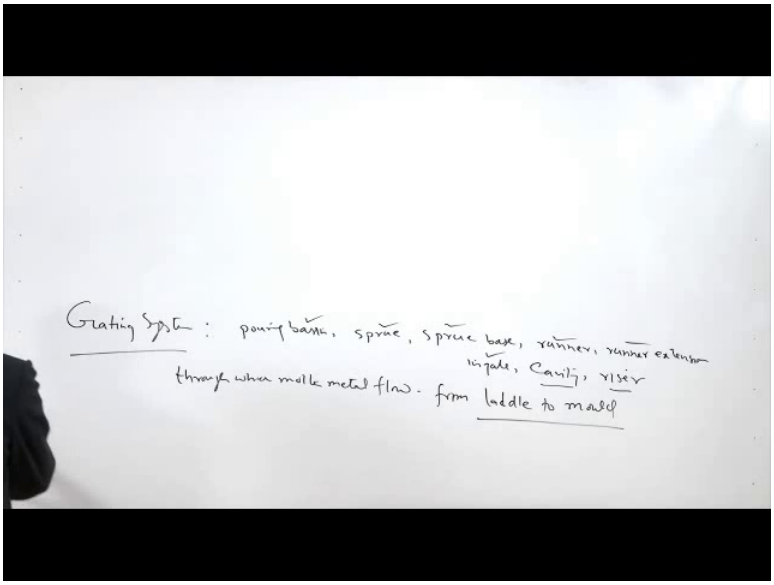
Fundamentals of Manufacturing Processes
Dr. D. K. Dwivedi
Department of Mechanical & Industrial Engineering
Indian Institute of Technology, Roorkee

Lecture - 18
Casting: Gating System

Hello, I welcome you all in this presentation. This presentation is related with the topic casting and in this one we will be talking about the gating system.

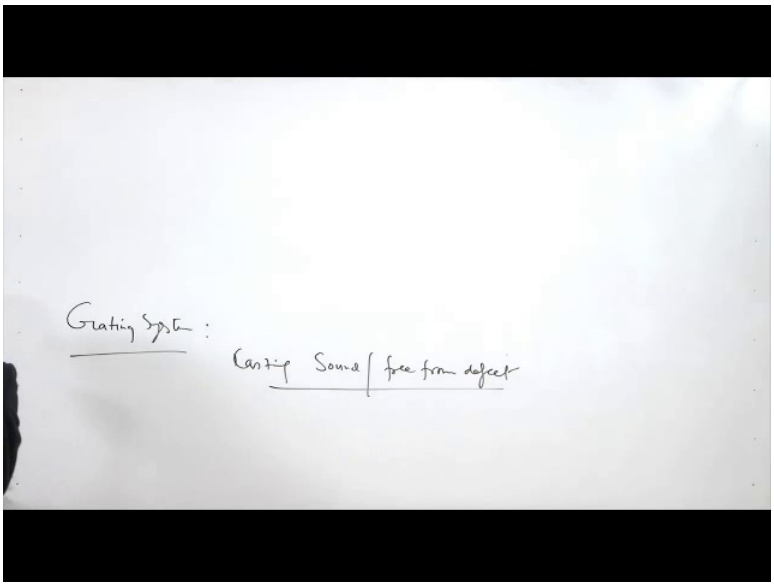
(Refer Slide Time: 00:29)



Gating system comprises number of the elements or the parts, which includes like pouring basin. Then like sprue then sprue base, then runner and then sometimes a runner extension is also there. And then in gate after the in gate we have cavity or the mould and then riser. So, these are the different elements through which you see this is the sequence through which molten metal flows from the ladle to the mould.

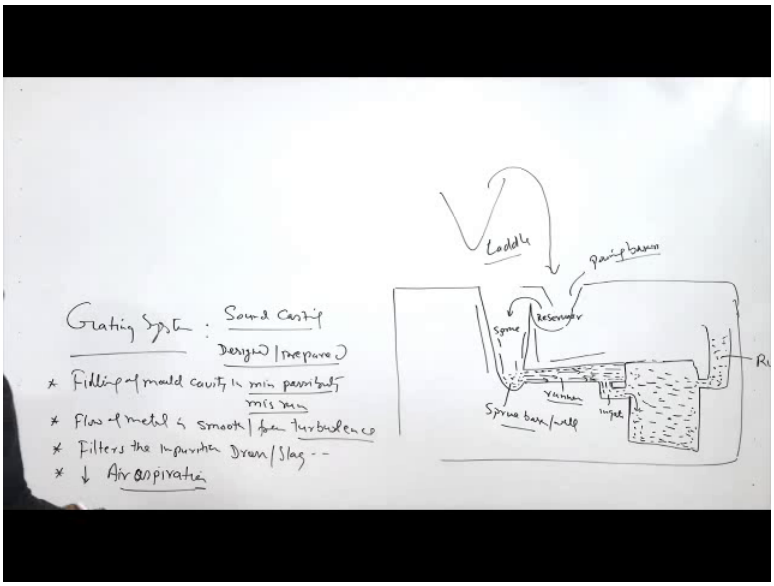
So, the journey of the molten metal from the ladle to the mould goes through the it passes through the pouring basin sprue sprue base runner extension in gate and fills in the cavity and then into the riser so that it can take care of the shrinkage related aspects. But what we want that this movement of the molten metal up to the mould cavity is in such a way that we get basically.

(Refer Slide Time: 02:25)



Ah the casting which is sound or free from defects. And for this purpose number of the aspects are focused while making the gating system. So, I will make one typical diagram and which you we can say can is expected.

(Refer Slide Time: 02:54)



Like say, it goes in like this is the mould, this is where the extension.

