Textured Yarn Technology
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Lecture – 26
Air-texturing jets

We go to the next lecture and this time we will be talking about Air jet texturing jets, some fundamental aspects of the design of jets is what we would like to discuss in this lecture.

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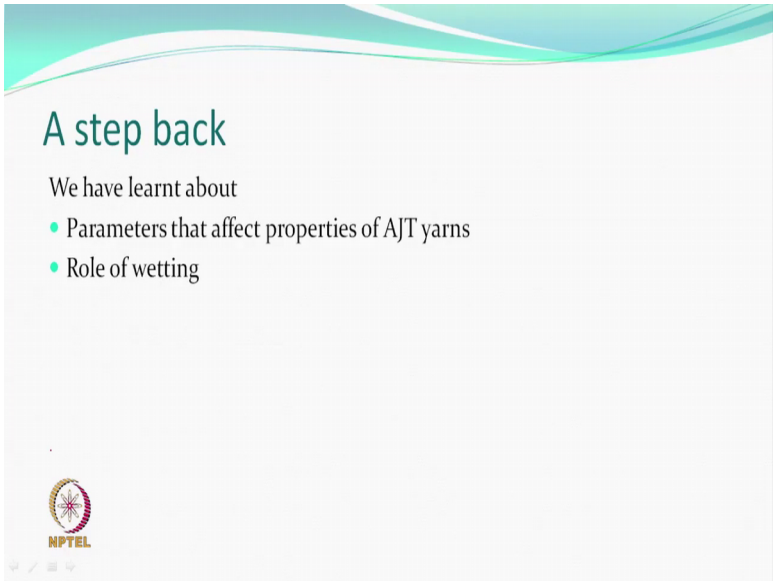

Let us see what we have learnt till now we have learnt about various parameters that affect the properties of air jet textured yarns in addition we have also learnt the role of wetting which was that it always in all cases reduces instability and that was because the tension at the exit of the yarn is always high because of wetting.

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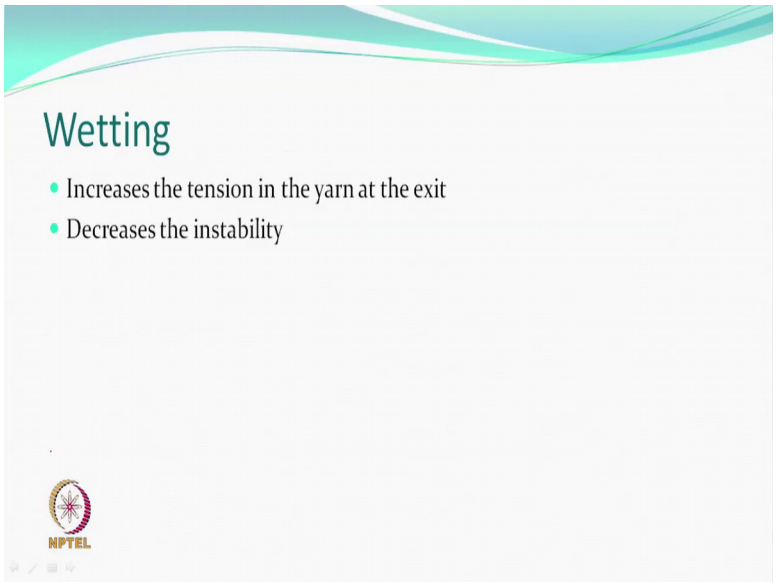

So, wetting increases the tension in the yarn at the exit and therefore, decreases the instability.

