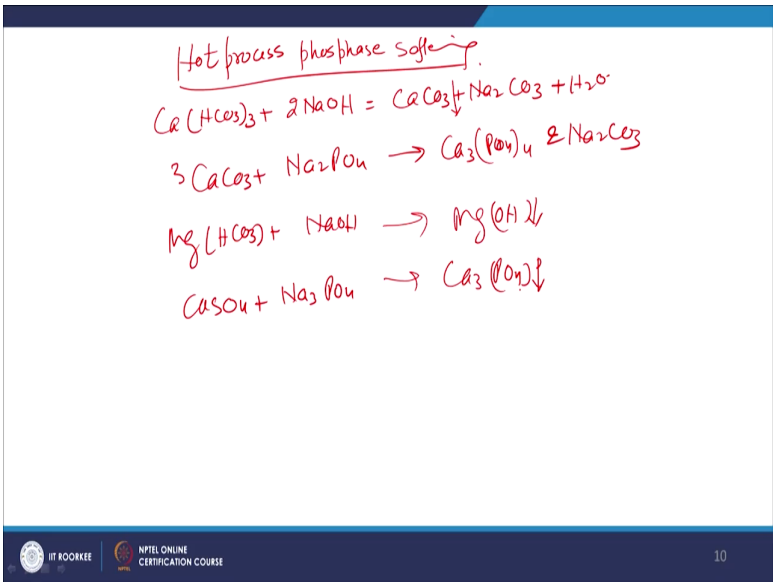

Another process is hot process, hot process phosphase softening. Now, here sodium hydroxide is used calcium H CO 3 bicarbonate plus caustic soda is used. First of all, here we get CaCO 3 plus Na 2 CO 3 plus H 2 O. So, here CaCO 3 gets precipitated. Now, similarly CaCO 3 reacts Na 2 PO 4 and it makes the substance Ca 3 PO 4, PO 4 and Na 2 CO 3.

Similarly, magnesium hydrocarbonate, it reacts with Na OH and Ca SO 4 it reacts with Na 3 PO 4 and you can do this equation, I mean work by yourself and you will find most of the salts which are precipitated because here you will get Mg OH, it will be precipitate, either you will get Ca PO 4 2, this will be precipitated. So, permanent hardness is removed. By either you can use either of these processes; this is how you can remove the permanent hardness.

Now, for removing permanent hardness or making water soft there is another method which is known as ion exchange method, right.

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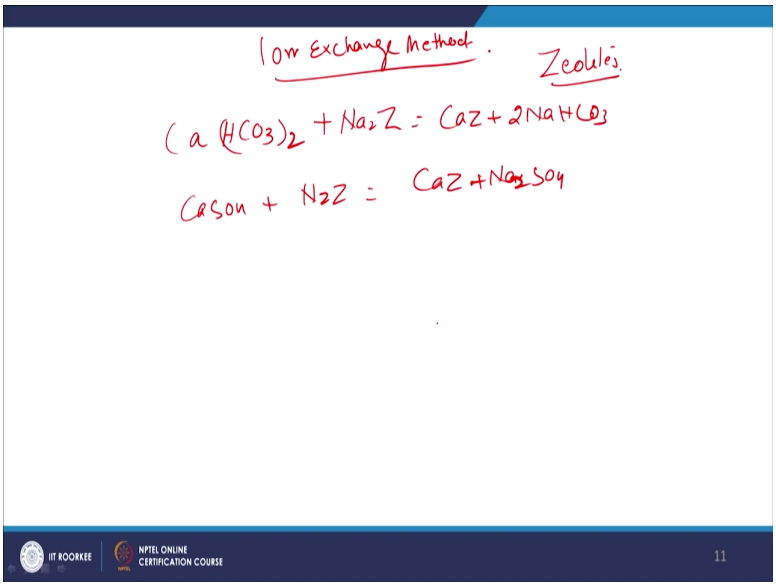

In ion exchange method zeolites are used, right and for example, calcium hydrocarbonate 2, sodium zeolite this will form calcium zeolite plus 2 Na HCO 3. Similarly, calcium sulfate is there, then again it will act with Na 2 Z; it will form Ca Z plus Na 2 SO 4. So, this you know zeolites are made, magnesium or calcium zeolites are made and water gets softened. Later on this zeolite has to be charged with help of sodium chloride. Sodium chloride is passed through the zeolite and again sodium ions are restored with the zeolite. And this is a very popular method in not only in thermal power plant, but also in many you know industries where water softening has to be done. This is all for today.

Thank you very much.