Modeling of Tundish Steelmaking Process in Continuous Casting

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Lecture - 03
Types of Continuous Casting Machine

Welcome to the lecture on Types of Continuous Casting Machine. So, in the last lecture we had the discussion about the role of tundish in continuous casting machine; but coming forward from the lecture one where we had discussed about the continuous casting machine or its introduction.

So, in this lecture we are going to have some more discussions on the types of you know continuous casting machine, types of tundishes which are used and also certain essential details.

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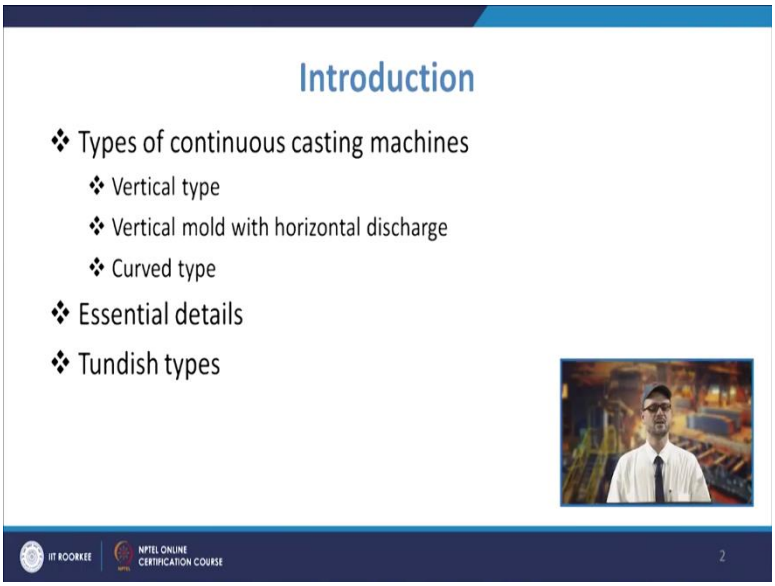

So, coming to the you know content in this lecture; I must tell you that this is we are going to discuss about the types of continuous casting machines. So, they are normally vertical type or vertical mold with horizontal discharge and also curved type.

And then we have will talk about the essential details what are those components which are there in the continuous casting setup and their roles. And we will further discuss about the different types of tundish.

So, you know when we talk about the continuous casting machine; so as you know, we have already discussed that in this case the ladle will be feeding the liquid metal to the tundish and then from tundish it will come to the caster. Now, you know when it passes through the mold.

So, in the mold which is made of copper and which is externally cooled with water. So, they are basically you are you will see that the solidification starts; so you have the skin freezing at that point and then further it comes down. And then you know as it will come down, it is further to be cooled from the sites with the help of water sprays; and in that case the thickness of the solidified cell will go on increasing.

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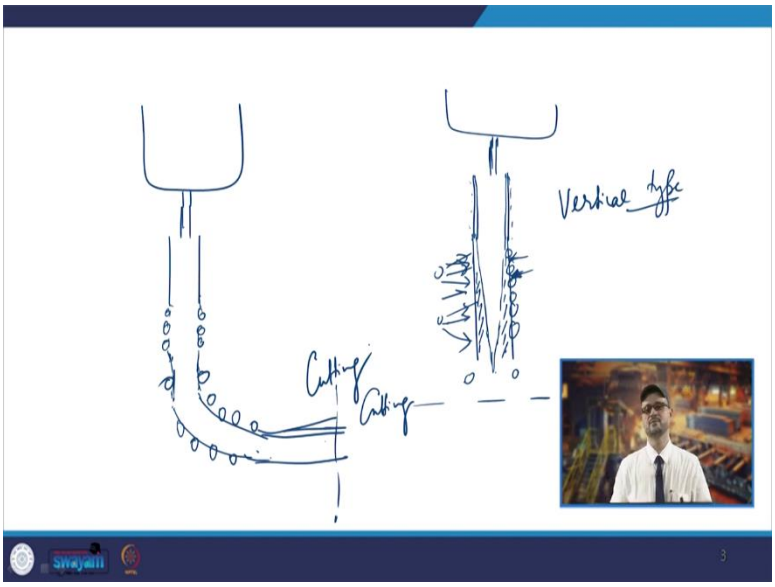

So, basically you know what happens that you have the, this is your tundish; so you have tundish outlet and from there you know with the help of this SEN, so it will go into the mold.

