Metal Casting
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Module - 03
Melting, Fluidity And Solidification
Lecture – 02
Treatment Of molten Metal

Good morning friends. In the previous class, we have learnt about melting practices. Once we obtain the molten metal there is a need to treat the molten metal. So, in this lecture, we will be seeing Treatment of Molten Metal.

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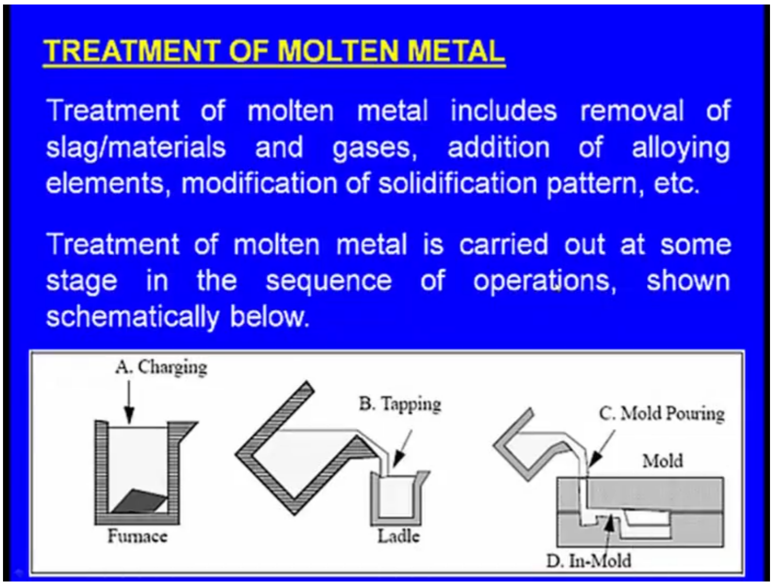

What is the meaning of treatment of molten metal? Treatment of molten metal means removal of slag, removal of unwanted materials, or gases from the molten metal. Treatment of molten metal means addition of alloying elements or modification of the solidification pattern.

So, all these activities together constitute treatment of molten metal means either we will be removing some material or we will be adding some alloying elements or we will be removing some gases or will be changing the solidification pattern.

Now, this treatment of molten metal is carried out at some stage in the sequence of operations shown below what are what are they ones this can be done or this treatment of molten metal can be done when the molten metal is in the furnace. So, this is the furnace or this treatment of molten metal can be done when we tap the molten metal into a ladle this is the ladle and this is the furnace or this treatment can also be done after we pour the molten metal into the mold. So, this is the mold at any of these stages treatment of the molten metal can be done.

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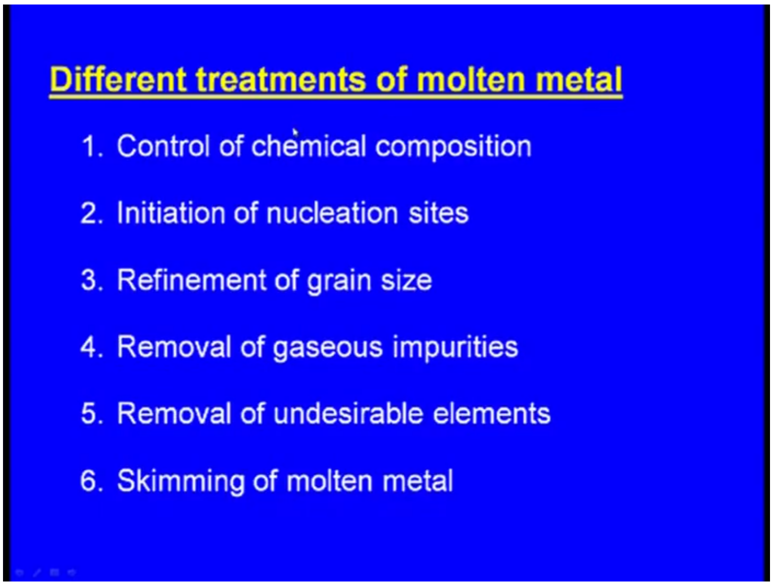

Now, these are the different treatments of molten metal; one is control of chemical composition means here we add alloying elements to change the composition of the molten metal. And next treatment is the initiation of nucleation sites. Third treatment is the refinement of grain size. Fourth treatment removal of gaseous impurities and Fifth treatment removal of undesirable elements and last is the skimming of molten metal means removal of dross; dross means mixture of slag and other impurities mixing with the molten metal. So, this is the dross. So, this dross can be removed in the skimming.

Now, let us see all these what say treatments one by one. First let us see the control of chemical composition.

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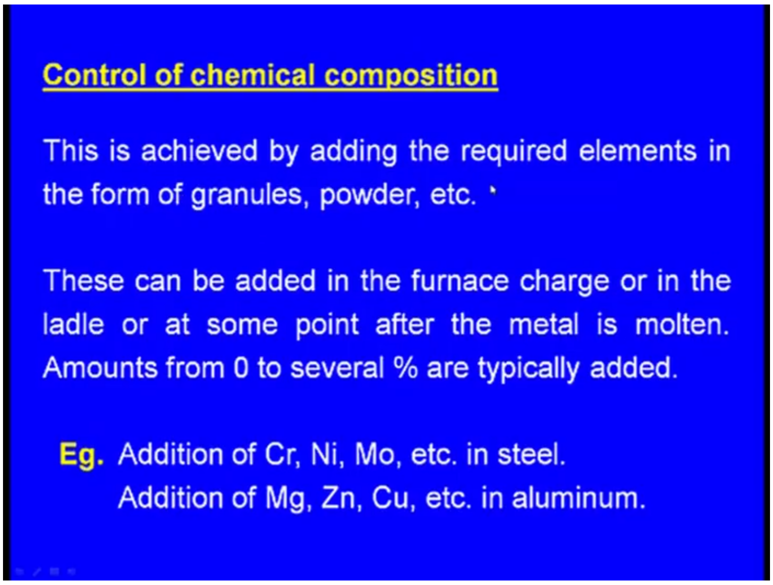

In the control of chemical composition this is achieved by adding required elements in the form of granules powder into the molten metal. Suppose the molten metal requires suppose if we are melting steel if it requires chromium we will be adding chromium granules into the molten metal or nickel granules into the molten metal right.

So, this can be added in the furnace charge or in the ladle you see this can be done at 2 stages, one is the furnace charge or in the ladle or at some time after the metal is molten amounts from 0 to several percentage are typically added. So, these are the best examples in the steel say we require chromium as an alloying element or nickel or molybdenum as the alloying elements.

So, these alloying elements will be added into the molten metal in the form of granules. So, ultimately the chemical composition will be changing. Similarly in the aluminum we add magnesium. So, and zinc copper these are the very good alloying elements of aluminum. So, this will be added into the molten aluminum. So, that the composition will be changing so this is the one of the treatments that is the control of chemical composition.

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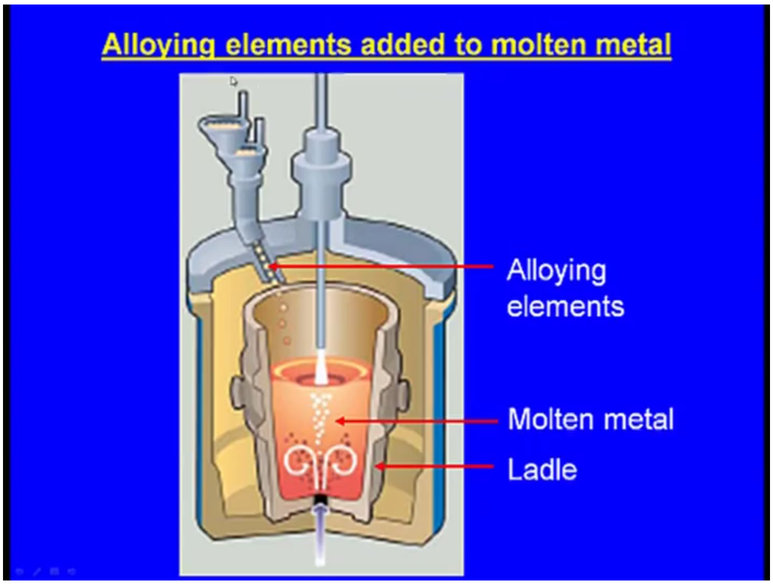

Now the chemical what say elements alloying elements can be added like this here we can see. So, this is the furnace this is the furnace or the ladle right. In fact, this is the ladle and here the molten metal is being coming in coming into the ladle and here we can see there is a hopper in this hopper there are granules are. So, these are the granules of the alloying elements different alloying elements.

So, this will be dropped into the molten metal one by one these granules. So, these granules are coming inside and they will be steed and they will be mixed together finally, the composition of the allowing what say molten metal will be changed as per our requirement the next treatment is the initiation of Nucleation sites.

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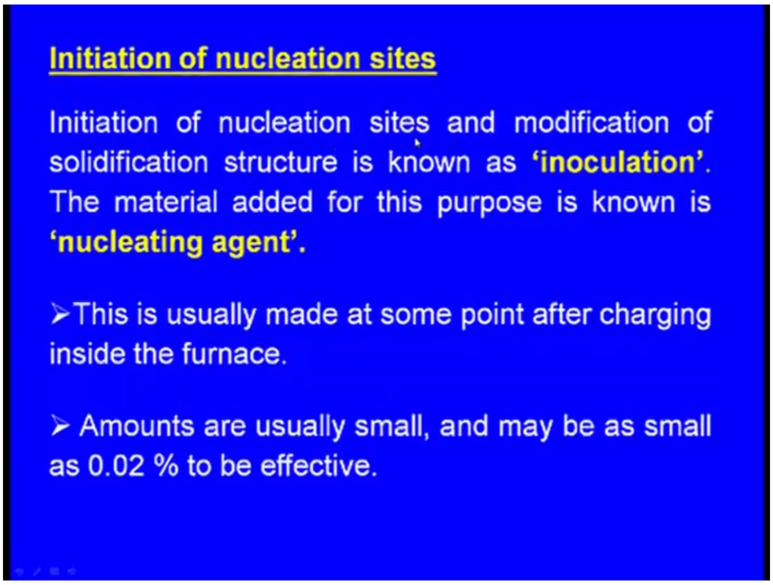

What is this initiation of the nucleation sites initiation of nucleation sites and modification of solidification structure is known as inoculation right. So, here we add certain elements to change the solidification structure, the material added for this purpose is known as nucleating agent. In the first case we have seen the alloying elements we were adding here we will be adding nucleating agent. So, that the solidification structure will be changing so that the solidification structure will have better properties this is usually made at some point after charging inside the furnace.

Now, amounts are usually small and may be as small as 0.02 percents to be effective.

