Indian Institute of Technology Kanpur
National Programme on Technology Enhanced Learning (NPTEL)

Course Tiltle
Bio energy

Lecture – 38
Fluidized Bed Gasification

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Welcome back to the lecture series in bio energy so last class we were talking about the Bed Gasified designs and we have talked about the two different kind of fix Bed gasifies. So the broadly I mean there are two broadly used Bed Gasifies and there is a third type which is not very commonly used. Okay so today what we will do we have talked about the fixed gasifies.

Today we will be talking about the fluidized gasifies as the name indicates it is a form of gasifies or a design of gasifies where there is an opportunity of lot of mixing between the reactants between the biomass material and the air oxygen mixture which is coming there and this reaction is enabled in a fluidized bed.

A bed where it is almost like a platform where you have the reactants and the catalyst ant in the form of what you are what is being used to in a combusted and it is given a lot of more time. So to start off with fluidized bed is classified into two different categories. One is called Circulating method the other one is called a Bubbling method.

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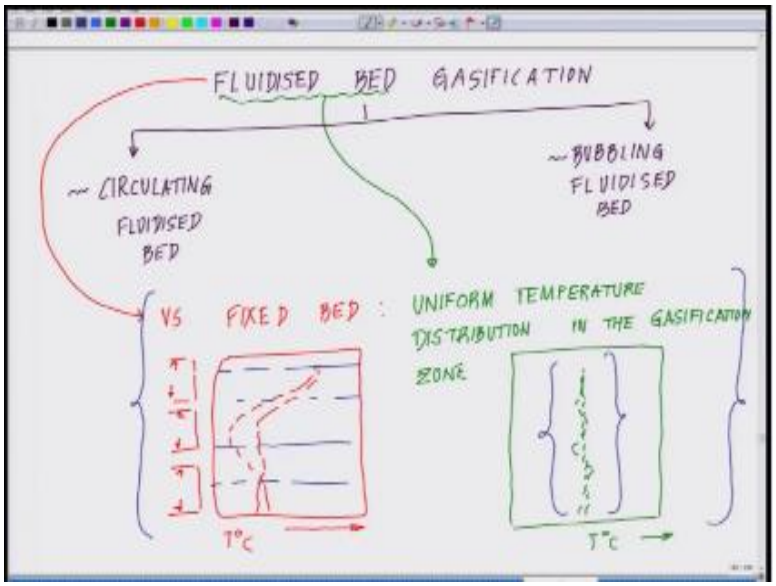

So let us start of it with so to start with Fluidized bed gasification. Okay and within Fluidized Bed Gasification we classify them into two different categories. Category 1 which constitutes Circulating Fluidized bed well the second one is Bubbling fluidized bed and the name itself is self-explanatory bubbling fluidized bed.

That you are bubbling in the fluid and you are having the ingredient gets circulated. So in one word if you have to distinguish between Fluidized bed verses if you want to do a classification with the fixed bed verses fixed bit. One of the most fundamental differences is in the case of Fluidized bed the case of fluidized bed you have a uniform temperature distribution achieved in the gasification zone uniform temperature distribution in the gasification zone.

So if you remember when we talked about the Fix bed gasifies if you remember I showed you that graph that when you are introducing the biomass the drying temperature followed by the increase in temperature from 200 degree to 400 600 and all the way to 1000 and more than 1000 in the combustion chamber and finally it comes back to 200 in one case the other case it remain a 900 of the existing gas.

So what is happening across the chamber what you see in the case of fixed bed what you see the temperature kind of you know varies depending on which part of it is remember like something like this or something like this likewise. So where your X-axis is showing the T degree centigrade differences and these are the different zone. So for example this is where the drying is happening this is where combustion is happening and likewise when and so forth okay whereas in the case of uniform temperature distribution in the case of second A the temperature is T degree centigrade it is more or less remaining in the form. It is hardly any difference okay and we will talk about it. How such uniform temperature distribution is achieved?

So your take home message from this part is get this different very clear in your mind how the temperature varies in both of them. Here the temperature remains very constant so if it is 1000 degree it will remain 10000 degree all throughout. So in other words there is a homogeneous mixing which is feasible in the fluidized bed compared to the circulated as compared to the fixed bed. And in the fixed bed you really have to be very careful.

Because if you could see it here itself you are maintaining temperature at different level and that needs a lot of finer control which has to be maintained as compared to this situation where you do not have to really bother about the temperature. You really can fix it at point and allow the reaction to you know carry over a period of time. So this is a very significant and very important difference between fluidized beds as against the fixed bed. So by definition of you have to go what we meant by the fluidized bed.

Is basically it is achieved by is achieved by using bed of fine grained material fine grain material into which air which is the form of fluid air is introduced and if you this definition is clear to you then you will realize that when I will do the drawing it will make sense. So essentially fluidizing the bed material and ensure intimate mixing. As I told you there is a lot of opportunity of a very homogeneous mixing intimate mixing of the hot bed material. There are three things which are mixing here so here is the hotbed where the mixing is occurring hot bed material.

