Iron Making
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Lecture – 18
Iron Making Lecture 18

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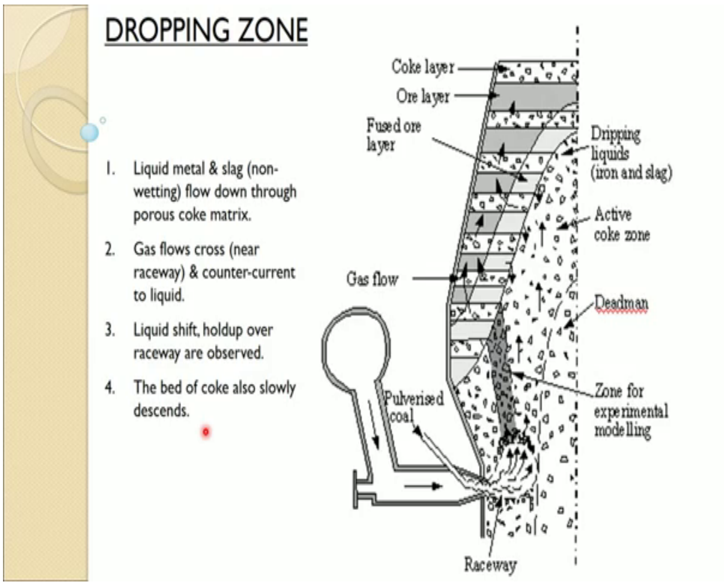

Ok, now we will start talking about a dropping zone, which is very important zone in the blast furnace. This dictate all the aerodynamics of the blast furnace vocalized-noise] and figure shows the dropping zone which you are already familiar by now.

So, at the bottom you have pulverised tear through with the oxygen or hot air is placed and the pulverised coal or oil or anything else is injected through this pipe and the combustion occurs at the front of the tear. So, hot gases goes up and as you know and the cohesive zone it is a massive zone where liquid iron slag is in semisolid solid form and start melting in the lower boundary of that.

So, liquid and slag drop down, gases are going up and this cohesive zone gives big resistance to the gases. So, very high pressure drop in this region. So, we would be talking some in this region it is mostly coke which is in the solid state all other thing is in liquid or fluid state. So, slag and liquid iron is flowing down gases reducing gases are going up and due to the combustion of the coke, coke is getting consumed and due to this consumption is descending down to replenish the consumed coke here.

So, you solid is also moving down liquid is moving down, slag is moving down, gases are going up and in this region near the or in front of the tear you are having a gas moment and perpendicular direction of the liquid and solid flow. And this boundary shows the deadman where coke is mostly in inactive form. So, and this keeps more mechanical support of course, the deadman. So, this is a very complex part in terms of aerodynamics of the blast furnace because this part dictates how the gases are going to distribute in the upper part of the blast furnace which is important for the reduction.

So, many phenomena which occurred here liquid, metal and slag and there usually non wetting in nature for with respect to coke flown down through porous coke matrix; So, you are already now familiar by packed bed. So, it is like a packed bed. So, this is a coke matrix gas flows across. So, near the raceway region or near the tear and counter current flow of liquid occurs in this region and liquid shaped hold up over raceway are observed. So, melting liquid is flowing through this, so liquid holdup in this region one can expect. So, quite a lot liquid holdup is observe and the bed of coke also slowly designs in this direction. So, this is some with respect to liquid it is like a co current flow which I think you are familiar by now.

So, we would be talking really in a more detail way about this region in the next few slides and seeing that how does the zone affects the performance of the blast furnace.

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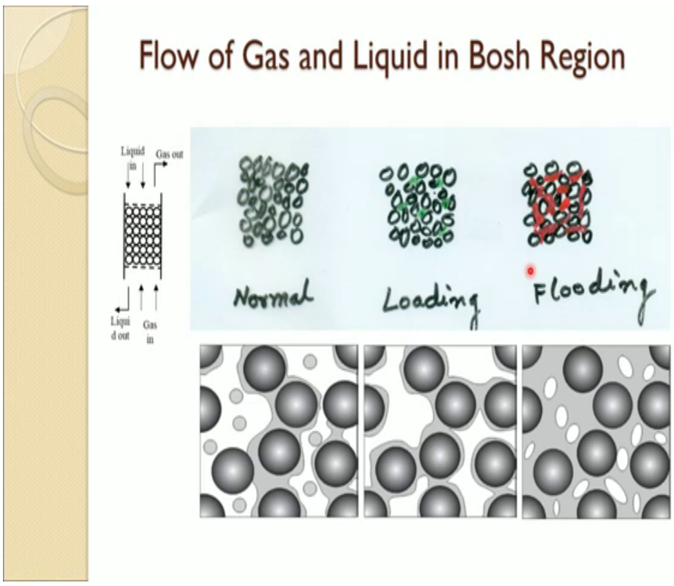

So, the first one is about flow of gas and liquid in bosh region as you know this region known as is a dropping zone or the bosh region we call it. So, we are talking about that and we said about the liquid holdup.