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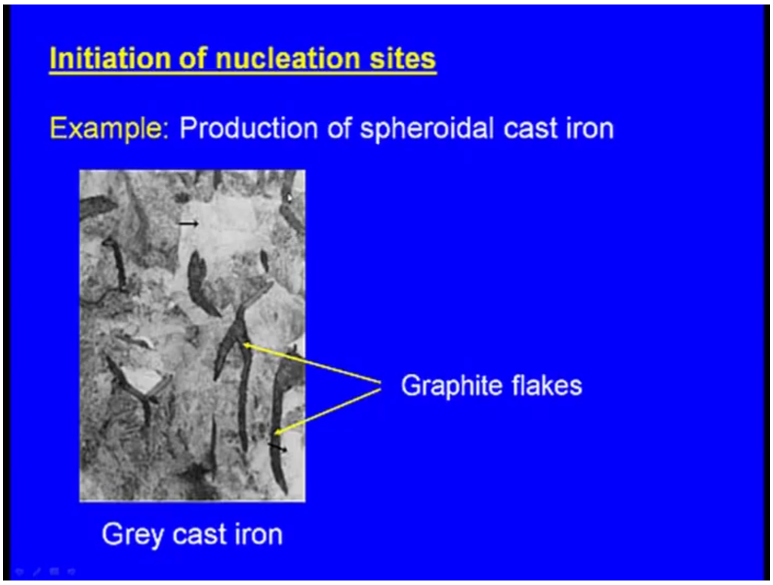

Now let us see an example production of spheroidal cast iron. This spheroidal cast iron is also known as ducktail cast iron or it is also known as nodular cast iron. Now initially there is a gray cast iron see if we see the gray cast iron. So, this is the what say structure solidification microstructure of gray cast iron and here we can see these are the graphite flakes long graphite flakes are there this helps us in machining right. So, they will help us to get the what say discontinuous chips that way it is good, but mechanical properties may not be very good.

So, to improve the mechanical properties we will be modifying the solidification structure. Now we produce the spheroidal cast iron during production of spheroidal cast iron calcium or barium or strontium or zirconium or magnesium and even rare earth metals are added in very small quantity to the cast iron molten metal.

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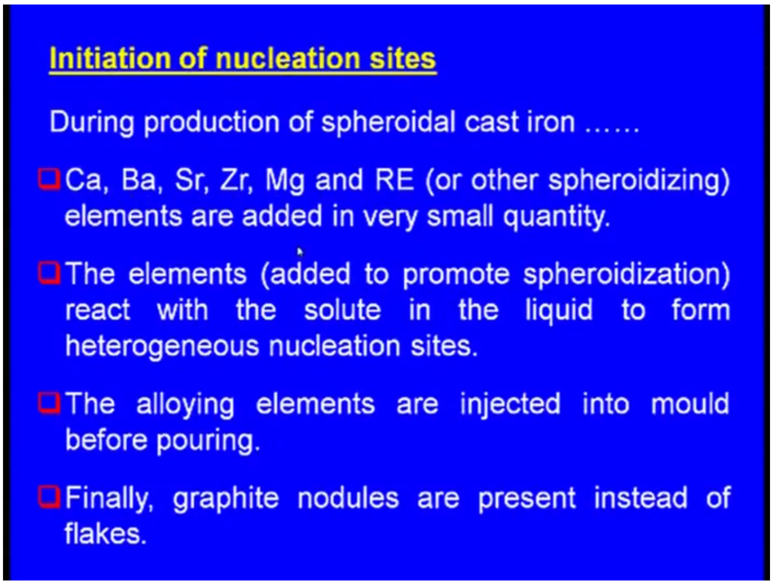

The elements added to promote periodization react with the solute in the liquid to form heterogeneous nucleation sites. Now these elements that we add as the nucleating agents will be acting as the nucleating agents means; they will be spreading all over the melt all over the molten metal around these nucleating particles the molten cast iron will be solidifying. They will be solidifying like spears that are why it is known as the spheroidal cast iron the allowing elements are injected into the mould before pouring finally, graphite nodules are present instead of flakes.

Now, what happens previously in what say gray cast iron carbon was present in the form of the graphite flakes, now here because we are adding these nucleating agents around the nucleating agents the cast iron is solidifying? So, many spears are produced that is why we also call it as the spheroidal cast iron. Now here we can see this is the structure of the spheroidal cast iron. And so many is what say spears are there we can see so many spears.

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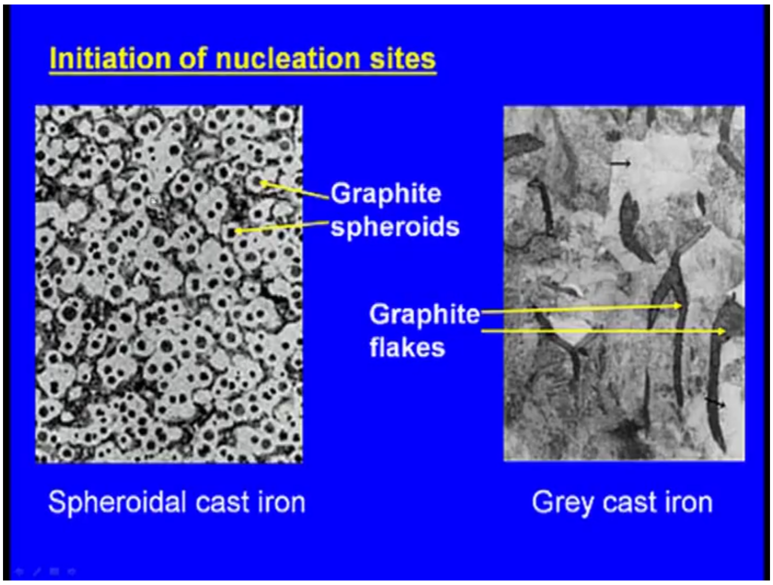

So, these are all the graphite spheroids here we can see. So, these what say what says spheroids improve the mechanical properties of the spheroidal cast iron or the ductile cast iron or the nodular cast iron. Whereas, the microstructure of the gray cast iron is like this it is not so favorable as far as the mechanical points are concerned.

Generally a carrier material is doped with a minor additive or the "nucleant" which produces the nucleant particles in the iron melt. So, to add this nucleant to the molten metal a carrier material is used.

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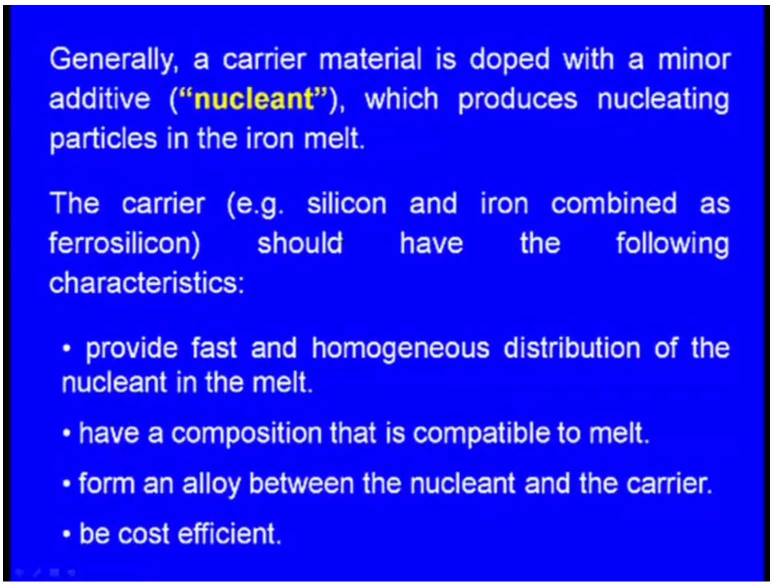

This carrier for example, silicon and iron combined as ferrosilicon. So, here the ferrosilicon acts as the carrier should have the following characteristics, it should provide fast and homogeneous distribution after nucleant in the melt. It should have a composition that is compatible to the melt means it should not disturb the composition of the melt and it should form an alloy between nucleant and the carrier and it should be cost effective. So, these are the what say characteristics required for an a for a good carrier material.

Next one let us see the third refinement right that is the third treatment that is the refinement of grain size

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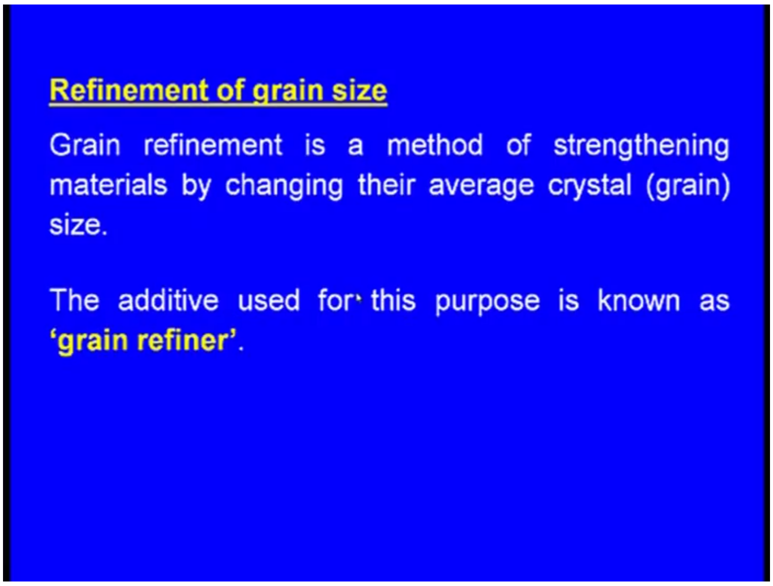

What is this refinement of grain size grain refinement is a method of strengthening materials by changing their average crystal or grain size, the additive used for this purpose is known as grain refiner.

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Typical grain refiners for various casting alloys

Metal	Grain refiner
Cast iron	FeSi, SiCa, graphite
Mg alloys	Zr, C
Cu alloys	Fe, Co, Zr
Al–Si alloys	Al-3B, Al-4B, Al-5Ti, Al-1Ti-3B, Al-5Ti-1B
Pb alloys	As, Te
Zn alloys	Ti
Ti alloys	Al-Ti intermetallics

Now, these are the typical grain refiners for various casting alloys. So, this is these are the metals right for cast iron the grain refiners are ferrosilicon, silicon carbon, calcium, and graphite. For magnesium alloys the grain refiners are zirconium and carbon, for copper alloys the grain refiners are iron cobalt and zirconium, for aluminum silicon alloys the grain refiners are aluminum 3 boron, aluminum 4 boron, aluminum 5 titanium, aluminum 1 titanium 3 boron, aluminum 5 titanium 1 boron. And for lead alloys the grain refiners are as and Te next one for zinc alloys it is the titanium and for titanium alloys, aluminum aluminum titanium intermetallics. So, these are the what say grain refiners used for different molten metal's.

Method of grain refinement how these refine grain refiners are added to the molten metal. One is grain refinement using master alloys.