The hot combustion gas the hot combustion gas and the biomass feed. So what is significant in this is you have to remember these three. Ensure intimate mixing this is very important this part

what of the 1A the hot bed material which is the platform where this reaction is happening. So you needed a bed material something like this it is a bed on which you have the biomass coming which has to be converted and from underneath or from side or what so ever having you are introducing the combustion gas.

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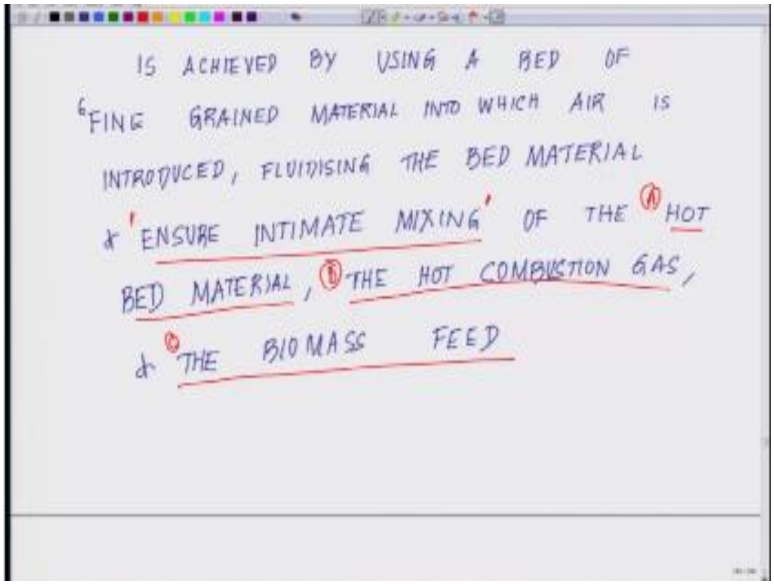

So this is that hot combustion gas which is the second important thing okay and the biomass feed. So what you are allowing imagine a vessel where you are allowing all of them you are fluidizing the vessel by adding air into it and you are allowing the reaction to take place at a uniform temperature.

And if you go back a slide back this is what is happening here if I had to introduce you are the three components a B and C which is so you have the reaction bed, bed material you have the biomass which has to be converted into gas and you have the combustible air so these ABC what I just now put together they are there is an intimate mixing of all these things which results to the generation of the gas. This is the framework on which we will be talking about the two different kind of fluidized bed one which is called the circulating one the second one which is called the

bubbling one. So basic logic is this so keep this logic in mind okay. So now let us go for these two classifications.

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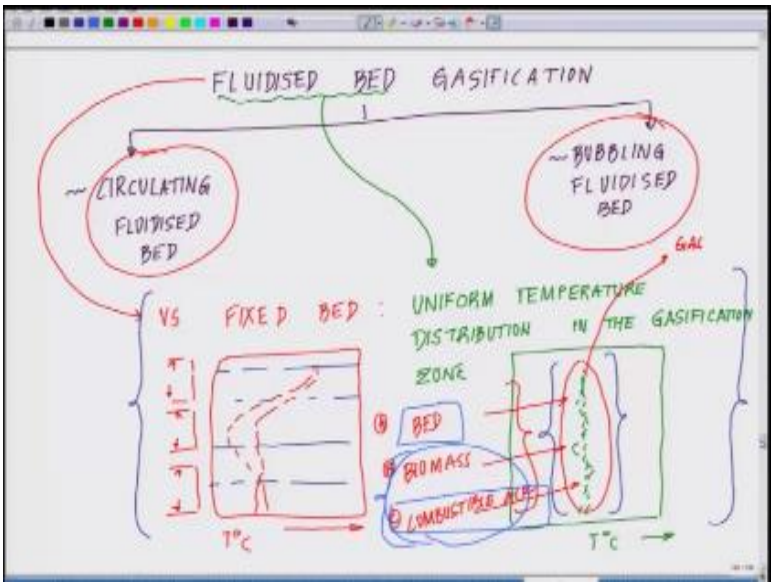

The circulating fluidized bed and the bubbling fluidized bed what does that mean? So we will follow same pattern what we did earlier we will have the schematics of these two and then based on the schematics so the drawing should get embedded into your imagination look at this is how the reaction takes place in these kind of chambers and what is the difference?

So whenever we talk about circulating it means some component is circulating here circulating fluidized bed okay and we took them to bubbling it means you are bubbling something out of and what all what could be the component you have only three component and no end of the day. You have either you have the bed is fixed you cannot really shift the bed so there is a bed where the reaction is happening okay that is a platform that you cannot ship what all you can shift you can shift the product out of this.