And this is where we have the mould cavity, and this is the cavity in this case we may have the riser here. So, metal at enters and then goes up this manner and this is how it is covered, it goes in like this. So, actually from the ladle molten metal is poured. So, you

can say this is ladle and it is poured into the pouring basin. So, this acts as the pouring this is basically pouring base basin acts as a reservoir of the molten metal. So, the metal from the pouring basin basically goes to the sprue. And after flowing through the sprue it goes to the sprue base or sprue well and then here there is a change in direction of the flow of the molten metal. So, this is another reservoir which is created it here from the molten metal molten metal if you reaching to their sprue base and then or else sprue well. And then there will be change in direction for the flow of the molten metal into the runner. So, this is basically runner.

So, when the metal is flowing into the runner all the lighter impurities will be floating over the top surface, here the runner sometimes a runner extension is also made so that molten metal flows directly into the extension, and the clean molten metal enters through this in gate. So, this is in gate. So, at the end of the runner we will see that there is a in gate and through the innate molten metal enters slowly into the mould. So, this is the mould here it will be filling in the cavity.

So, here molten metal first reaches through this wall to the bottom of the mould and then this to starts filling the cavity and once the cavity is filled in then molten metal will be rising into the or it will also be filling the our riser. So, this is the riser.

So, these are the different elements of a gating system. And these are made or designed these are designed and prepared in such a way that they perform a certain functions, so that the sound casting main goal of producing sound defect free casting can be made. So, what are those? A specific objectives which are realized through this the system of the gating which comprises number of elements for producing the sound casting it includes that the that the gating system is designed in such a way that the when molten metal is fed into the pouring basin.

It fills in the mould cavity in the minimum possible time. So, the first thing is that the filling of the mould cavity in minimum possible time. This is important to avoid that. So, at one location solidification has I started another location, the molten metal has react to reach. So, this kind of situation can lead to the number of the issues and like miss run is one of them, where molten metal may not be able to reach it if it is taking very long time if it is very it will taking very long time then temperature of the molten metal may reduce

significantly. And in that case the esteems coming from the 2 sides may not fuse together and that may will reach that may lead to have the defects like cold shirts.

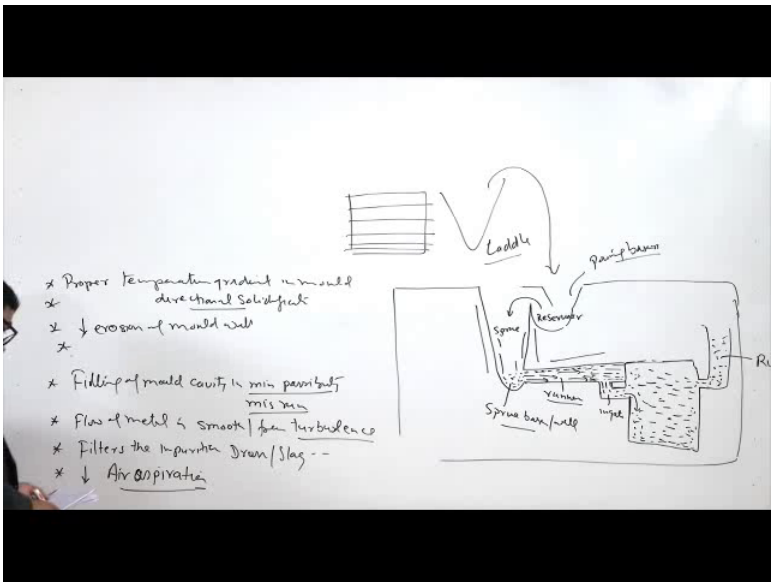
So, the feeling of the molten metal in the minimum possible time is really important so that the molten metal at the correct temperature reaches to the different sections before the commencement of the solidifications for the entire zone all the sections are filled in effectively by the molten metal.

Another is the flow of the molten metal flow of molten metal or metal is smooth, and free from turbulence. This plays a big role in the developing sound castings, because otherwise it will damage to the if there is a turbulence and damage the walls of mould sand moulds. So, this will change the geometry and then size of the mould. And so, accordingly there is a casting of the different size will be realized and it also increases the air entrapment enterapment of the air.

So, air pockets or air aspiration tendency increases when there is a turbulence in the flow of the molten metal. So, the turbulence of in the flow of the molten metal is reduced. Another important thing is it should the design of the runner as well as pouring basin is such that it filters the impurities, impurities like draws slag and other impurities which are lighter in weight and floating over the surface. So, basically the pouring basin is designed and runner is designed in such a way that they filter or remove the impurities and feeds the clean molten metal into in the mould cavity.

Another is the flow should be such that as I mentioned it reduces the air aspiration air aspiration is reduced. So, for this purpose basically the sprue design design of the sprue and design of the runner is made in such a way that they are they are always full of the molten metal, and no negative pressure is created so that air can be aspired through the pores which are present in the 7d mould. And so, therefore, the design of the runner and this sprue should be such that air aspiration is reduced. Otherwise this will be leading to the presence of the number of gaseous defects in the casting. Another important factor or the function which is expected from the gating system is that the proper Temperature gradient in the mould is achieved.

(Refer Slide Time: 11:20)



