Manufacturing Process - I
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Module - 2
Lecture - 10
Metal Casting

Good morning. In the earlier episodes, we have been learning about different casting processes, and we have learnt different melting practices, and the gating system design we have seen.

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And today, in this episode, let us see the casting defects.

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Casting defects have been persisting ever since man has invented the casting process. Metal casting has been invented thousands of years before Christ. Those days, this process was used mainly for art purposes.

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Here we can see an ancient Egyptian bronze statue. This bronze statue, we can see without any defects. In fact, this casting process has been developed in ancient Egypt, ancient Mesopotamia, ancient China, and also in ancient India. Those days also these defects were arising. When the defect was arised, they use to ignore the casting.

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For example, here we can see another Egyptian bronze statue and there are so many defects - surface defects, surface cavities are there; still they have ignored these defects and this was displayed. Today, we cannot ignore the defects, because today we are using the casting process for scientific applications and industrial applications, and if there is any defect in this casting, it will affect the performance.

Those days, thousands of years before Christ, whenever there is a defect in the casting, sometimes they use to totally reject the casting. Today we cannot afford rejecting the casting, because it will affect the productivity. So, when we are making a casting, every care has to be taken to prevent the casting defects. So, in this episode, let us see how to prevent different casting defects. And before that, we need to learn different casting defects. And before that, let us see the classification of the casting defects.

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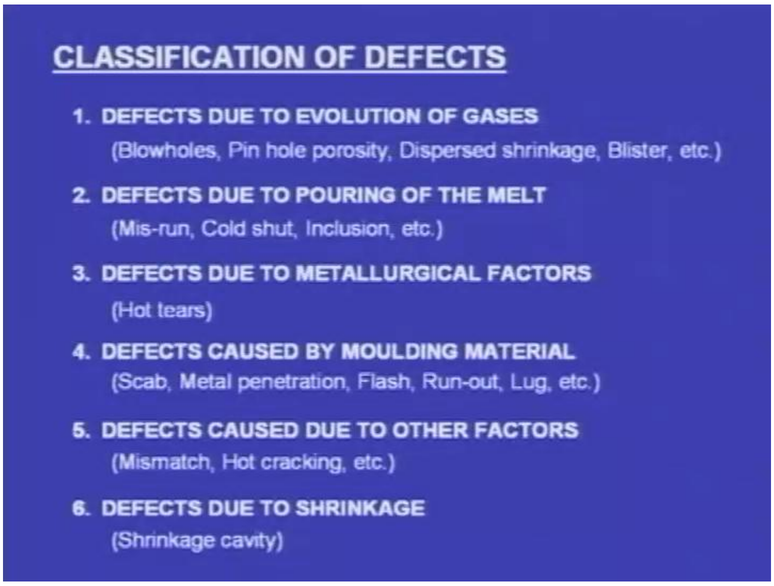

And this is the classification of casting defects. One is defects due to evolution of gases; they are blowholes, pin hole porosity, dispersed shrinkage, blister, etcetera. And defects due to pouring of the melt - mis-run, cold shut, inclusion, etcetera. Next, defect due to metallurgical factors; that is the hot tears. Next one - defects caused by molding material; that is scab, metal penetration, flash, run-out, lug, etcetera. Next, defects caused due to other factors; they are mismatch, hot cracking, etcetera. Next, defects due to shrinkage - they are shrinkage cavity. So, this is the broad classification of the casting defects. Now let us see these casting defects one by one.

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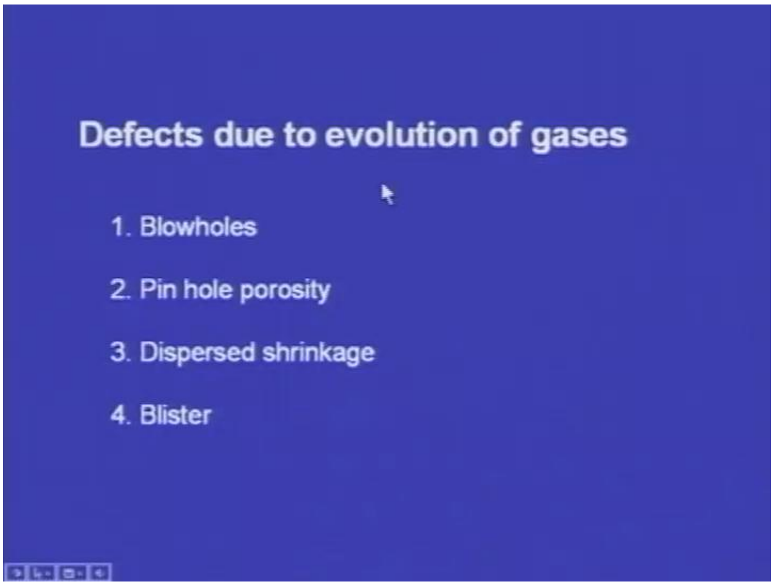

First, let us see the defects due to evolution of gases. Under this classification, we can see blowholes, pin hole porosity, dispersed shrinkage, and blister.

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First, let us see the blowholes.

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So, this is the typical appearance of blowholes, and here we can see smooth and semi round holes all over the surface of the casting. So, these are the blowholes, and what are the causes for these blowholes?

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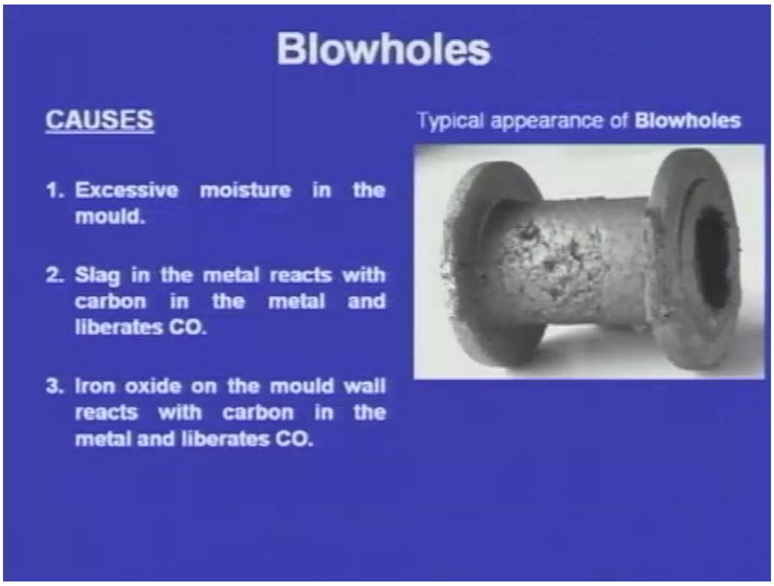

One is excess moisture in the mould - when there is excess moisture in the mould and when we pour the molten metal, this excess moisture will turn into vapour and this vapour will result in blowholes. Next one - slag is responsible for the formation of the blowholes. Slag contains oxides; these oxides react with the carbon in the molten metal and form carbon monoxide, and this carbon monoxide will create blowholes. Next one - iron oxide on the mould wall is responsible for the blowholes. This iron oxide reacts with the carbon in the molten metal and forms carbon monoxide, and this carbon monoxide will be creating blowholes. Now, how to prevent these blowholes? What remedial measures we have to take to prevent these blowholes?

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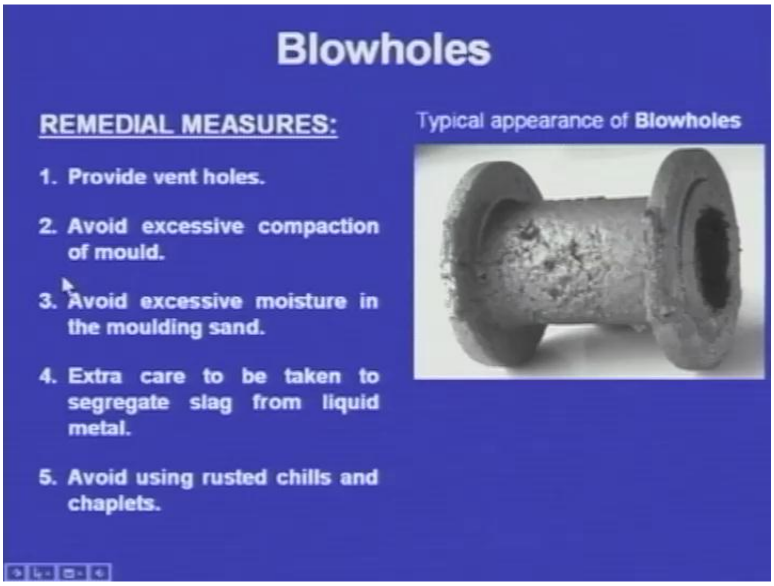

So, these are the remedial measures. First, one is provide vent holes. When we provide sufficient vent holes, if there is excess vapour is formed inside, that excess vapour will be escaping through the vent holes. Next one - avoid excess compaction of the mould, because we have seen that the molding sand possesses one property called permeability, because of which the hot gases will be escaping through sand particles, and if we compact the sand very hard, the hot gases cannot escape. So, we should prevent, we should avoid excessive compaction of the mould.

Next one - avoid excessive moisture in the molding sand. When we add excessive moisture in the molding sand, this excessive moisture will be turned into vapour, when we pour the molten metal, and that will result in blowholes. And we have seen that slag are responsible for the formation of the blowholes. This slag will be coming through the molten metal. So, when we pour the molten metal, extra care has to be taken to segregate the slag from the molten metal.

Next, avoid using rusted chills and chaplets. We use chills and we also use chaplets. These are the metallic components, and sometimes these may be rusted ones, means there is iron oxide on the surface of this chills and chaplets that are rusted, and this iron oxide will be reacting with the carbon in the molten metal, and carbon monoxide is formed; this carbon monoxide will be resulting in blowholes. So, these are the remedial measures to prevent blow holes.

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Next let us see the pin hole porosity among this classification.

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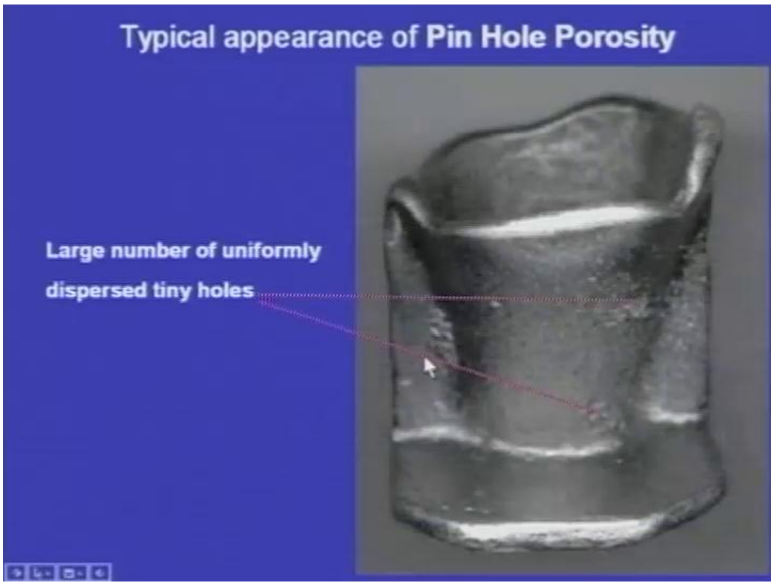

So, this the typical appearance of pin hole porosity, and here we can see large number of uniformly dispersed tiny holes here. So many tiny holes are there on the surface of the casting. So this is the pin whole porosity. And what are the factors responsible for this pin whole porosity?

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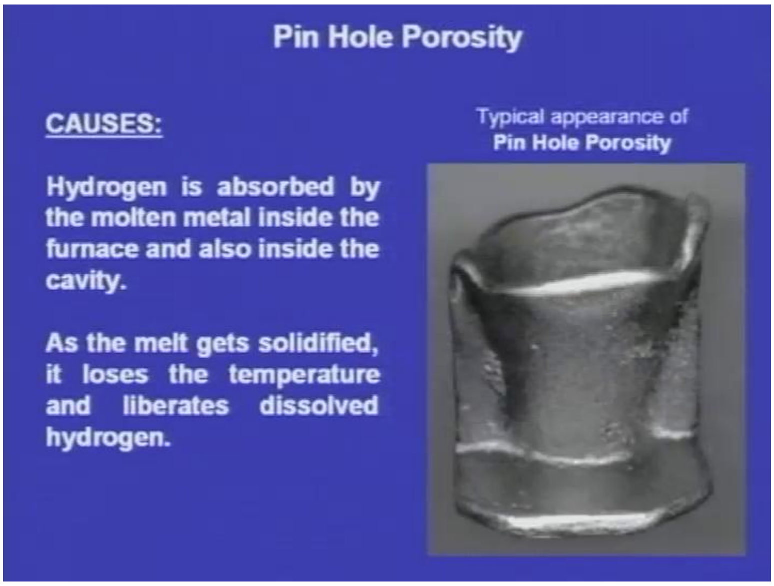

The main factor is the hydrogen. Molten metal absorbs hydrogen at two places: one place is in the furnace; in the furnace there is heat; when we melt the metal, the molten metal absorbs the hydrogen in the furnace. Again, when we pour the molten metal into the cavity, there is moisture - that is the water, that is the H2O - this will be disassociating into hydrogen and oxygen, and this hydrogen is absorbed by the molten metal, and this absorbed hydrogen will be inside the molten metal, and it will be going inside the cavity.

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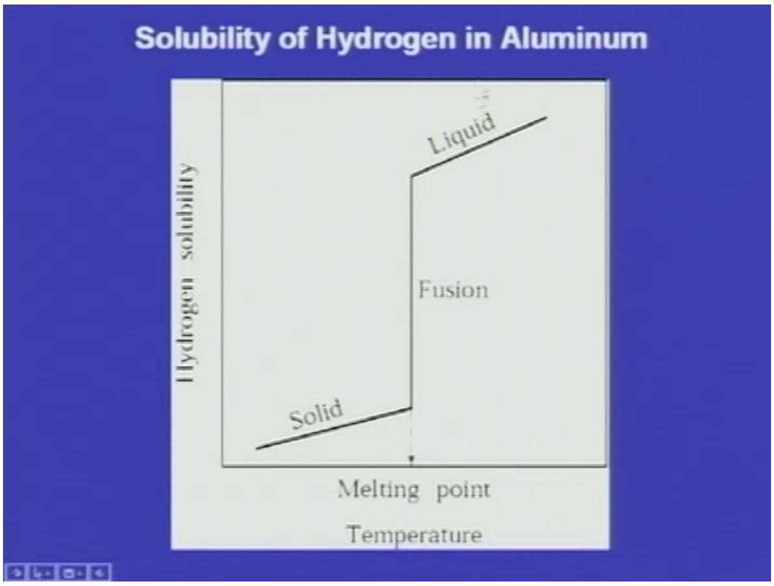

And let us see the solubility of hydrogen in aluminum. At the liquid state it is very high, and at solid state the solubility is drastically coming down.

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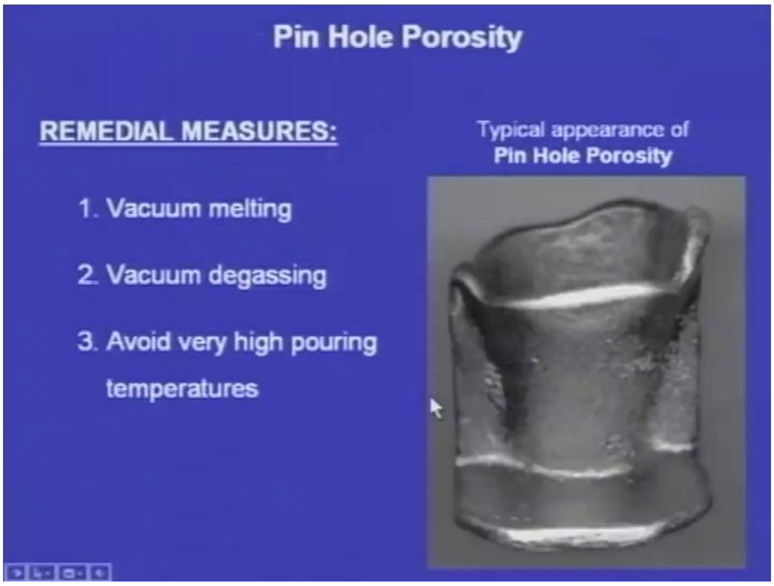

Now, what happens is during solidification its solubility drastically comes down - the solubility of hydrogen - and once this solidification is over the excess hydrogen will be liberated out, and this liberated hydrogen will be coming to the outer part of the casting and forming pin hole porosity.