So you can either circulate some of the product which are form here or you can bubble combustible air just remember what all you can move there you cannot move the bed. Bed will

remain constant at one taste so on the top of the bed you have this biomass like this you are giving the fluidized air so you can either bubble it or what the product which is coming you can re circulate it and you could have a hybrid system. Two out of these two okay so let us get into the details of it now.

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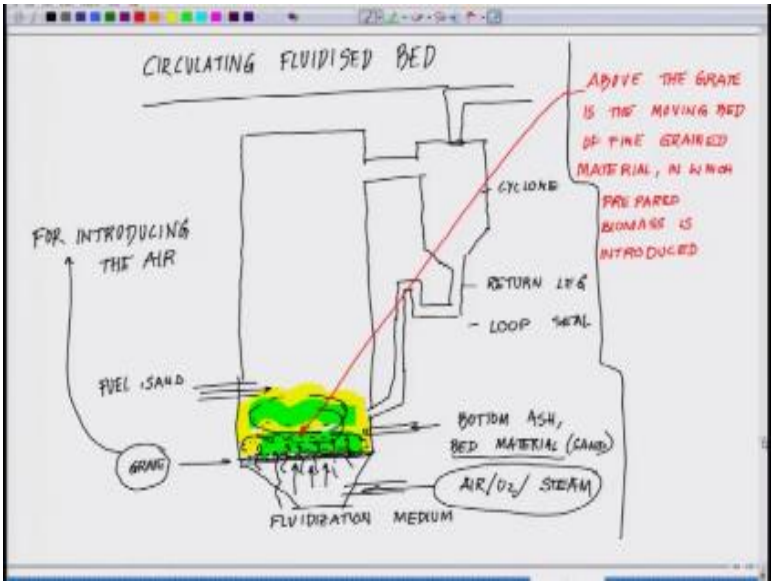

Okay so we will start with the circulating fluidized bed. Circulating fluidized bed gasifies okay. So the design if we have to show let me first of all draw the design of it that will help for the better understanding of it. Something like this is just an schematic I am not drawing by the scales. Okay and then the port out here and no so you have from here you are putting the fuel into it will and sand which is basically forming the bed and there is a great out here great and from here you are putting the fluidization medium. Fluidization medium to kick this is where you have the bottom ash and man bed material sand bed material mostly the sand.

It is something like when I talk about sent so all of many of you see when they make popcorn on the roadside all of have seen the how they make it? So you see a big vessel there a metallic vessel only they put a lot of sand you have seen and they heat of the sand and then they put the corns into it and the corns start flapping into the forming the popcorn. Exactly very similar to

that just imagine you see the popcorn walas were and you will see how they are making it so there is a sand bed.

So your vessel on that there is a sand bed sand is getting warm up and you put the popcorns and then you take out the puffed corn okay. So that is precisely almost very similar to that if you have to make a one-to-one correlation what you see in your day-to-day life okay so this is where the bed material which is the sand which is kind of the reaction unit okay and this is called the cyclone where things I have been re circulated back and this is called the return leg. There is something called a loop seals here and from here out here there you are putting air oxygen and steam this is the entry port for all the three stuff .

So this is where you are having the fluidizing medium moving through and most of the reactions so the reaction zone is out here so this is where the reaction is happening okay which I put in yellow one blue okay this is where most of the reaction is taking place. Now what is happening out here is it so just put it down word so once again let me keep this in mind so it consists of a great at the bottom through with the air is introduced so here is the great okay for introducing the a or in other word this great what you the great material what I am shading now is the one which is allowing the fluidized materials to move through.

So this is where you are having the sand and all those things and it is the fluid equities you are making the fluidized by introducing this whole mixture outer so this part is all getting heated up so there is a uniform temperature regime which is created here okay so now what you do on top of it you are having the all the biomass which has to be converted okay. So above the great is the moving bed of fine grain material so this is where we are talking about so this is the zone let me pick up another color.

So this is the zone where we are talking about at this is above the great okay above the great is the moving bed you can move the bed up and down the moving bed of fine grain material of fine-grained material okay in which prepared the biomass in is introduced in which prepared biomass is introduced. It is exactly the same analogy what I was trying to explain you say for

example just I am drawing it for you for your understanding you have seen them see the scene the popcorn maker.

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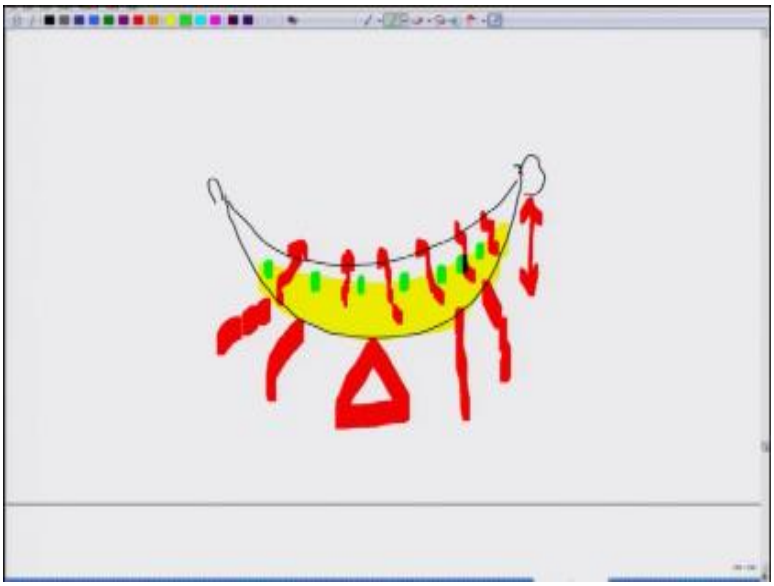