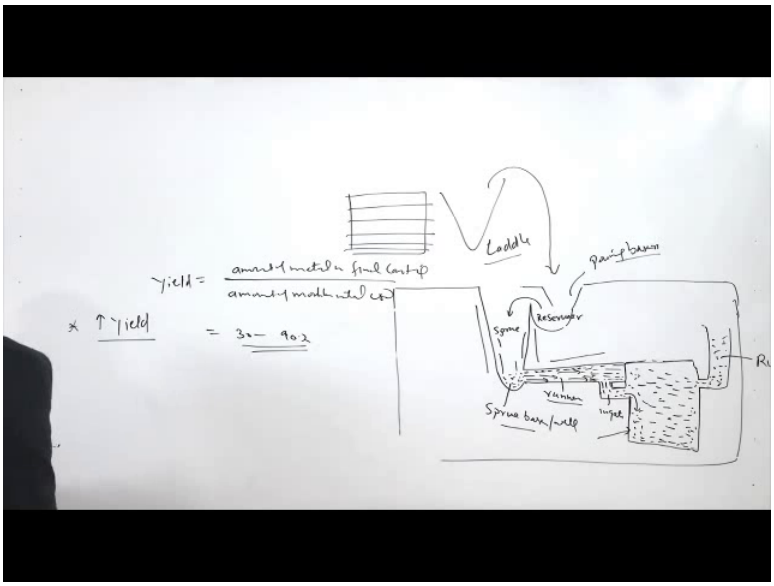
What is the meaning of this proper? Means the temperature gradient in the mould is such that that unidirectional solidification is realized, wherein the solidification is starts from the end from the remote place and then it goes on towards the hottest possible place which is close to the riser or the in gates. So, this kind of the unidirectional solidification will be possible if the proper temperature gradient is there. And if this cannot be maintained properly then we can use chills or we can locate the risers suitably so that this temperature gradient is maintained. So, this actually helps in realizing the directional solidification. If this is realised then number of the impurity is and the shrinkage cavities.

They will be exposed to the surface which can be taken care of effectively, otherwise they will be located inside the casting. And which will make the casting with the defects. The design should be such that they reduce design of the gating system should be such that the flow of the molten metal is as a smooth as possible so that it reduces the erosion of the mould walls. This kind of erosion and otherwise if it arroweds and leads to the defects like cuts and the washes in the casting. So, to avoid this kind of the defect tendency in the castings the arrows and tendency of the moll mould walls is reduced.

And the gating system is designed also in such a way that it feeds required amount required amount of the molten metal In the different sections and different zones zones and sections as per required. If it does not happen then it will lead to the incomplete filling of the sections and the cavities and which will be leading to the presence of the

miss rum kind of the defects. So, the design of the gating system should take care of about the feeding of the molten metal in the required quantity, a part from the feeding in the required quantity there are 2 more functions which are like the design of the gating system should be such that it increases the yield.

(Refer Slide Time: 14:21)



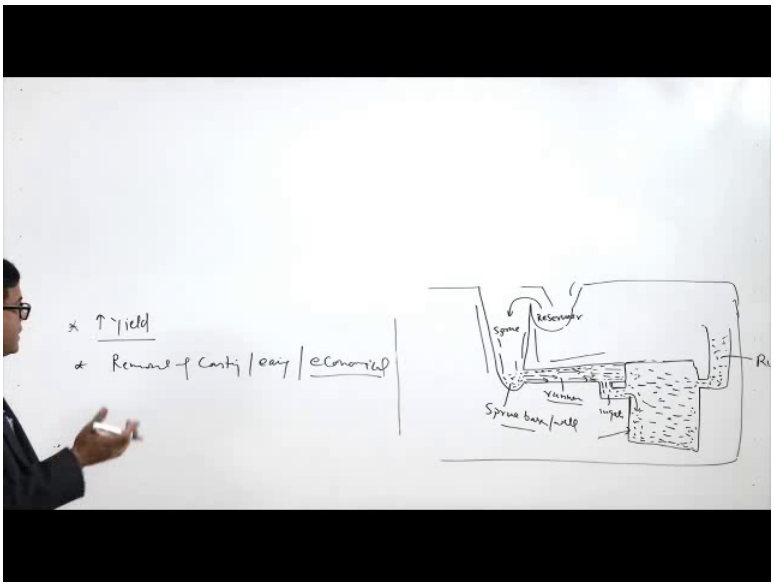
What is the yield basically the amount of the molten metal used divided by, oh sorry amount of the molten metal used a ratio of the amount of the metal in final casting.

So, basically ratio of these 2 gives us the yield so that we know that there is a lot of wastage of the molten metal, because of whatever molten metal is fed from the reservoir to the sprue then runner and then mould cavity and riser. So, the molten metal which is there in the mould cavity will be producing the sound casting, and the casting which is desired while the molten metal which is left in the runner, which is left at the riser is not used for any other purpose. This molten this solidified metal need to be after the solidification of the casting. These riser and the in gates and the runner all these metal need to be removed so that is not used for any other purpose, but that is to be you melted again for making the casting.

So, if the design of the gating system is such that it requires lot of the metal, it means the lot of molten metal is left in the riser as well as in the runner and in gate and it will be leading to the reduction in the yield. So, basically it is common to have the yield maybe say 30 to 90 percent depending upon the mourning and the casting methods which are

being used. So, higher lower is the yield means greater is the wastage of the molten metal, and it requires a wastage I means it is also the wastage of the energy which is needed for melting of the metal again and again. So, yield should be high and the last one we can say.

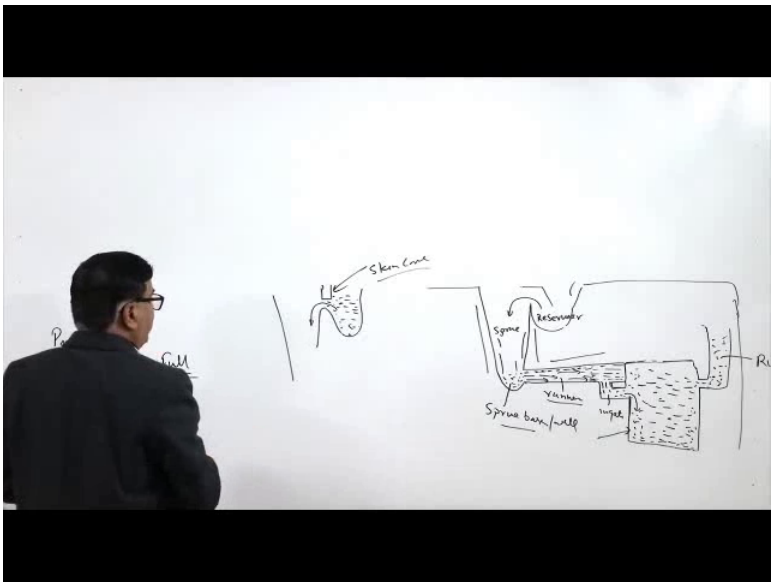
(Refer Slide Time: 16:52)



The removal of the casting should be easy and it should be the entire exercise should be economical.