Now, after the mold, so it has to go further you know down. So, when we talk about the vertical type; it means the mold is also vertical and the discharge also is vertical. So, this mold which is you know externally cooled with water and this is copper mold; so the some certain amount of thickness of the solid shell will be developed towards this end. And then it has to go you know finally, you know slowly it will go on increasing.

Now, in initial days this was devised and at that time it was a vertical machine itself. So, your mold is also completely vertical. And then further you are you know cooling, so you will be you know cooling through the water sprays as you come downwards. So, it will go on increasing it is you know, text thickness of this solidified shell this is the solidified shell.

So, and then once it is completely solidified, then after that you are you know cutting; so cutting with the help of torch. So, this is basically known as the vertical type of continuous casting machine, because the mold is also completely vertical and the discharge also what we take is in the vertical direction.

Now, what is important in this case is that, you know you have any way to start this work at a height. So, and then since the you know the product is coming in the vertical direction. So, actually you need a vertical space.

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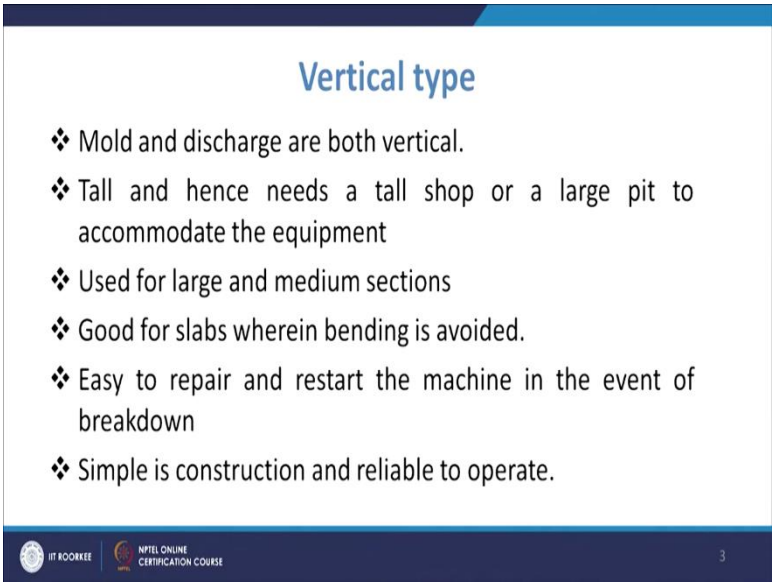

So, basically the height will be too high and that is why you need to have a tall kind of machine and you need a tall shop or a large pit to accommodate the equipment. So, either you have the tall shop; so you need to have the equipments which can handle it, you need to have the tundish at a higher level, you need to have the caster at the mold at the higher level. Then further it will come down and then you have to ensure that it was solidified. So, it will have the you know, you will have the cutting facilities; so you can cut it at a

particular point. So, and then it has to be taken out. So, basically you need a space where which is tall enough, so that the equipment can be accommodated.

Now, this is used for large and medium sections and also for slabs where bending is avoided. We will see later on that in many case you know, when we go for the other design of the caster. So, in that case there is bending or wherever bending is to be avoided, you go for these things; because in this case, it is coming vertically down.

So, normally it is used for large and medium sections and why we you it is suitable for large and medium sections because; when there is bending involved, so that is very difficult for the large and you know large sections especially or heavy sections. So, the large sections if you are casting in those cases, you preferred to have these kind of equipments that is your vertical type of equipment.

So, you have the roller arrangement; so and in between the lots of ones rollers in bit, once you move from the mold you know mold region downwards you will have the rollers. And in between you will have to accommodate you know in such a manner these are all distances in between the rollers also the distance and also you have to do cooling, so that you know there is a sufficient amount of cooling optimum amount of cooling. So, that there is proper solidification goes on.