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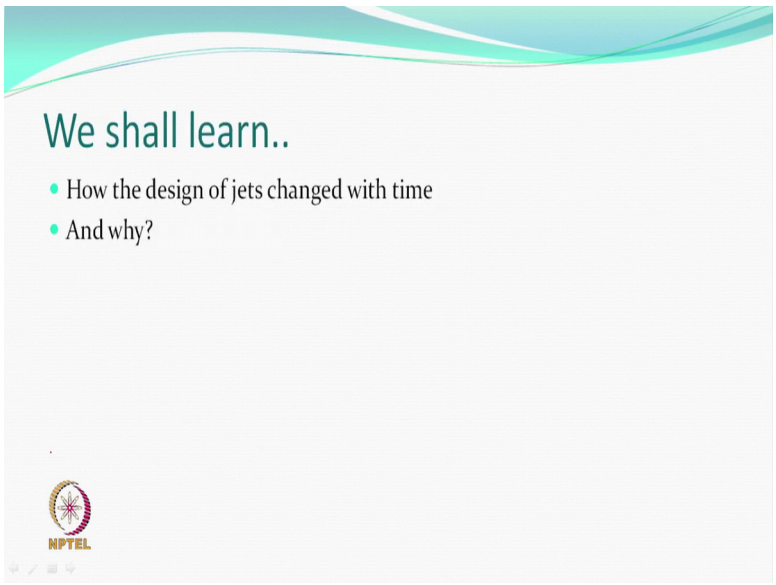

Today we shall focus on the design of jets how they change with time and why air jets.

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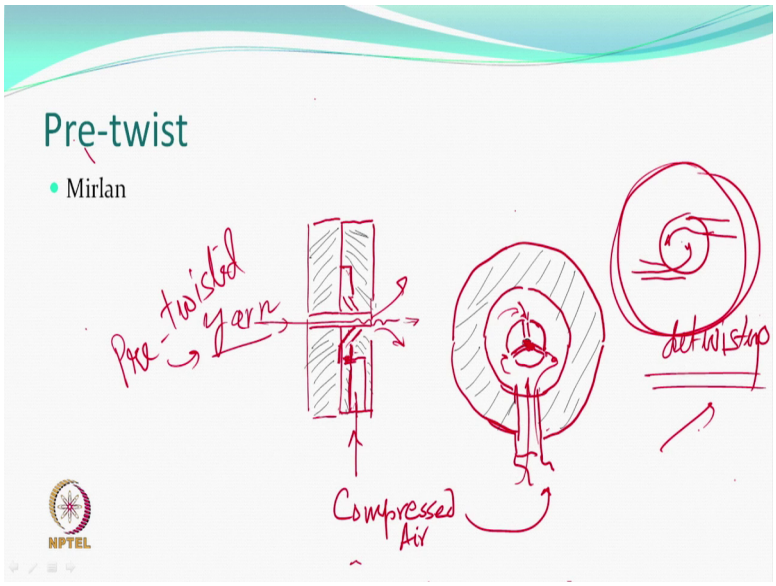

Remember we said that although the principle of air jet texturing was known pretty early you are not able to get commercial machines because the productivity was low the speeds of the texturing machines were very low because otherwise the entanglements would not be good yarn would have higher instability which; obviously, is a bad property bad thing to happen

So, there was one concept which people wanted to try can we do a bit of a pre twisting instead of just putting the filament yarns untwisted filament yarns for air jet texturing can we do some pre twist and then texturize the yarn. And this is what people actually checked it out and found that during the air jet texturing process the pre twist gets opened gets untwisted. Entanglements are facilitated and as the yarn would exit it was hoped that the twist will flow back and the entanglements become tighter and therefore, possibly the yarn instability textured yarn instability would be low.

One of the interesting jets was called the Mirlan jet it was designed in Czech Republic earlier called Czech Czechoslovakia now what was there is this yarn there is a jet the yarn which is a pre twisted yarn is fed of course, overfed, but the air is going through a chamber from outer chamber to the inner chamber from where if we look at the cross section the yarn may be coming out for example. The air is entering the from the sides and through this chamber it goes from here to there to here and also if you see from this there was a angle which is towards the exit.

So, the air is going to be pushed out generally, but because of this thing that it is entering the innermost chamber in 3 directions it would push the yarn in a manner that it starts rotating. So, a bit of a twist or untwist we are interested in untwist. So, the directions could be such that this actually behaves like as if is untwisted and the over because overfeed you would have loops formation and entanglement everything else and as it comes out the effect of this swirling motion may be reduced or finished.

And so, the twist flows back in this some position and so, yarn becomes still tighter. So, you start with the pre twisted yarn and you end up with a pre twisted yarn post twisted yarn right start with a pre twisted yarn end up with a post twisted yarn in between the twists has been opened the yarn filaments become loose they do make loops entanglements and the twist flows back as it exists. And so, tighter filaments are there tighter loops will tighter entanglement will be there so, less instability.

