Principles of Casting Technology
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Lecture – 16
Gating System design
Introduction, Fluid flow fundamentals

Welcome to the lecture on Gating System Design. So, in this lecture, we will have the introduction about the gating system and we will also know about the fluid flow fundamentals. Introduction to gating system, what a gating system is? Basically in the casting process, you have 2 things, one is that you have to deliver the molten metal inside the cavity and then you have to ensure that it properly solidifies and whatever is the requirement during that solidification process that is properly taken care of.

The delivery of the molten metal inside the cavity is important. Now the cavity certainly is somewhere which is not accessible directly. So, you will have to pour at some point and through certain channel it passes and goes into a cavity. So, that all that system which basically takes the liquid metal at the top at some location and then it comes from here and goes into the cavity which is a part of gating system.

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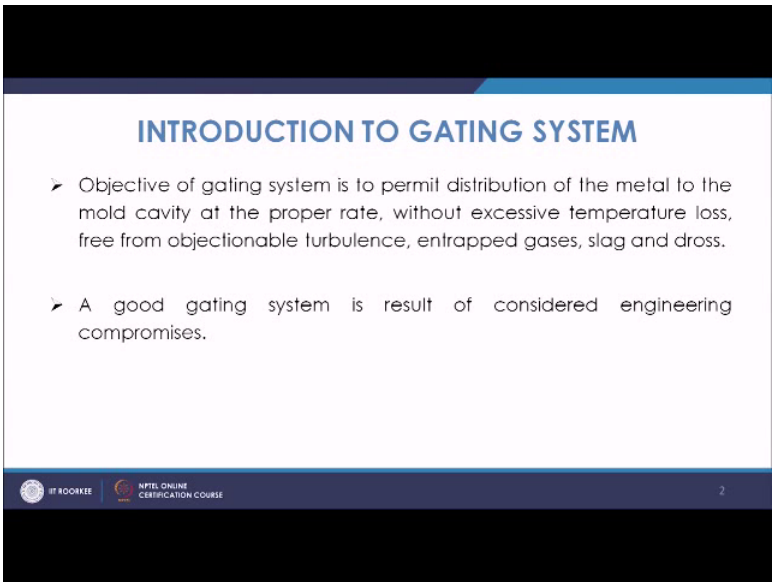

Objective of gating system is to permit distribution of the metal to the mold cavity at proper rate without excessive temperature loss free from objectionable turbulence entrapped gases, slag and dross.

Now what is, what do you mean by all these points? The distribution of metal to the mold cavity at proper rate proper rate is important because you think of putting the cavity filled in a certain amount of time. The time should be minimum because if you take larger amount of time that will lead to unwanted results. If the pouring time is quite high or if there is a problem in passes of the liquid metal so that it goes ultimately in the cavity if that takes in longer time, it is going to be detrimental because it may. So, happen that the molten metal may solidifies somewhere or there may be problem in complete filling.

The proper rate also to talks about a very fast rate, it as to be avoided if it is very fast rate it may have undesirable effects like it may induce a large amount of turbulence it may have weathering action it may erode the mold surface. So, that is why you will have to see that at a proper rate metal as to flow through that channel without excessive temperature loss as we discussed that once it goes it should go smoothly, it should not have such a route because of which there must be a excessive temperature loss and if there will be a excessive temperature loss there may be problems related to solidification or there may be problems related to fussing of the streams. So, this excessive temperature loss should also be not there free from objectionable turbulence.

We discussed that if we try to product if larger rate or if our channel is such that a large amount of turbulence is being created, this turbulence is basically not good in the sense that the turbulence will try to effect in the terms like erosion of the mold walls there may be aspiration there may be absorption of the gases from the outside. So, that leads to a large amount of defects. So, the turbulence as to be minimized you have to see that how quietly, how smoothly, the molten metal enters into the cavity that is also to be ensured.

Entrapped gases, you must design a proper gating system, your proper gating system must be there because of which there should not be any chance of a gases getting entrapped. So, the system should be such that even if there are entrapped gases, there should be a spilled off and otherwise there should not be any chance of the gases to be entrapped from outside into the cavity. So, that is also to be considered.