And then ultimately after you know once you feel that it is completely solidified, you can cut with the torch and you can remove it. So, you know that also is one very important point which needs to be looked into. And then you have pinch rollers after that and then for that you go and cut it. So, it is good for slabs where bending is avoided.

Easy to repair and restart the machine in the event of breakdown, so that is another advantage of this type of machine; because here you will have the easy in repairing and as well as the starting, because it is all vertical and you do not have the bending involved. So, it is simple kind of construction. So, it is relatively easier and to start this machine also. Whenever there is a breakdown whenever there is you know interruption in the casting because of many reasons; so in that case it is relatively easier as compared to the you know other types of machines which we will talk about, so in those cases.

Then they are simple in construct, this is simple in construction and also reliable to operate. So, they are normally, because you do not have much of the design component involved

what should be the bending or so. So, in those cases you have it is normally simple in construction and it is also reliable to operate.

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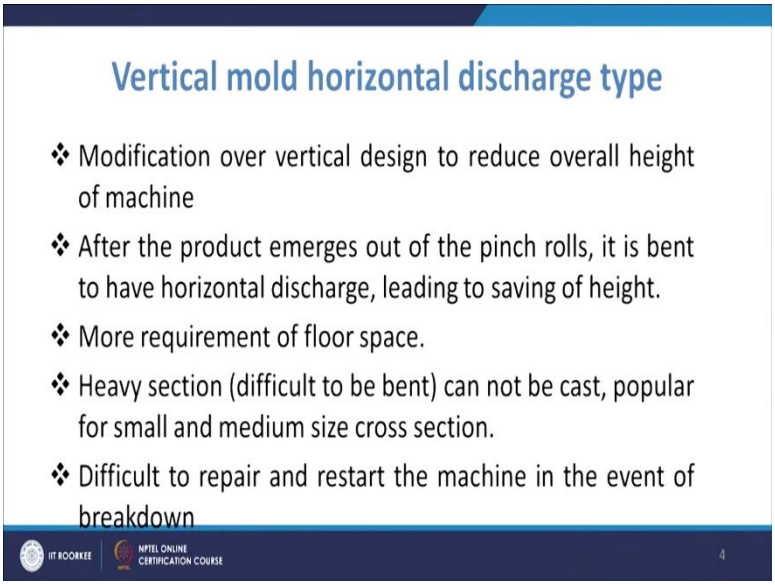

Coming forward you have another kind of you know design of the you know mold or the strand. So, that is a vertical mold and the horizontal discharge type. So, what we do in these cases; we have the vertical mold, but discharge is taken in the horizontal direction. So, cutting will be taken, cutting will be done you know when the slab or the billet is moving in the horizontal direction. So, you are cutting it.

Now, what we have seen in the earlier case when we have the vertical type of machine. So, you need the vertical space, it has to come down then you have to cut it and further you have to go. So, you need a very large space and handling basically is certainly an issue. So, whenever we feel that we should think of reducing the overall height or the height or handling is an issue; in those cases we go for the you know modification in the vertical type of machine which we have discussed. So, what we do is that, when the product will be emerging out of the pinch rolls; then it is bent to have horizontal discharge leading to saving of height.

So, what is happening? So, this is your vertical type and here what is happening you have you know after this you have the again pinch rollers are there. Now, in that case, in the case of these type of you know a vertical type, so it is all completely vertical. Whereas, what we do in the case of you know the vertical type mold; but then discharge is horizontal,

so mold will be you know, it will be mold will be vertical and then you will have roller. So, you know and then after that you will have in the end you have the you know pinch roller here.

And then you know once it will come out of that, then you are giving a bend. So, you will have the support also on the sides. So, you are giving a bend and then after bend it will come in the horizontal fashion and by the time it gets solidified and then you are cutting it. So, basically you have the vertical mold only; but then after the pinch rollers you are you giving a bend, so that from vertical movement slowly it will have a movement in the horizontal direction; and then after that at one point of time you are cutting it. So, and then you are taking it from this off floor.