And what are the remedial measures to be taken? One is vacuum melting where there will be vacuum in the furnace; no atmospheric air will be there, but this is very expensive. Next one is vacuum degassing; by vacuum we can degas any gas that is present in the molten metal. Next one is avoid very high pouring temperature; when the pouring temperature is very high, its tendency to absorb hydrogen is fine; it will be absorbing more hydrogen. And after solidification, it will be liberating the hydrogen that is absorbed. And finally, that hydrogen will be responsible for forming pin hole porosity. So, these are the remedial measures to prevent pin hole porosity.

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Next in this classification, let us see dispersed shrinkage.

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And this is the typical appearance of dispersed shrinkage. We can see small shrinkage cavities dispersed throughout the cavity, and these cavities will be generally one centimeter deep; they will be dispersed at some places.

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And what are the causes? Excessive moisture. Another one is very high pouring temperature. The metal may be boiling; that time bubbles will be inside; and these babbles will be responsible for forming dispersed shrinkage.

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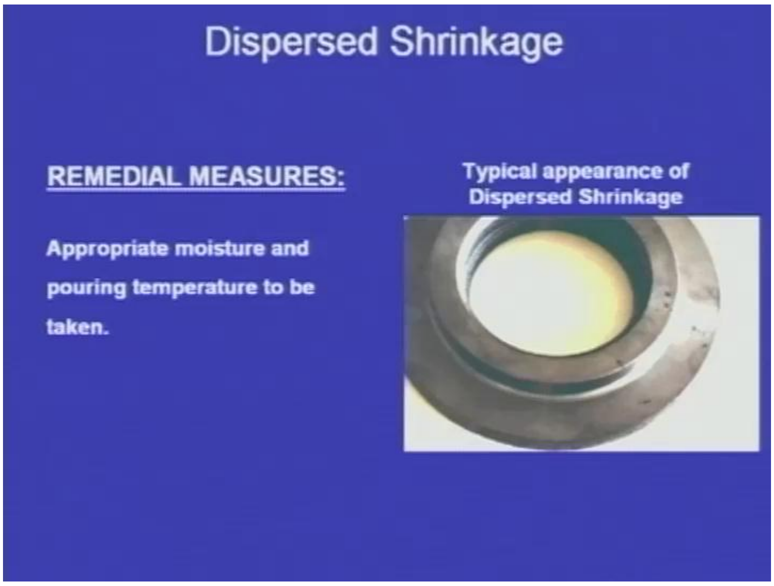

And what are the remedial measures to be taken? Appropriate moisture, and pouring temperature to be taken.

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Next in this classification, let us see the defect blister.

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And this is the typical appearance of a blister, and here we can see bubble like bumps, here one bump, and here one bumps, and some more bumps; bubble like bumps are formed at some surfaces. And what are the causes for this blister?

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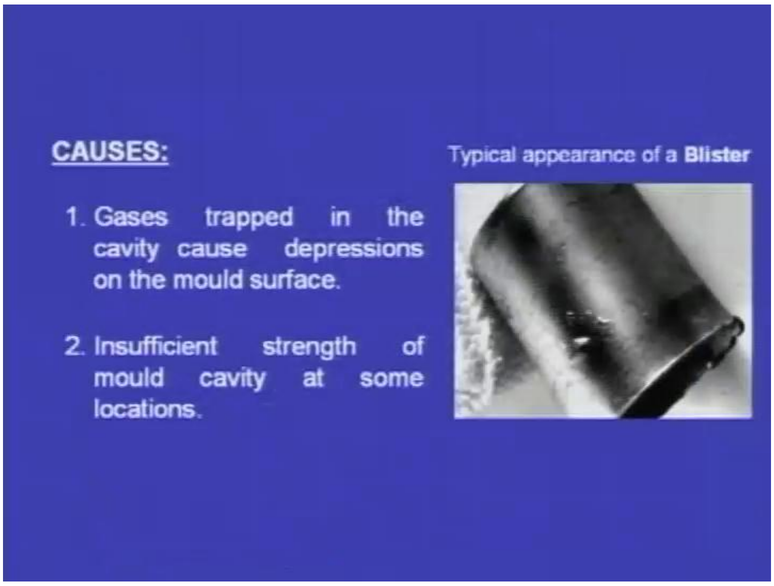

Gases trapped in the cavity cause depressions on the mould surface. Some depressions are created because of the gas is trapped in the cavity, and the molten metal goes into the depression, and forms this blister. And again, another reason is insufficient strength of the mould cavity at some locations, there these depressions will be occurring.

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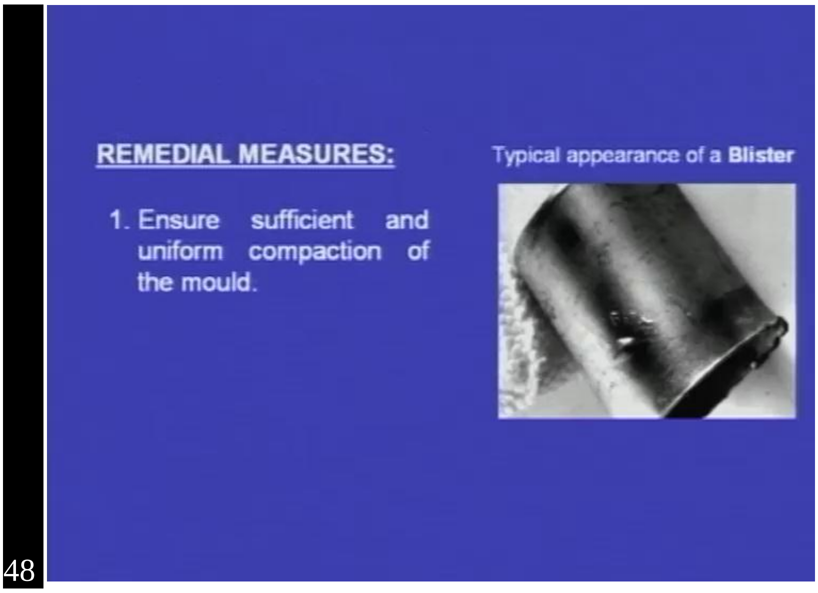

And what are the remedial measures to be taken? Ensure sufficient and uniform compaction of the mould.

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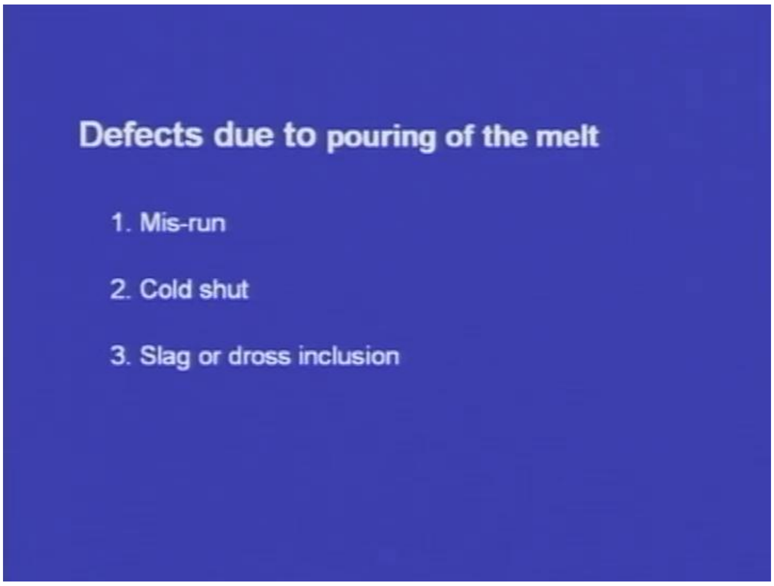

Next, let us see another classification - defects due to pouring of the melt. In this, we have mis-run, cold shut, slag or dross inclusion.

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First, let us see the mis-run.

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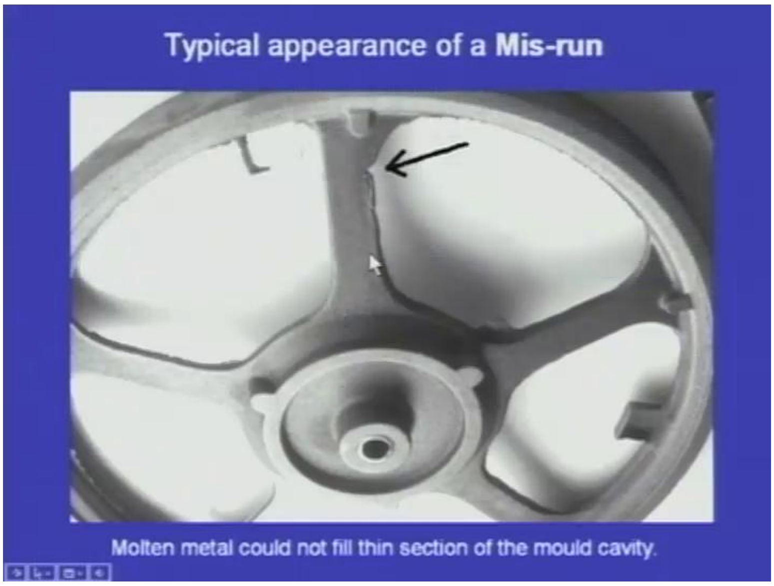

So, this is the typical appearance of a mis-run and here we can see a casting - wheel type casting - and here we can see five ribs, and this rib is not properly cast; the molten metal could not fill in this rib. What are the causes for this defect?

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And here we can see another casting, and here we can see there is a gap. Again here the molten metal could not enter in to this thin section.

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Let us see another casting. And this is another casting. Again, the molten metal could not enter in to this small section.

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Let us see another casting, and this is a turbine blade, and this turbine blade is manufactured by casting. And here we can see this turbine blade is thin section - thin sectioned casting - and we can see every blade, at some locations, the molten metal could not fill the cavity. Here there is a gap, and here there is a break, and here there is a break, and here there is a break. That is at several places molten metal could not enter in to the small section cavity

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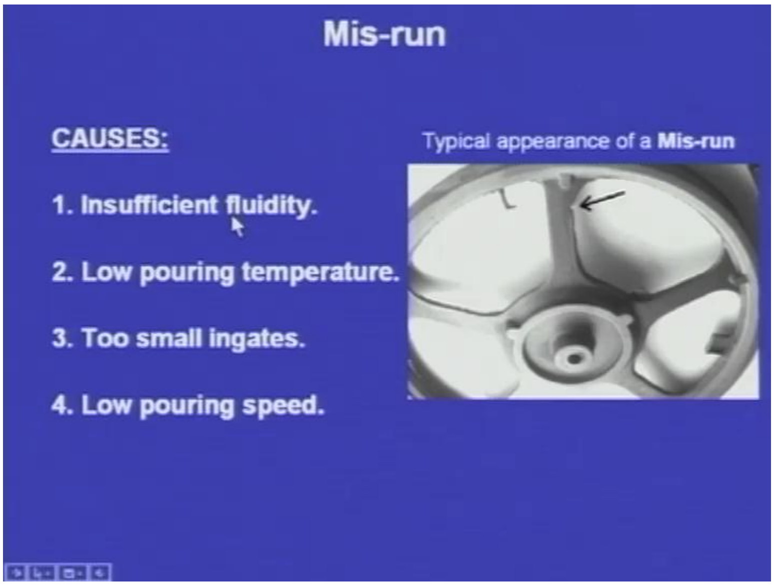

What are the causes for this defect? First one is insufficient fluidity; the molten metal has got insufficient fluidity, because of that it could not enter into the thin cavities - thin sectioned cavities. And again, low pouring temperature - when the pouring temperature is low, the viscosity will be more; when the viscosity is more it cannot enter into thin sections. So, low pouring temperature is another factor responsible for mis-run.

And another factor - too small ingates, because of the too small ingates the molten metal, its pressure is reduced, and it cannot fill the cavities. And low pouring speed - again this speed is dependent on the pouring height, and if the pouring height is not sufficient, the pouring speed will be reduced, and if the pouring speed is low, then it cannot fill into the narrow cavities, and that is how this mis-run will be arising. Now, what are the remedial measures to be taken to prevent mis-run?

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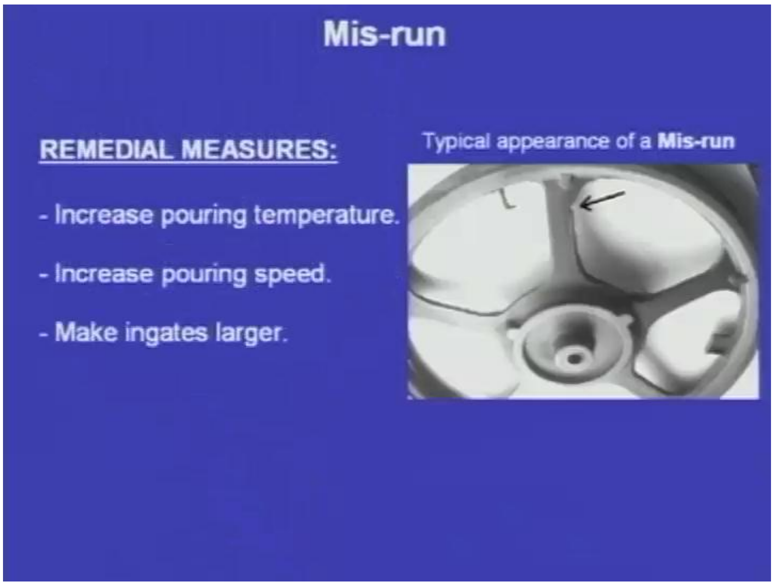

Increase pouring temperature - the pouring temperature should be sufficient; it should not be low. Next one - increased pouring speed. And make ingates larger, sufficiently large, so that the molten metal will be passing through the thin sections.

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Next, let us see the cold shut in this classification.

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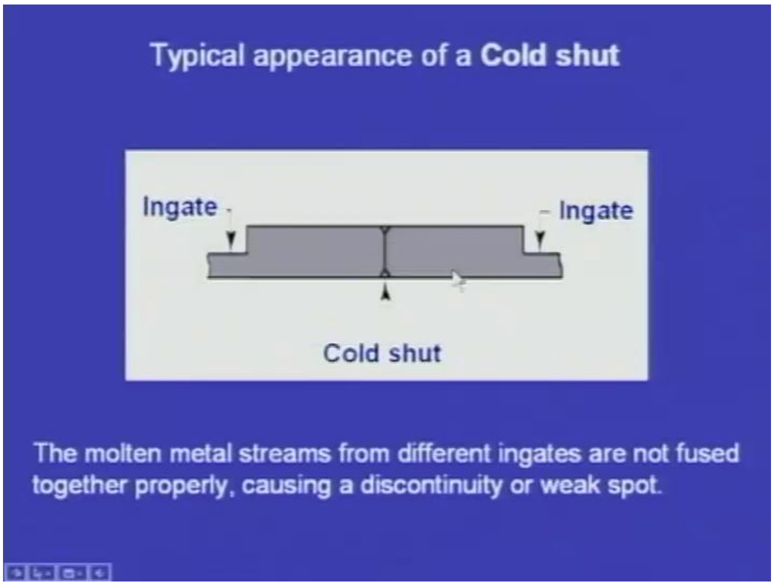

This is the typical appearance of a cold shut, and here we can see a long casting, and here there is one ingate, and here there is one ingate. Molten metal is passing through this ingate, and molten metal is passing through this ingate; and two streams of molten metal are entering into the cavity in two directions. And here these two streams of the molten metal are supposed to join and fuse together perfectly, but unfortunately due to some reasons they are not fused properly. So there is a weak spot or unseen separation; this is cold shut. Sometimes it may not be noticed, it may not be visible, but when we use this in the practical application the component will fail.