Slag and dross, you know when molten metal are poured, the metal may have slags or they may have impurities or during the processes of the molten metal into the channel there may be chances of the formation of certain drosses or getting you may get certain impurities. So, basically you have to see that they are generated to minimum and if they are generated there must be ways to take them off. So, all this systems are to be taken care off.

So, first function is that the entry into the cavity must ensured properly, it is you must be able to feed the molten metal into the cavity appropriately second is that you must avoid turbulence third is that you must see that you are not sending any slag impurities or dross particle, you are ensuring that they are basically driven off they are not entering inside the cavity. So, a proper gating system takes care of all that and for that there are a lot of engineering compromises. So, you have to consider a lot of compromises for controlling something you may have to compromise on certain aspects. So, basically a proper gating system is that is why defined as a result of considered engineering compromises.

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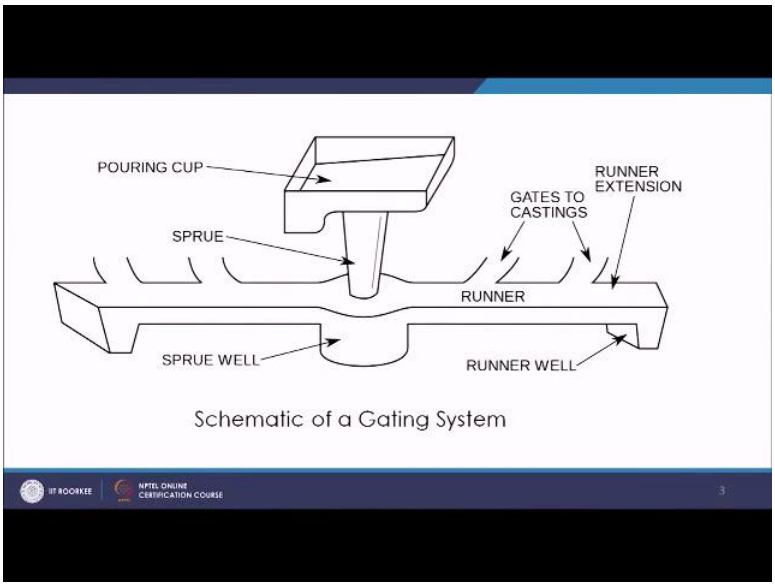

Let us see the schematic of a gating system. So, in the gating system you have a pouring cup or pouring basin now molten metal is coming here and from here it goes through this vertical channel that is known as sprue and it goes into this runner well sprue well it is basically and from this is sprue well, this liquid stream is basically directed towards these directions. So, this channel from this sprue well from where it goes in the directions this

is known as a runner then this runner from runner you have you have these in gates. So, they are basically the entry points to the cavity. So, that is why they are known as gates or in gates.

This portion is this vertical portion is known as sprue, this is runner and this is the gates and this is known as runner extension. So, these are the basically elements, they are known as the elements of a gating system now all this elements have certain job or there is certain definition to these elements they have some I mean defined functions.

Let us talk about the pouring cup, what pouring cup does. So, pouring cup is basically a reservoir which basically holds the liquid material the liquid material is basically transported from the melting unit to this casting unit. So, this liquid metal has to be transported.