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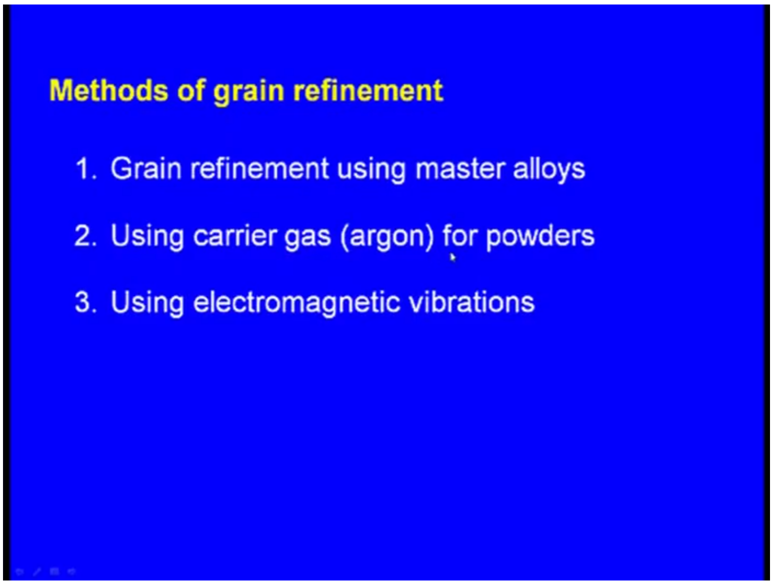

Next one grain refinement using carrier gas for or for powders next one using electromagnetic vibrations: in the case of The grain refinement using master alloys grain refiner master alloy will be made in the form of rods or bars right.

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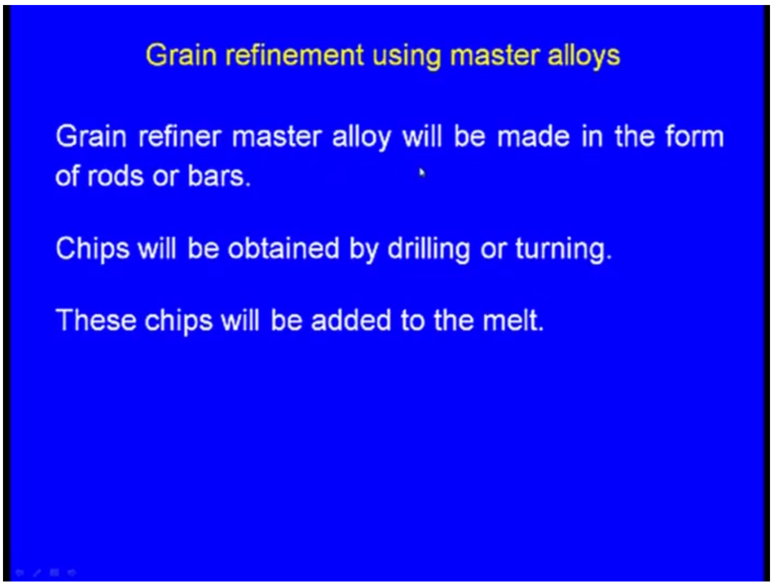

So, these generally these are made as the circular rods. So, this can be turned on a late machine and chips can be produced. So, right chips will be produced by drilling or they can even be drilled and the chips can be removed.

So, these chips will be added to the melt after it is tapped into a ladle.

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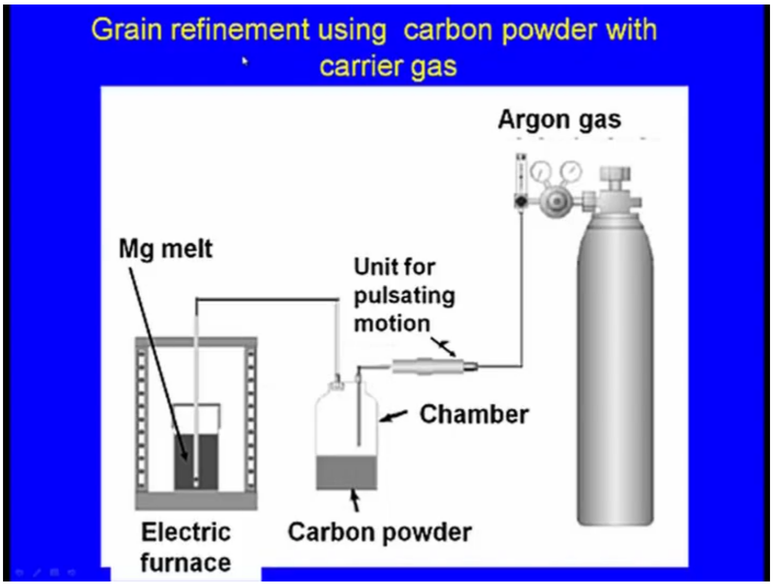

Next one this is the second method of grain refinement, grain refinement using carbon powder with carrier gas. Now here we can see this is the molten metal. So, this is the base metal is magnesium here. So, it is inside you have electric furnace now here this magnesium molten metal is what say grain refine using carbon powder means carbon powder is acting as a grain refiner. Now this carbon powder is kept in a chamber we can see here so this is the chamber. Now this is the argon cylinder from the argon cylinder the argon gas will be coming and here we can see a unit for pulsating motion right. So, means at one stage the motion will be high at one stage the what say a movement of air this argon gas will be less. So, it will be going inside this chamber and it will be taking certain amount of carbon along with that then it will be going inside the furnace and it will be mixing with the molten magnesium.

Now, this carrier gas is inert to gas. So, it does not react with the molten metal, but only the carbon powder which is going along with the carrier gas will be mixing with the molten metal and grain refinement will be done because of the carbon powder. So, this is another method of grain refinement means using a carrier gas.

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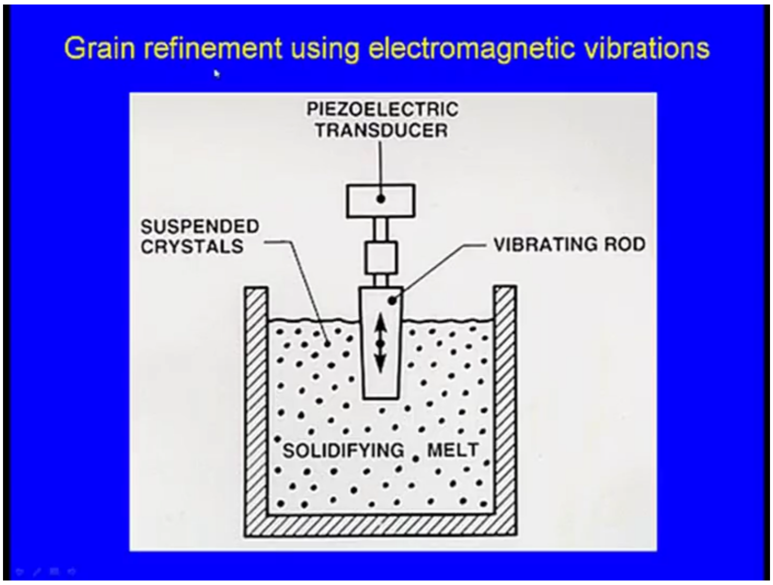

Now, let us see the third method of grain refinement using grain refinement using electromagnetic vibrations and here we can see this is the molten metal right. So, this is the we can see here this is the vibrating rod and here we can see piezoelectric transducer, when we pass electricity through this piezoelectric transducer this electrical energy will be converted into mechanical energy means this vibrating rod it will be making vibrations ultrasonic vibrations. Because of that here we can see this is the solidifying melt the grains will be refined, their size will be changed that is how the grain refinement will be done using electromagnetic vibrations.

Till now we have completed 3 treatments that is the control of chemical composition initiation of the nucleation sites and refinement of grain size now let us see the removal of gaseous impurities

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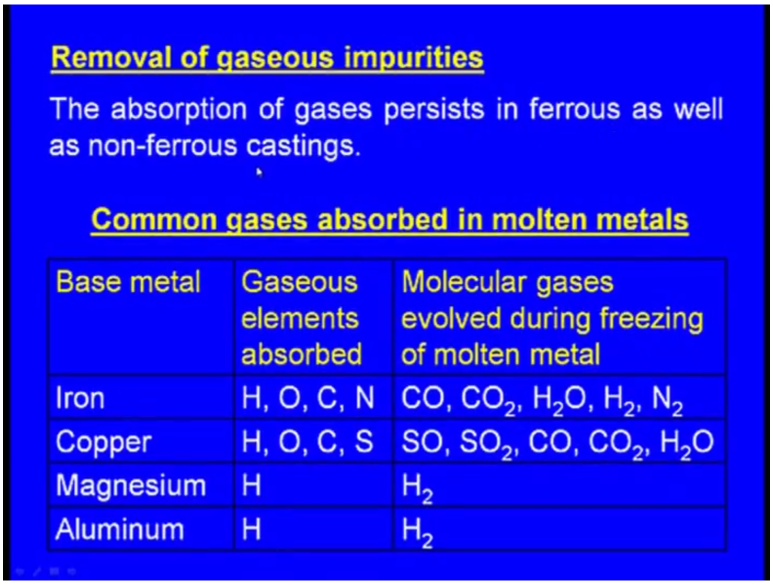

Base metal	Gaseous elements absorbed	Molecular gases evolved during freezing of molten metal
Iron	H, O, C, N	CO, CO_2, H_2O, H_2, N_2
Copper	H, O, C, S	SO, SO_2, CO, CO_2, H_2O
Magnesium	H	H_2
Aluminum	H	H_2

Removal of gaseous impurities the absorption of gases persists in ferrous as well as nonferrous castings in every molten metal there will be gases and gases will be absorbed at different stages of melting. So, there is no exemption every molten metal is prone to absorption of gas then what are the gases observed by the molten metals. So, these are the common gases absorbed in molten metals.

So, iron metal the gaseous elements absorbed are hydrogen, oxygen, carbon, and nitrogen. Then these gases will be coming out of the casting as the molecular gases like carbon monoxide, carbon dioxide, H 2 O molecular hydrogen and molecular nitrogen. Initially they are entering as the what say atomic elements and they are coming out as the molecular gases. Next one when the base metal is copper the gaseous elements absorbed are hydrogen, oxygen, carbon and sulfur. In turn these will be coming out as sulfur monoxide, sulfur dioxide, carbon monoxide, carbon dioxide and H 2 O. So, these are the molecular gases coming out from the casting during solidification.

Now, this is the magnesium melt the gasses element absorbed is hydrogen initially it will be going inside the hydrogen melt as the atomic hydrogen, but it comes out from the casting during solidification as the molecular hydrogen. Similarly when the base metal is aluminum the gas element absorbed is atomic hydrogen, but it comes out from the casting during solidification as molecular hydrogen.

Now, the question is from where these gas gaseous elements are coming how they are entering into the molten metal.