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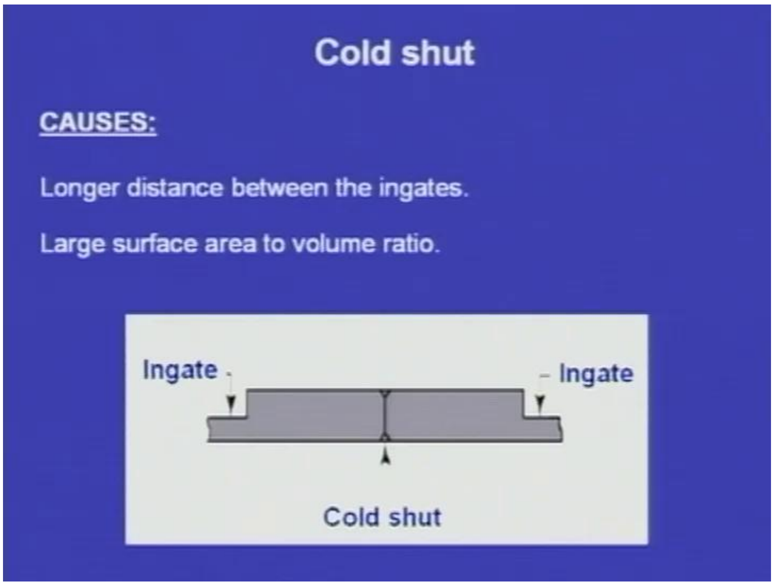

What are the causes for this defect? Longer distance between the ingates - the distance between the ingates is too much. So by the time the molten metal from this side and molten metal from this side has reached this portion, the temperature has come down; once the temperature comes down, their fluidity comes down, and their ability to fuse together comes down. And large surface area to volume ratio - large surface area to volume ratio means surface area is more. What happens when the surface area is more for a casting? It is more exposed to the mould wall, then freezing occurs fastly, then its temperature will come down, and viscosity will be increasing, and it is ability to mix with the other stream will be less. That is how this cold shut will arise.

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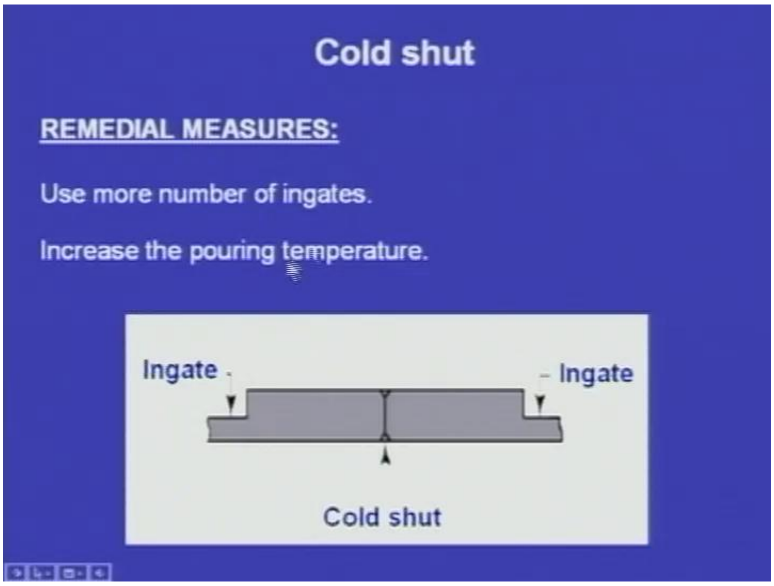

And what are the remedial measures to be taken? Use more number of ingates. Next one - increase the pouring temperature, that is how we can prevent this cold shut.

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Next, let us see the slag or dross inclusion in this classification. Sometimes this is also known as inclusion.

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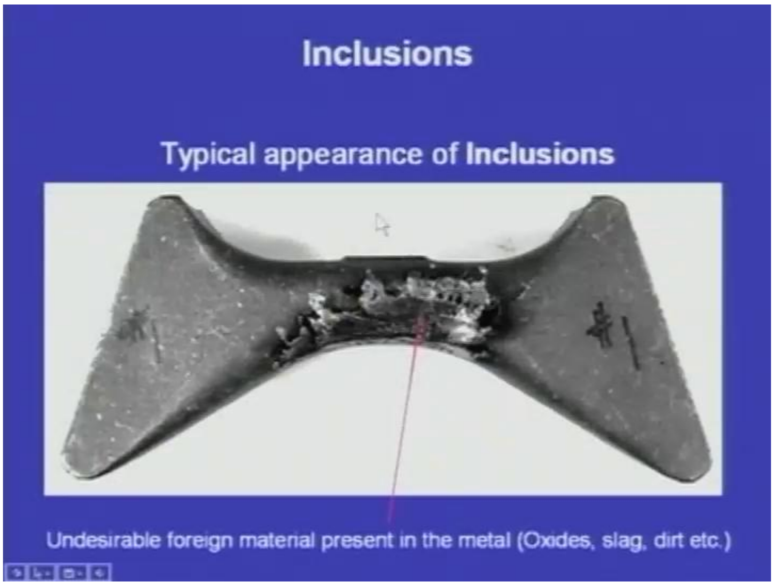

And this is the typical appearance of inclusions. Undesirable foreign material is present on the surface of the casting, and when we remove these oxides or this foreign material, there will be discontinuity in the casting, and that is a defect, and we call this defect as the inclusion. Most of this times these foreign materials will be oxides and slags present in the molten metal.

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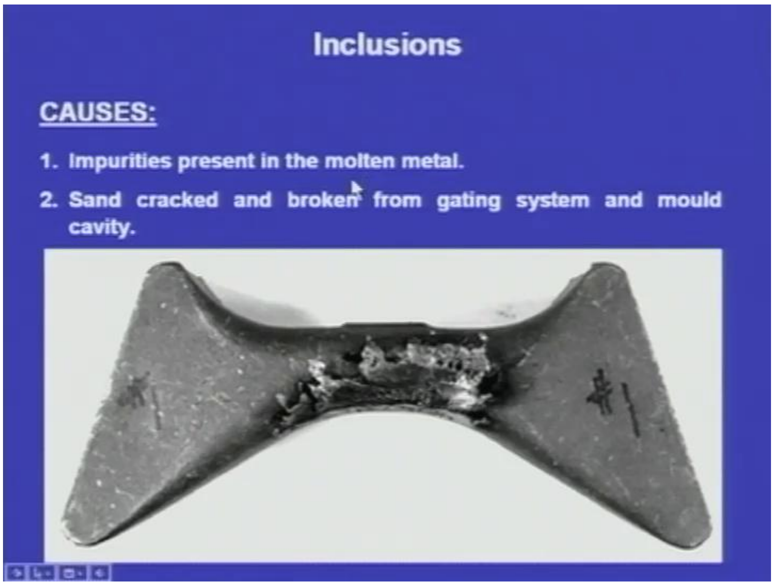

And what are the other factors responsible for the inclusion? One is impurities present in the molten metal oxides are slags present in the molten metal. And sand is cracked in the gating system when we pour the molten metal, and this small traces of sand will be flowing through the gating system along with the molten metal, and it will be resting on the surface of the cavity. And this sand will be responsible for slag inclusion.

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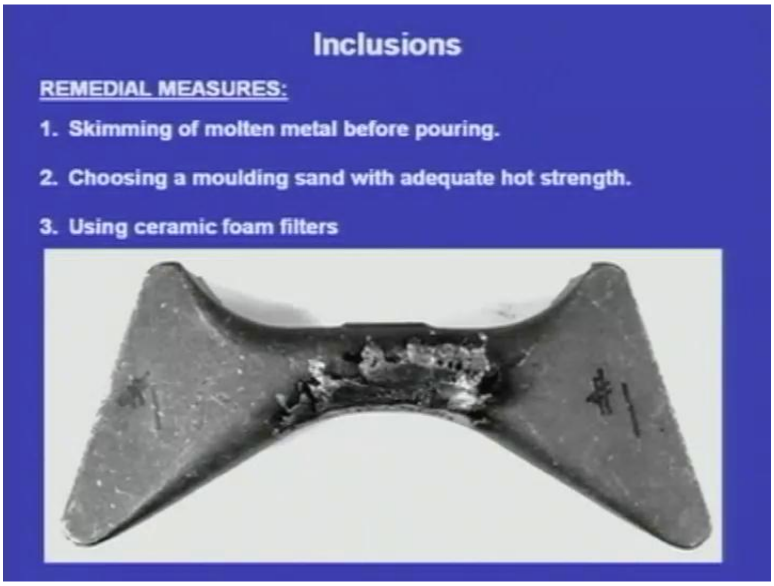

What are the remedial measures? Because we have seen that this inclusion will be arising because of the slag or oxides present in the molten metal, skimming of the molten metal is necessary. When we skim the molten metal, the oxides and slags will be segregated. And choosing a molding sand with adequate hot strength.

And next, one using ceramic foam filters - by using ceramic foam filters we can filter this foreign material.

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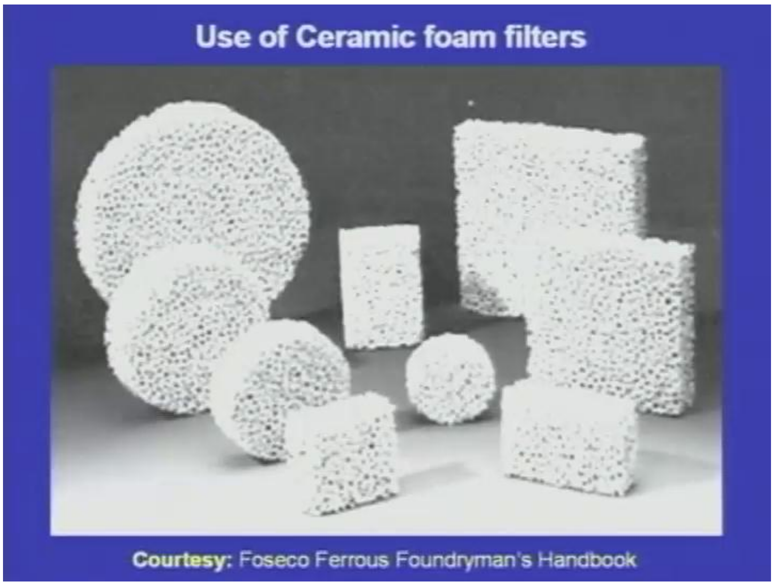

So, these are the typical appearances of the ceramic foam filters. So, they are available in different shapes and different sizes.

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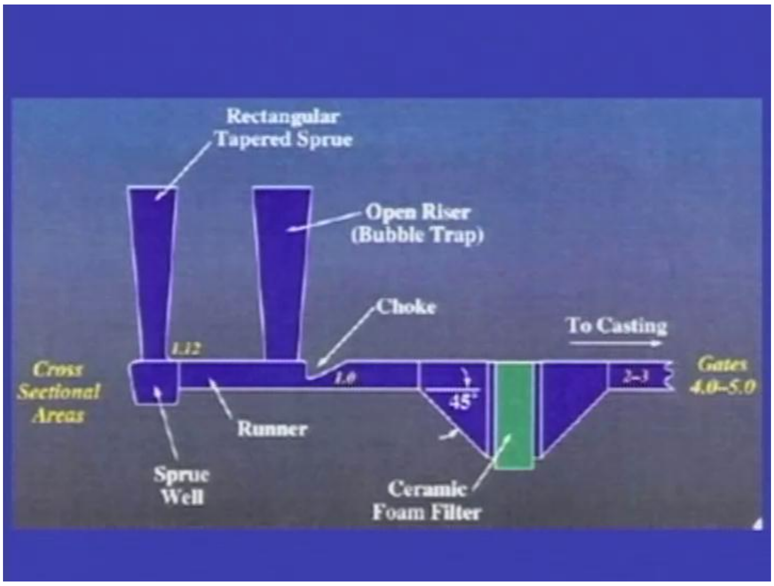

So, these ceramic foam filters are to be inserted inside the gating system, like this. So, this is the sprue, and this is runner, and here the ceramic foam filter is placed. And this side there is the molding cavity.

And the molten metal through the sprue, it will be falling and this is the sprue well, and through the runner, it will be passing through the ceramic foam filter. When it is passing through the ceramic foam filter, these foreign material, the slag's oxides, and the broken sand particles will be filtered before they enter into the cavity. So, only pure metal will be entering into the cavity. So, this is how the foreign material can be filtered using ceramic foam filters.

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Next one - defects due to metallurgical factors. Under this we can see the hot tears.

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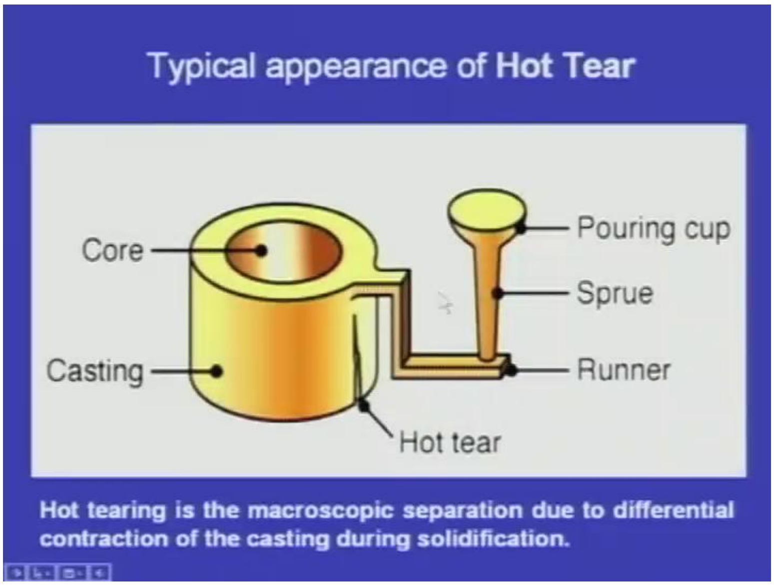

So this is the typical appearance of a hot tear, and here we can see a ring type of casting. To produce this kind of - ring type - of casting, inside a core is used, may be a metallic core or a sodium silicate core, which will be very hot. And here, of course, this is the gating system and here we can see the crack, which is formed during solidification. So, this crack is known as the hot tear. And this is the macroscopic separation due to differential contraction of the casting during solidification. So, during solidification the casting tried to undergo shrinkage, but it was prevented from undergoing shrinkage. So, the crack has developed.

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And what are the causes responsible? The casting could not undergo shrinkage freely during solidification due to casting design or the presence of the core. And here we can see hot tearing has arised due to the casting design. This part - this horizontal part - has frozen a little earlier then the vertical parts and it tried to undergo shrinkage, but it is prevented; that is how the hot tearing has occurred here.