So, the gating system is designed and prepared in such a way that it is economical as well as the castings after the solidification can be removed effectively from the mould. So, these are some of the functions which are expected from the gating system. Now we will be going the component wise and the role which is performed by them first is pouring basin.

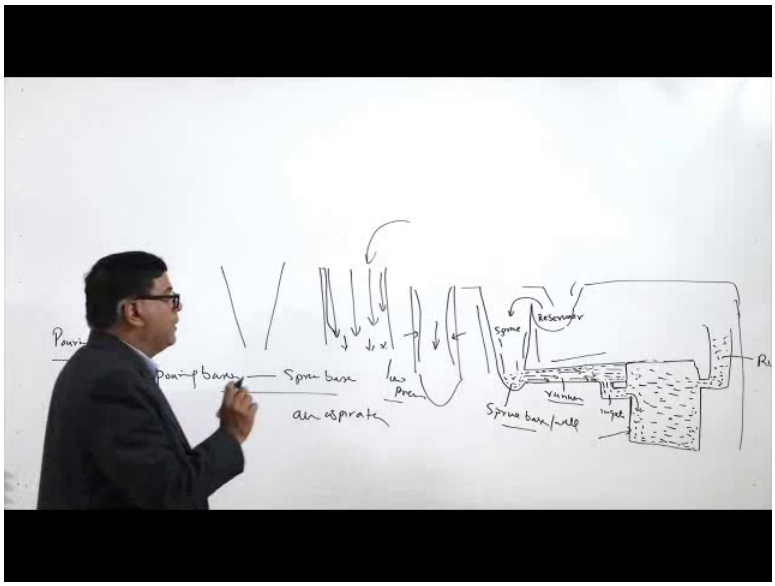
(Refer Slide Time: 17:30)



So, it is basically as I have said this is the reservoir of the molten metal which will be receiving the molten metal and it is designed. It can be designed in the 2 ways one is a simple like this. So, here the molten metal is there and then it will be reaching to the sprue. And another design here we put some obstruction so that the molten metal when filled in the pouring basin.

It filters the draws and the impurities and thereby feeding the cleaner molten metal into the mould cavity. And for this purpose it should be the full of the molten metal. So, sometimes the one a scheme core is a is provided in the pouring basin, this is the scheme core which is provided in the pouring basin helps in proper filtering of the impurities which will be floating at the top a layer of the molten metal in the pouring basin. Then the sprue, sprue is the Channel or the passage through which molten metal flows from the pouring basin to the sprue base.

(Refer Slide Time: 18:48)

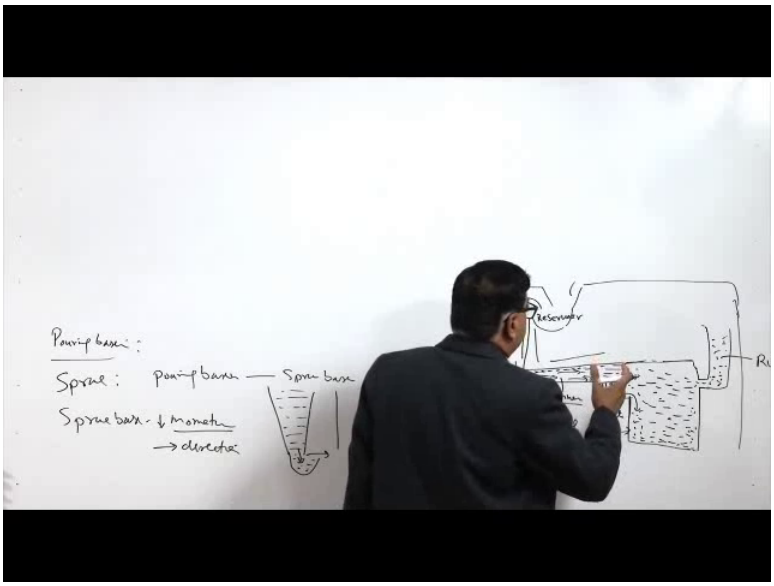


So, it is a design it is a proper design of the sprue is needed.

Because the simple cylindrical is sprue promotes the air aspiration as compared to the tapered is prove. We know that if the molten metal is being fed from the top. So, with the with the change in position the velocity as the molten metal move is down, there is increase in velocity and because of this the separation of the molten metal from the walls it starts and this kind of the separation basically in the lower zones leads to the development of the low pressure regions and these low pressure regions due to the increasing velocity of the molten metal during it is journey from the top to the bottom of the sprue base, a low pressure zone is created and that leads to the air aspiration from the porous moulding sand and this leads to the presence of air, which will be leading to the mixing of the air and the air pockets and the air lot of dissolved air with the molten metal which will be increasing the tendency for the gaseous defects in the casting.