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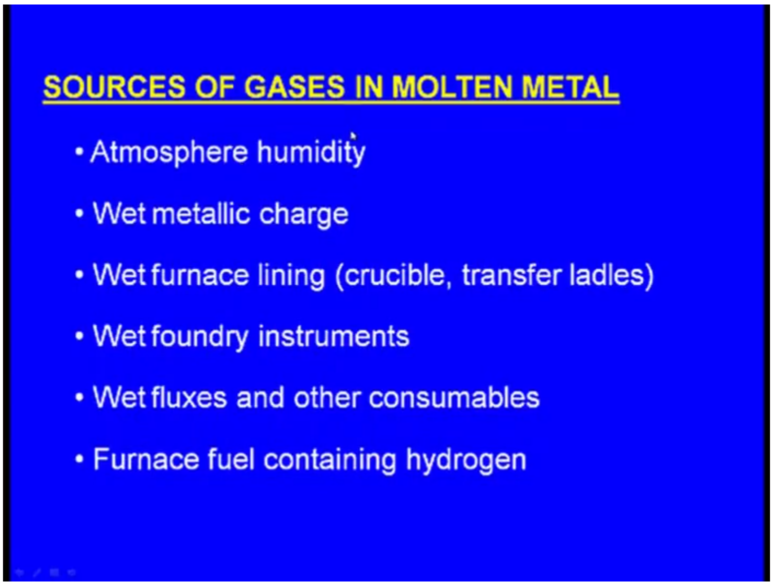

One source is atmospheric humidity. So, in the atmosphere there is what say humidity. So, because of that there is always moisture, now we keep the what say molten blocks or the charge several times outside the charge that is kept outside will be absorbing moisture and that charge will be kept inside the furnace and we melt it that is how the hydrogen will is trapped and also oxygen is trapped.

Next one so even this wet metallic charge is the same thing, next one wet furnace lining most of the furnace they have lining refractory lining will be there. Now these linings can absorb moisture because of the humidity in the atmosphere, now what happens when we put the metallic charge inside and when we heat this moisture will be decomposing and it will be forming hydrogen and oxygen that will be going inside the molten metal. Next one wet foundry instruments means for steering purposes we used to insert some rods and we used to stir the molten metal, that time these what say foundry instruments may have moisture this moisture will be decomposing and it will be releasing oxygen and hydrogen.

Next one wet fluxes and other consumables we add fluxes into the molten metal, these fluxes are sometimes they contain hydrocarbons, these hydrocarbons will be decomposing and releases hydrogen and other consumers also may contain other gaseous elements.

Next one furnace fuel containing; hydrogen sometimes most of the times now, a days we use electric furnaces, sometimes we also use what say oil fired furnaces, oil fired furnaces what is there what is the fuel we use some oils as the fuel. So, these are the hydrocarbons when these hydrocarbons are burning what will happen hydrogen will be evolved. So, this hydrogen will be going inside the molten metal. So, these are the sources of gasses in the molten metal.

Now, the question is. So, what if the gasses are going inside the molten metal what is the problem? What are the adverse effects of the dissolved gases one is the gas porosity defects we get gas porosity on the defects.

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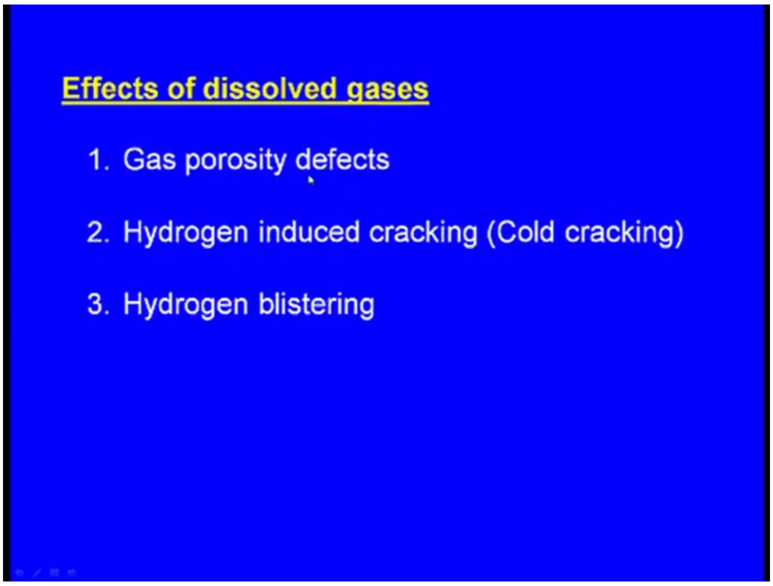

Second one hydrogen induced cracking this is also known as cold cracking. Third adverse effect of dissolved gas is hydrogen blistering. Now let us see all these details.

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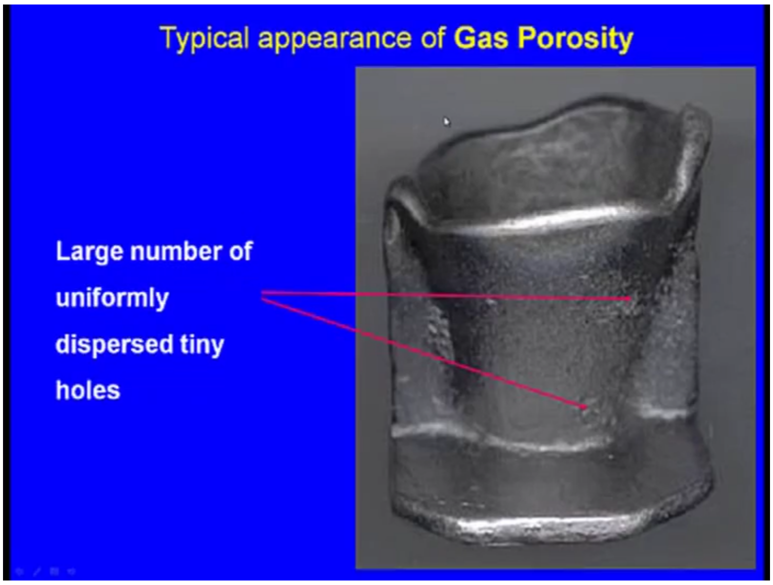

Now, this is the first adverse effect of gas absorption in the molten metal. So, we get the gas porosity on the casting here we can see this is a casting, but the solidified casting is, but on the surface of the casting we can see. So, many small what say holes are there tiny holes are there, we can see several holes are there this is due to the absorption of hydrogen gas. The hydrogen gas will be releasing from the casting during solidification and it will be occupying on the surface of the casting that is how there are several holes on the casting.

So, this is the gas porosity defect.

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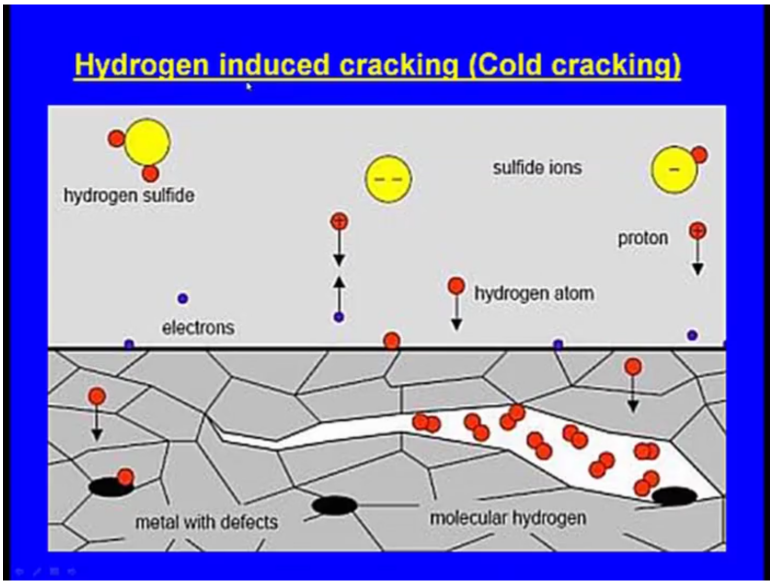

This is the second adverse effect of gas absorption in the molten metal hydrogen induced cracking this is also known as cold cracking. What is this now here we can see this is the what say hydrogen, we can see these are all the hydrogen these hydrogen atoms are going inside the molten metal at several stages maybe during what say melting in the furnace right. So, it is going inside as the atomic hydrogen yes as, but after what say we pour the molten metal into the mould during solidification what will happen initially crystals will be forming these crystals will be enlarging and they will be forming grains.

Now, these atomic what say hydrogen they will be what say making bond with the neighboring atoms. Now it will be forming into molecular hydrogen, it is entering as the atomic hydrogen during solidification, it is becoming as the molecular hydrogen. Now as this solidification is advancing the gap between different grains is reducing slowly it is reducing. As the what say casting solidifies this gap still comes down and the inter atomic space cannot accommodate the molecular hydrogen what will happen several molecules. In fact, 1000s and what say millions of such atoms are trapped inside they, but they have gone inside as the atomic hydrogen finally, they will be exerting pressure on the casting finally, the casting will be cracking.

So, this occurs when the what say casting cools down it does not occur when the casting is in a hot state when it occurs only when the casting cools down that is why it is known as the cold cracking. So, this is very what say severe adverse effect of gas absorption in the molten metal.

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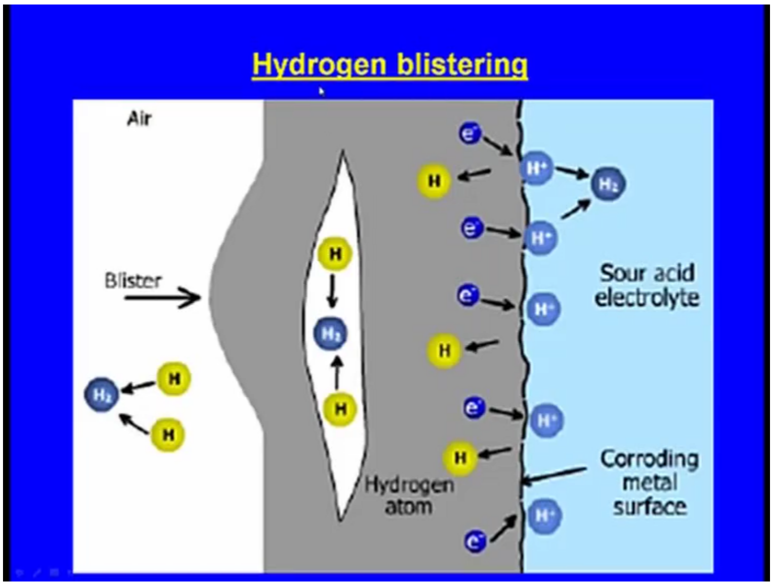

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And another adverse effect is hydrogen blistering what is this here we can see this is the casting and here we can see here we can there is an hydrogen atom is there and here hydrogen atom is there. So, hydrogen atom and hydrogen atom they become molecular hydrogen. Now they are trapped inside the grains inside the casting they will be exerting some pressure, that is how there is a bulging of the casting you see this is the bulging of the casting actually the casting should be like this the casting should be like this there is a bulging. So, this is known as the blister and inside there will be gaseous what say what say presence will be their gas presence will be there. So, this is a another severe defect and it is the blistering are blister formation.