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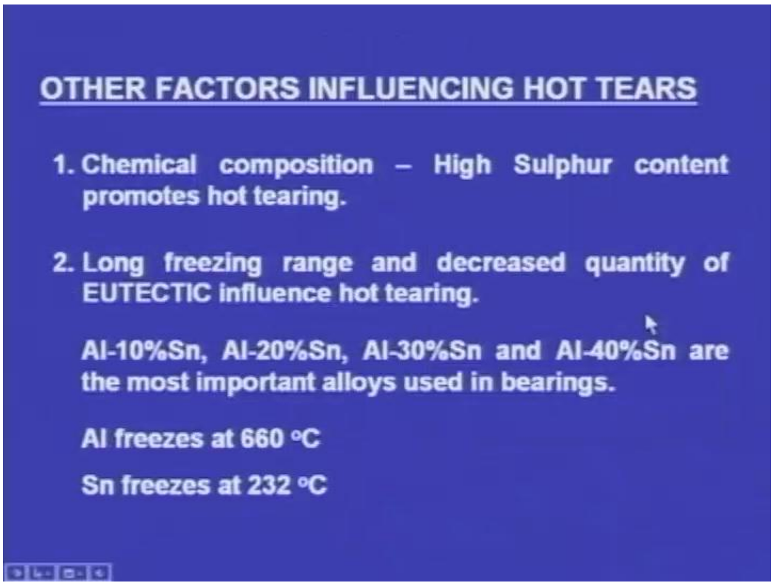

And there are other factors responsible for the formation of the hot tearing. One is the chemical composition; high sulphur content promotes hot tearing.

Next one - long freezing range of an alloy is responsible for the formation of hot tearing. Pure metals they will be freezing at a particular temperature; whereas an alloy freezes over a range. For example, aluminum tin alloy is used in the bearings. Aluminum freezes at 660 degree centigrade, whereas tin freezes at 232 degree centigrade. And depending upon the composition, the freezing may start at 660 degree centigrade and it may go on up to 232 degree centigrade. Now, here aluminum 10 percent, or aluminum 20 percent tin, aluminum 30 percent tin, aluminum 40 percent tin - they are the most important alloys used in the bearings. So, this long freezing range is responsible for hot tearing.

Another factor is the decreased quantity of eutectic in the alloy. Eutectic means the element of the mixer having the lowest melting point. So, here tin has got the lowest melting point. So, tin is the eutectic in this alloy.

Let us see how this long freezing range and eutectic will be promoting hot tearing. And in this alloy of aluminum and tin, aluminum starts freezing much earlier at 660 degree centigrade. When the freezing is complete, it undergoes shrinkage; when it undergoes shrinkage, the shrinkage is compensated by the liquid metal in the raiser. So, this compensation of shrinkage by the liquid meal in the raiser will happen during the early stages of the freezing.

During the final stage of the freezing, the liquid metal in the raiser cannot feed the casting, because dendrites are formed. These dendrites will prevent the feeding of the raiser, it is that time the eutectic will be feeding. The eutectic is the one, which is having the lowest melting point - that is the tin. When the aluminum has frozen, tin is still in liquid state that will be compensating the shrinkage; wherever there is shrinkage that will be compensating. And the problem arises when there is decreased quantity of eutectic. And if this tin is not sufficient, then it cannot compensate the shrinkage of the aluminum. Finally, it will be resulting in cracking, that is the tearing, which we call it as hot tearing. So, this long freezing range and decreased quantity of eutectic influence hot tearing.

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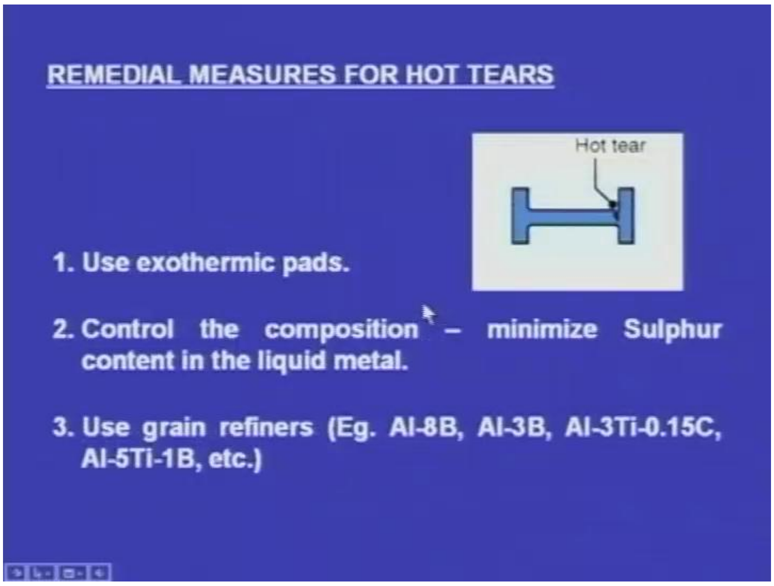

And let us see the remedial measures for hot tears. Use exothermic pads and this is the casting, and we have already seen that this horizontal portion has frozen little earlier than the vertical portions. If we can delay the freezing of this horizontal portion, then this shrinkage can be delayed; the shrinkage can be avoided. So, by using exothermic pads, exothermic pads will be covered in this region, then this portion will be taking more time in forming the vertical parts of the casting; then this shrinkage can be avoided; and the tearing can be avoided. So by using exothermic pads, we can prevent hot tearing.

Next one - control the composition - minimize the sulphur content in the liquid metal. Then the hot tearing will be coming down. Next one - use grain refiners; for example, aluminum 8 boron, aluminum 3 boron, aluminum 3 titanium and 0.15 carbon, aluminum 5 titanium and 1 boron. So, these are the different grain refiners. These grain refiners, we will be mixing to the molten metal before solidification, may be about 1 percent. The specialty of these grain refiners is that they would not affect the composition, but yet the refine the structure, they refine the grains; when we refine the grains, the tendency of the hot tearing will be coming down.

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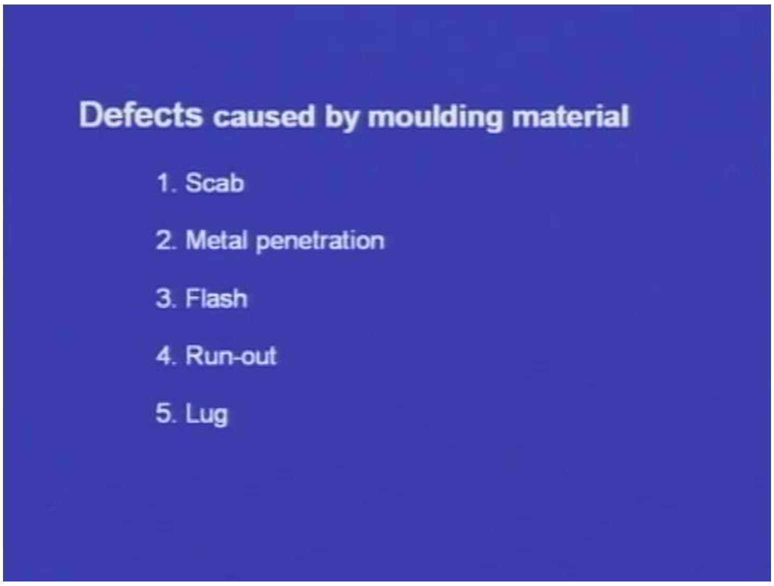

Next classification - defects caused by molding material. In that, we can see scab, metal penetration, flash, run-out and lug.

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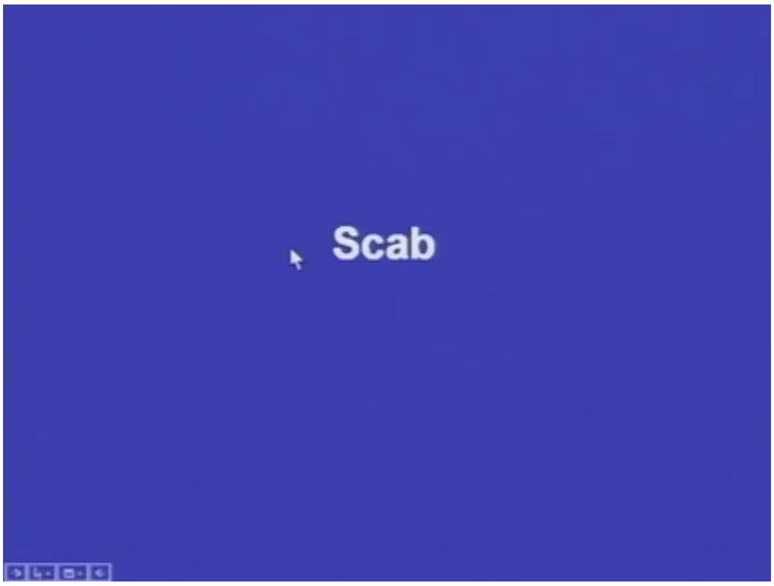

First, let us see the scab.

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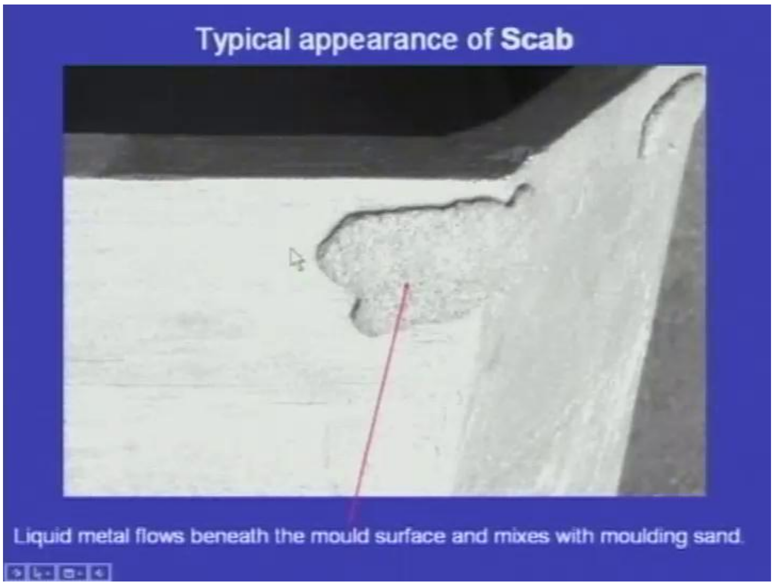

And this is the typical appearance of a scab. Liquid metal flows beneath the mould surface, and mixes with molding sand, and forms a shell on the surface of the casting. And here, we can see this shell. This is the mixture of the molding sand and the molten metal. And this is very difficult even to machine. So, this is the scab.

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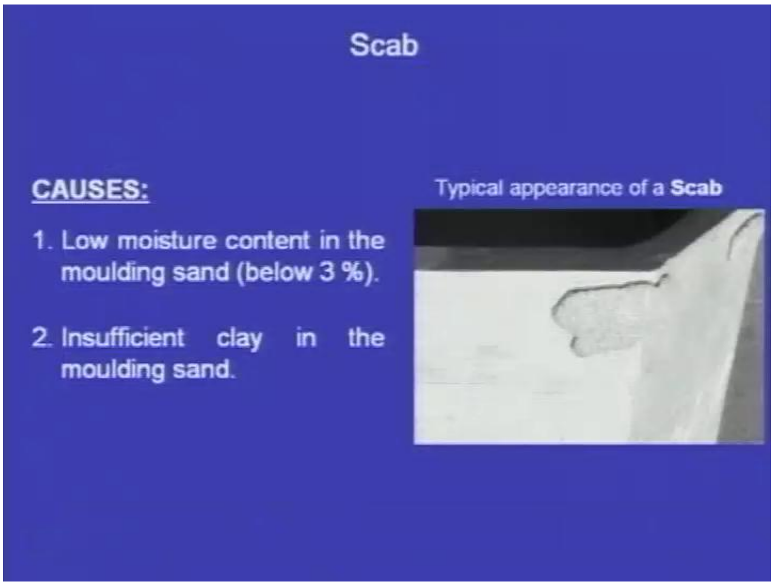

And what are the factors responsible for this scab? Low moisture content in the molding sand; especially when the moisture content is below 3 percent this problem will arise.

Next cause is insufficient clay in the molding sand. When the clays not sufficient, then the molten metal will pass beneath the molding sand, and mixes with the sand, and this scab is created.

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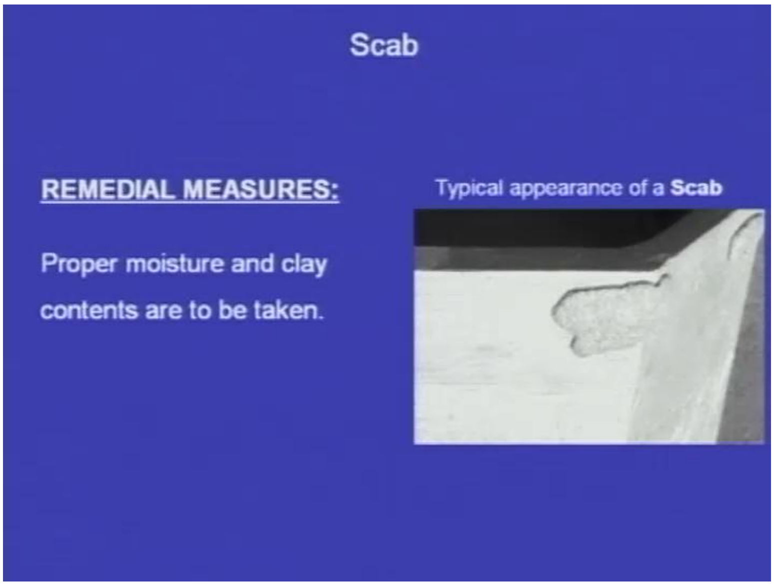

And what are the remedial measures? Proper moisture and clay contents are to be taken.

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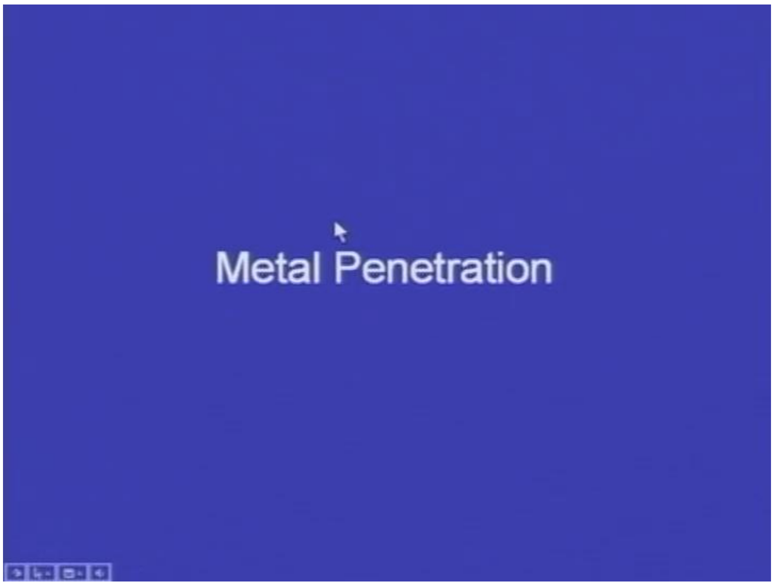

Next, let us see the metal penetration in this classification.

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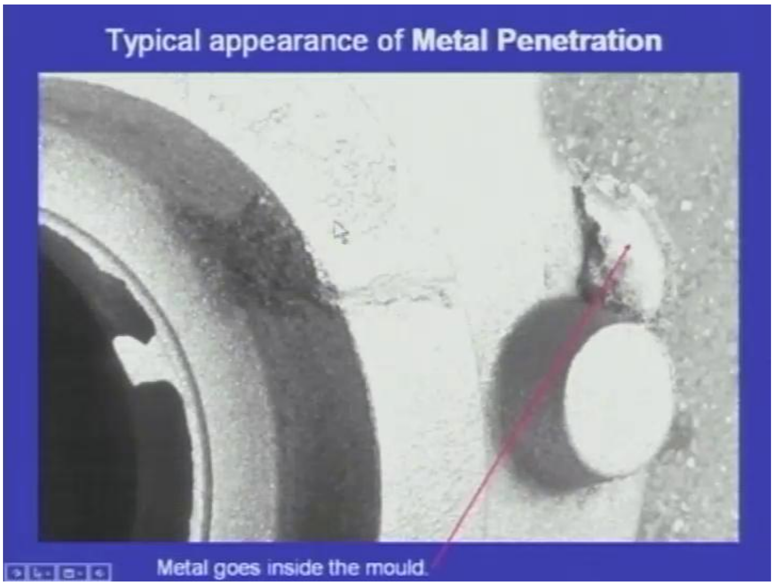

And this is the typical appearance of metal penetration, and here we can see metal has gone inside the mould. This is not the scab, and this is due to some factors.