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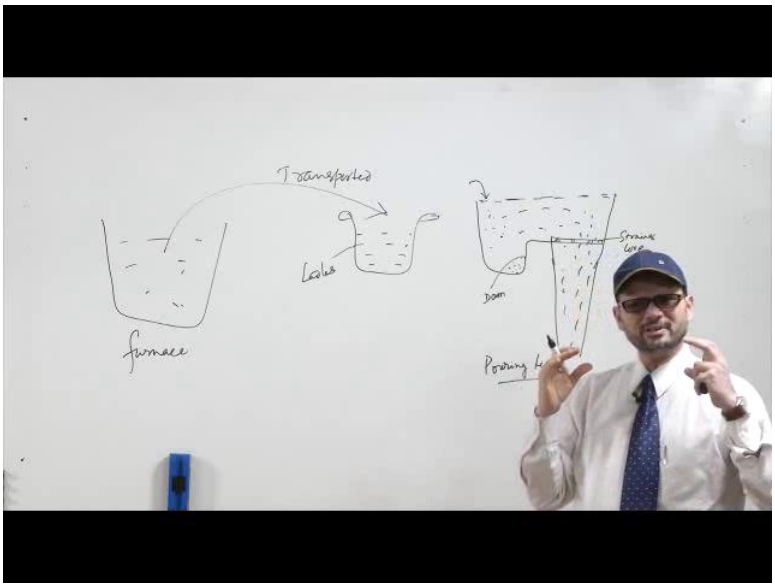

You have the furnace here, you have a furnace here and you have liquid metal this is to be transported. So, this transportation is done by number of ways you have ladles you have cranes. So, by that you take the liquid metal in the ladles. So, you have this ladles which are bringing this liquid metal from the furnace and then you have to put in this pour now directly you cannot give this liquid metal in the cavity. So, basically this serves as a reservoir which holds the liquid metal and it basically gives the liquid metal it basically allows it to go through this vertical passes and finally, it goes into the cavity

Now, here in the case of this pouring cup sometimes what is done is you have. So, you may have the projections like this. So, you may see the pouring basin like this and this is known as something like a dam. So, the purpose of this dam is that if you are pouring any liquid metal and if it as certain impurities this is heavier than the liquid metal than this impurities may get stuck here and this dam serves this purpose of removing any heavier impurities at this point and then the liquid metal will and liquid metal will lightly go you know if you pour directly the metal will go and there will be uneven flow of metal from here, but in this case the metal has a even flow the liquid level is maintained at this point and the metal will evenly flow through this sprue.

Pouring basins serves that purpose; you can have the dam in the case of pouring basin. So that if there is any impurity that can be stopped here in many cases you also have a strainer core a core is inserted here. So, strainer core is there. So, what it does is basically it basically filters it filters this liquid metal which as to go into the sprue and that is how you get the clean metal to go through it. So, this pouring basin serves that purpose.

Now, once you rear metal has left this pouring basin then it comes through this vertical passage known as sprue. So, this sprue is a vertical passage which in between the pouring basin and the sprue well. So, what happens once it the liquid metal comes from the pouring basin to the sprue well the liquid metal is passing or it is traversing a vertical distance further? So, if sprue can be defined as a vertical passage of liquid metal from these pouring basin to the sprue well and this case sprue we see that it has certain tapered section. So, we will discuss why it is tapered you may have trace sprues, but normally we have tapered sprues you have here the larger diameter at the top and smaller diameter towards the bottom. So, that is a sprue it may have a very type of cross section now this liquid metal which has which was here, it has come at the bottom of this sprue and it has been it has collected in this sprue well. So, sprue well basically now the purpose of sprue well is to collect this liquid metal which falling from certain height and then it has to go towards the runner.

What happens to the liquid metal which has fallen about certain distance? It has gained certain speed now due to this speed, it has now larger momentum and if it goes in that speed towards the runner, it may create a lots amount of turbulence and it has also know direction it may be uncontrolled. So, this sprue well basically arrests the momentum of this incoming fluid and then it also directs the fluid to go from this sprue well. So, from

here towards a channel that channel is known as runner. So, a sprue well it is purpose is to basically redirect the flow from which is coming from the sprue and it arrest it is momentum and it gives it a direction to flow towards the runner the runner is again a horizontal you know passage through which the liquid metal passes. So, it is having a larger cross section than this gas that we will discuss later now in this runner basically firm runner there are cavities. So, this is the cavity and the runner has to feed the liquid metal through this gate and that liquid metal will go into the cavity. So, this portion that is known as gates. So, they are in gates which will feed the liquid metal to the cavity.