So, this is another adverse effect of the gas formation now how to remove these gases how to removal of removing the gases impurities.

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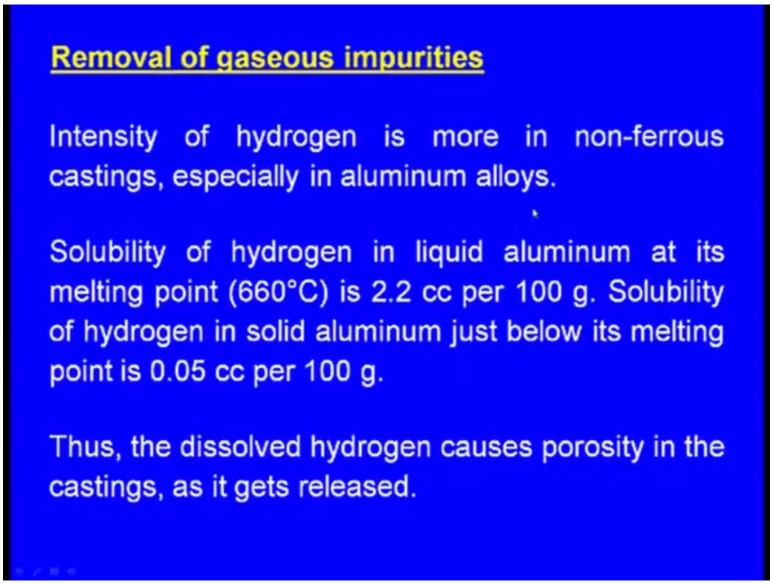

Intensity of hydrogen is more in non ferrous castings especially in aluminum castings, all the molten metals observe gasses, but in non ferrous alloys it is more absorption of gases is more especially in the aluminum alloys. Solubility of hydrogen in liquid aluminum at it is melting point that is 660 degree centigrade is 2.2 cc per 100 grams. Whereas, solubility of hydrogen in solid aluminum is just below it is melting point is just 0.05 cc per 100 grams. Thus the dissolved hydrogen causes porosity in the castings as it is released.

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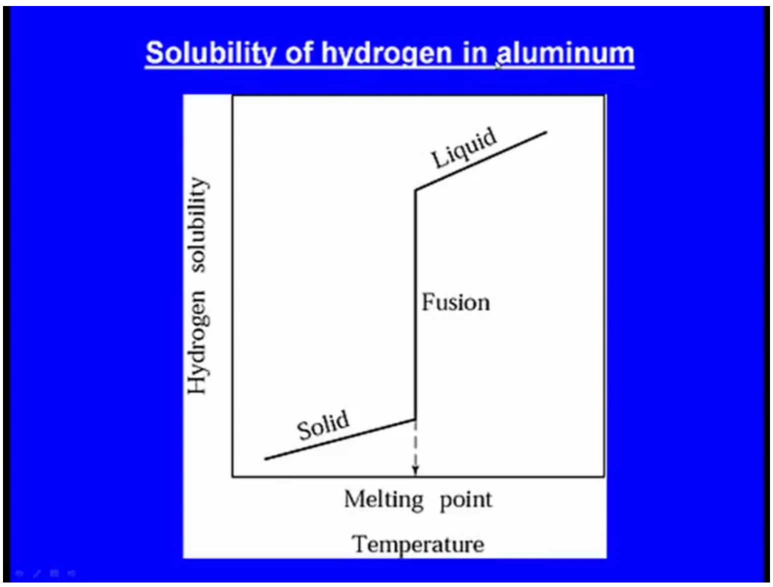

Now, here we can see solubility of hydrogen in aluminum in the solid state you see the hydrogen solubility is this much whereas, during melting once it is what once it is a liquid metal the hydrogen solubility is 4 times or even 5 times.

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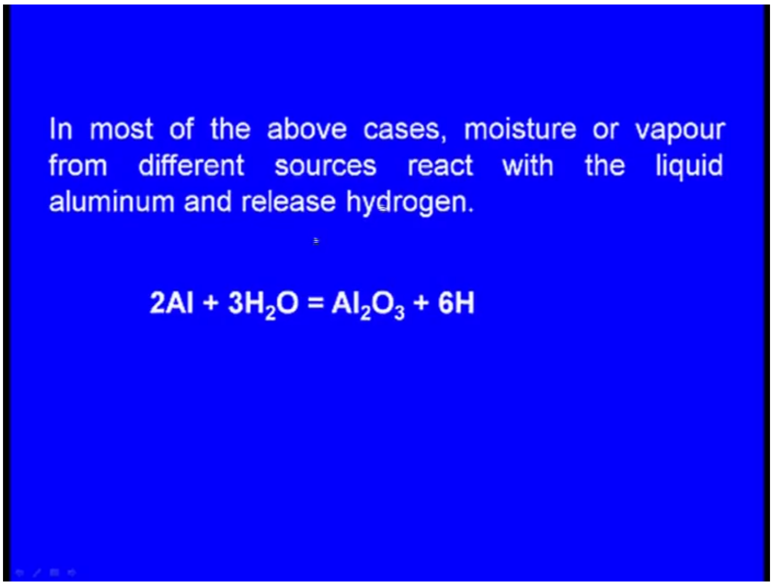

In most of the above cases moisture or vapor from different sources react with the liquid aluminum and release hydrogen. You can see here we can see aluminum and a water reacting aluminum oxide and nascent hydrogen is released. This nascent hydrogen can do any harm to the casting, it can go inside and it will form the molecular hydrogen and it cause, it causes cold cracking or the hydrogen induced cracking also or it can also cause the blistering.

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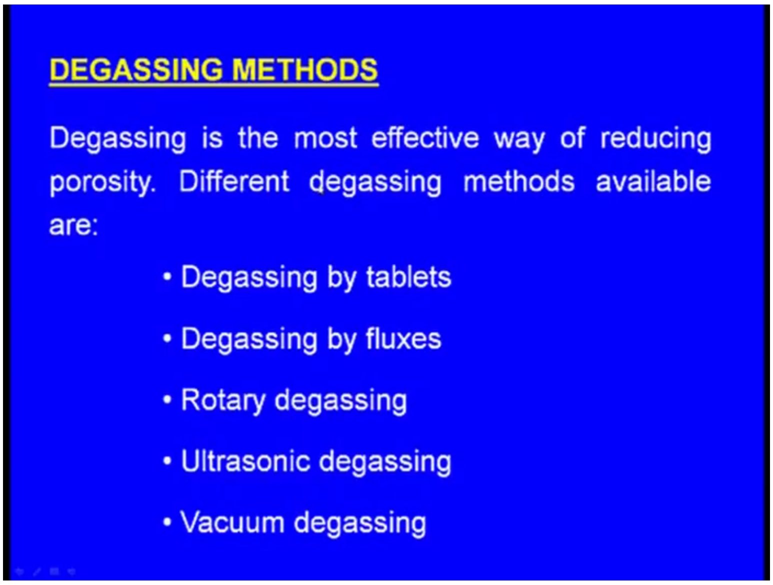

Now, how to get rid of these gasses degassing methods; degassing is the most effective way of reducing porosity. Different degassing methods available are degassing by tablet, us degassing by fluxes, rotary degassing, ultrasonic degassing and vacuum degassing.

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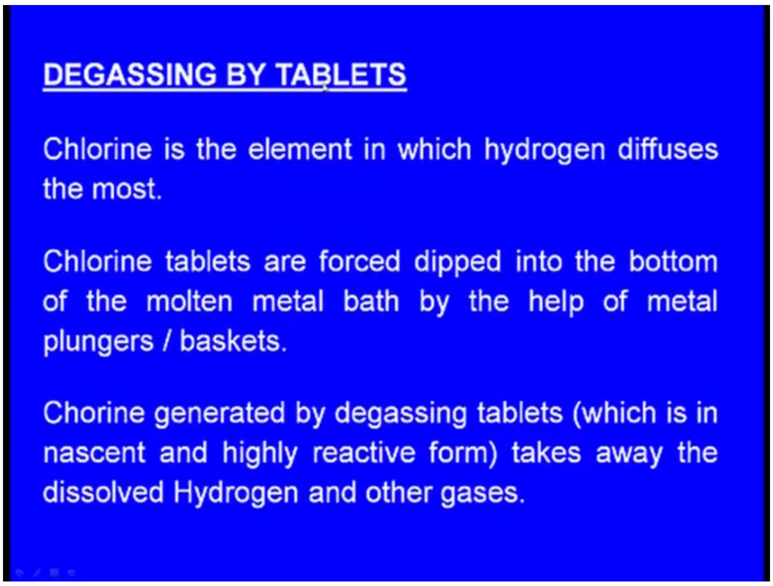

Let us see this one by one degassing by tablet us chlorine is the element in which hydrogen diffuses very much, now what we do is we insert the chlorine tablet us inside the molten metal. So, chlorine tablet us are force dip into the bottom of the molten metal bath by the help of a metal plunger or the baskets. Now chlorine generated by the degassing tablet us takes away the dissolved hydrogen and other gases. So, these are the typical chlorine tablet us and it is their formula is C2Cl6. So, these are the tablet us. So, these tablet us can be forced dip inside the molten metal, once we dip these tablet us inside the molten metal chlorine gas will be released this chlorine gas takes away the all the dissolved gases.

Now, next method is degassing by fluxes mixture of chloride based fluxes is sprinkled all over the bath of the molten aluminum.

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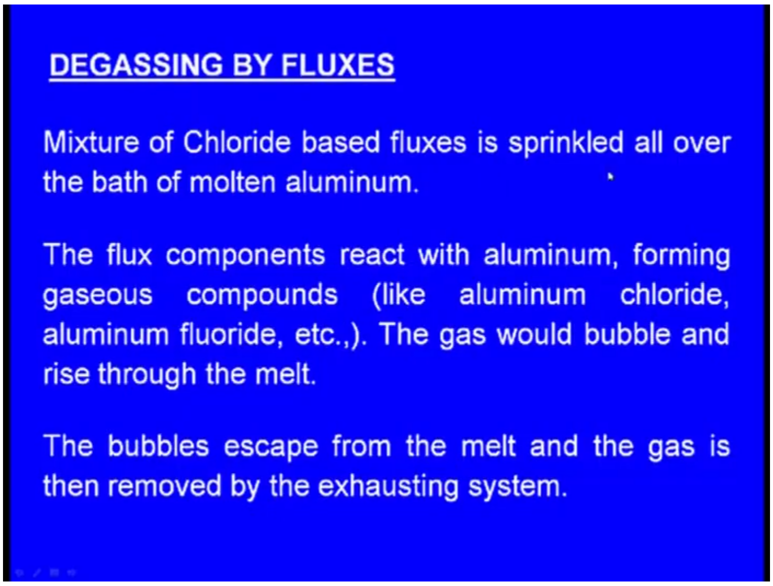

Now here we sprinkle chloride based fluxes; the flux components react with aluminum forming gaseous compounds like aluminum chloride, aluminum fluoride, etcetera the gas would bubble and rise through the melt. The bubbles escape from the melt and the gas is then removed by the exhausting system.