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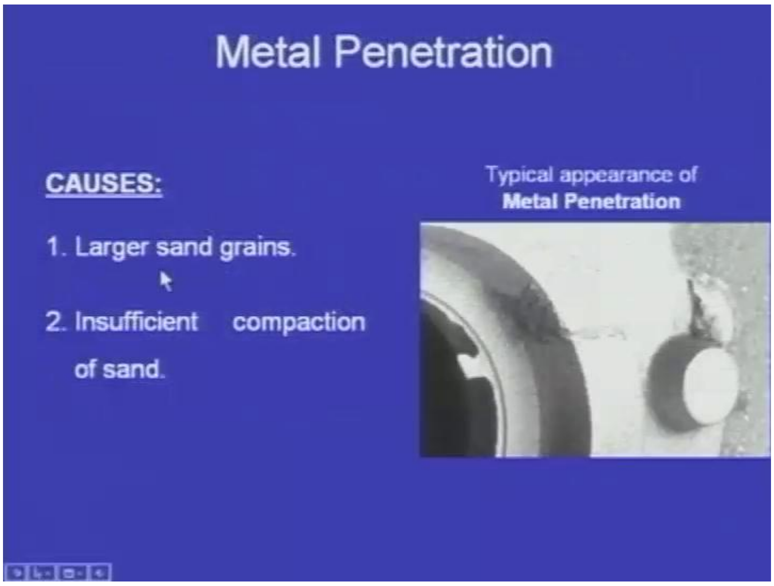

These are the factors. Larger sand grains and insufficient compaction of the sand, because of these factors, the molten metal has gone inside the cavity, and this kind of projection is created. So this is the metal penetration. How to prevent this metal penetration?

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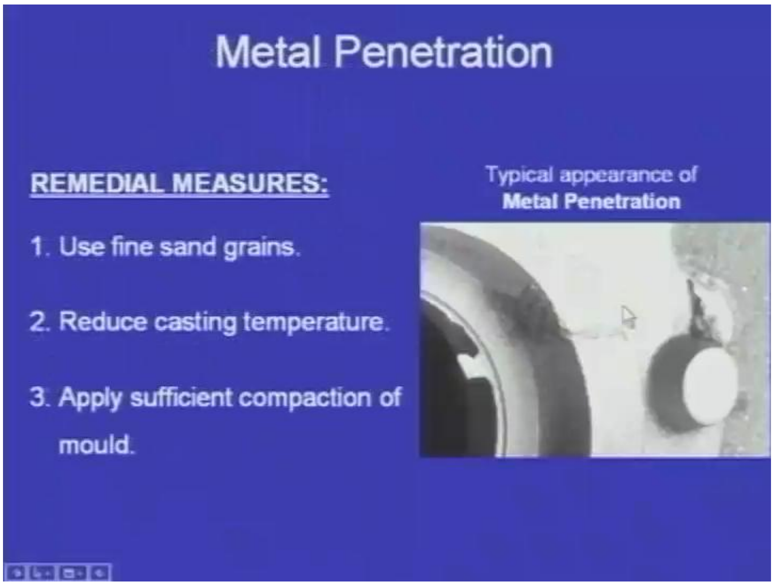

Use fine sand grains. Next one - reduce casting temperature; when the casting temperature or it is temperature of the molten metal is very high it will be going inside. So, the casting temperature should be appropriate. Next one - this problem happens when the compaction of the mould is not sufficient. So, apply sufficient compaction of the mould.

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Next, let us see the flash.

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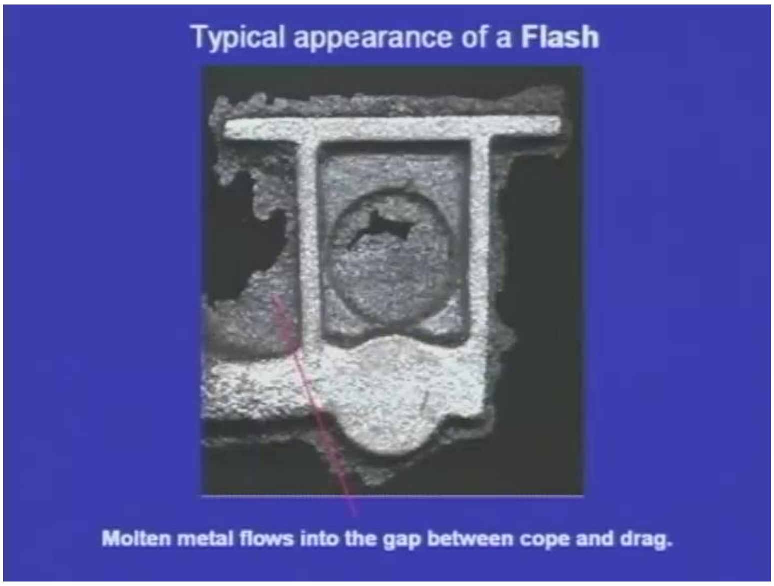

This is the typical appearance of a flash, and this is the casting, and here we can see outside a thin fin projected outwards; this is unwanted fin. So this is the flash. So, molten metal flows inside the gap between the cope and drag.

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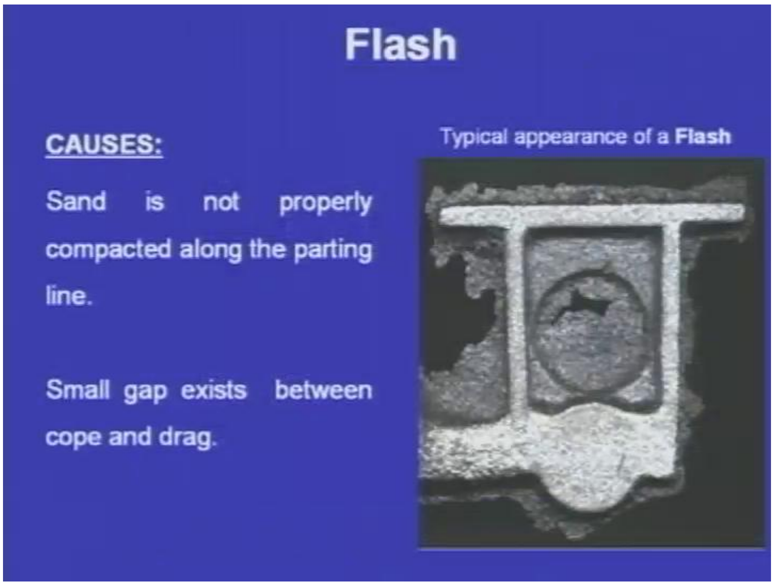

And what are the causes for this defect? Sand is not properly compacted along the parting line; means, there is a gap - little gap is there - between cope and drag along the parting line; naturally molten metal goes in to this gap.

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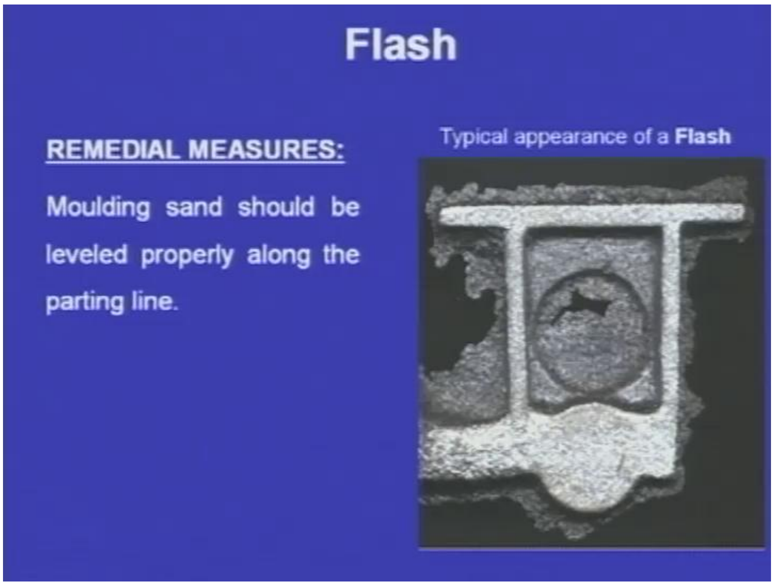

And what are the remedial measures? Molding sand should be leveled properly along the parting sand. There should be no gap between cope and drag along the parting line. Then this kind of flash will not arise.

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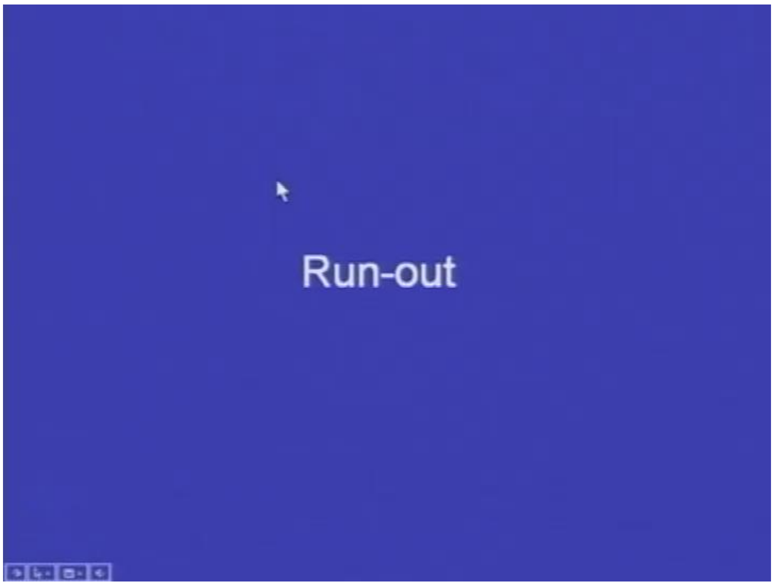

Next one - next let us see the run-out in this classification.

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This is the typical appearance of run-out defect and this is different from flash. In the case of the flash, the molten metal has gone in unwanted areas along the parting line, because the molding sand is not properly compacted, there is a gap along the parting line between cope and drag; that is why the molten has gone inside.

Here though the molding sand is compacted properly along the parting line, the defect is arising; some molten metal is flowing outside along the parting line. The hydrostatic pressure of the liquid metal lifts the cope. Then the molten metal will be going out along the parting line.

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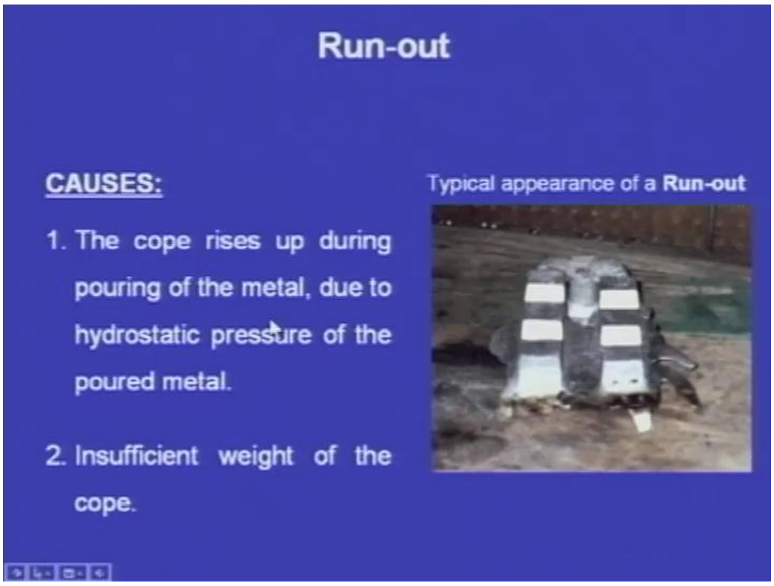

So, these are the causes. The cope rises up during pouring of the molten metal due to hydrostatic pressure of the poured metal. And another reason is the weight of the cope is not sufficient. That is why during pouring, the liquid metal could lift the cope up, and the molten metal could go outside along the parting line.

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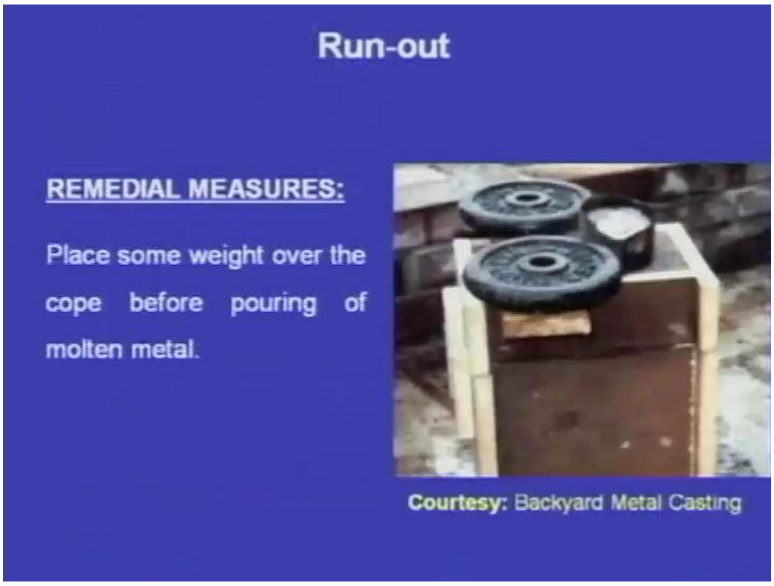

And what are the remedial measures to be taken? Place some weight over the cope before pouring of the molten metal. By placing some weight, we can prevent this defect. The molten metal cannot lift the cope up, because of these weights; then this run-out defect will not arise.

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Next, let us see the lug in this classification.

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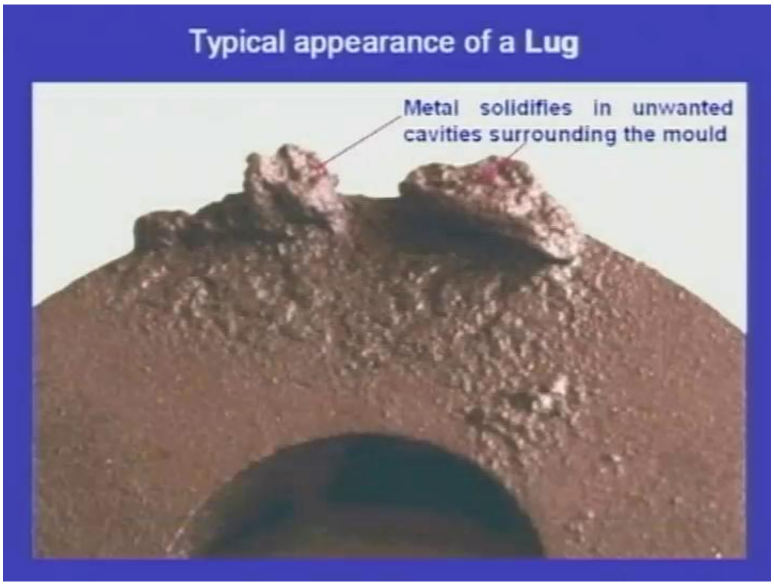

And this is the typical appearance of a lug. Metal solidifies in unwanted cavities around the mould. Unwanted cavities are there around the mould cavity, and the molten metal goes into these unwanted cavities, and solidifies; that is a lug.