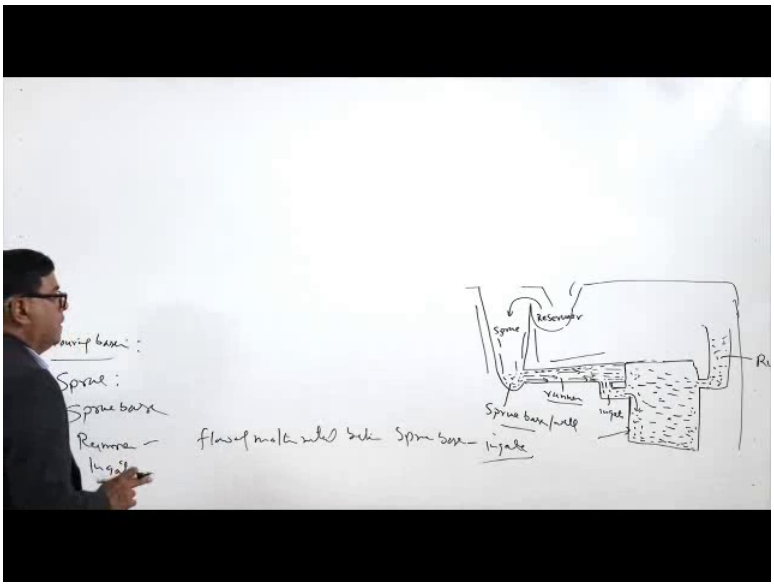
Under that is why instead of the simple cylindrical shape of their sprue tapered shape is used so that it will always be full of the molten metal and the increase in velocity is countered with the reduction in cross section in order to avoid any kind of the negative pressure zone.

(Refer Slide Time: 20:26)



And so, as to reduce the air aspiration tendency. So, the conical is proof is used for this conical or the tapered sprue is used for this purpose and the When the molten metal reaches at the bottom it fills the sprue base. So, in this sprue base it reduces the momentum and it is changes the direction. These are the 2 functions which are performed by the sprure base. It reduces the moment of the molten metal which is coming from the is sprue at a higher velocity as well as it changes the direction of the molten metal before so that it is a it can be directed for proper flow of the molten metal into the runner. Runner is basically channelled through which molten metal flows between the a sprue base and the in gates.

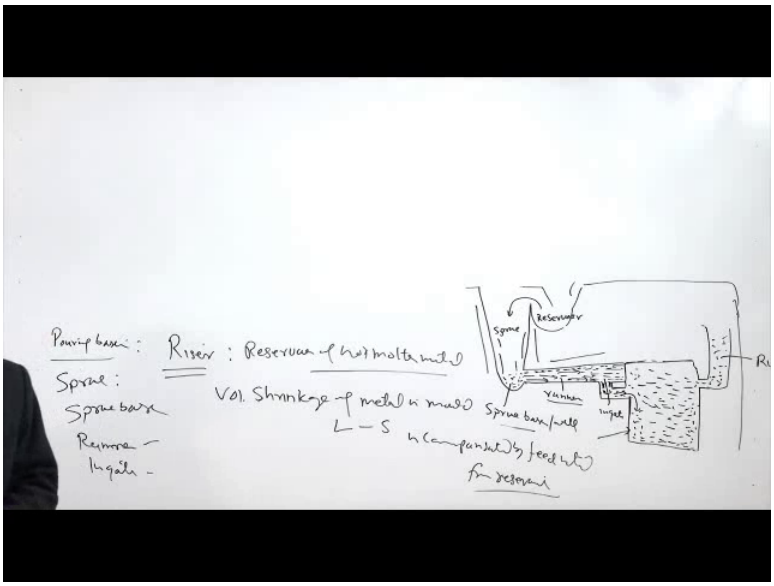
(Refer Slide Time: 21:37)



So, basically the runner facilitates the flow of the molten metal between a sprue base and the in gate. It is normally designed this sprue runner is normally made in the cope portion of the mould and that well the drag.

Well in gate is prepared in the in the drag portion of the mould. So, here one typical feature, which is which we can say there it is always desired that runner is always full of the molten metal so that no negative pressure zone is created. But they still when it is full the lighter low density material like in the impurities slag draws sand etcetera, there will be floating over the top layer. And well the molten metal is fed from the bottom. So, in gate is cut into the draw drag side so that the cleaner molten metal goes into the mould cavity, and then mould cavity is filled in mould cavity is filled in the minimum possible time through the proper design.

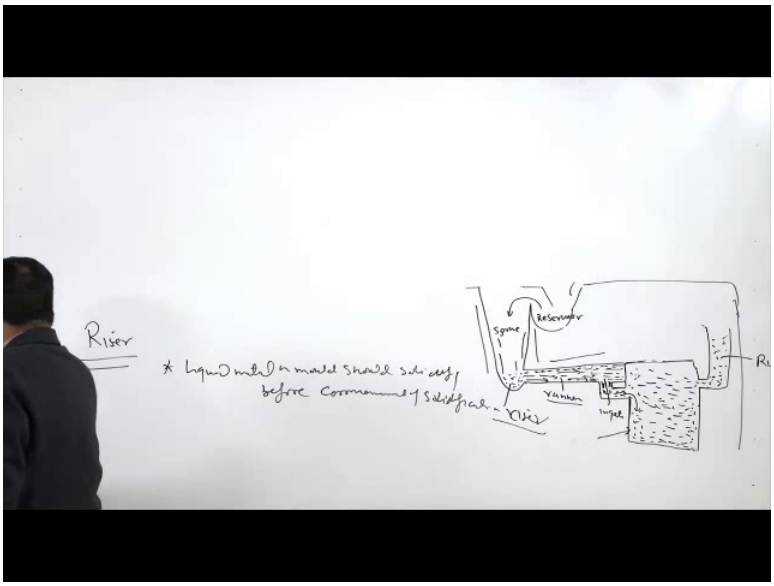
(Refer Slide Time: 23:16)



Then the riser is another member this is also a reservoir of in the hot molten metal. And this reservoir feeds the feeds the liquid metal to the mould cavity when there is a shrinkage of the molten metal. So, this a shrinkage basically volumetric shrinkage of the metal in the mould due to liquid to solid state transformation is compensated by feeding metal from reservoir. So, here it becomes important to consider what volume of the molten metal should be there, in the reservoir so that it can provide the required amount of the molten metal to the reservoir in order to cope with the shrinkage of the molten metal due to the liquid to solid state transformation in the mould cavity.