So, what is liquid holdup? I think before we move on to it you should be familiar about this term. So, liquid holdup as you know in the packed bed or in any packing when you are flowing the liquid from the top, and injecting the gas from the bottom at a very low liquid flow rate and gas flow rate you will see the liquid is checked dripping through this packing and coming out which what we call it is a normal operation. But if you increase the gas flow you will find that some liquid is just now hanging in between the voids of the packing and that conditions usually we call as a loading. And it is suppose keep the liquid flow rate same and increase gas flow rate further.

Then one situation will come. So, gas velocity is high enough or gas rate is high enough which does not let the liquid flow down and that situation is usually known as flooding and in that condition gas is very difficult for gas to come out. So, gas comes out in the form of bubbles this also show in big pictorial form. So, this is sort of a bit loading where most of the packing surrounded with the liquid film one like threat and in this one at some places it is there and it some places it is not.

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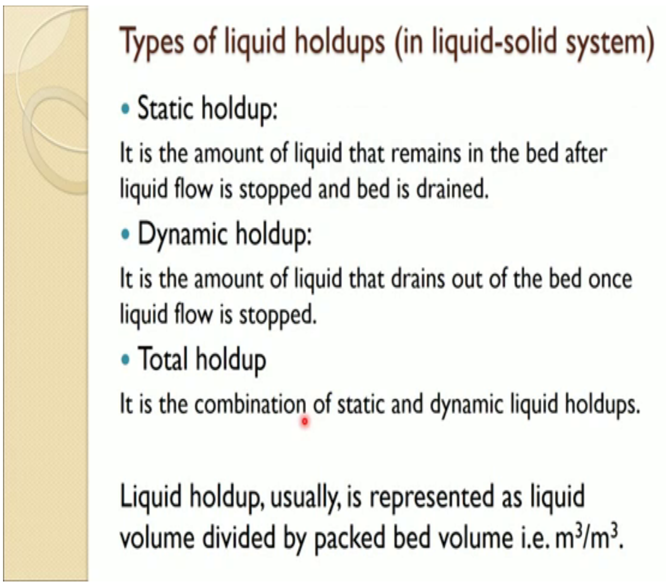

So, the liquid which is now we you have to familiarize couple of terms in this scenario, one is a static holdup. The static holdup it is the amount of liquid that remains in the bed after liquid flow is stopped and bed it drained. So, this is the one if you stop the liquid flow here and let a bed drain. So, in between the particle some liquid will stay there and that is the one which what we call the static hold up.

And there is another hold up is called the dynamic hold up it is the amount of liquid that drains out of the bed once liquid flow is stopped. So, this is what when you are stopping the liquid flow still there would be some liquid which is flowing through the voids which will come out. So, when you stop the liquid flow and the liquid which is coming out from that moment till it drains out that liquid you call it a dynamic hold up.

So, static hold up between the particle it is just staying over there after the liquid flow is stopped dynamic holdup is keep on its a moving liquid through the packed bed. So, once you stop the liquid flow whatever you collects that is known as the dynamic holdup. And the total holdup is nothing is the combination of both the addition of these two, so addition of static and dynamic liquid holdup known as the total holdup.

And usually it is presented or presented in the form of meter cube per meter cube that is the liquid volume what one collects is divided by the packed bed volume is known as the liquid holdup. So, usually it is non dimensional quantity represented have the unit in that form. So, it is a meter cube per meter cube basis and terms of fraction.

So, this is the, these are the two very important term which are used in the liquid flow through the packed bed. And in this case we have, in fact, in fact a very complex situation not only the only the liquid is flowing down gas is also flowing up and when we start putting fine pulverised coal or other thing. So, those un burnt coal or ash that also goes up, so that is also contributing towards the blocking of the voids.