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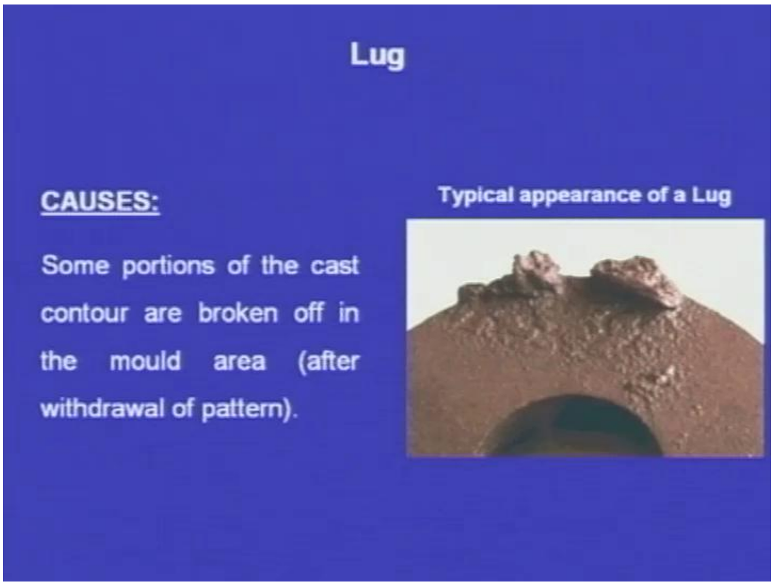

And what are the causes? Some portions of the cast contour are broken off in the mould area after the withdrawal of the pattern, and this breakage is to be noticed before pouring the molten metal, and if this is not noticed, then this problem will be arising.

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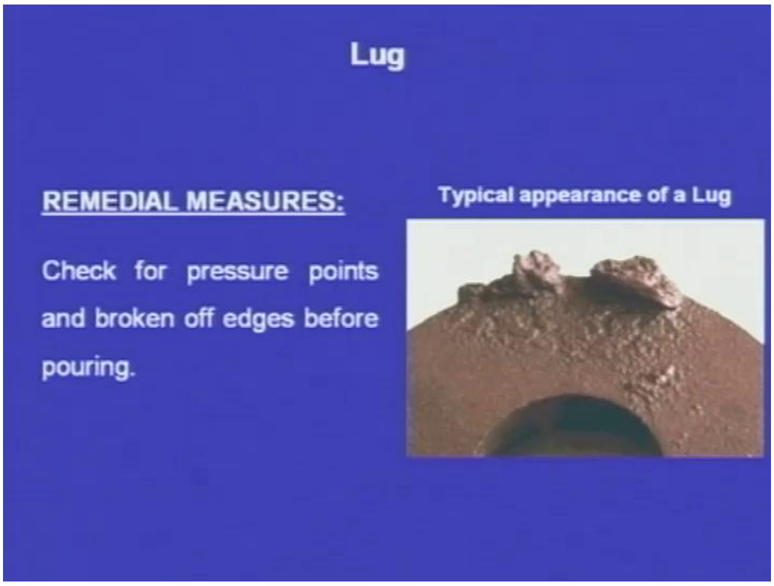

Remedial measures. Check for the pressure points and broken off edges before pouring. When we pour the molten metal, before that, we have to check the cavity whether any breakage is there or not. If there is any breakage, then we have to repair that.

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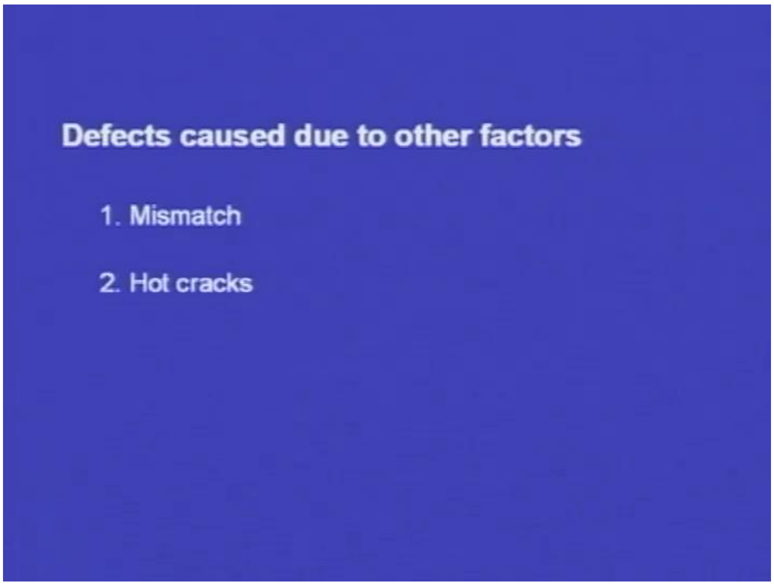

Next one - let us see the defects caused due to other factors. They are mismatch and hot cracks.

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First, let us see the mismatch.

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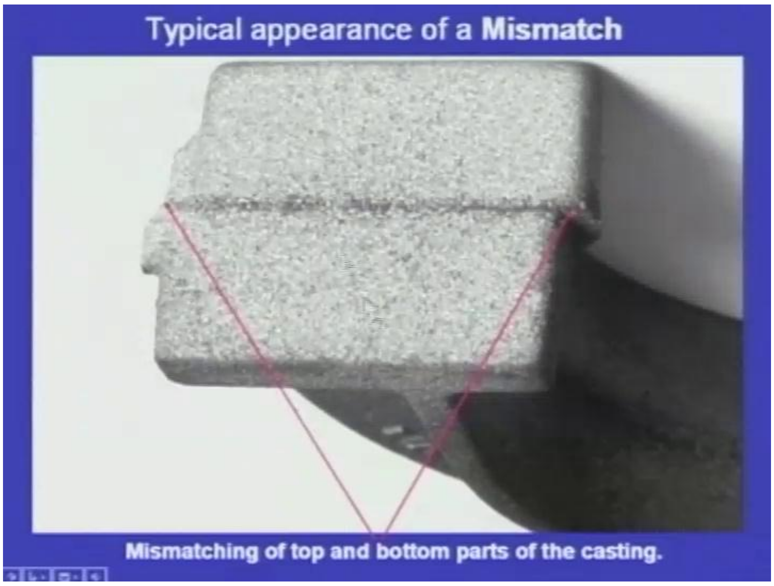

So, this is the typical appearance of a mismatch - the top and bottom portion of the casting are mismatching. So, this is a casting and the bottom portion is towards left and the top portion is towards right; they are mismatching, and this is a defect, and this defect is known as mismatch.

What are the causes for this defect?

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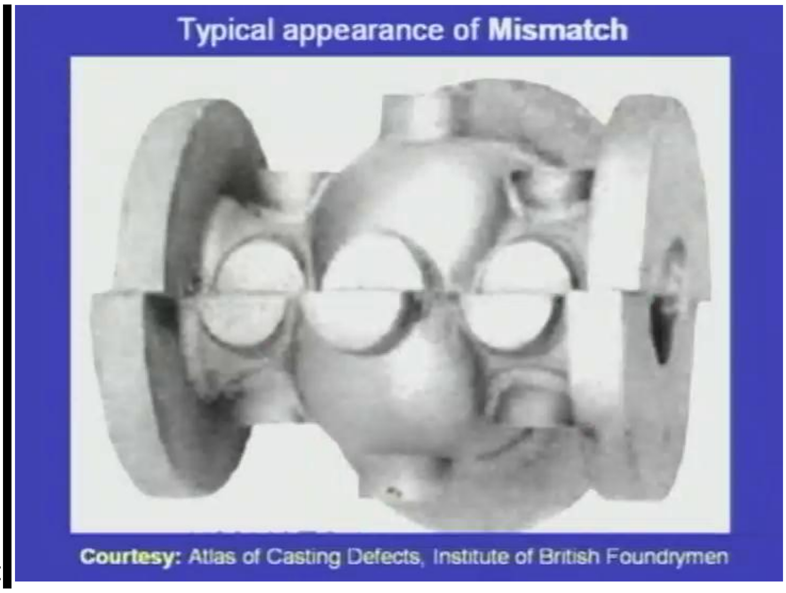

And before that, we can see another casting; this is another casting, where the similar problem of mismatch has occurred.

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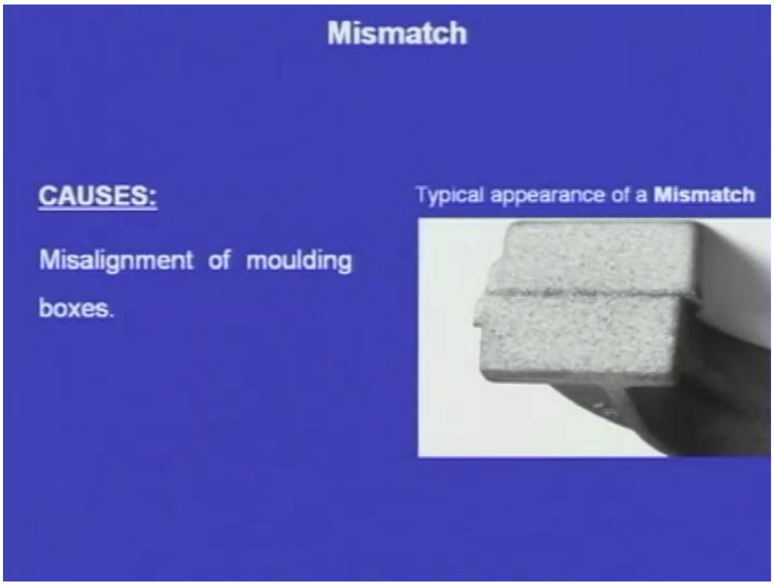

Causes. This is caused because of the misalignment of the molding box. The drag box and cope box are to be aligned properly and perfectly. And if there is any misalignment between this cope and drag, this problem will arise.

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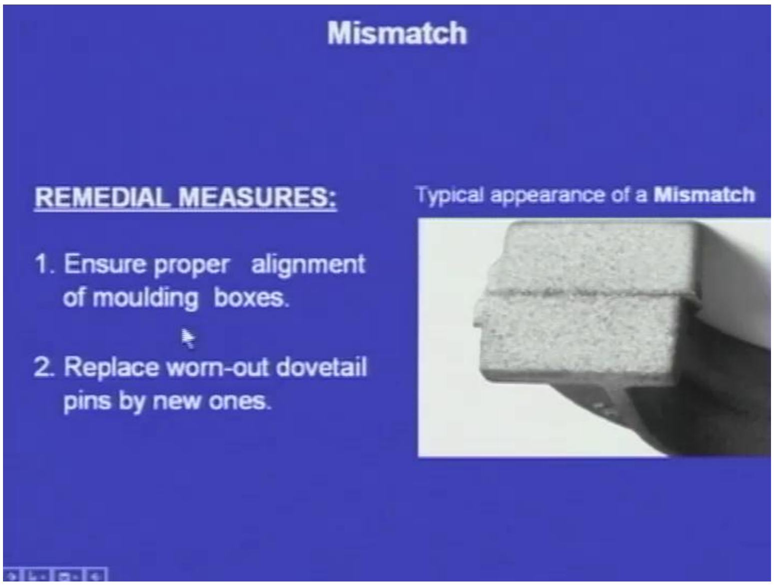

And what are the remedial measures? Ensure proper alignment of molding boxes before pouring. And sometimes to align the cope and drag, we use dovetail pins. And if these dovetail pins are worn out, and there is a possibility the cope and drag, may be shifted little bit; means there will be little misalignment, because of the worn out dovetail pins; then this defect will arise. So, replace the worn out dovetail pins by new ones.

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Next one - let us see the hot cracking.

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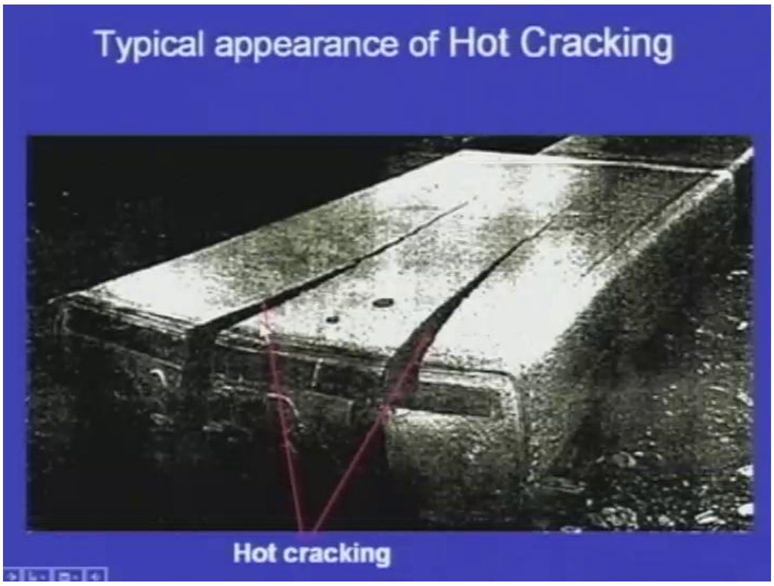

So, this is the typical appearance of hot cracking. These are cracks - large cracks - on a casting.

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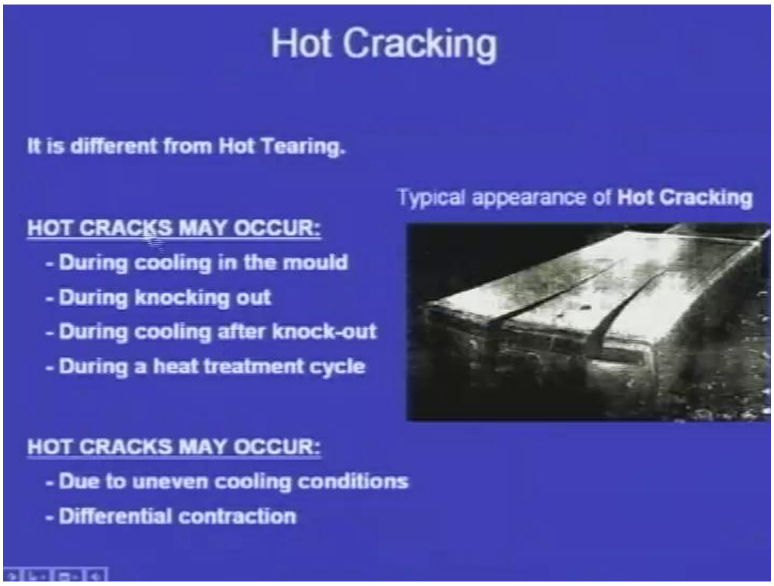

And it is different from hot tearing. And most of the times we hear hot tearing and hot cracking, and most of the times these two are misinterpreted. And it is presumed that these two are same. In fact, these two are different.

In what way these two are different - hot tearing and hot cracking? Hot tearing occurs during solidification of the casting, whereas the hot cracking occurs after solidification of the casting - that is the difference. Hot cracks may occur during cooling in the mould;

means after solidification or it may have to occur during knock out or it may occur during cooling after knock out or it may occur during a heat treatment cycle. So, all these cases - in all these cases - it is after solidification and hot may occur due to uneven cooling conditions and differential contraction.