So he will have vessel like this okay like this and on that vessel you will see a lot of sand out there okay you see a lot of sand like this on the bottom okay so what this guy will do so this is the sand in yellow so this guy is kind of heating it up okay so this is where he is heating it okay hitting lot of heat.

So what will happen the temperature of the sand is going to go up the temperature out here increases when the temperature increases it attains a uniform temperature so what you are having here is an uniform temperature at this point you will see this guy will be introducing lot of those you know cones out here and they might make popcorn. Exactly similar to the analogy of popcorn making analogy what you are doing.

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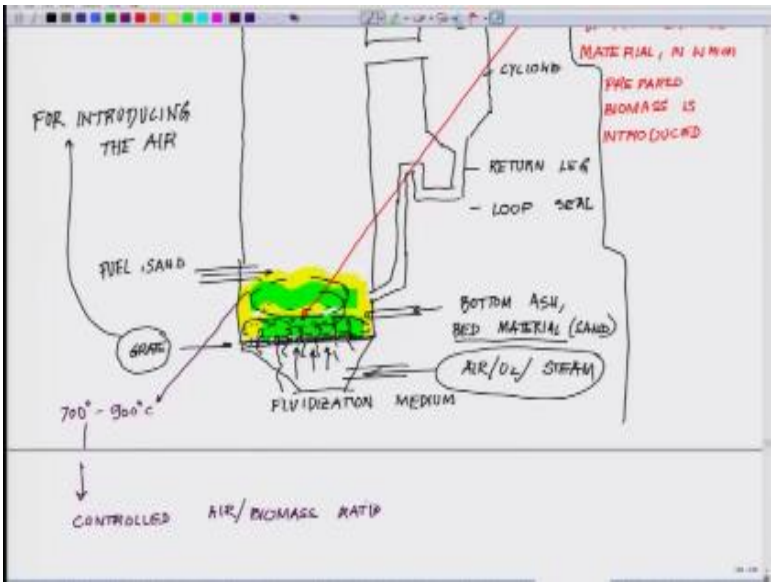

Instead of corn here you are introducing the biomass so you have the sand or the very finely made sand on which you are introducing the corn and that is what you are flopping out. So exactly the same thing what is happening here okay. so now coming back so these are the two critical points what you have to keep in mind okay and generally the temperature which is maintained out here is approximately 700 to 900 degree centigrade and this could be controlled further okay this could be controlled air /biomass a ratio you can control this temperature easily okay.

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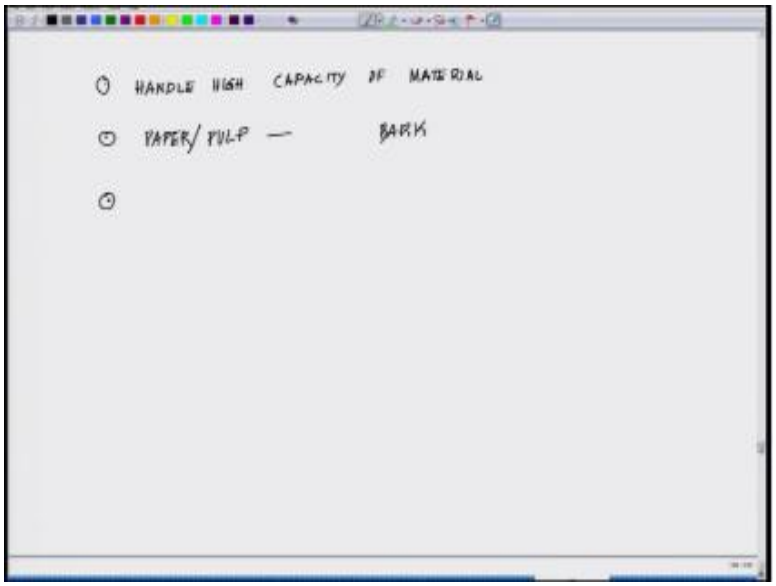

These kind of things could handle high capacity fairly high capacity it can handle high capacity of material second important thing is that this is even a day to the example you can see in the paper and pulp industry this is fairly common paper and pulp industry this is a common phenomena for gasification of the bark and other forest product where these kind of circulating fluidized bed is being used and the bed material this is very important that bed material is circulated between the reaction vessel and the cyclone separator where the ash is removed and the bed material and the char is returned to the reaction vessel okay. So that is one addition I wanted to-do you can also circulate this bed materials okay.