Next one; the rotary degassing.

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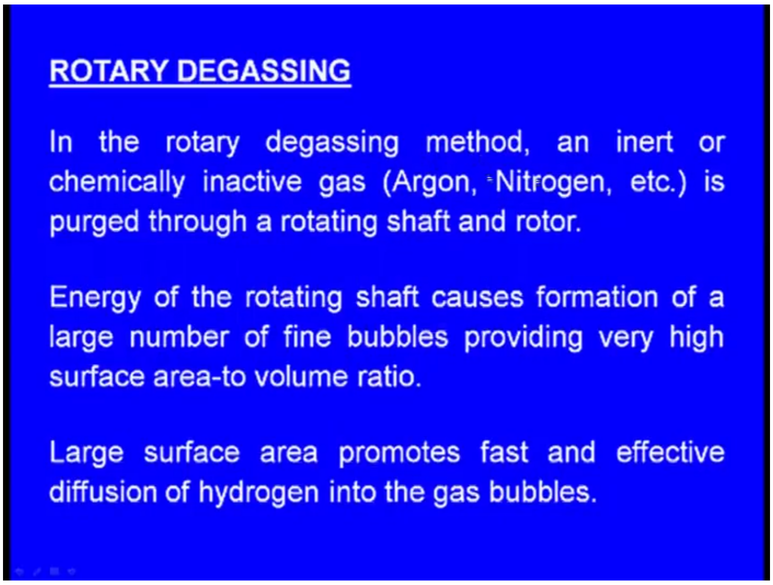

In the rotary degassing method, an inert gas or a chemically inactive gas like argon or nitrogen is purged through a rotating shaft and rotor. Energy of the rotating shaft causes formation of a large number of fine bubbles providing very high surface area to volume ratio. Now this large surface area promotes fast and effective diffusion of hydrogen into the gas bubbles.

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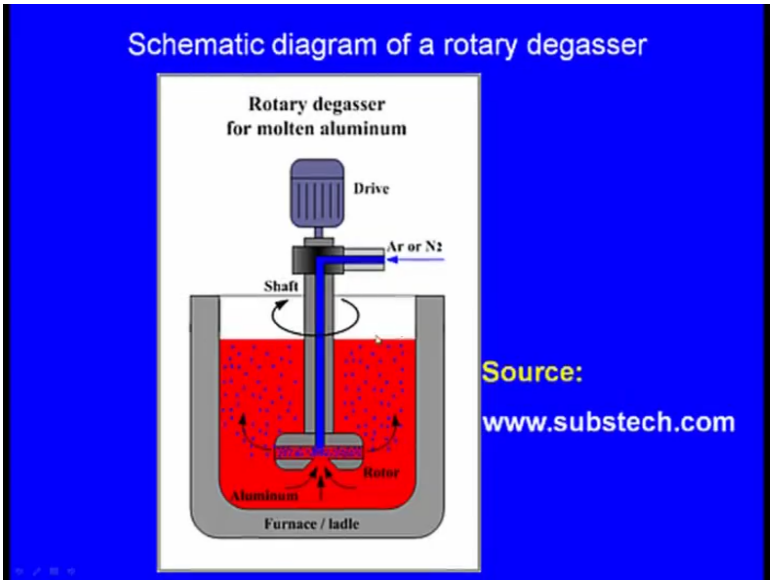

Means what we are doing yes here we can see, this is the melt and say this is the shaft and it will be rotating and here we can see there is a rotor and this is the liquid aluminum.

Now, we will be passing argon or nitrogen both this argon and nitrogen they are chemically inactive with the molten aluminum. Now this will be pa passing through the rotor and through the rotor they will be released and the shaft is rotating and they will be released and they will be forming bubbles tiny bubbles. Now these bubbles have a tendency to adhere with the what say hydrogen. So, hydrogen gas will be coming and it will be adhering with the gas bubbles of argon or nitrogen and they will be coming out they will be coming up and at the top there will be exhaust system will be there. So, a it will be it what say all the time it will be taking and collecting all the gas and it will be sending out that is how the all the gas both the argon or the inactive gas or the carrier gas and the gases that are absorbed in a molten metal will be removed from the molten metal. So, this is the rotary degassing and it is very effective.

Next one ultrasonic degassing.

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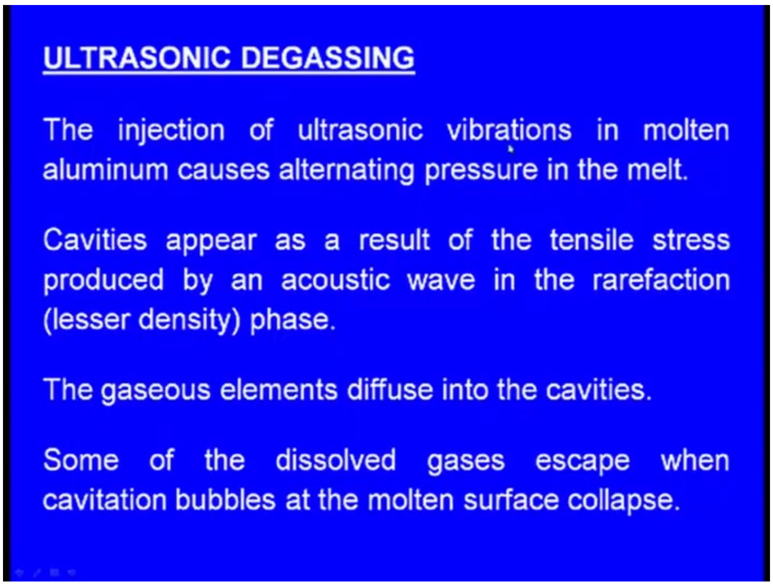

The injection of ultrasonic vibrations in molten aluminum causes alternating pressure in the melt. Now cavities appear as a result of tensile stress produced by an acoustic wave in the rare fraction phase the gaseous elements diffuse into the cavities some of the dissolved gases escape when cavitation bubbles at the molten surface collapse.

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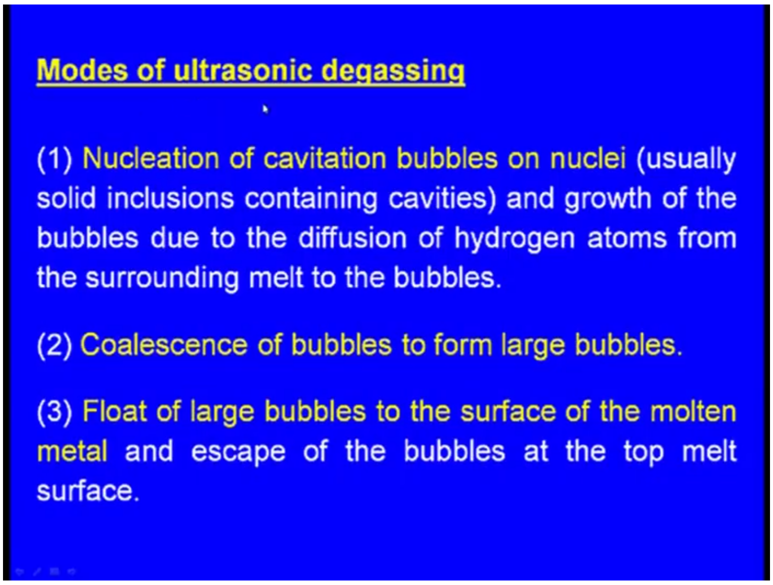

Now here we can see this is the modes of the ultrasonic degassing Nucleation of cavitation bubbles on nuclei. Usually these are the solid inclusions containing cavities, because of this; there will be growth of the bubbles due to diffusion of hydrogen atoms from the surrounding melt to the bubbles.

So, when what happens is during this ultrasonic degassing there will be nucleation of cavitation, right. So, because of this the hydrogen atoms in the melt will be diffusing towards those that nucleation yes region next one coalescence of bubbles to form the large bubbles finally, float of large bubbles to the surface of the molten metal and escape of bubbles at the top melt surface.

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And here we can see this is the chamber used for ultrasonic degassing and here we can see this is the ultrasonic transducer and this is the electric furnace and this is the vacuum chamber and here the molten metal will be there and this will be causing the ultrasonic vibrations.

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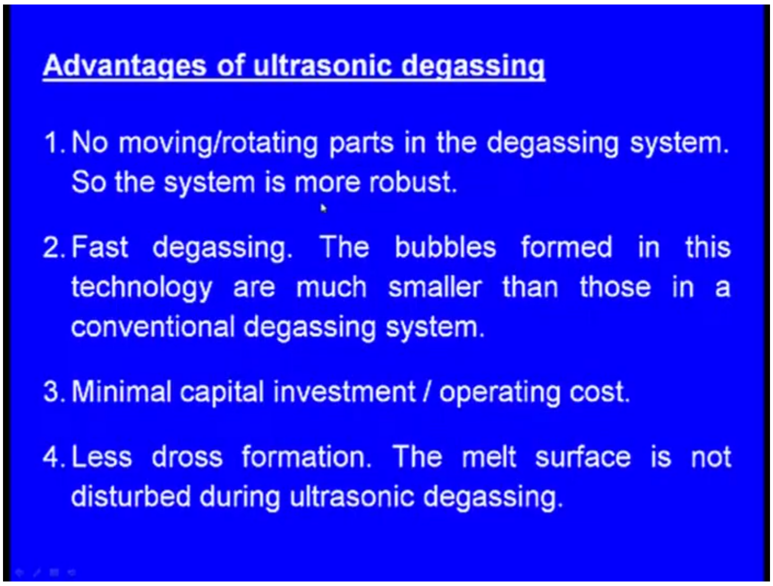

Now, what are the advantages of ultrasonic degassing no moving rotating parts in the degassing system? So, the system is more robust in this case of the rotary degassing what is happening all the time the rotor is rotating. So, that is how the what say system may be what say shaking, but here there is no such case the system is robust fast degassing the bubbles formed in this technology are much smaller than those in a conventional degassing system minimal capital investment and also the operating cost the capital investment is not very high.