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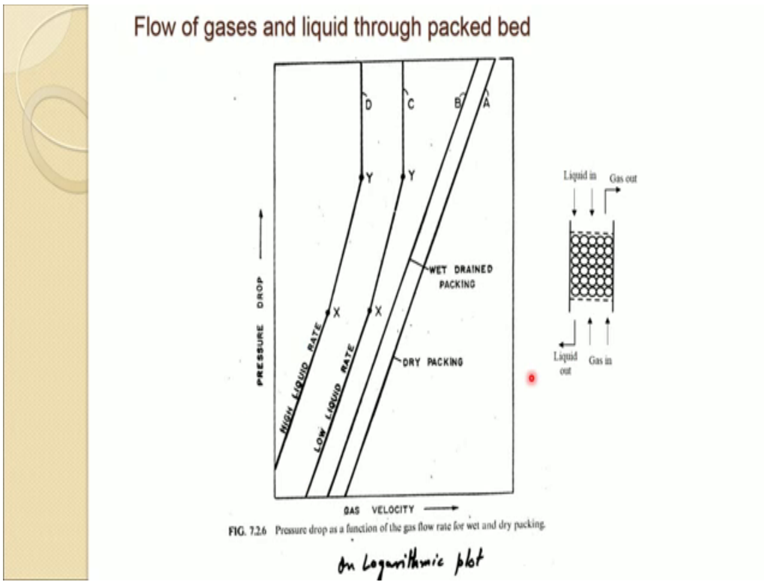

So, it is a quite complex process and we will be talking a little bit more on that. So, if we take a flow of gases and liquid through packed bed this figure represent what happens. So, when gas is flowing upward liquid is flowing downward the situation is known as counter current system which you are already aware of it from our last lectures.

So, in this counter current situation there is first things suppose there is no liquid flowing. So, only gas is flowing in and coming out what we call the dry wet and this is represented schematically by this line A. So, as the gas velocity increases your pressure drop increases more and more resistance is felt by the gas, so pressure drop increases. So, this is the normal situation which we have already discussed and this type of flow using the ergun equation we can calculate the pressure drop which already you are familiar with.

Now, when you start the liquid flow through this what happened because some liquid is depositing in between the particle and some liquid is flowing through these voids. So, essentially your void fraction has reduced and one is the void fraction has reduced and that gives more resistance to gas to pass through.

So; obviously, your pressure drop is increases and which is this second curve is showing when it is wet. And in fact, no liquid is flowing only packing is wet and the liquid is drained out what we said about the static holdup condition, where amount of liquid that remains in the bed after liquid flow is stopped and bed is drained in that conditions this is the wet drained packing. So, liquid is not flowing it has been drained. So, only static holdup is there which is between the particle and that is anyway is reduced void fraction a bit and due to which the pressure drop has increased.

Now, instead of just a drained packing liquid flow is there. So, when liquid flow is there it will occupy this spaces between the particle through which it will flow down and come out. So, again it is occupying more voids void more space in the packing which will create more resistance for gas to flow through this. So, pressure drop will increase.

So, now as the gas velocity increase naturally in the starting there would be a uniform sort of pressure drop resistance would be um. In fact, the liquid would be facing more gas drag when gas velocity is increases and liquid flow is constant and gas velocity is increases then the drag force on the liquid will increase. So, the then which means the resistance for gas flow will increase and pressure drop will increase. So, as the gas velocity increases pressure drop keeps on increasing.

But at one stage what is going to happen the gas velocity is quite high enough that some of the liquid is getting entrapped. So, the drag force on the liquid at few places is high enough which is entrapping the liquid between the voids and it, so it is having a more resistant field. So, it is trying to occupy the spaces which are empty. So, it builds liquid settle down in between the voids and that is where more resistance is faced by the gas and that phenomena that part is represented in this curve by X and Y. So, this phenomena is known as flood loading. So, in this one liquid is more loading in between the packing. So, that is a loading condition.

And one situation will come then most of the voids even filled up with the liquid because the gas velocity is high enough if you keep on increasing the gas velocity all the voids have a liquid has occupied all the voids. Then gas has to travel through these liquid as bubble, and with that that is the situation which we described in this figure schematically where gas is coming out as a bubble through the liquid in the packed bed and that is the flooding situation and this is a very bad situation and one cannot operate any reactor in this condition. So, and the pressure drops sharply increases.

So, as you can see from the graph if you increase the liquid flow rate naturally the situation will become worse and at high liquid flow rate your pressure drop becomes very high and this situation deteriorate. Further at a very then low velocity due we will encounter with the flood loading situation and then the flooding.

So, certainly blast furnace cannot operate type of this, it is a abnormal operation problem will come the liquid metal and slag would be carried out in the upper zone which is lower temperature zone and it will deposit over there and solidified. So, and blast furnace operation would it would be like a ever normal operation.