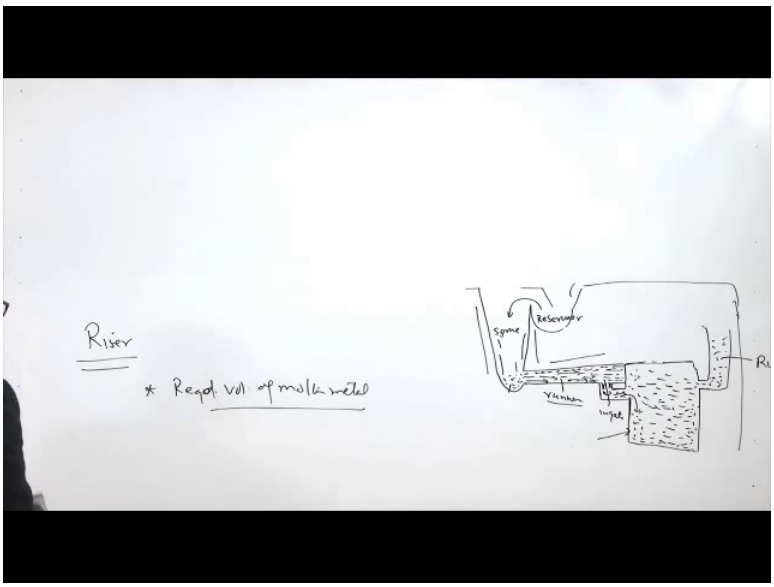
For that purpose it is required that the reservoir is able to perform the 2 functions reservoir will be performing that function performing it is function of providing the liquid metal in the required quantity under the 2 conditions effectively in order to have in a in order to avoid any defect like shrinkage cavity is that the liquid metal in the mould should solidify liquid metal in the mould should solidify before commencement of solidification in the riser.

(Refer Slide Time: 24:51)



Means the molten metal in the riser should solidify at the end before that the solidification should be completed in the mould, so that whatever is the deficit amount of the metal Which is desired on account of the shrinkage, related with the liquid to solid state transformation that can be effectively met with the this riser.

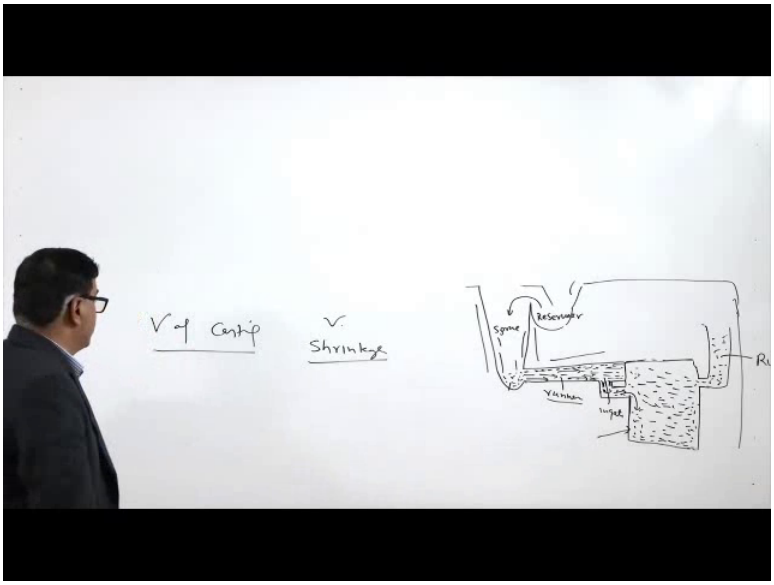
(Refer Slide Time: 26:00)



And another important point is risers should fill the required volume of the molten metal so that whatever is the shrinkage that can be compensated effectively. So, the volume of

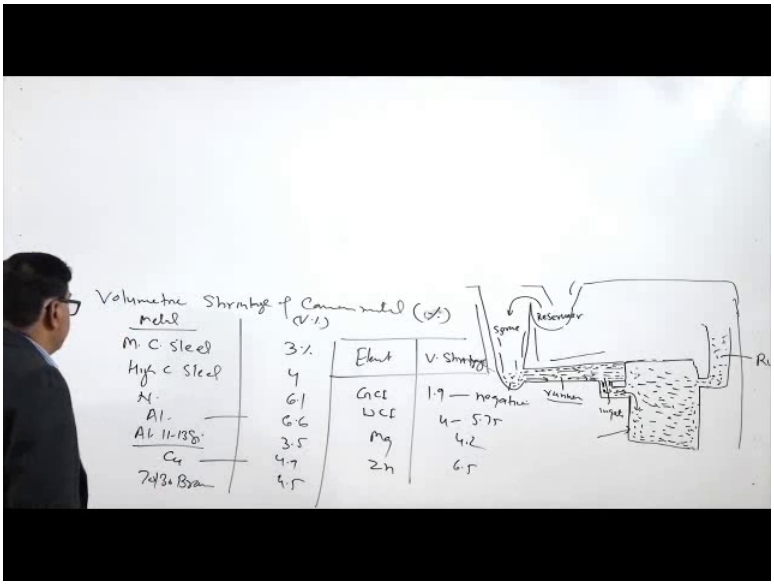
the molten metal in the shrinkage volume of the molten metal in the riser need to be obtain in light of the kind of shrinkage which is expected.

(Refer Slide Time: 26:28)



So, say the volume of the casting for that purpose we need to determine and with respect to the volume we need to consider. What is the volumetric shrinkage of the metal on account of the liquid to solid state transformation? And for that purpose what we need to consider is the metal which is being subjected to the casting means which is being processed by the casting rout.

(Refer Slide Time: 26:59)



So, what we need to see the Volumetric shrinkage of the common metals. This will be used because it is always expressed in terms of the percentage of the volume of the casting like the shrinkage allows for the patterns, we have considered the linear dimension for calculation of the shrinkage allowance, but here it is the volumetric shrinkage which will be considered for determining the volume of the metal in the riser that should be there so that required a liquid metal can be fed due to deal with the shrinkage of the molten metal shrinkage of the metal and due to the liquid to solid state transformation in course of the solidification.