Less dross formation dross means mixture of slacks unwanted materials and molten metal. So, that is the dross sometimes this dross will be floating on the molten metal. So, here in the case of the rotary degassing because of the rotation of the rotor this dross will be collecting at the top of the molten metal and removal or segregation of the dross sometimes becomes tough, but here less dross formation the melt surface is not disturbed due to ultrasonic degassing the melt surface is not disturbed once it is disturbed. What will happen the top layer will come to the bottom layer will go to the top means new what say surface is exposed to the atmospheric oxygen and hence there will be oxidation, but here all the time only one layer one what say region is exposed to the what say atmospheric conditions.

So, here repeatedly different surfaces are not exposed to the atmosphere. So, that is an advantage next one the vacuum degassing here, we can see this is the molten metal and here we can see this is the vacuum pump and here it is the addition hopper if we want to add any allowing elements and also this is the vacuum chamber.

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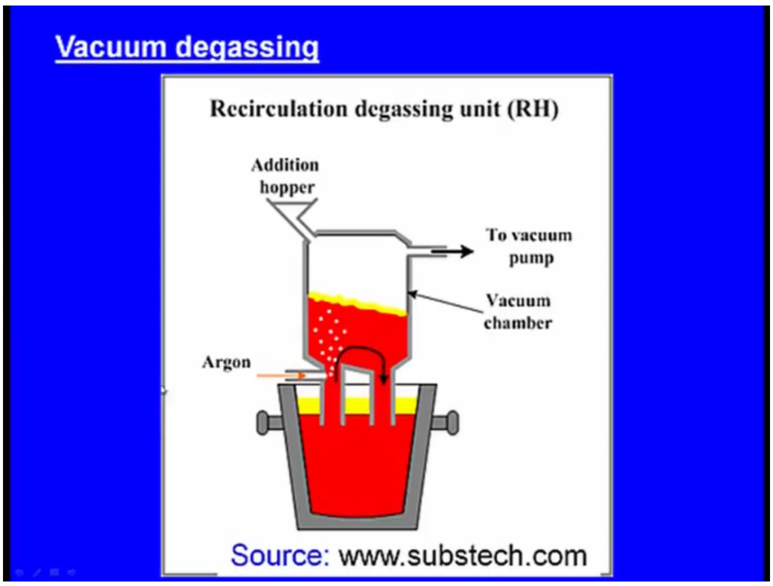

Now from one way we are sending the inert gas that is the argon, this argon will be going and the; we are getting the molten metal like this you see; it will be falling into this container. Now because of this now at the same time we will be applying the vacuum because of that the gases that are present inside will be removed other precautions to reduce gas absorption use big pieces of molten charge metal charge as they are least susceptible to contamination.

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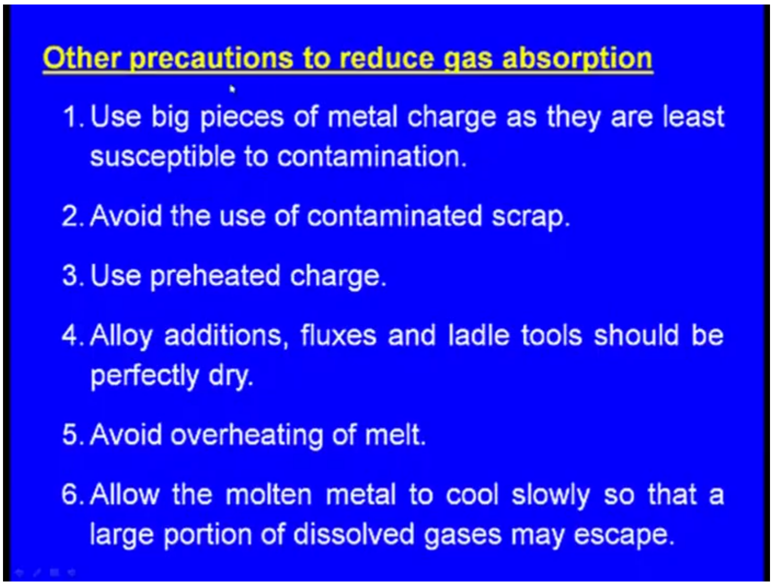

Second one avoid the use of contaminated scrap next one use preheated charge most of the times the charge what say can contain some moisture if we heat this moisture will be removed. Next one alloy additions fluxes and ladle tools should be perfectly dry, if these; what say fluxes or the ladle tools are not dry or if they contain some moisture then there will be gas absorption by the molten metal. Next one avoid overheating of the melt if we what say over heat the melt what will happen heat up it will be absorbing more and more gases allow the molten metal to cool slowly so that a large portion of dissolved gas may escape.

Longer the time of solidification what will happen longer the escape of the gases from the metal that is why allow the molten metal to cool slowly. So, that a large portion of dissolved gases may escape next one removal of undesired undesirable elements so this is the fifth treatment of the molten metal removal of undesirable elements.

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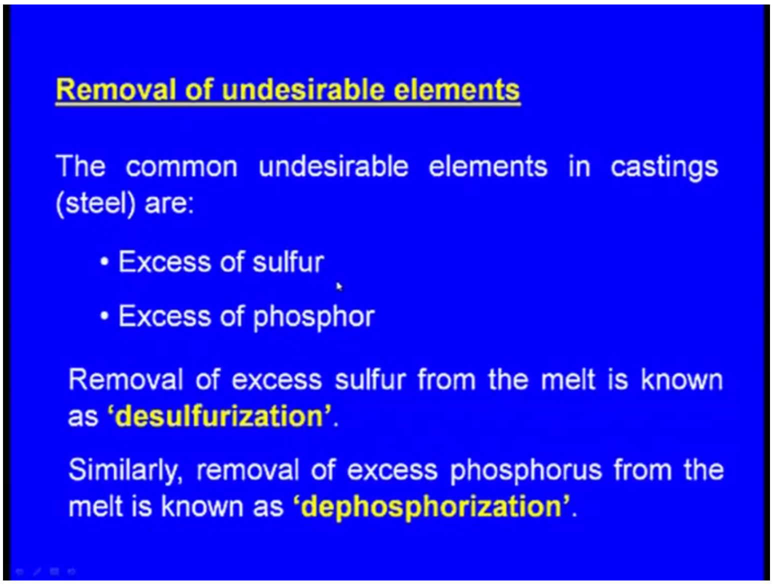

First of all what are the undesirable elements in the molten metal the common undesirable elements in castings especially these appear in steel castings in steel they are excess of sulfur excess of phosphor. So, these are the undesirable elements.

Now, these must be removed. So, removal of excess of sulfur from the melt is known as desulfurization means Sulfur content is removed it is reduced. Similarly removal of excess of phosphor phosphorus from the melt is known as dephosphorization. So, this excess sulfur excess phosphor must be removed.

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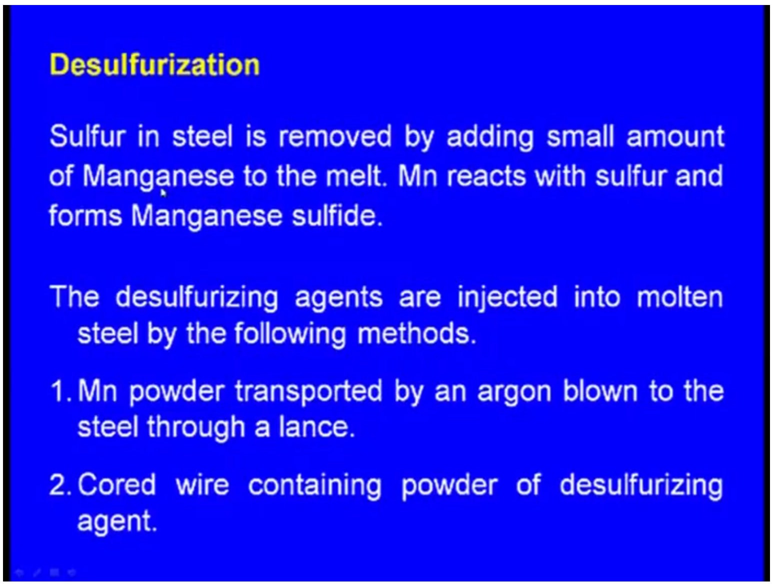

Desulphurization; desulphurization means removal of excess of sulfur from the liquid metal.

Sulfur and steel is removed by adding small quantity or amount of manganese to the melt. So, this manganese reacts with sulfur and forms manganese sulfide and it comes out along with the slag that is how the excess sulfur in the molten steel is reduced. The desulfurizing agents are injected into the molten steel by the following methods manganese powder transported is transported by an argon gas is blown into the steel through a lance means lance means a long pipe. So, manganese powder which reacts with the steel and forms sorry with sulfur and forms manganese sulfur is transported into the molten metal through a lance.

Next one cored wire containing the powder of Desulfurizing agent means this cored wire contains the powder of manganese that will be continuously fed into the molten metal.

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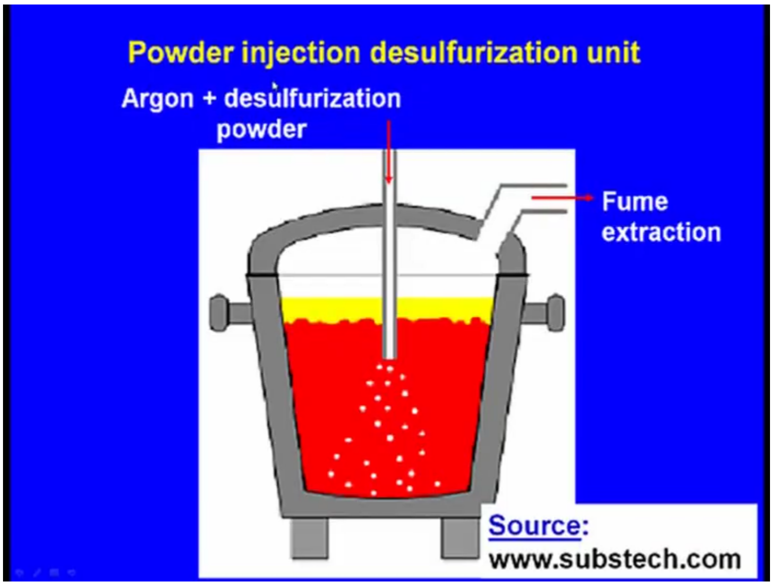

Now here we can see this is the powder injection desulphurization unit. So, this is the what say liquid steel, now there is a lance is there so this is the lance means a long pipe. Now we are sending argon plus desulphurization powder means the what say here we can see that is the manganese powder; manganese powder and argon is sent through this lanes. Now what will happen this manganese will be reacting with sulfur and forms manganese sulfide and that will be collected as the slag at the top and it has to be removed and here we can see the this here is a system for fume extraction. So, that is how the excess of sulfur can be removed from the molten steel. So, that is the desulfurization.