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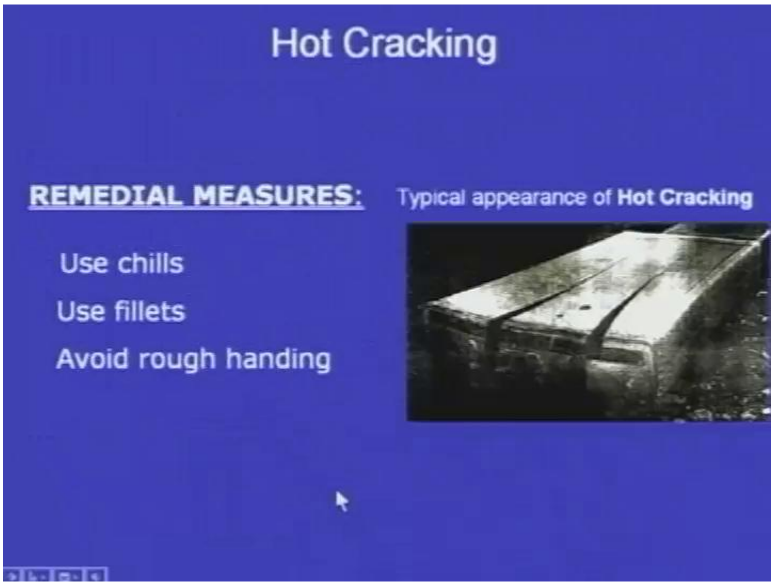

What are the remedial measures? Use chills, especially when the cross section of the casting is not same, it is different at different sections, there will be uneven cooling. By placing chills we can ensure uniform cooling of the casting. Next use fillets where there are abrupt changes in the casting design, we can use fillets. Then this hot cracking will come down. And finally, hot cracking may occur due to rough handling also. So, avoid rough handling of the casting.

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Next one - defects due to shrinkage; that is the shrinkage cavity.

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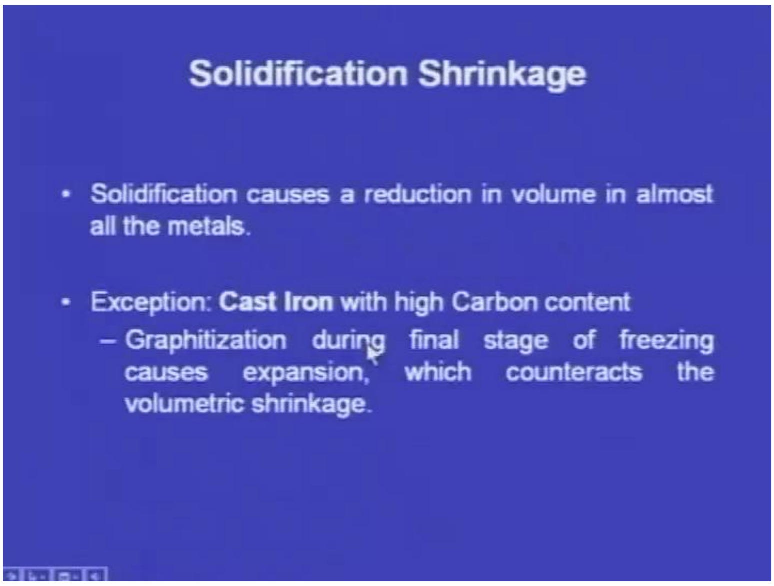

Solidification causes reduction in volume in almost all the metals; that is a well known fact, but there is an exception, especially with cast iron, with high carbon content. During the final stage of the freezing these carbon causes graphitization, which will be expanding and counteracting the shrinkage; except that, all the metals undergo reduction in volume.

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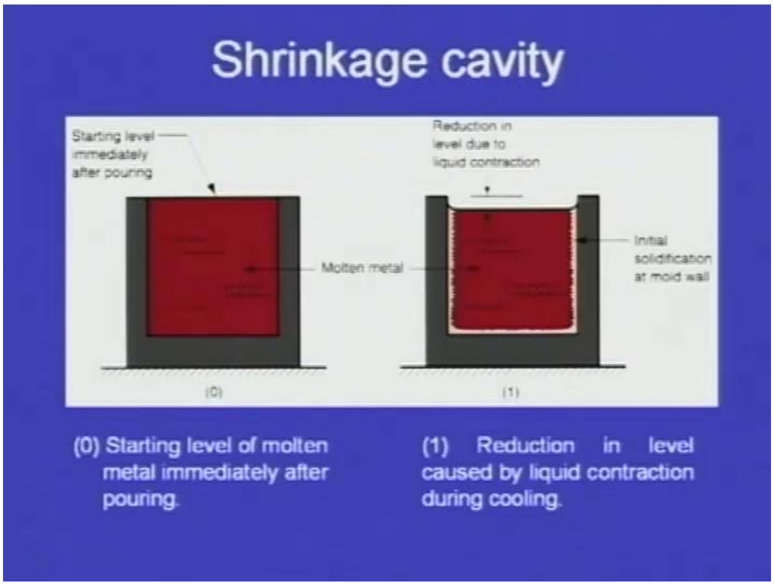

And here we can see the starting level, when we pour the molten metal, after pouring it may look like this - starting level, immediately after pouring. And here we can see the reduction in volume; here on the side we can see - that is the liquid shrinkage. Yes, when we pour the molten metal, we pour it at a higher temperature; the melting point of aluminum is 660 degree centigrade, but we may pour at about 725 degree centigrade. And from 725 degrees to 660 degree centigrade it is in liquid state. There is a temperature drop, that time it will undergo liquid shrinkage.

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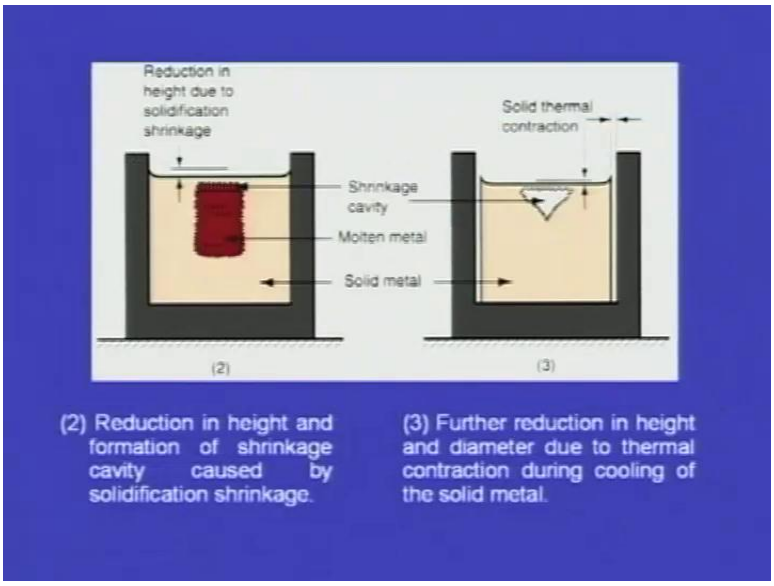

And here we can see reduction in height and formation of shrinkage cavity due to solidification shrinkage. And once the liquid metal of the aluminum reaches 660 degree centigrade it undergoes solidification, and during solidification there is shrinkage. And here we can see a shrinkage cavity.

And during solidification, if it is pure metal, the temperature will be constant and after solidification still it is at a higher temperature. From high temperature, it will be coming down to the room temperature. Again there is a temperature drop; again it contracts; that is the solid contraction. Here we can see after solidification it has contracted; that is the solid shrinkage. And this liquid shrinkage and solidification shrinkage are compensated by the raiser. Whereas, this solid shrinkage is compensated by providing shrinkage allowance to the pattern.

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And here we can see a casting with out any riser, because there is no riser, there are shrinkage cavities; here we can see one shrinkage cavity, and here we can see one shrinkage cavity, and here, and here, there are shrinkage cavities due to the options of riser.

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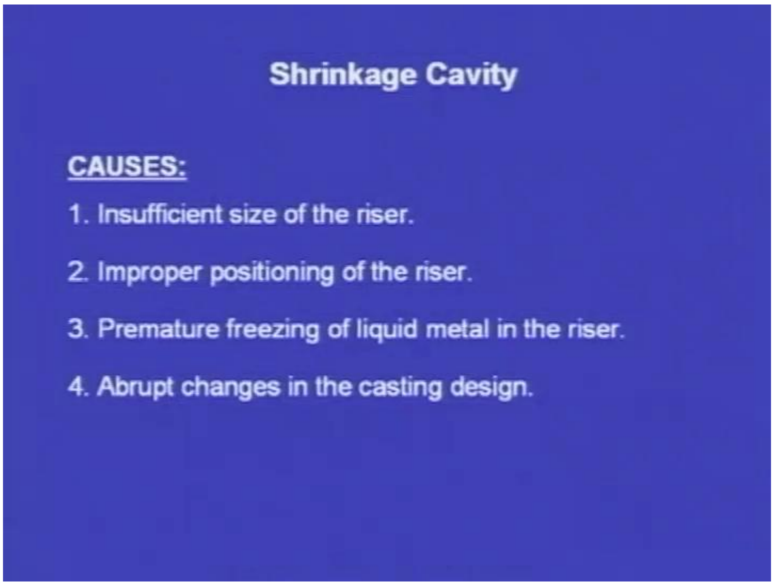

Causes. One is insufficient size of the riser. If the liquid metal in the riser is not enough to feed the casting or to feed the shrinkage during solidification, then this shrinkage cavity will arise. Next one - improper positioning of the riser. This may cause shrinkage cavity. Next one - premature freezing of the liquid metal in the riser. The riser has to solidify after the casting, then only it can feed the casting during solidification. It can so happen if the design is not correct, the liquid metal in the riser may solidify first, then it cannot compensate the shrinkage cavity. Next one - abrupt changes in the casting design; this may be responsible for shrinkage cavity.

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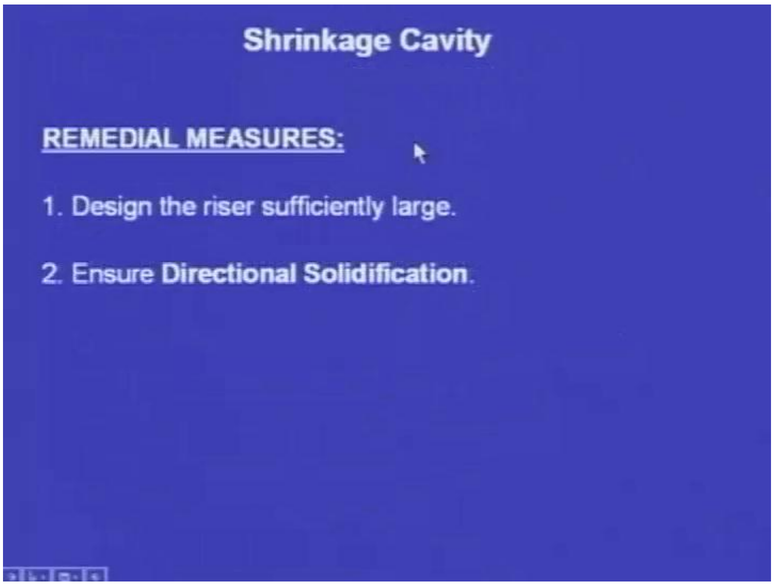

What are the remedial measures? Design the riser sufficiently large. Next one - ensure directional solidification.

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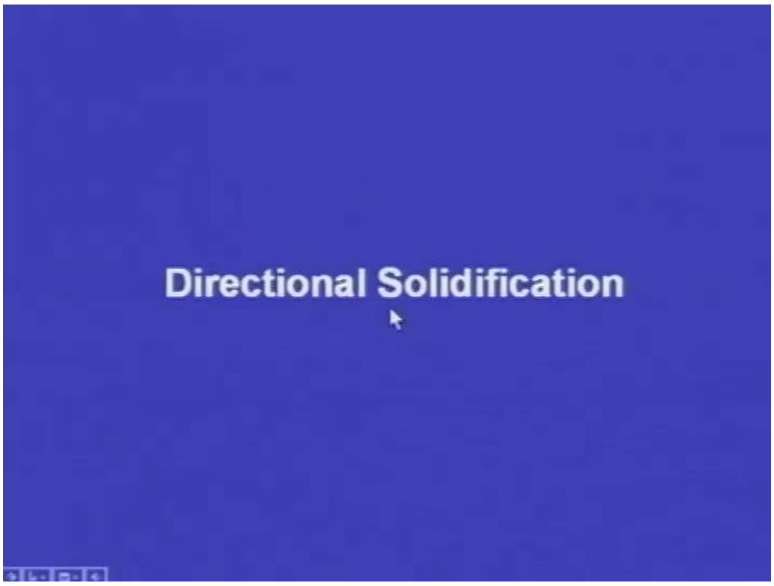

What is this directional solidification?

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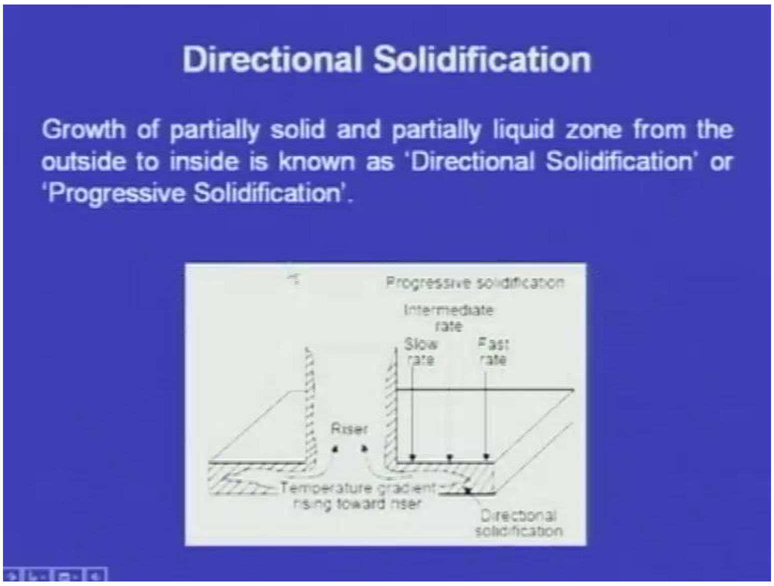

And here we can see a casting, and this is the riser, and this is the casting. As per the directional solidification of the casting, that solidification has to start from the other end - the end which is away from the riser - there the solidification has to start. And slowly solidification has to propagate towards the riser - that is the directional solidification.

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Now, this directional solidification is very important to prevent shrinkage cavities. And how to achieve this directional solidification? One is the risers should be located away from the sections with lower volume by area ratio. Lower volume by area ratios - means what? If a section has got lower volume by area ratio means the area of this surface is more; means that will be freezing much earlier, then shrinkage will be; shrinkage will not be present. So, riser should be located away from the sections with lower volume by area ratio.

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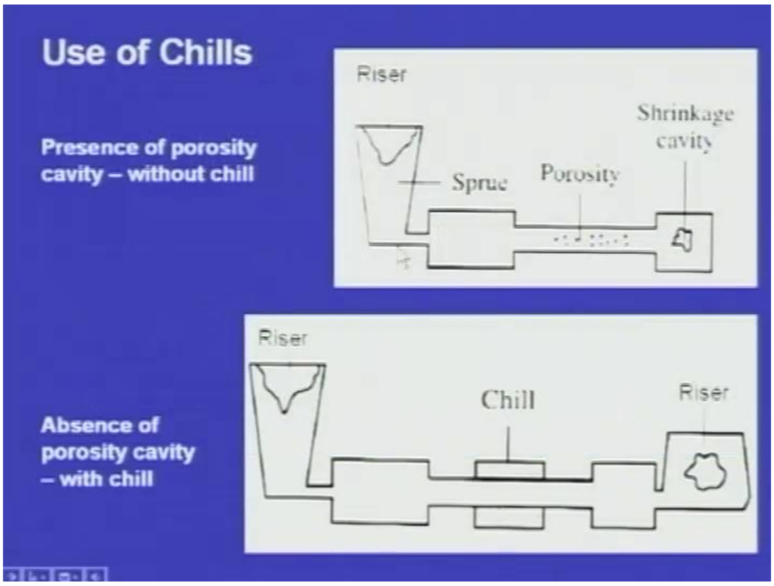

Next one - use chills at required locations. What are these chills? And here we can see this is a casting and here the porosity has arised. So, finally, it will result in shrinkage cavity.