So, blast furnace should be operate somewhere in this region for the maximum efficiency. So, for that purpose one has to have a proper knowledge about the liquid holdup, how much liquid holdup is there, and what sort of gas velocity should be there. So, one can operate blast furnace efficiently in this range. So, we will be now talking about the liquid holdup.

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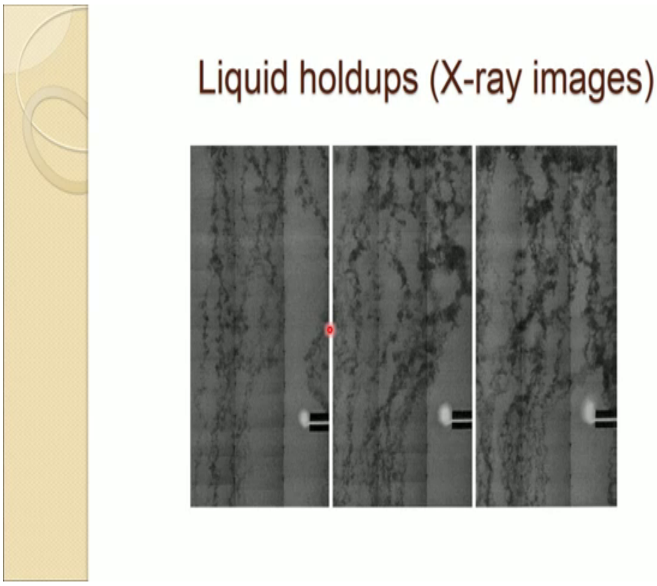

Before we go through you know this is a high temperature a region where we are talking about 1500 1400 degree Celsius temperature. So, it is very difficult to visualize that in live way some attempts have been made to see through cameras and have been successful there which are the recent one, but people have tried to visualize this phenomena is using various other visual technique dry and other. And one of that the (Refer Time: 19:14) is using the X-rays and trying to replicate the blast furnace, dropping zone phenomena and see how the liquid, and gas behave.

So, this is one picture of that where the liquid flow is coming from the top mimicking the iron and slag, and gas flow is coming from the tear from the side as in the blast furnace and raceways form and one can see how this liquid shift is occurring.

So, is going away quiet and the one can see also quite a lot liquid holdup. And this one, one has used sort of water, so the density difference quite a lot. So, one would be seeing a high deviation big deviation of liquid away from the raceway, but in actual situation density is almost 7 times more, one would not expect that much deviation here. Can expect some deviation but not that much, and certainly liquid would be going more at the back and coming down this way in the raceway region probably we will see in one of the video later on about this phenomena in the raceway.

But about the liquid flow this cold region one at this next slide will show you a video about it which probably you can see in this.

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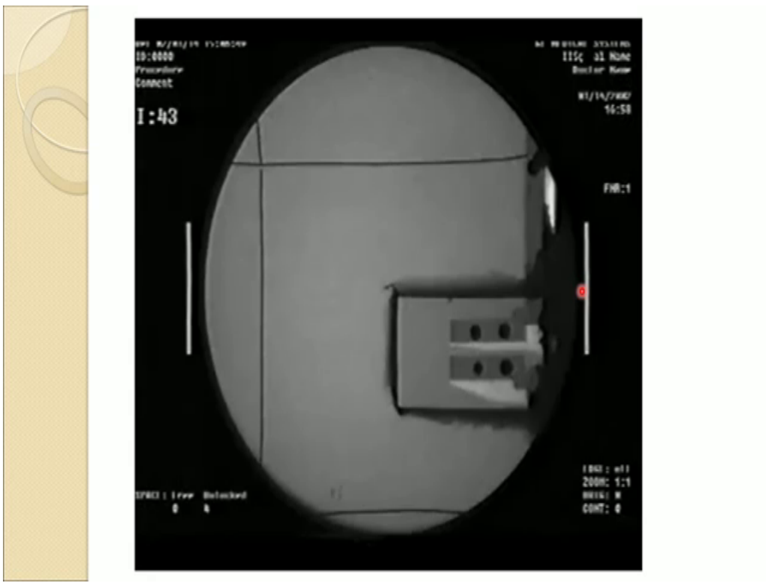

So, this video shows about that picture which we show just now that how the liquid flow occurring in the dropping zone.