Now, there is another component which is shown is runner well or runner extension now this runner well or runner extension it is basically an extension at the end of this runner it is ensuring that if there is any impurity which is coming along the runner. So, because of the inertia this impurity will go and at the end it will go in this well. So, the impurities if they are carried away in this stream this impurity will basically go and get trapped. So, this runner well or runner extension serves the purpose of taking the inclusions or foreign particles out from this system. So, these are the different elements of the gating system which have the different functions and every element as a certain job to perform. So, that the liquid metal enters the cavity quietly and the rate of the entry of molten metal inside the cavity basically it is ensured that the amount of metal entered from all the gates should be nearly equal.

Then you have also to see that the metal basically will while traversing it will also pass through certain changes the velocity may decrease or increased at some point of time if there is change in the cross section or there will be change in the pressure. So, all this things are to be seen and the final aim is to ensure that the liquid metal enters this cavity from here into the cavity quietly and it goes into the cavity feeds the cavities in it determined in time.

That is the purpose of a proper gating system once it is done then because once the liquid method will be poured then it will start solidifying. So, gating system also plays an important role how from where the metal is getting poured where the metal is into the cavity at which portion the metal is striking first which is getting filled up first because the solidification will start from there and ultimately it is the quality of the cast product that is of importance and the quality of cast metal or cast product will depend on the type of solidification or the way solidification is complete without much of the interference

without much of the impurity is coming into picture and that. So, gating system that way is very important. So, we have to also see that it properly goes and it is basically giving a good condition. So, that proper solidification takes place at proper time and proper place.

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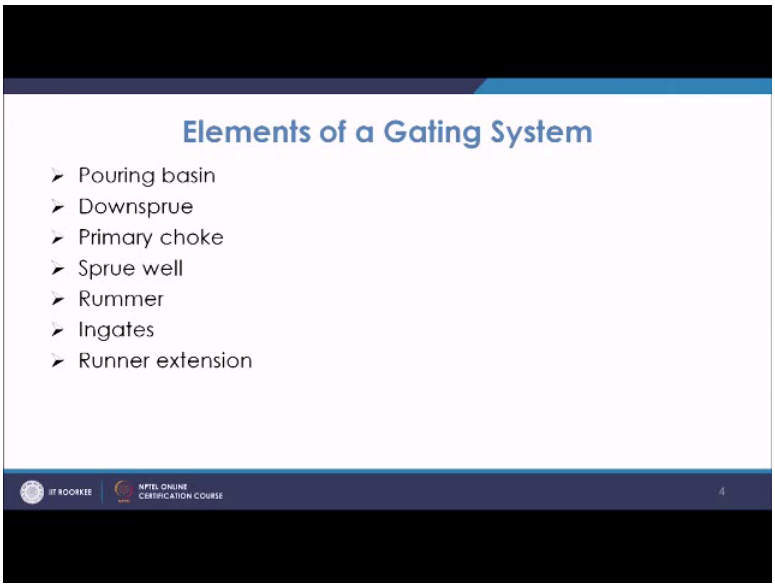

We have seen that you have these different elements of a gating system you have pouring basin. So, this is sprue, it is also known as downsprue then you have a choke, now this choke is basically the minimum cross sectional area in this channel which basically concludes the pouring rate. So, that is known as a primary choke, normally it is at the bottom of this sprue, but it may be at any other place. So, that is known as a choke because it is controls that is why it is known as the choke.

Then you have a sprue well as we have discussed it arrest the momentum of the incoming fluid particle from certain height falling into it you have a runner. This is runner not rummer. So, this is this takings into a writing this is runner you have ingates and runner extension. So, what we have discussed is that the ultimate aim is to get a good cast product and that basically depends upon how the casting solidifies.