So, it was true and seen by many workers that pre twist helps. So, it was one of the solutions, but one must remember every time you do a twisting a real twist because the pre twisted yarn means there is a real twisted yarn and if that real twist is there then it becomes the batch process. So, batch process means first you do twisting they make packages then take the packages and try to do the texturizing. So, a batch process a costly process. So, this jet may actually be doing this de twisting in a way by swirling that is what the jet can do.

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So, shall we say that the Mirlan was using a pre twisted yarn the mechanism was something like a false twist insertion or false untwist twisting and a result was instability was reduced, but as we mentioned again that it will be a batch process twisting will be a batch process, so, costly. So, you needed something else; that means, he wanted jets to use untwisted yarn and exactly produce the quality that is desired.

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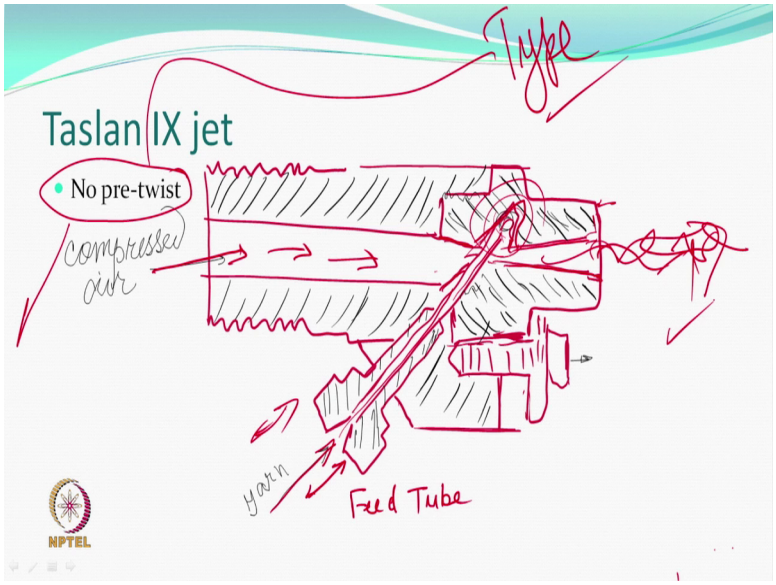

So, very series of jets were introduced by DuPont they were known as Taslan jets. So, you can see we are talking at the moment of something like a jet which was type 9. So, previously other versions; obviously, were introduced in the market and the learning was going on. So, one of the jets which is the type 9 Taslan became a commercially successful jet what it also meant that good quality yarn at little higher speeds in which there was a feed tube which is this feed tube is at an angle you can see this at an angle the yarn is going to be fed through this tube.

And therefore, this is also entering the jet at some angle the compressed air is coming directly in a straight direction, but it would interact the feed tube and the yarn coming out at some place here. So, there is some kind of a cavity here, the feed tube can go up or down this you can see is the converging point and because its converging the velocity will be high the pressures at this point will be; obviously different.

So, high pressure because area is less. So, there is some additional turbulence will be there and then another attachment which is this different; obviously, at different parts.

So, the feed tube can go come in out this particular exit of the jet can also be moved in one direction or the other based on what the requirement is and the textured yarn would come out entangled from this side.

So, interestingly this was not obviously, using any twist this one advantage. The turbulence was being created because the movement direction movement of the yarn direction and the direction of the air were different and so, they were entangling at some point and so, a lot of things with them. You know lot of patrons are available; obviously, what should be the angle at which the yarn must be fed.

So, ultimately various angles have been tried and finally, it appears to be close to 45 degrees at which it is entering. So, yarn is being pushed the yarn is being sucked by the air which is that right it its a different angle and the yarn by itself is coming in a straight way and obviously, it can go out only, there is no other way.