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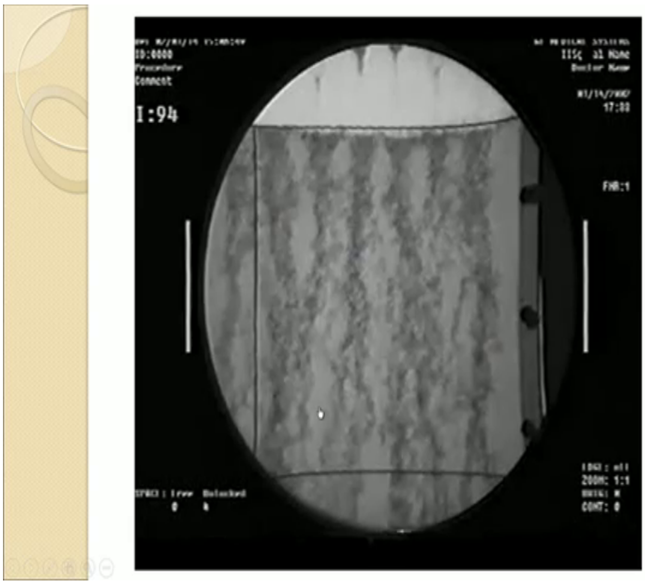

So, you can see that this is a dry bed in the starting and then liquid from the top is a fall through the trips.

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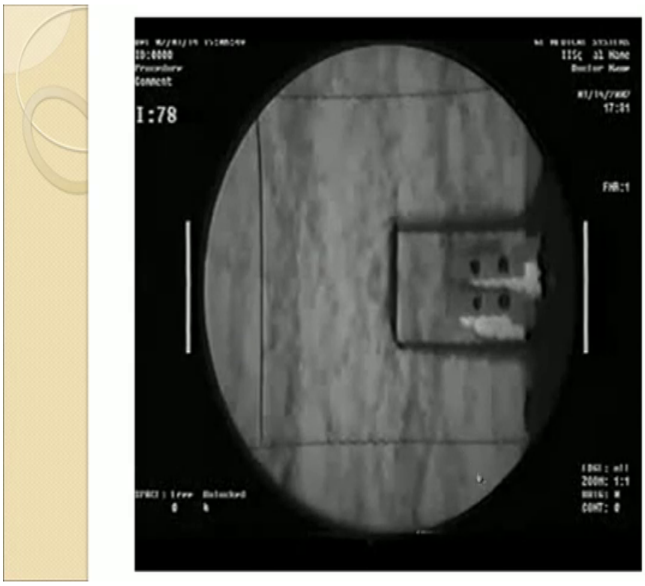

And you can see the liquid which is a sort of a lots of liquid holdup you can see here, here, quite a lot liquid holdup is there. Gases and the started jut and once gas is start you will see the liquid will start moving, but at the moment now gas has started you can see and liquid is pushed away liquid is pushed away here. So, that is due to the high drag by the gas, it now the raceway and see how the liquid has gone up really from the side and side and on the other side.

So, very high drag, once the raceway is found very high drag on the liquid and its shifted it is not only shifted, you can see also the liquid hold up. Some of the liquid is just not coming down as if you see, plenty of liquid holdup which is restricting the flow of the liquid near the raceway and this will absorb most of the effect the chemical reaction and the heat transfer in this region.

So, look at all the holdup at various places. Now, this shows when the liquid has been stopped, but so you can see the static hold up in one. Few regions, places you can see quite a lot holdup is there and there is no liquid is coming out that is called a static holdup. So, this would be like a the liquid iron.

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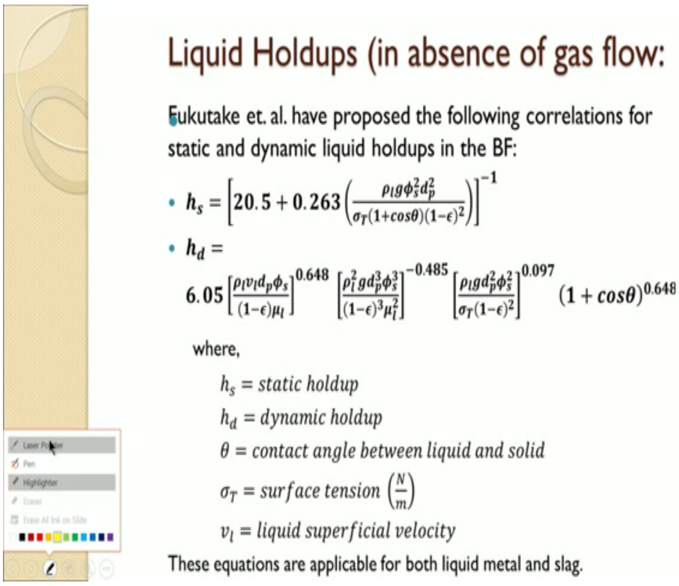

So, this is one of the thing and now; so I hope you understand now with that that what is the importance of the liquid holdup.