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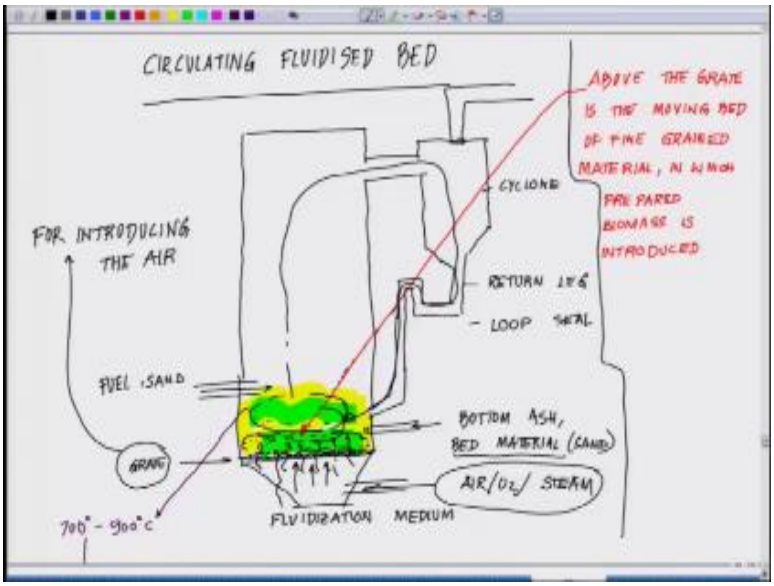

So what is happening here when this whole reaction is taking place so the bed material circulates like this order the product like this comes back so there is a movement of the bed material which can go and come back so how that happens this is very important for you to realize.

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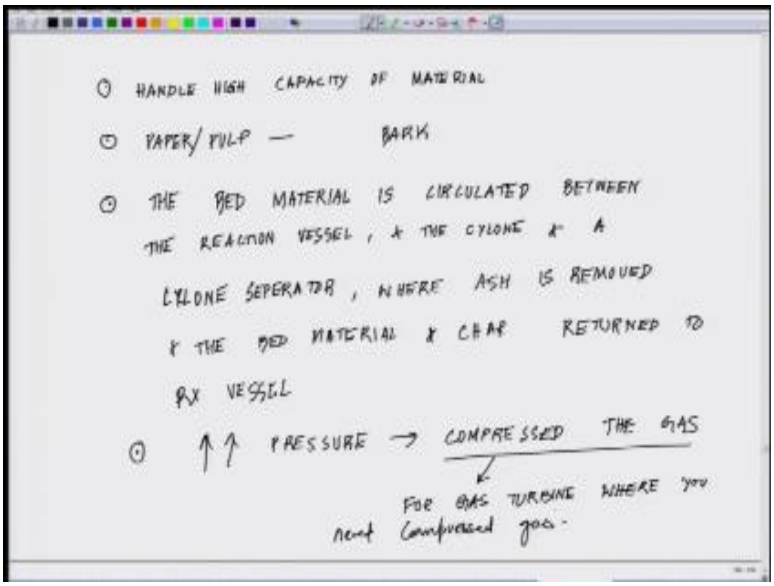

So the bed materials circulated between the reaction vessel between the reaction vessel and the cyclone okay and a cyclone separator cyclone separator okay where ash is removed we will come back to the drawing and I will show you.

What does that mean remove and bed material and char return to reaction vessels return to a reaction vessel and this that can operate at very high pressure there is no issue about it withstanding the pressure and because of it you can compress the gas and especially for gas turbines where you need compressed gas you can compress the gas and especially for situation where you need for gas turbines where you need compressed gas this can come very handy where you need compressed gas okay so this method comes very handy in those situations further there are two more points what you have to consider is that.

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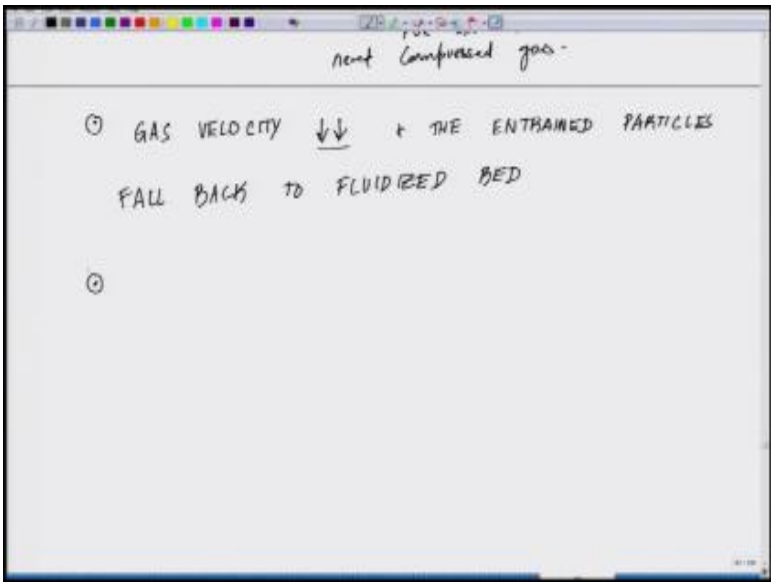