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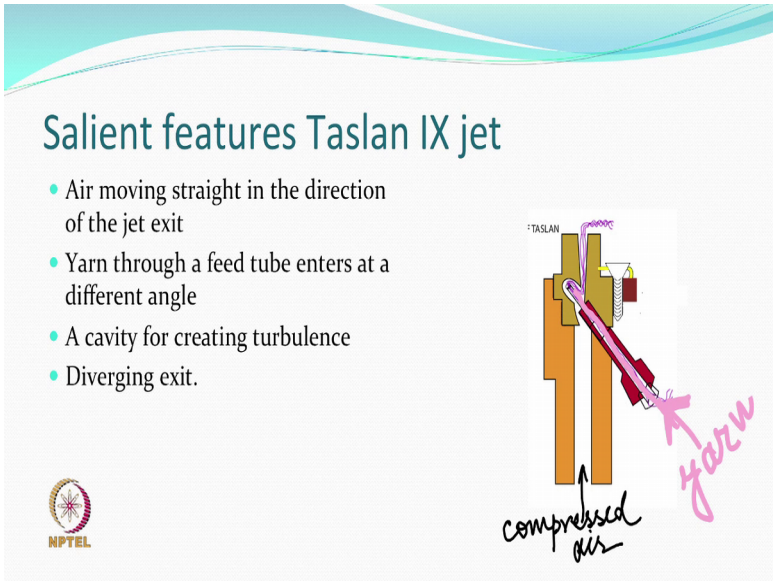

This had therefore some salient features air is moving straight in the direction of the exit of the jet the yarn through a feed tube enters at a different angle.

Now, this angle can be changed, but the tube can also come in or go out. A cavity is therefore, creating turbulence of the yarn the air has to go and take a curved path increase turbulence and go of course, there is going to be convergence and finally, it appears there is a divergence also and diverging exit and convergence initially. So, that the pressure

increases in some way and velocity particularly becomes high, so, you cross the Reynolds number.

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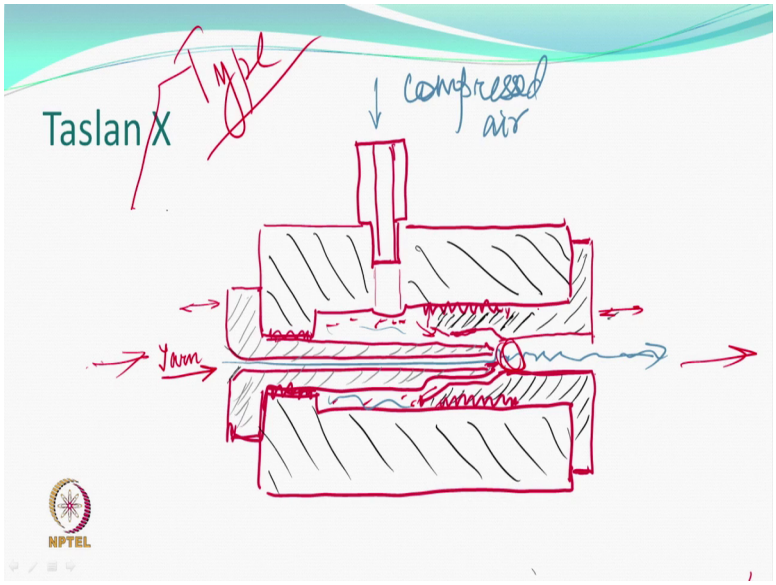

The next version which we call as Taslan X or Taslan shall we say type X jet some order has been changed here, what has been changed? Now the air is coming from a different direction now and the yarn is entering in this direction and exiting this way. So, this is as the nozzle direction is there in the same direction the yarn is moving while the air is coming from almost right angles it comes and gets into the chamber all across then goes like this and somewhere here they meet the yarn and the air they meet.

Interestingly, you can see the exit was jet is not diverging here while there is a convergence as the feed tube enters the air all along comes and then moves then what do we do that.

So, here somehow it was felt that there was no need of diverging exit. So, yarn gets sucked yarn gets sucked from the front end the feed tube can also go in and out the exit element can also go in and out, but from the type IX this was a major change. So, what should the angle of the few tube etcetera they were no more important.