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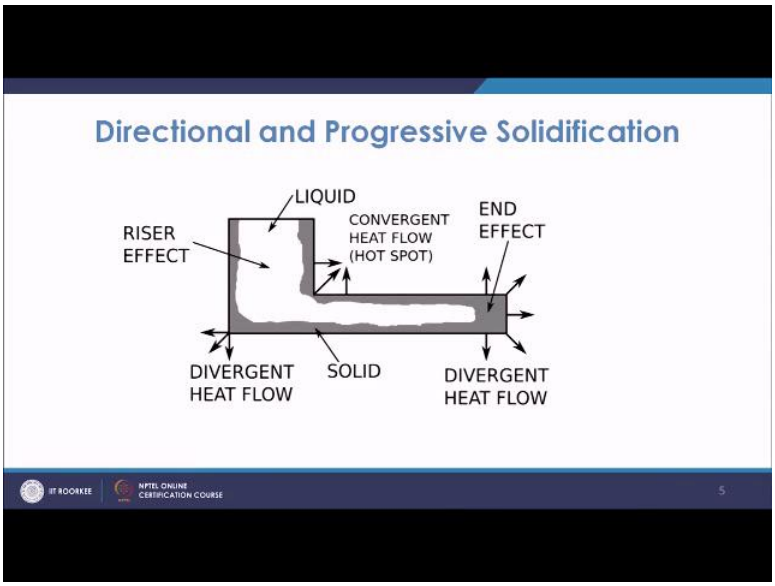

What we see is there are 2 terms of solidification directional and progressive solidification what is directional and what is progressive solidification that we must know here?

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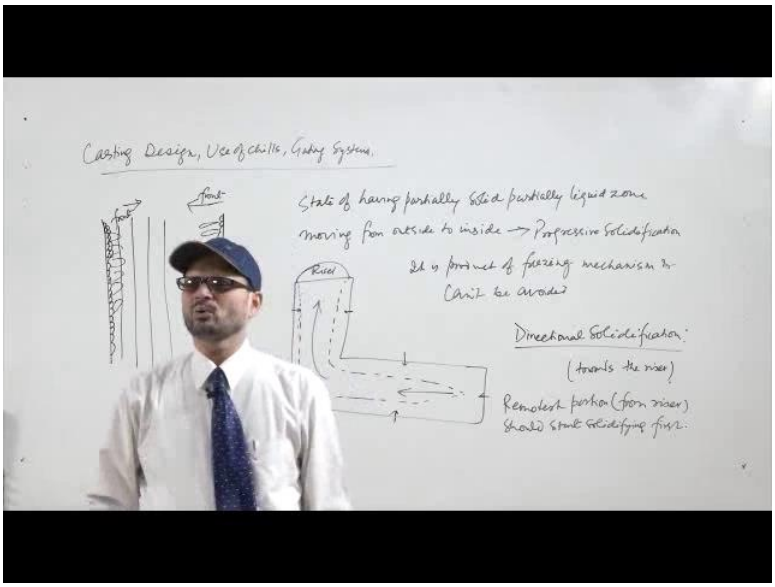

This progressive solidification as we have seen when we studied the solidification, what we have seen is in case of solidification when the metal is there, your solidific first solidification crystals are formed near the walls. So, and then they grow inside. So, basically solidification is nothing, but forming these crystals at the mold walls and then

they further grow inwards. So, this condition of a state because what we see is whenever the liquid metal will be poured and it will touch the walls of the container the solidification will start at the walls and as the time progresses from both the walls if there it has 2 side or if it had four sides from the opposite sides these front will advance. So, here also the front advances the front advances ultimately this front goes in this direction this goes in this direction.

With this front solidification front basically moves from the wall towards the inner portion. So, this is this condition of state, the state of having partially solid partially liquid zone moving from outside to inside this is this state is known as progressive solidification.

As we see that is if we have such condition if we have such condition and if it is riser suppose. So, what will happen from all these places the front will try to move in this fashion the front will try to move in this fashion the front will try to move in this fashion now this state because the initial crystals will be formed at all these walls and these crystals basically try to grow from outside towards inward. So, that is known as progressive solidification it is product of freezing mechanism and it cannot be controlled cannot be avoided. In fact, it can be controlled, but it can be avoided.