Gas velocity decreases as gas velocity decreases perishing decreases and the entrained particles fall back to the fluid edge bit and entrained particles fall back to fluidize bed fall back to slower dies bed okay and those particles are separated from the from the gas in a cyclone and is returned to the bottom of the bed so what exactly is happening for let us see the diagram okay.

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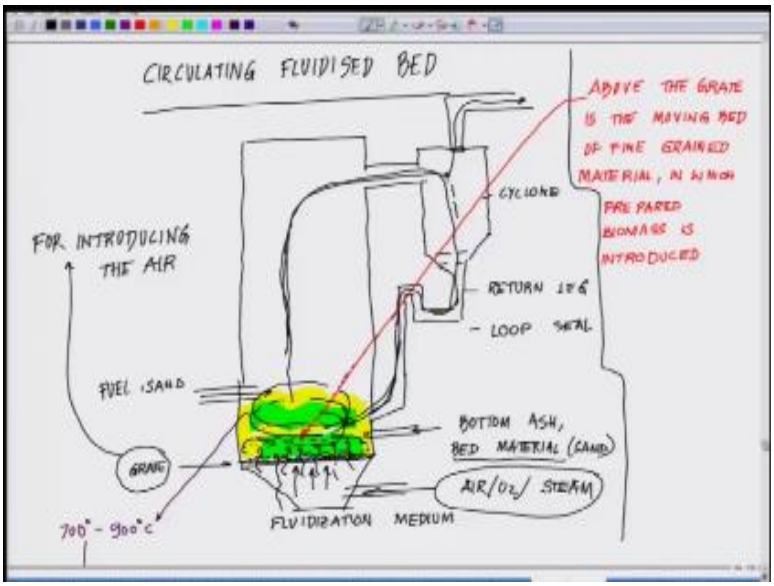

So here the reaction is happening all the reactions so the gas is about to move out along with the particulate matters out here lighter one is getting collected like this and the heavier one again fallback and there are a lot of filters out here and it is returned back so what you are essentially doing in this circulating fluidized bed you are.

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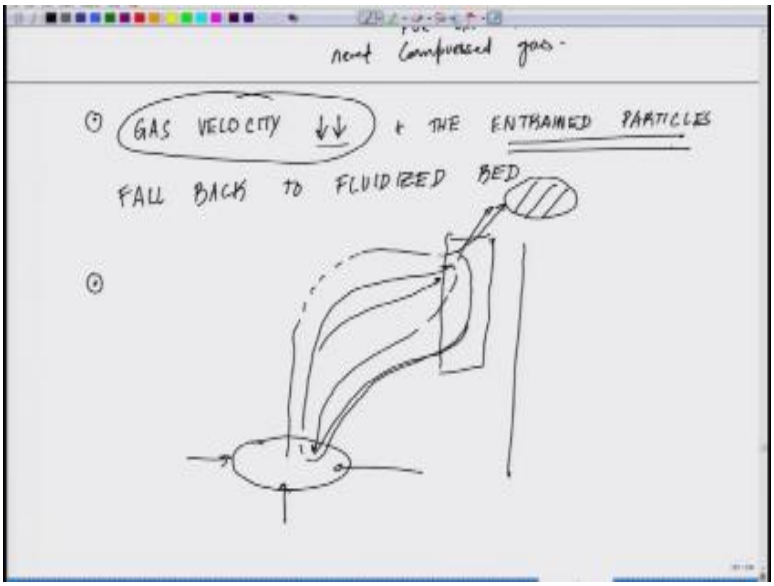

So this is where the reaction vessel is so reaction is happening it is going back part of it is getting escaped and getting stored out here and part of its coming back and again doing the reaction again another cycle run again part of it going out part of it is coming back likewise when I am so forth okay so it is a kind of a circulating journey and out here where things are getting separated they get separated mostly on the density gradient.

So the density the higher particles again comeback okay so this is how this whole fluidized model of circulating fluidized bed work and the advantage is that this can work as I mentioned at a so very high pressure and secondly the gas velocity it decreases of the entrained particles this is exactly what it meant by that and fall back to the fluidized Bay and again the reaction continues.