So, it is basically relatively easier to handle when you have a horizontal movement or horizontal discharge. So, you can use the crane and further you can load it or you can send it to other sections or so. So, you can you know on a horizontal platform you can directly you know load it. So, these are the you know horizontal type of mold with vertical discharge type. So, after the pinch rolls it will be bent. More requirement of floor space; now in the earlier case you need the more kind of vertical space, because the you know product is coming in the vertically downward direction.

But in this case the product will be bent and then after that it becomes horizontal. So, you will have to have the horizontal space requirement you know larger. Now, in this case heavy section cannot be cast. Now, the problem with the heavy section is that, the bending is a problem in those cases; there may be you know defects or in fact, bending requires you know larger forces and in that process it may there may be a lot of errors.

So, whenever you have heavy section which is difficult to be bent; now they are advised not to be cast using this you know process, because the bending is a challenge in those cases. And this kind of you know machine is more suitable for the small and medium size cross section elements. So, normally whenever we have to you know cast the small and medium size cross section elements like billets or so; in those cases we go for and the vertical mold and horizontal discharge type continuous casting machines.

It is difficult to repair and also restart the machine in the event of breakdown. So, in this case as we know that you know, after the you know vertically down portion in the mold and up to the pinch rollers you have a bend and then further it will be going further. So,

straightening and then you have to cut it. So, because of that it becomes a complex geometry and whenever there will be repair requirement or if there is a breakdown and you have to further start.

In that case it is somewhat difficult; because you know you need to have all those design aspects in mind you know, because it is getting bent at certain angle. So, any kind of you know defect; what we feel that it may be likely to come that should be avoided. So, you have to have the extra care for that purpose.

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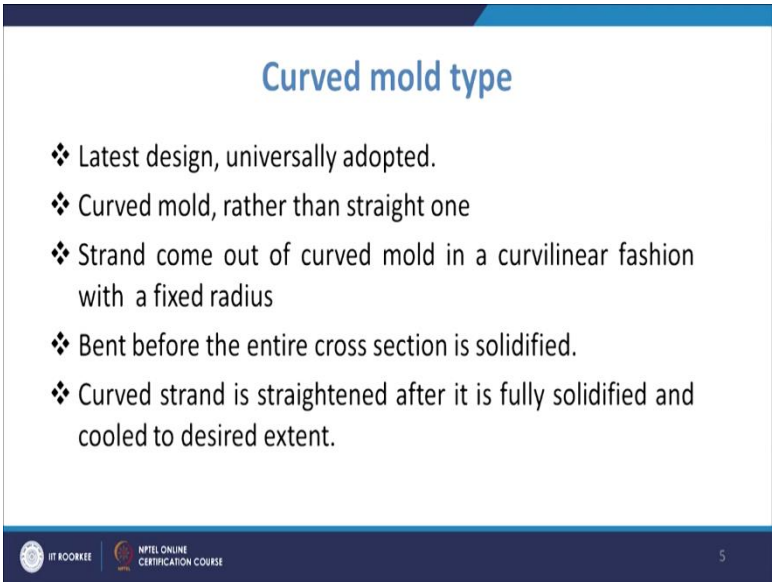

Next is the latest you know trend of the mold type which is used in the case of continuous casting; so that is your curved mold type. So, what you see that in this case now, the there will be curve mold rather than the straight one. In the last two cases you have seen that, you will have the straight mold and then after a certain point you need to have the bending. Now, in the case of this curved mold type which is the advancement in this you know design of the continuous casting unit, the mold itself is curved.