It is the product of freezing mechanism it is the characteristic of any freezing process that whenever the liquid metal go into a cavity the solidification will start from the walls and we have already studied about the process why it starts because it will lose it is temperature it will it lose it will lose it is superheat and with the under cooling there will be nucleation at this point and then further growth inward. So, because there is heat transform in the outward direction. So, what we see is you have a solid partially solid partially liquid state moving inward from outside this type of solidification mechanism is known as progressive solidification.

Now, another is the directional solidification, now what we see is you have a riser. Now what happens that you have certain portion which is quite different quite distance from the active liquid fluid channels? So, basically those should solidify first and where ever if they are liquid which is actively involved or which is near to the riser basically they can have the charge to solidify in the end. So, this kind of condition or this kind of solidification is known as the directional solidification. So this directional solidification,

basically it is getting derived from the name direction means the certification has certain direction to be followed. So, that you do not get any kind of defect and the direction is towards the riser towards the riser and it will see that the remotest place from the riser. So, they start solidifying first.

Remotest portion from riser, to start solidifying first, this condition or solidification is known as directional solidification in this case you see that. So, basically what happens that is why it is shown that because of the progressive solidification your solidification goes like this and then it will because of the directional solidification. So, this kind of solidification which as certain direction towards this is the directional certification whereas, this direction in which the interface will loose from outside to inward it is known as progressive solidification and both must be controlled. So, that you get a good casting with good property.

That is how this directional solidification and progressive solidification will control directional solidification is the product of casting design use of chills gating system, they are all important they are they can affect this directional solidification they can control the solid directional solidification and this all is basically in the hand of the foundry man the person who is making this mold. So, basically you can control the direction and solidification you can have the say on the directional solidification by what way which portion you want to see that this solidify first this you can control by putting certain chills by putting certain paddings you can control where you want increase the cooling rate or where you want to decrease the cooling rate. So, this way you can control the direction and certification.

But in this case also you can control the progressive solidification, its order can be controlled, you can see that if you use the sand mold and if you use the metal mold, certainly the time taken to freeze for the or the start and end of the freeze will certainly be less in case of meter mold whereas, in case of sand mold it will be certainly more. So, this way it is order can be controlled, but you cannot avoid it; however, control is important here and this is in the hand of the foundry maker who can change it. So, this cannot be changed; however, this can be changed. So, there are issues and back the thing is that you should see that this have a proper combination proper coordination that will give you a casting of good quality good solidification.

When we discussed about the metal casting the molten metal is nothing, but a fluid and it has to pass through certain cavity. So, we should know that it is just like a fluid flow which is going into the cavity and that is why certain fluid flow principles are required to be understood by you.

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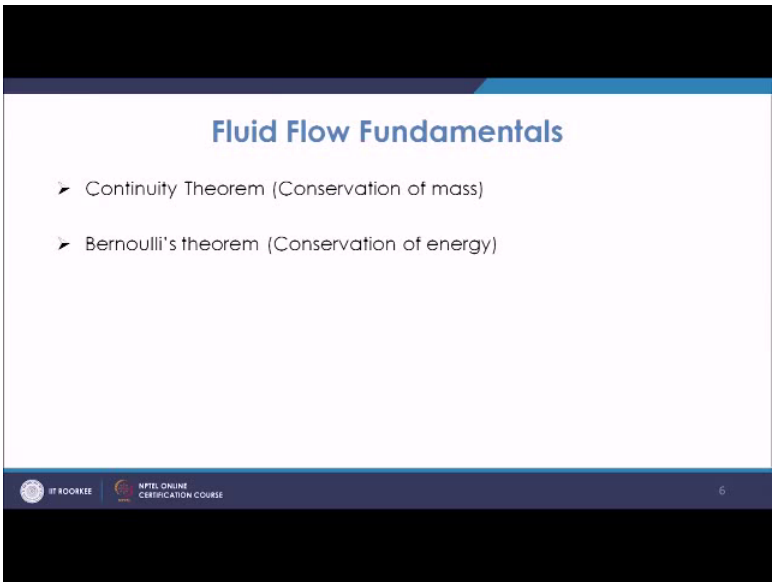