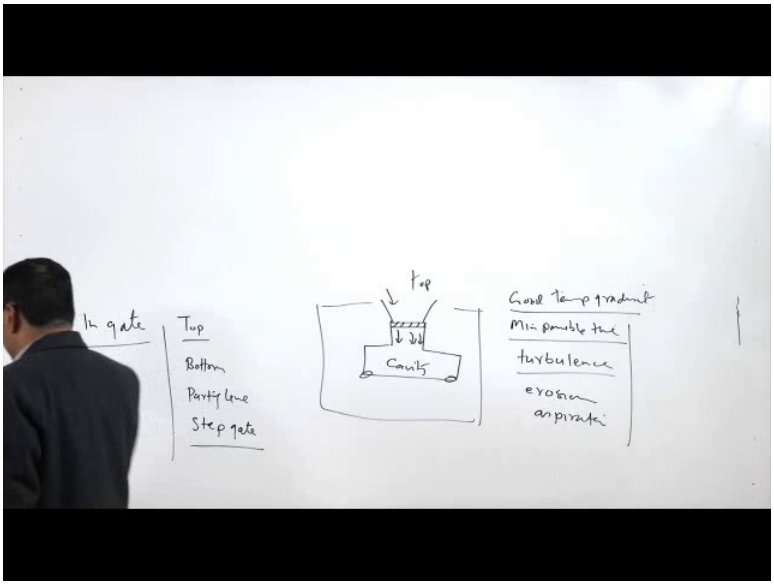
And For this purpose what basically we use is the shrinkage of the different metal. So, here this is the volume percentage, and here we have the metal. So, the metals having the higher volume percentage shrinkage they need much larger reservoir as compared to those which will be having the low volumetric shrinkage. Say for medium carbon steel the shrinkage is 3 percent. For high carbon steel the shrinkage is 4 percent. For nickel it is 6.1 percent. For aluminium 6.6 percent it is much higher for aluminium this is aluminium pure and this is aluminium 11 to 13 percent silicon this is aluminium eutectic silicon alloy for which the volumetric shrinkage is very low.

That is why it is very favourable a casting alloy of the aluminium. Then for copper is 4.9. Then for 70, 30 brass it is 4.5 coming to the metals like element and the volumetric shrinkage is for this few more metals. Like it is a gray cast iron, it is lower or it sometimes there is even increase in volume. So, 1.9 to the negative volumetric shrinkage, means sometime even there is increase in the volume due to the graphitization. So, depending upon the graphitization the change in volumetric shrinkage can happen for the white cast iron for white cast iron it varies from 4 to 5.75 percent for manganese magnesium.

It is 4.2 and for zinc it is 6.5. So, oh if we see there is the significant variation in the volumetric shrinkage which happens, and it can vary from very negative means increase in a space increase in volume percentage to the shrinkage volume as highest 6.6 percent for the pure aluminium or for a nickel it is a 6.1. Similarly zinc 6.5. So, very high volumetric shrinkage these are also possible. So, depending upon the metal to be processed by the casting rout the riser, now is to be riser is to be designed properly so that it can deliver the required molten metal to compensate the shrinkage related with the solid to liquid state transformation liquid to solid state transformation.

Now, we will we will be talking about the different types of the gates are also which are used.

(Refer Slide Time: 31:26)



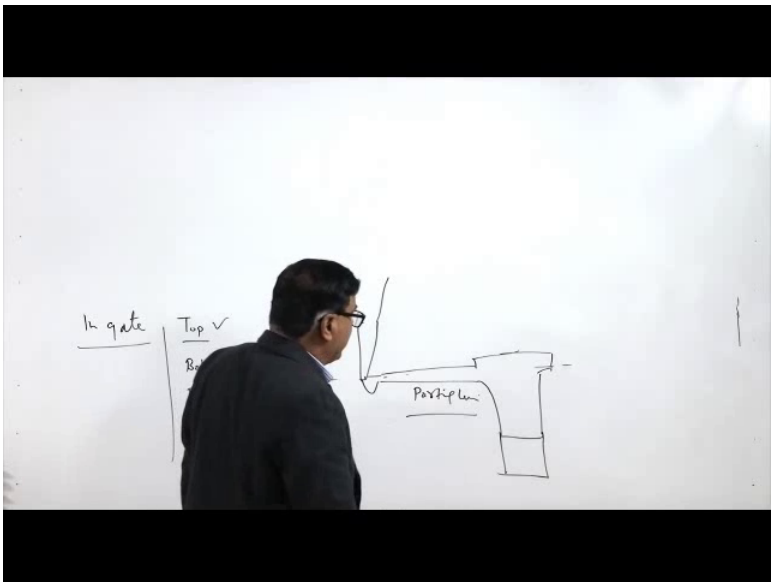
So, the in gates there are 3 types or 4 types of the in gates which are used, one is the top gate then bottom gate then parting line gate and a step gate. So, for the different situations different gates are found to be suitable. In case of the top gate like say the mould cavity is fed from the top. So, say this is the pouring basin, and here we may put this screener or some sprue to for filtering purpose. And the molten metal is fed from the top and this is the cavity and all around we have the moulding sand.

So, this is the top gating where feeding is done. From the top the advantage of the top feeding is that it takes the minimum possible time for feeding, but it causes a lot of turbulence in the turbulence in the mould and this also leads to the increased arrows and tendency increased air aspiration tendency.

So, these are the unfavourable sites related with the top gating, the advantage is that it fills the cavity in the minimum possible time. Another favourable part is that the good temperature gradient is achieved which means the feed the molten metal is fed at the remotest possible a zone first and thereafter the molten metal is fed at the last means even if there is a tough feeding the molten metal which will be receiving at the last will be at the top. So, in this case mostly the directional solidification is achieved, That is what is termed as the favourable temperature gradient in case of the top of gating system.