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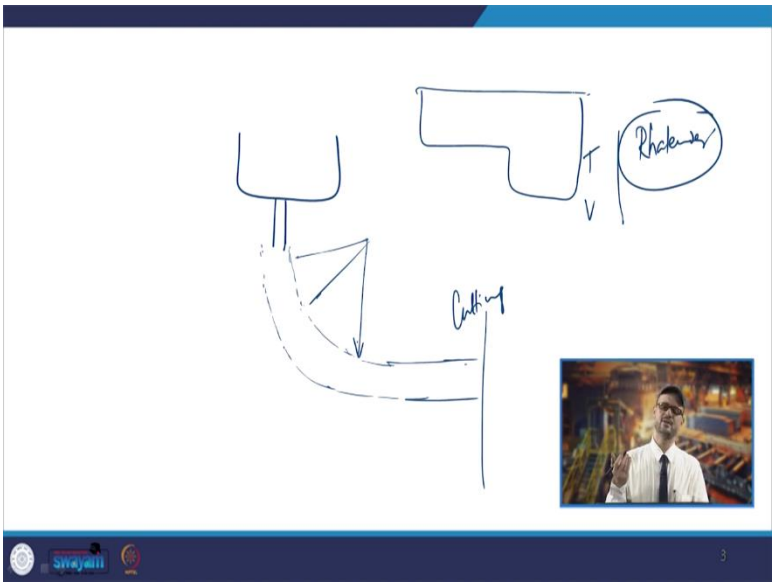

So, when you go for the equipment; so you will have this is your submerged entry nozzle and then after that the you know; from here the mold itself, so there will be some kind of you know bend will be there. So, some curvature will be given here itself.

And then finally, you are coming and then it becomes horizontal and then you are cutting it. So, from there itself you are a giving certain kind of curvature and that is known as the curved mold. So, strand come out of curved mold in a curvilinear fashion with a fixed radius. So, you have a particular radius. So, what we do is you know; in these cases the radius which is defined, so you will have certain you know radius from here or so. So, we many a times it is a variable also.

So, you will have the radius and based on that radius basically you design that curvilinear portion, so that you have the proper you know flow and a heat transfer taking place. And you have ultimately to see that the solidification is complete up to a certain point and then you are cutting it at this reason, because it is difficult further straighten. So, you will have the rolls whose job will be to further straighten is, because it is all curved. So, you are straightening it and then you are cutting at that particular portion. So, this is the, you know schematic of the curved mold or as type of mold many a times we call it as.

So, bent before the entire section is solidified and curved strand is straight and after it is fully solidified and cool to the desired extent. So, what we do as we see in these cases that, you have the curved strand which is because of the curvilinear you know profile. So, they

need to be straightened, so with the help of pressure. So, because when you are cutting; the cutting has to be at that particular point when the you know product is moving in the horizontal direction.

So, it is ensured that it is fully solidified and also cooled to the desired extent. So, those are the situations where you know. So, all these parameters of design and all these are. So, what should be the radius, how much should be obtained the radius in the optimum manner; all these things are to be looked into in such cases. And you know this is the latest design which is normally opted in most of the industries which uses the continuous casting process as a popular one. So, these are the different types of you know continuous casting machine.

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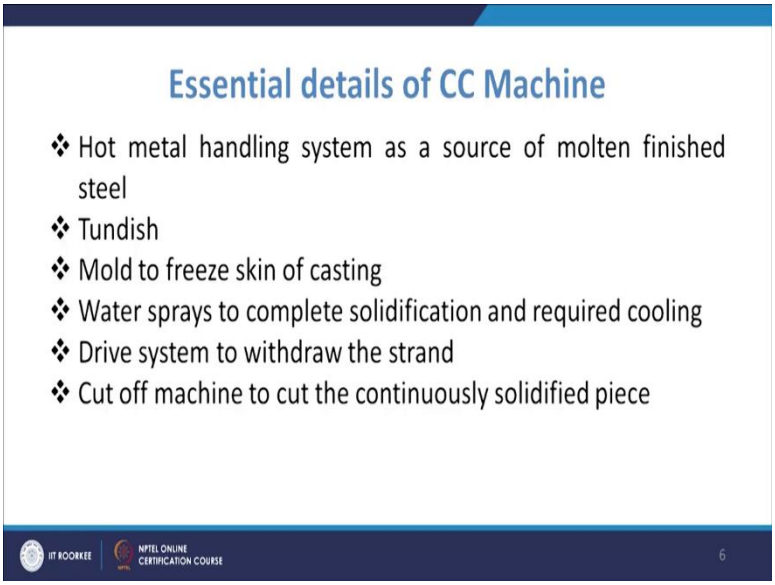

Now, if you talk about the essential details of the continuous casting machine. So, here what you see is you have the hot metal handling system as a source of molten finished steel. So, one is that that system which is handling this hot metal, so you will have the ladle which will be bringing that you know liquid metal from the furnace or from that you know steel melting place. The now then you have a tundish; that is as we have already discussed the tundish that is the actual reservoir which is there as an intermediate reservoir which will be feeding the liquid steel to the you know mold.