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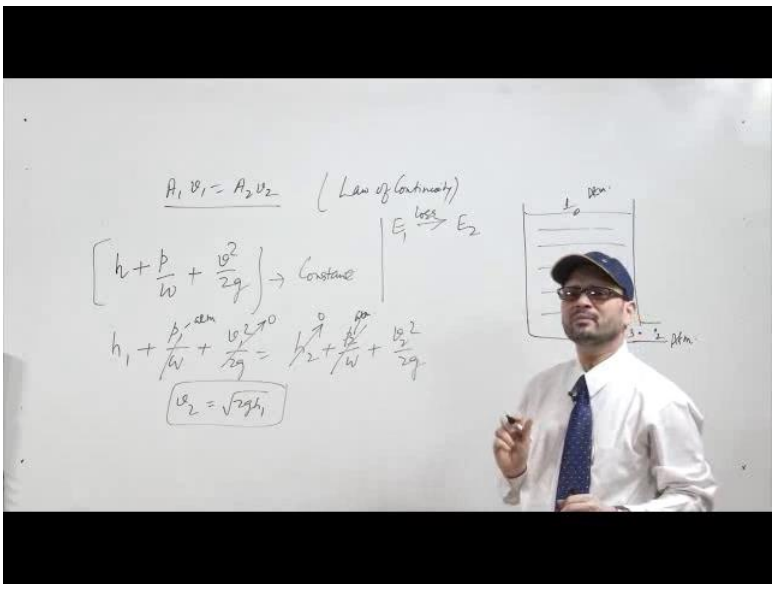

And the 2 main principles are, one is the continuity theorem that is conservation of mass. So, if we are talking about in compressible fluid, then we know that this A 1 v 1 will be equal to A 2 v 2. So, that gives you the conservation of mass principle and that is known

law of continuity. So, that basically helps in making you understand that wherever the channel will be constricted, the channel will be a small there will be larger velocity of the liquid metal and wherever you have a wider cross section then you have lesser velocity at that point. So, this basically tells that this is based on the mass conservation principle.

Similarly, in this case, we also see that metal has to follow certain path now in that case this conservation of energy also supposes what we see is. So, suppose you have a liquid column and do you have a portion one and this is 2 and 3 portion. Now the Bernoulli's principle is or theorem is nothing, but the conservation of energy theory.

Basically what it tells is that you have 3 types of energy heads. So, it tells that you have h plus p by w plus v square by 2 g. So, you have 3 types of heads and this is constant. So, what is said is that when you are pouring the liquid metal in the pouring basin, it comes down to the sprue, well moves further into a runner goes into the cavity. So, during that it passes at different points these values changes, but it is value all together has to be same. So, what it tells is that when you are at this point you have maximum value of h while when you come at this point this h is minimum. So, if the pressure is this pressure. Now if the pressure is here and here same suppose this is atmospheric pressure this is also atmospheric pressure in that case if you take h 1 plus p 1 by w plus v 1 square by 2 g equal to h 2 plus p 2 by w plus v 2 square by 2 g it tells that these 2 values will be same although we are assuming that there is no loss, but it tells that if there is e 1 and e 2 in that there is certain loss, but if you assume that there is no loss you can say that and if they are the atmospheric pressure if both had that atmospheric pressure they are gone.

And this is if they this is the datum line then h 2 will be 0, if it is at the datum line. So, you have h 1, in that case you can directly say and at h 1, the fluid at rest. So, this is also 0. So, what you see is v 2 is root 2 g h 1. So, what we see is when you are tried to pour something and you have a vessel like this you have metal here and you are trying to pour from here what will be the velocity of this stream that can be found out by using these Bernoulli's theorem.

Basically these are the 2 most fundamental principles which govern the fluid flow inside the cavity which I told that the pressure will be more or pressure will be less, velocity will be more, velocity will be less like that and then that governs the different conditions we can study about it may be in our coming lectures more.

Thank you.