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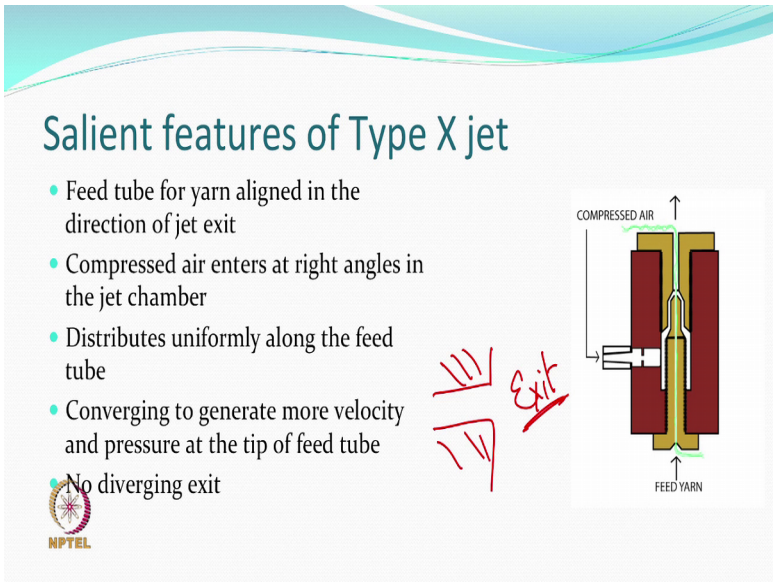

So, for this type X jet the salient features were changed from type IX the feed tube for yarn aligned was aligned in the direction of the jet exit that is one change. The compressed air enters at right angles in the jet chamber so, there is this jet chamber. It distributes a uniformly right it distributes uniformly all along the feed tube, but converges. So, the overall volume through which it is going to enter is being reduced and so, again velocity will increase turbulence will increase and so, drag will increase and hopefully all the kind of entanglements etcetera would also increase and they famine that this was efficient enough.

So, converging to generate more velocity in a way more mass flow within the same time period and at the tip of the feed tube there is interaction with the yarn. So, everything that is supposed to happen would happen here, but there was no diverging exit it was simple straight exit. So, the previous research was almost thrown out.

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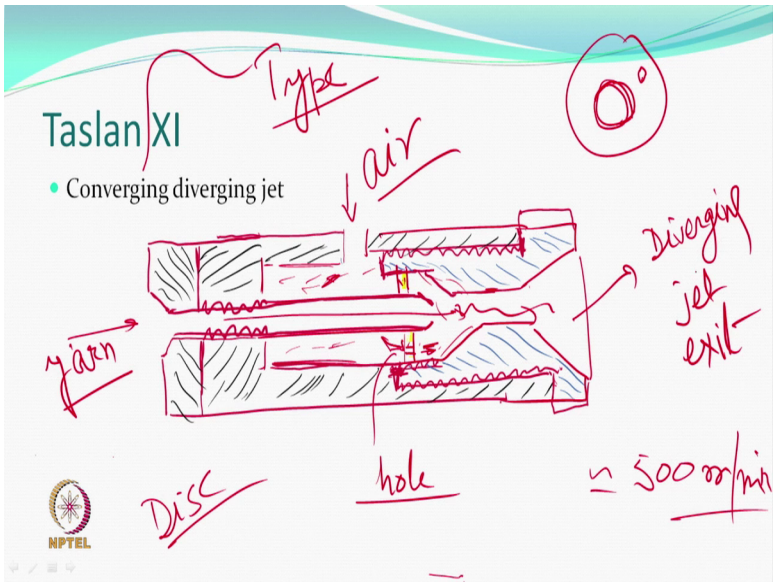

Then the Taslan type XI; type XI you see some difference here the air is coming from here; obviously, compressed air now I am sorry the yarn like type X is coming the same direction the air is at right angles entering they somehow realize that diverging jet is a good idea. So, diverging jet exit they found was a good idea.

So, they brought it back again; however, it was still converging. So, the air enters in a chamber and then gets converged and then goes out, but interestingly they put another disc over the feed tube the feed tube was going inside the desk there was a hole, but the air first was collecting in a chamber like this, but was not going symmetrically and meeting the yarn.

So, the asymmetry was created how this disc would only allow the air to pass through only one hole at one side right. So, there is a hole here. So, a symmetry was created why because they found asymmetry is better for creating more turbulence rather than symmetry in the type X the air was symmetrically entering all across the feed tube and interacting with the filament at the end of the tube.