Then you will have mold to freeze the skin of the casting. So, you have. So, liquid metal will be coming to the mold and as we know that this mold is normally made of copper and

then it is externally cooled with the water. So, you will have the freezing process initiated and then you will have the freezing skin of formation.

Then after that once we move down, so you will have the water sprays which will be ensured to complete the solidification and also the required cooling. So, for that you have to adjust the you know what way you are you know spraying and what should be, how much you should you know do the cooling you know. So, that there is proper solidification, complete solidification and proper cooling taking place.

Then you have the drive system to withdraw the strands. So, that is another part and then so, you will have the rollers and then the rollers will be rotating around that it will be moving towards the final zone where it has to be cut. So, you will have to cut off you know, so you will do the cutting process with the help of a machine and the when you cut it will be a completely you know solidified piece which will be coming out.

So, these are the details and every you know, component has its essential characteristics. So, you will have to have proper balance, proper you know monitoring of these all these issues to have a defect free you know a product in the case of a continuous casting; right from the liquid metal going into the mold and then taking the metal passing through that, having the oscillation in the mold.

Then further stripping of many putting the negative strip, then it the skin will be leaving that mold and then they coming out; when they are coming out you know only a small thickness of the solidified cell is solidified of the whole cross section. And then further that is increasing as it moves through the secondary cooling zones. So, all these things you know these are the essential details of the machine.

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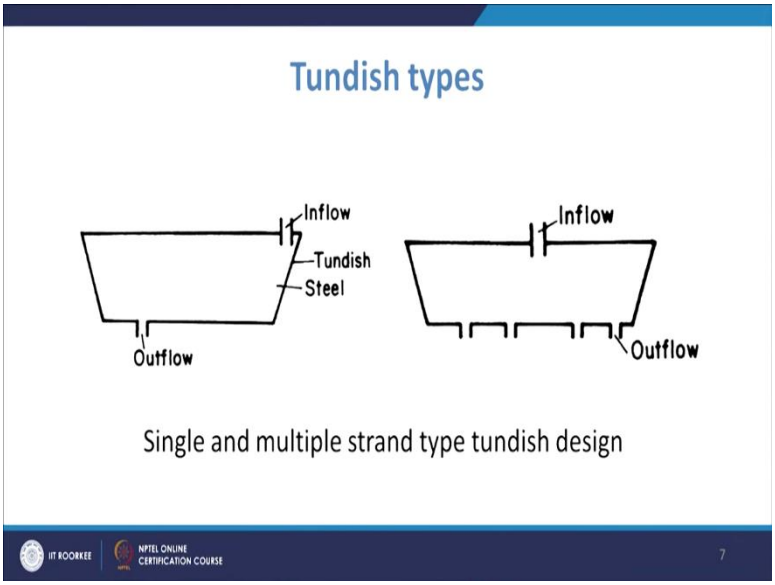

Coming to the different types of tundish; so as we know that you have the tundish which is the intermediate reservoir. So, depending upon you know the requirement of the product which you are making type of product or the shape of the product; you know we can have the different tundish design.

So, one is that you will have a single tundish, single strand tundish and this is your multiple strand tundish. So, we get call it as a tundish with one outlet, so that is your single strand tundish. And if this is, if there are many outlets; then you call it as the multiple strands. So, this is four strand tundish, this is a single strand tundish. So, this will have inflow of the liquid metal, you will have the tundish; this is a liquid metal in it will go.