On the other hand, we have kept a chill here; chill means a metallic block; sometimes this metallic block is made up of the same material as that of the casting. So, this will be absorbing the heat rapidly from the casting. So, this because of the presence of the chill, the casting solidifies fast. So, the possibility of the formation of the shrinkage cavity is very less. So, by providing chills, we can prevent shrinkage.

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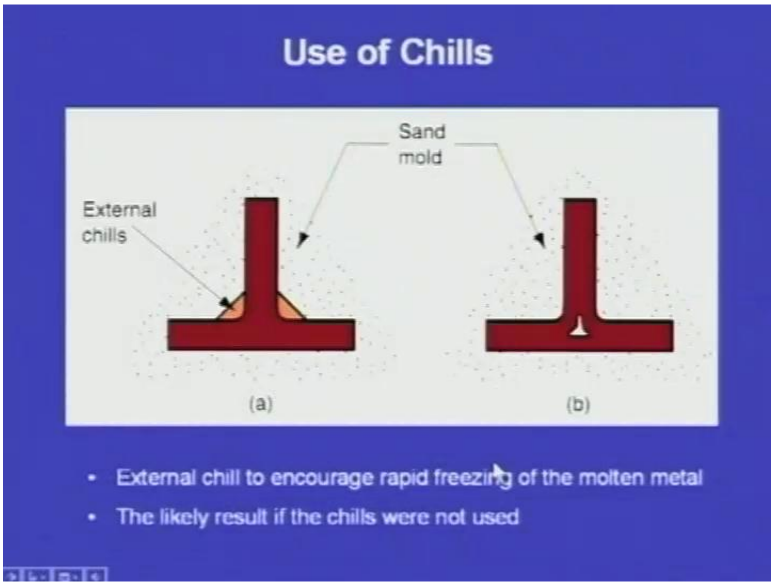

Here also, this is the casting and here one shrinkage cavity is arised. And here we have kept chills - means the metallic blocks - and these blocks have extracted heat rapidly from the casting. So, this portion has frozen much earlier or little earlier. So, the possibility of the formation of the shrinkage cavity is not there.

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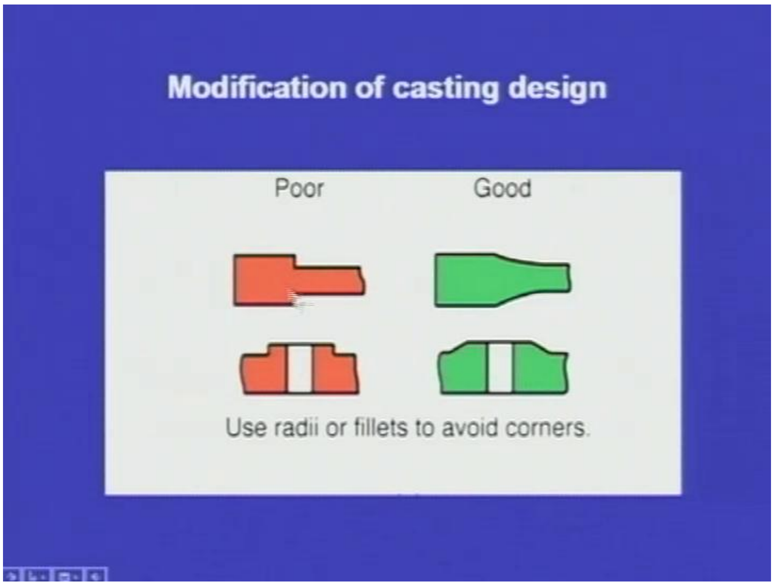

Next one - modify the casting design such that it promotes directional solidification. And this is the casting design, and here we can see abrupt change; this is not correct one; this is a poor design. Instead, we can modify the design like this; this is good. And here also we can see abrupt changes; this is poor design; and here we can see we have modified; this is better.

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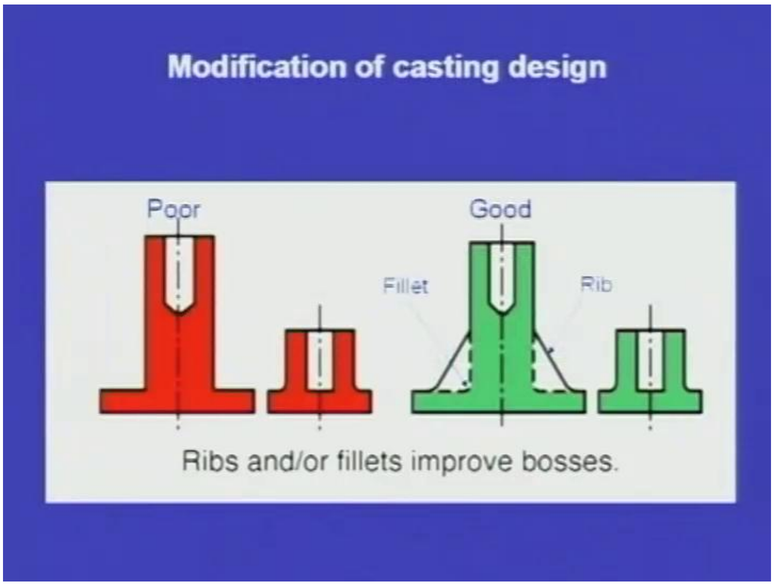

And here also we can see there is abrupt change in the casting design and this is poor. And here we have used rib and also there is a fillet; this is good design. So, by modifying the design, we can prevent shrinkage cavity.

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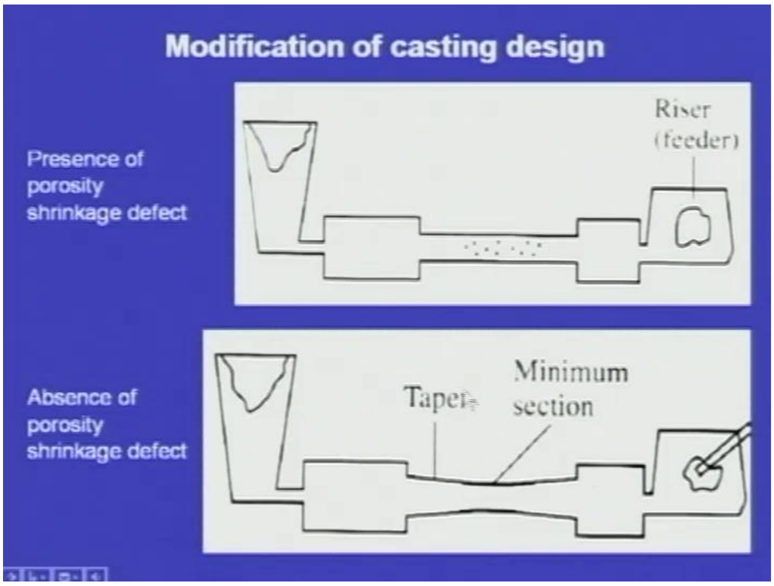

And here also, because of this thin section, there is possibility of shrinkage cavity. And here we have tapered it, so that the shrinkage cavity will be prevented.

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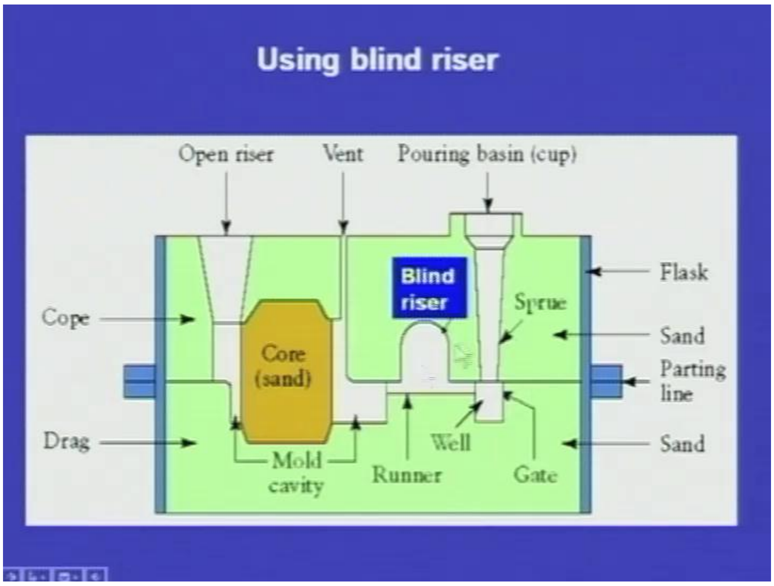

Next one - by using blind riser we can prevent shrinkage cavity. What is this blind riser? So, this is a mould, and this is the drag, and this is the cope, and this is a open riser, this is a vent hole, and this is the sprue.

And the open riser, the problem is here this area is exposed to the atmosphere; then heat dissipated to the atmosphere. So, because of that it will be freezing quickly. On other hand, there is a blind riser, which is totally inside the mould. Like the open riser, it is not exposed to the atmosphere. So, less heat goes to the mould wall. So, the metal in this blind riser will be in liquid state for prolonged time, and if there is any shrinkage cavity the liquid metal from the blind riser will be compensating that shrinkage cavity. So, by using blind riser, we can prevent shrinkage cavity.

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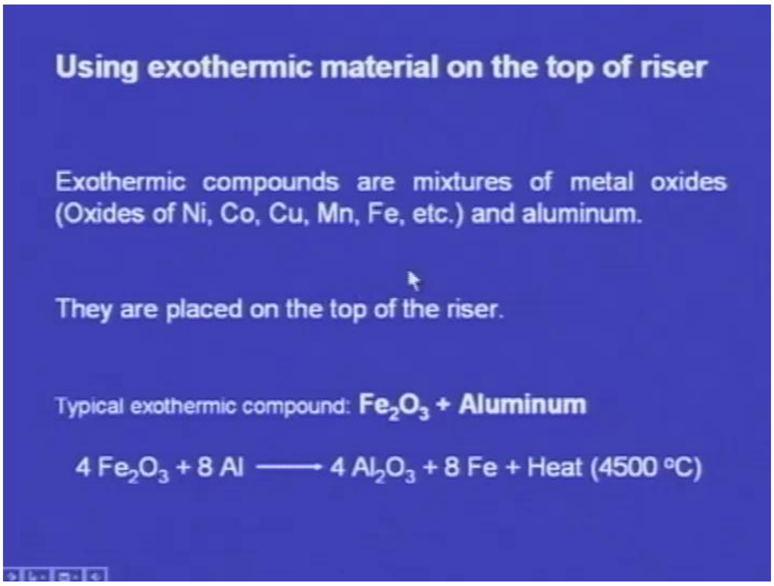

Next one - use exothermic material on the top of the riser. Exothermic compounds are the mixtures of metal oxides and aluminum. Metal oxides means oxides of nickel, cobalt, copper, manganese, iron, and so on. And these oxides of metals and aluminum will be mixed together; this mixture is known as exothermic material. And this exothermic material is placed on the top of the riser. And let us see what happens when we place this exothermic material on the top of the riser. And this is the exothermic material mixture Fe 2 O 3 plus aluminum and let us see this reaction. And lot of heat is generated. And because of this heat generated, the metal in the riser will be in liquid state for prolonged time. And if there is any shrinkage cavity in the casting, this liquid metal will be feeding that shrinkage. So by using exothermic material on the top of the riser, we can prevent shrinkage cavities.

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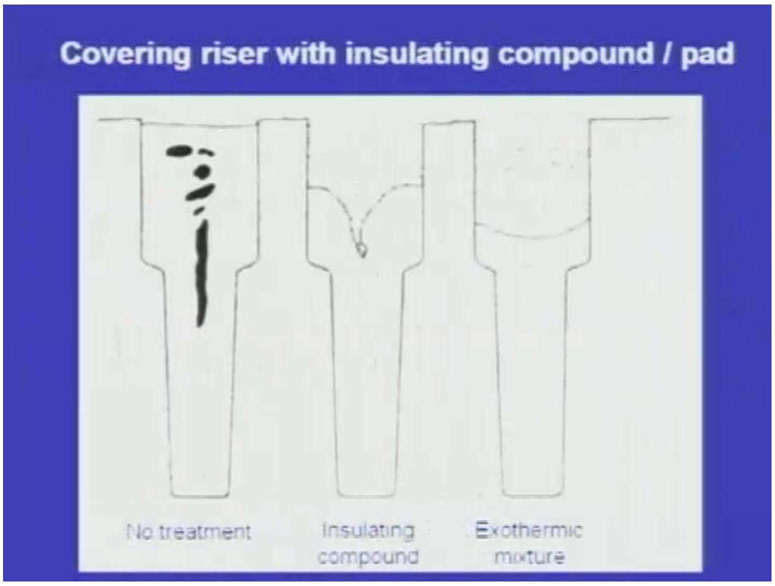

Next one - let us see another factor - that is cover the riser with insulating compound or pad. And here we can see, this is a riser, and here we have placed the exothermic material and what happens? On the top we have kept the exothermic material, but on the sides the heat is dissipated to the mould wall. So, if we can prevent this heat dissipation through the mould wall, the liquid metal in the riser continues to be in liquid state for some more time. So what we do is, we insulate it; there will be insulating pad; that insulting pad will be covered on the sides of the riser. Sometimes insulating material is placed on the top of the riser.

By using insulating pad, and insulating material and insulating sleeves around the riser, we can ensure that the liquid metal in the riser continues to be liquid state for prolonged time. When it is in liquid state, it can very well compensate the shrinkage in the casting.

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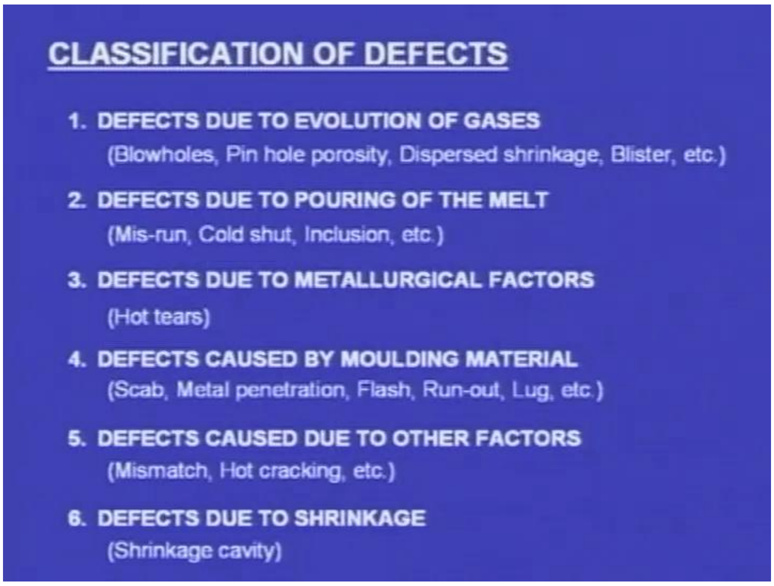

So, in this episode we have seen the classification of the defects. We have seen that there are different types of defects - defects due to evolution of gases, and under that we have learnt about blowholes, pin hole porosity, dispersed shrinkage, and blister. And we have seen defects caused to pouring of the melt - they are the mis-run, cold shut, and inclusion. And we have seen defects caused due to metallurgical factors and they are the hot tears. We have seen defects caused by molding material such as scab, metal penetration, flash, run-out, lug. And defects caused due to other factors like mismatch and hot cracking. We have also seen the defects due to shrinkage, that is the shrinkage cavity.

And in a survey it was found that each year about 25 percent castings are rejected due to defects; this drastically reduces the productivity of an industry. Today castings are used in industries, in automotives, in spacecrafts components - they are used, and every care has to be taken to prevent the defects. If every care has to be taken to prevent the defects, if we can achieve the castings with zero defects, that will be really a great success.

Thank you.