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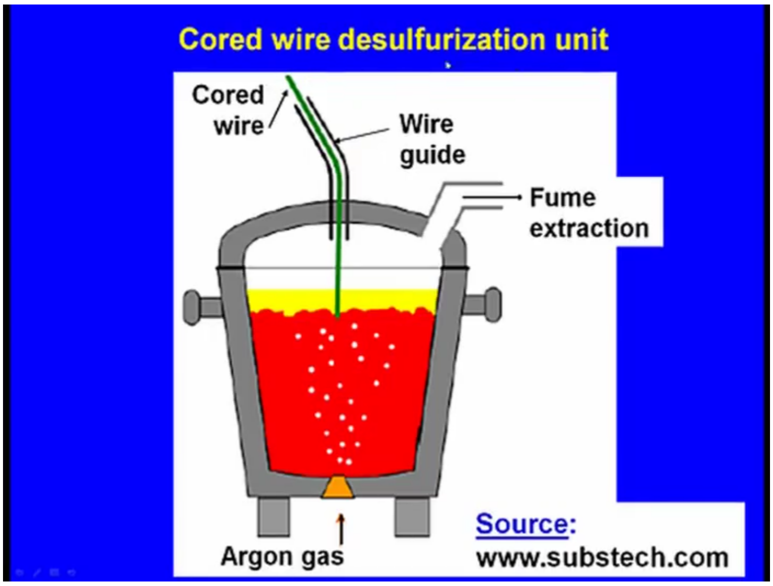

Next one this is the cored wire desulfurization unit and here we can see this is the liquid steel and this is the wire guide is there. Now here there is a cored wire is there this cored wires takes the what say manganese powder along with that and this cored wire is continuously fed into the liquid metal. This manganese again this manganese powder reacts with the mold what say sulfur in the molten steel and forms manganese sulfide again it will be coming up as the slag and it has to be removed, again here we can see there is fume extraction system is there to what say remove the hot gases and fumes.

Now, there are other desulfurizing agents are there.

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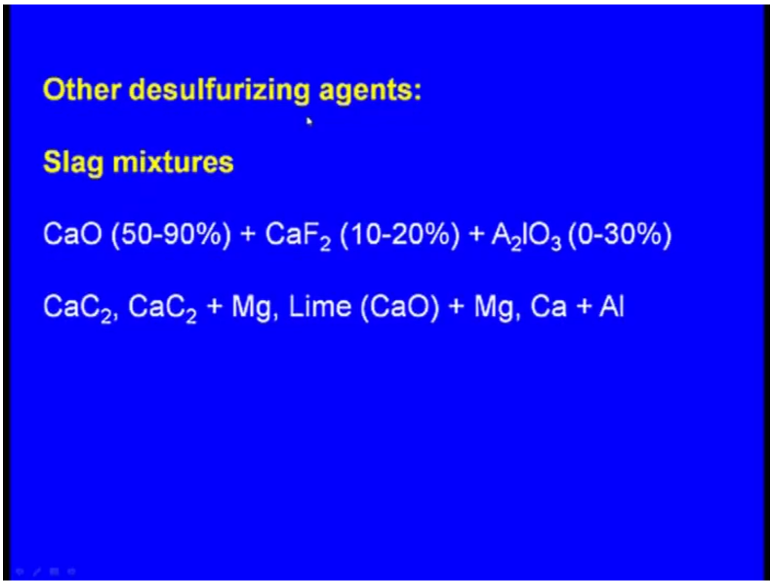

Sometimes slag mixtures also act as the desulfurizing agents slags are unwanted materials in the molten metal, but they help us to cause the desulfurization or to remove the sulfur content in the steel. Here we can see this the CaO it can present from 50 to 90 percent and this is the calcium fluoride and it can present from 10 to 20 percent, aluminum oxide and it can present up to 30 percent.

Now, calcium carbide and magnesium line magnesium calcium and aluminum. So, these are all the slag mixtures, these slag mixtures will be helping us to remove the sulfur content or to act as the desulfurizing agents.

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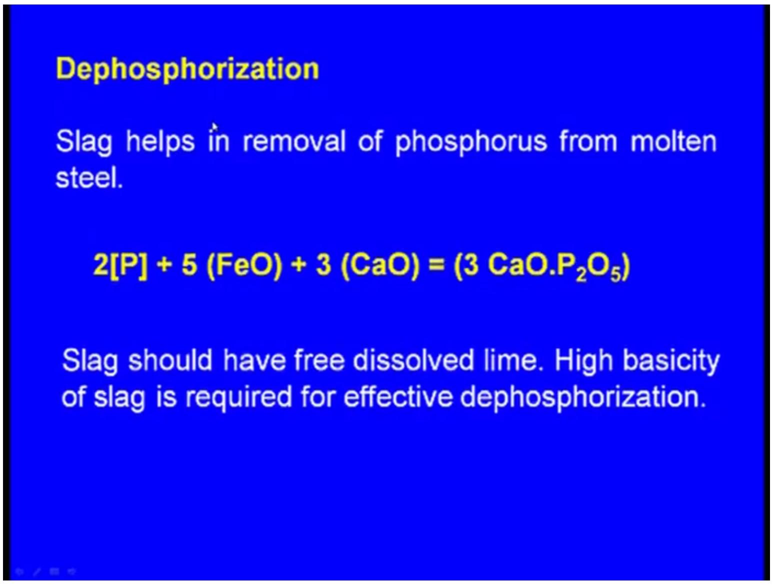

Next one dephosphorization just like desulfurization here there is another method dephosphorization; dephosphorization means removing excess of phosphor phosphorus from the molten steel here slag helps in removal of phosphorous from molten steel. Here we can see this equation will reveal us how slag will help us in the removal of sulfur see here in this equation we can see this is the slag is what say created. So, this is the slag now the slag should have free dissolved lime is there. So, right high basicity of slag is required for effective dephosphorization.

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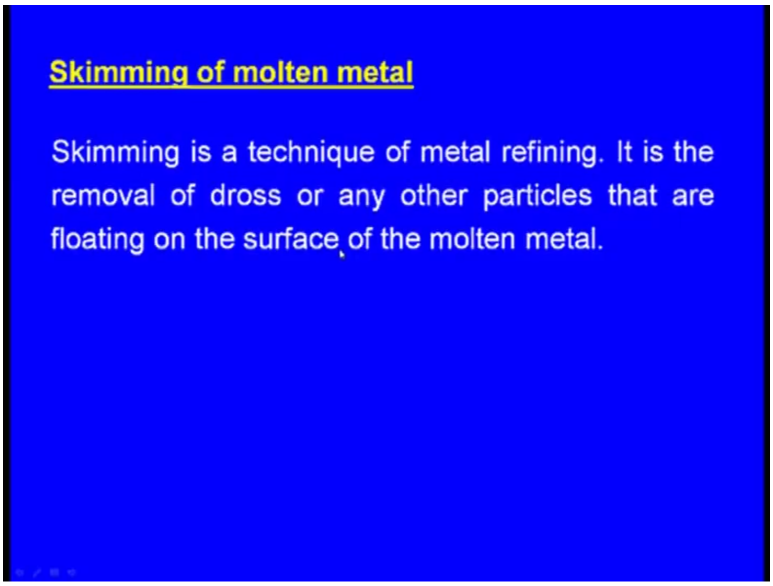

Next one skimming of molten metal skimming is a technique of metal refining it is the removal of dross or any other particles that are floating on the surface of the molten metal. So, sometimes the dross will be floating on the surface of the molten metal draw, what is dross again I am telling what say mixture of slags and impurities they will be floating on the molten metal, unwanted material, this is the dross sometimes this dross if it is only floating on the liquid metal yes it can be removed it can be easily removed sometimes it will be going inside the molten metal at such times it is very difficult to remove the dross.

Now, how to get rid of this dross by skimming of molten metal now here we can see for this skimming there will be what say skimming what say what say apparatus will be there. So, this is the draw skimming station will is available.

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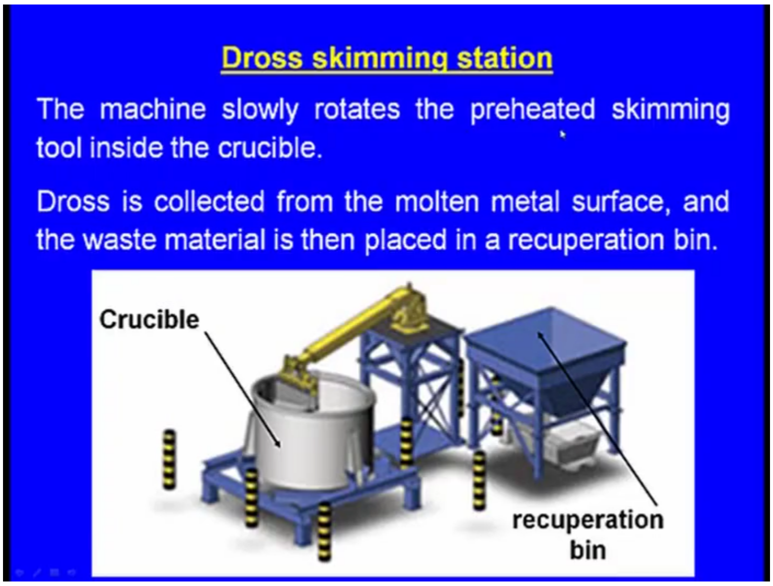

So, the machine slowly rotates the pre heated skimming tool inside the crucible here we can see this is the crucible. So, this is done after we collect the molten metal from the furnace and when we collect it into a crucible at that time this is skimming can be done. So, here we can see this machine. So, here we can see this is the crucible and here we can see there is a skimming tool is inside this is this is the skimming tool. So, this will be rotating.

So at a very slow speed it will be rotating then what happens as it is rotating the dross is collected from the molten metal surface and the waste material is then placed in a recuperation bin and next to that here there is a recuperation bin is there means like a dustbin. So, this tool will be rotating right and dross will be though it may be present inside it will be collected because it is rotating because of the centrifugal force what will happen the dross density is very less compared to the density of the molten metal. So, this will be collected at the center because less centrifugal force will be falling on that.

Now, this will be collected at the center then it will be removed and it will be kept inside the recuperation bin, again it is done in stages again this what say skimming tool will be rotating, again the dross will be collected at the center that will be removed and it will be kept inside the recuperation bin, that is how the dross can be reduced removed from the molten metalwell friends in this lecture we have seen different treatments of molten metal we have seen control of chemical composition means we add the alloying elements if we the molten metal requires certain alloying elements if they are deficient we add them in the form of granules.

So, this is the control of chemical composition we have seen next one initiation of the nucleation sites this is for modifying the what say solidification structure. So, that we get better mechanical properties from the casting. So, these are. So, we have seen next one refinement of the grain size means altering the size of the grains or the crystals and we have also seen another treatment how to remove the gaseous elements from the molten metal in different cases we have seen.

Next one removal of undesirable elements we have seen how to remove undesirable elements like sulfur and phosphorus we have seen finally, removal of dross from the molten metal that is the skimming of the molten metal. So, these are the different treatments given to the molten metal we will see in the next class the fluidity of the molten metal.

Thank you.