Now, what happens that many a times when you are, you can certainly work with only one caster only one strand; but then that certainly will not lead to very high productive system, because you are getting only one you know billet or slab or so. But you can have a you know mold; you can have a tundish where there are different outlets. So, these are used when you need to have; so here you will be four molds, and four products will be coming out at one point of time.

So, basically you are economizing the process, you are having you are getting these process I mean in lesser time you are getting more number of parts. So, the time in which it you will get one part; you will get here the, you know four parts. Another aspects are the cost, because you know with one tundish itself you are anyway learning you have to do

after some time. So, this becomes more and more you know beneficial when you go for this multi strand type of tundish.

Coming to the different tundish types; so the earlier tundish type, this is the this tundish is the very simple in shape and they are known as the boat shaped tundish. So, in that case what you see that it may have the some design changes; like you may have the walls which may not be inclined that may be straight and the inflow may be at this place or it may be towards the middle. So, accordingly you may have the changes in that, you know the parameters of the tundish design. Now, if you come to the requirement point of view, so you need to have the multi strand, so you are going for this.

Now, what we mean to say is that, in this case many a times when the metal will go; in normal simple boat shaped tundish, the metal which will go towards these regions they will be try to they will be likely to be getting trapped. So, there are certain zones which are basically not the active zones and that is why we call it as a dead zone. So, dead zone formation is there. So, many a times we have the use of outflow modifiers; but dead zones in certain tundishes, you know certain shapes of tundishes are there you know normal traits or characteristics that we have to understand.

Now, for the requirement of the quantity also that you should get larger, you know number of strands and more amount of metal should be teeming out. So, for that also and from other point of view; like to increase the you know to ensure the increasing the quality, we go for different designs of the tundish.

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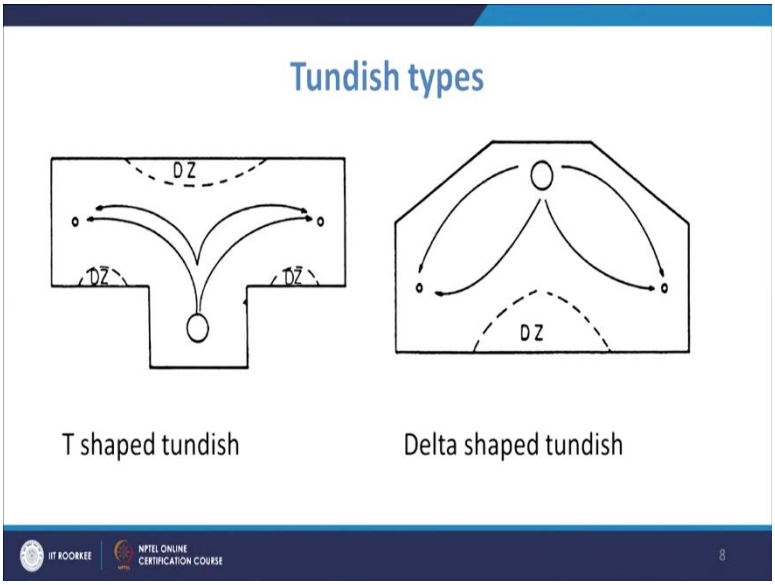

Now, this is another you know tundish design, which is this is known as the T shaped tundish. So, this shape which is in the T shape this is known as the T shaped tundish. Now these tundish is they can be studied and what you see this is shown by; so the metal which will come, this is a plan views a metal will come and then it has to you know move in this fashion. So, you will have outlets here and it should be passing through these outles; that is what normally happens in the case of the T shaped tundish.

Now, in this case the one of the challenge which is there, because what you see these zones which is shown they are DZ; DZ means the dead zones. Now, in any tundish when we talk about the volume of the tundish; so you have, we will talk later that you have the plug zone or mixed zone or dead zone. So, now, we should confine only to dead zone; and dead zone are those regions where basically it does not remain so active and the metal which is there in that part that becomes stagnant.