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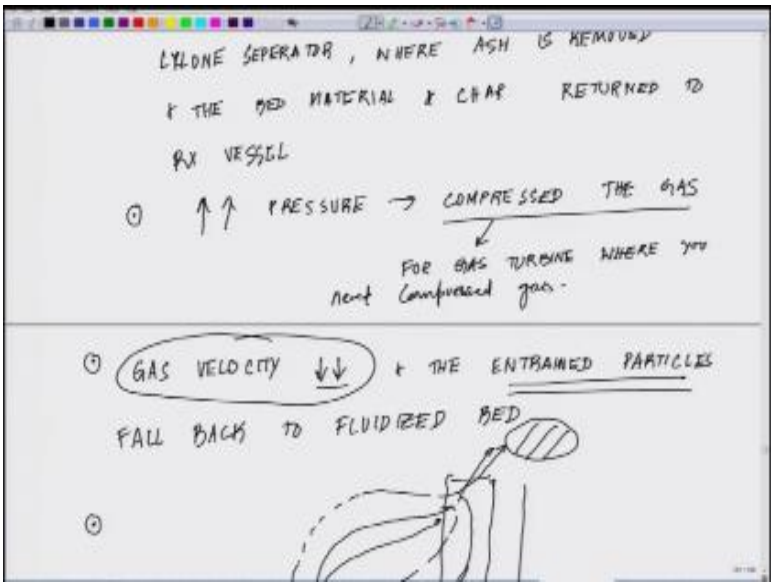

So in a way in this kind of situation you are taking time for the reaction to happen over a prolonged period of prolonged cycles that way you are making the system to utilize all the possible materials or the biomass which are present there okay.

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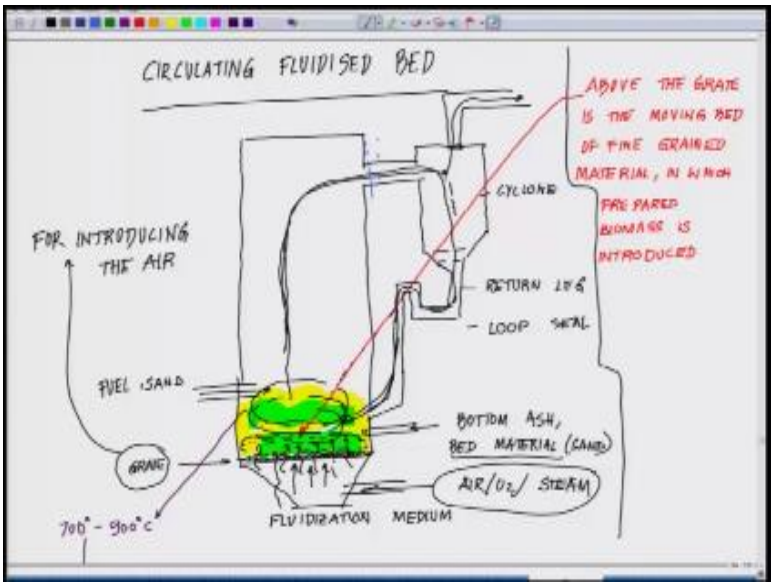

So now from here with this drawing in your in front of you we will talk about the next one which is the bubbling bit okay bubbling bit so in bubbling with only basic fundamental difference will come here this is the zone where the basic fundamental there would not be any circulation okay so let me draw the bubbling bed.

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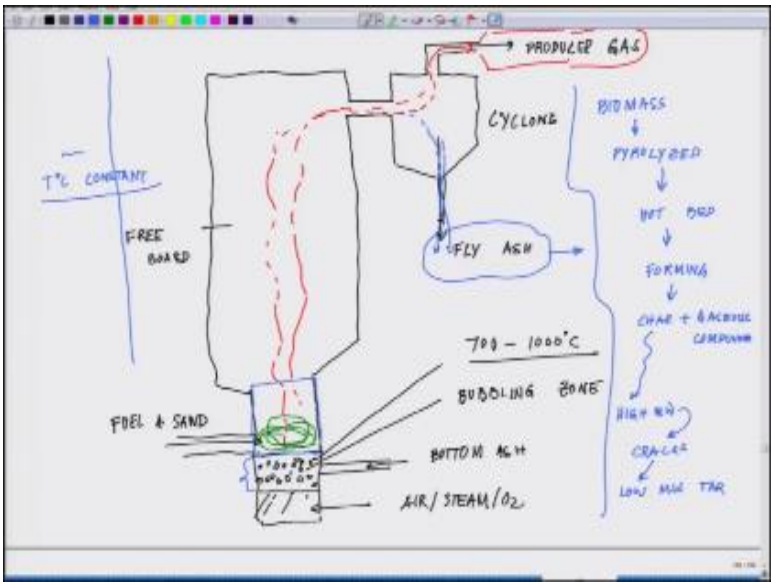

That will make more sense so the bubbling bed is essentially you have something like this the architecture is very similar except that the connector okays if you remember in the previous one and the cyclone is getting connected to the back to the vessel so here you have the producer gas okay and this is where the fly ash come out you have to collect the fly ash because that needs further treatment because that is a fairly bad pollutant okay so now if you look at this diagram this is what is happening here you are introducing the fuel and sand which is making the reaction bit like here okay out here this is the bottom ash.