But since it in this leads to the turbulence and increase the tendency of the arrows on. So, there are more chances for the draws and inclusions possibility because of the increase in turbulence and erosion tendency for the top gating system. So, to overcome these issues some of the bottom gating systems are used where like the feeding is done.

(Refer Slide Time: 34:14)

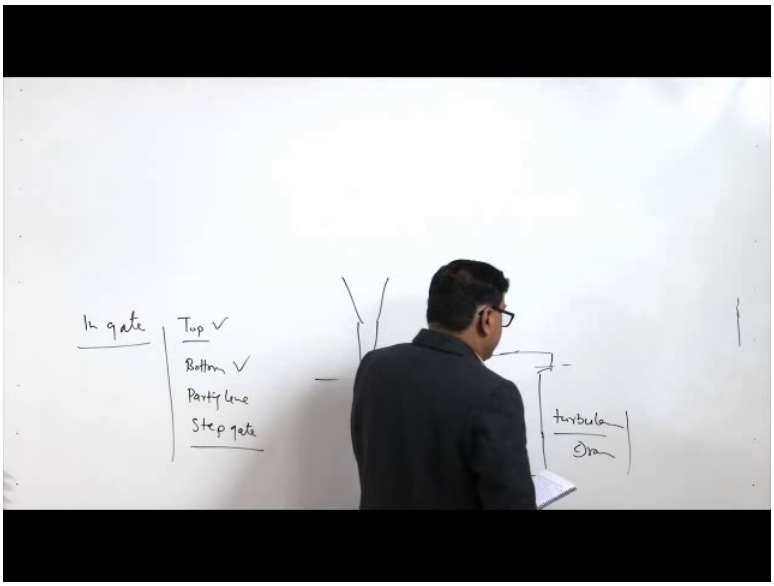


From the ladle to the pouring basin then molten metal is brought to the bottom of the mould cavity, and here we have the mould cavity like this. So, in this case basically the molten metal enters from the bottom side of the cavity the good part is there is minimum disturbance or turbulence to the molten metal.

But only problem is that. So, there is no erosion on and all that, but only problem is that it leads to the unfavourable temperature gradient. So, which may lead to which in this case it is difficult to realize the directional solidification as well as it may lead to have the internal defects like the shrinkage cavity in the mould. So, parting line gating system is same as what I have said like the gating system then we have the sprue then sprue base, then is the runner and then in gate mould like this. So, this is what is there this is what we have already talked this is the typical where now the gate is made at the parting line.

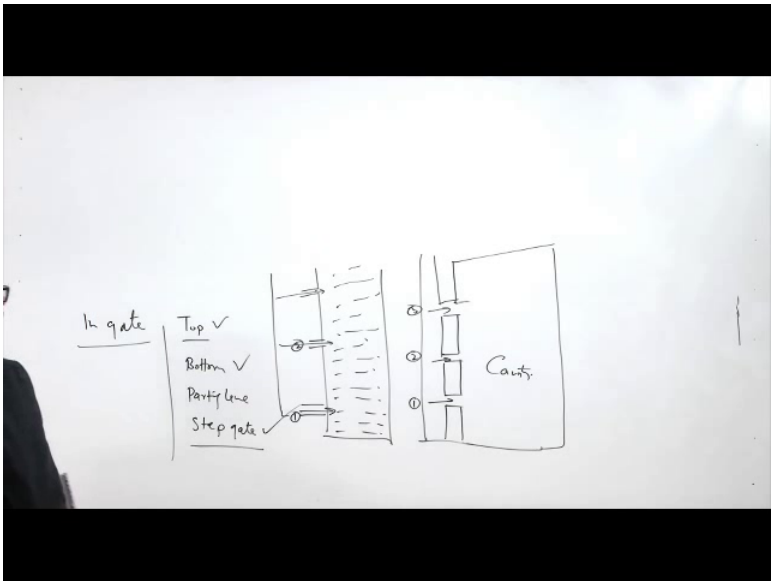
So, this compromise is basically both the top as well as the bottom tries to have the benefits of the both and, but if the depth of the depth of the cavity in the drag is much higher then again it causes the turbulence and the draws formation tendency.

(Refer Slide Time: 35:52)



But if the depth is shallow this balance is the turbulence and draws formation tendency is. So, what in better way by having the parting line gating system. In case of the large sized castings in case of the large size castings the step gating system is used, so that the molten metal can be fed into the cavity through the number of gates one typical example for this is like this.

(Refer Slide Time: 36:24)



Here molten metal is fed to the cavity through the number of gates like this is the cavity and this these are the in gates and this is the runner. So, runner like this is the top view of

the cavity. So, here molten metal will be fed through these different in gates at the same time.

So, the large size cavity can be filled in the minimum possible time through these number of the gates. And if we see these in front view then basically what we try to achieve the feeding starts in that in the front view this is the gate at number one which we can see here is at the lowermost gate number 2, again in the mi at the middle and at the gate number 3 again at the top.

So, basically we try to feed the molten metal first through the bottom in gate then from the middle and then from the top. So, here the feeding starts from the bottom and they then gradually it is filled in up to the top in order to facilitate the directional solidification and I have the suitable temperature gradient. So, the purpose of having the number of gate is to fill the cavity large sized cavities in the minimum possible time as well as while realizing the filling of the cavity in minimum possible time and having the favourable temperature gradient.

So, here I will now summarize this presentation in this presentation I have talked about the role of the gating systems and the different elements related to the gating systems. And what are the points we need to keep in mind while designing the or while identifying the size of the risers as well as what are the options available for preparing the different types of the gates, so that the suitable sound casting can be made.

Thank you for your attention.