So, you know for that matter it is not advantageous. So, what you see that in these type of tundishes there are likely, it is likely that there will be dead zones are formed in certain these regions. We just look at the T shaped tundish, so it will be moving at this place and then it is moving to outlet. So, what you see this portion is not in the loop metal; but also does not go towards that region, because and the mattress velocity becomes too small also in those cases. So, basically these formation of dead zones may be there; but there has been studies on the tundish and certainly the designs which we are seeing they are, you know accepted many of the companies use it.

Now, if you look at the another design which is normally used by many steel makers is the delta shaped tundish. So, in that case what we see is you will have such kind of the structure. So, you will have the inlet here and then it will move to the outlet. So, you will have the likelihood of certain dead zones; but then these dead zones are not in those regions. So, as you see that in this zone, because of the you know inertia of the fluid, it will move like this towards the outlet.

Now, in this case it is going, so because streamlining effects; so it will go and directly go into outlets. So, dead zones which were likely to be formed in this; here in these zones, here it is not. So, in the case of delta shaped tundish, these dead zones are avoided in these regions; however, there is likelihood of formation of these dead zones.

Now, on these tundishes, you can certainly use the tundish signatures or the flow modifiers to have the effect on the formation of these dead zones, the dead zones can be reduced. So, for that we use the different kinds of flow modifiers like dams or weirs or baffles or so they are the different studies which are being carried on, on these you know tundishes.

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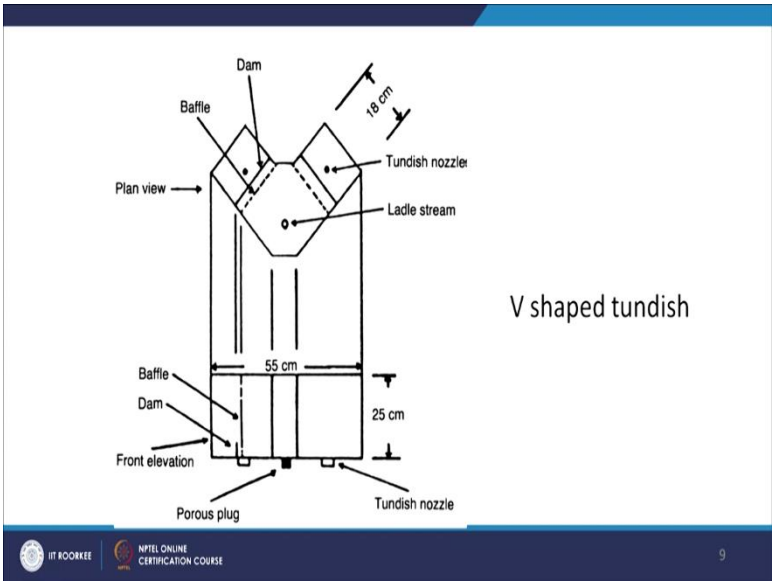

Now another design which is also popular in the case of a tundish is the V shaped tundish. So, you have a tundish which is of V shape, so it will come and then you have an angle. So, this angle, on this angle this shape is there.

So, liquid metal will come and then it will move through. What we have seen may be an extension to these two designs where you are getting the dead zones in this opposite side. So, maybe you know Rhalender has again given this design apart from the t shape also. So, you have seen that it is made here narrow, so it will the move in that fashion.

And accordingly you can also place, you know these; so these flow modifiers in these cases. So, there will be you know used and, you know for the altering the flow into this tundish. So, this is this design is provided by the Rhalender who is who has worked on it; who has divides these tundish a different designs on this tundish. So, the T shape as well as V shape, so it has been by the one of the researchers, so that is by the Rhalender.

So, these are the different you know types of tundishes which are normally used in the case of you know continuous casting units. And so, you have boat shape, T shape, delta shape and the V shape; many a times we have also you can come across the tundishes which come and there you have also certain kind of this kind of a structure also you see, that you have you know the bottom is not at all at the same level.

So, then we have different designs depending upon the requirement, you can have the different designs of the tundish which serve to function as the buffer vessel; and which will be supplying the liquid metal to these strands when wherever especially when there is a you know discontinuity in terms of the ladle changeover or so. So, we should, so we will talk more about now that aspects in our next lecture.

Thank you very much.