Okay and out here you are introducing the air steam and oxygen your bubbling this part okay and generally the temperature which is maintained out here is again in the range of 700 to 1000 degree centigrade okay and this is what is called the bubbling zone and this is the freeboard and from here you are getting the soap fluidized gas. So here you are having the tons of biomass which is on the top okay so now what is happening here is this you are bubbling slowly and the gases which are being produced move along with the ash and everything and out here the gas escapes like this.

This is where you are collecting the gas cylinders or whatever and the ash which is contaminated with it is rejected out this fly ash has to be collected I know they are used for making breaks and other things okay so this is how the basic architecture of it looks like so again there is a grating through which you are introducing the air and you introduce there so here is the grating where you are introducing the area and you introduce the air in form of you are fluidizing it in bubbles okay so biomass basically spiral zed in the hotbed forming char and gaseous compounds of high molecular weight.

So what is happening out here is that there are two three processes which are happening let us enumerate them so the biomass which is introduced there that gates paralyzed In the hot bed forming char plus gaseous compounds and this char is a very high molecular weight and this high molecular weight char is further cracks and giving product of low molecular weight MW stand for molecular weight low molecular weight are compounds okay this is how it works and in this situation the temperature is constant and low throughout okay.

So you can maintain a constant temperature out here is constant and due to automatic density separation in the bed dense particles sink while the light particle leaves so what is happening out here if you see this column this column is where there are it almost forms a gradient so if I really magnify this column it will look.

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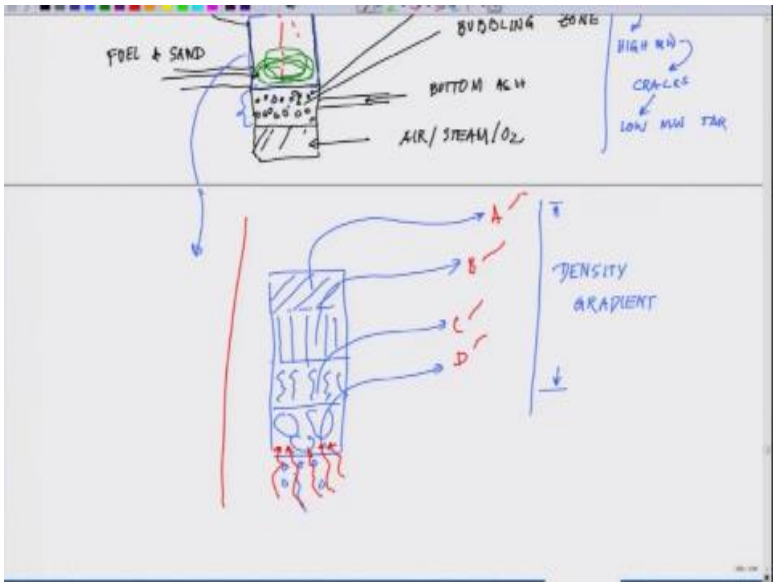

If you see this column context this column will be more like this so the lighter particle will be other talk higher than that will be underneath it further higher will be underneath it and the heavier ones will be like this so these ones will be the one which will be escaping fast followed by the one this one then the these layer then the fourth layer so there will be a almost like those who have studied about density gradient centrifugation there is not density gradient so because of the slowly fluidizing which is coming from the bottom when I shoot in the red okay it creates a kind of our interesting gradient phenomena out here the first one to get out second one third one fourth one so it takes time but at a uniform temperature you can really achieve this okay.

So this is what we talked about the basics of the two different kind of fluidized bed reactors okay so what we will do after this is that, we will talk about the operation and performance of the fluidized bed reactor followed by since we have talked about the thermal chemical method after this we have talk about the biochemical roots of gasification and then we will summarize the different routes by which different kind of wills could be developed solid liquid gas okay.

But gases preferred big time because transportation is easy and could be used in several operations much more easily as compared to the liquid or the solid will definitely solid the its

transportation is a challenge it is complete gas so overall just to summarize what we have learnt about the gasifies we have talked about the fixed bit and we have talked about the fluidized bed and the different kind of cigs bed like the up drift down drift and cross-sectional side to side movement.

And then we talked about the fluidized bed where we talked about the one where we have bubbling the one we are re-circulating so again let me trait another aspect that there is no one way really when you have whenever you have to pick up one particular aspect you really have to think several times that depending on the properties of the material what is the best you can do so there is no one thumb rule like you know you can it always is a function of the material what you will be using for making energy materials out of it.

So for it is always keys by case but as long as your basics are clear you really can you know work around it to figure out what is the best way do you know play the game so I will close in here and in the next class we will talk about the pros and cons of the few days back followed by the by clinical root of transforming bio mass to energy materials like gases okay gasification using biological roots like anaerobic digestion and ancillary processor thank you.

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