Now the whole chamber has been divided to 2 parts where the air first collects the first part and then it enters cannot enter from let us say this side is closed it enters only from let us say this side. So, it is a disc and disc has a hole somewhere the air enters through this hole feed tube is fixed tightly here. So, around the feed tube now you see the air is

going to be entering from a small hole or orifice in the disc and going to be a symmetrically entering they consider this will give higher turbulence.

Now remember, the speed started increasing of the air jet texturing machine they could get into 500 meters per minute, earlier remember we are talking about 30 meters 50 meters per minute kind of environment in the beginning now you are getting into 500. So, its basically texturing or air jet texturing is now quite became quite competitive with these kinds of jets coming in as the speeds increase. So, production high cost is less at the same time entanglements are good; that means instability is low that what basically was required to be done.

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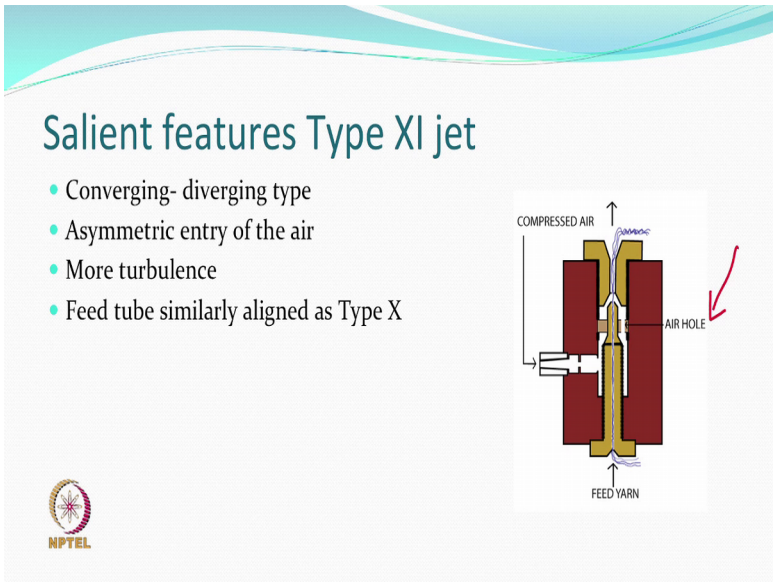

So, some salient features of type XI jets. So, become converging diverging converging. So, that velocity increases diverging again they gave back as to this will be more important we will talk about the diverging and effect of this asymmetric entry of the air around the feed tube to create more turbulence, the feed tube is similarly aligned as the type X all right. So, difference only is a symmetric entry and of course, converging diverging type of a jet.

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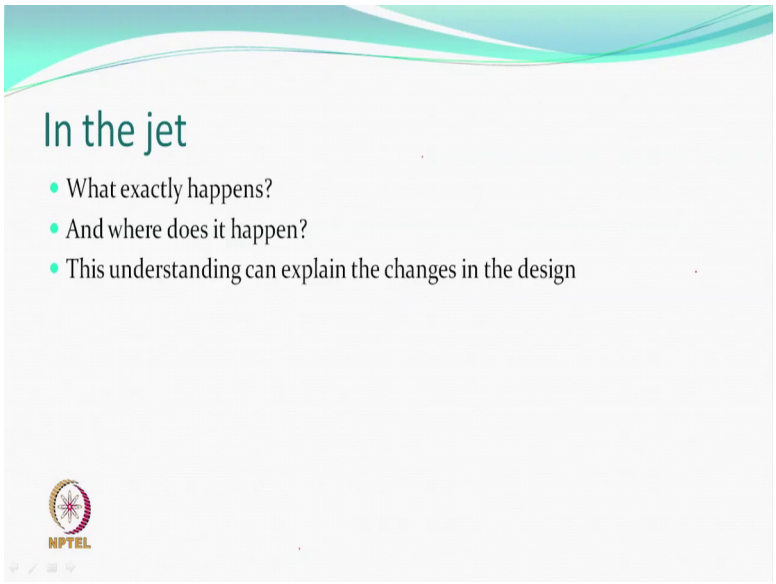

So, why this all changes were made what happens exactly in the jet and where does it happen this understanding can then explain what changes which have been done before why such changes have been done and what more changes could be done? What do we want from the air jet texturing jet? We understood earlier there are three things need to be done.

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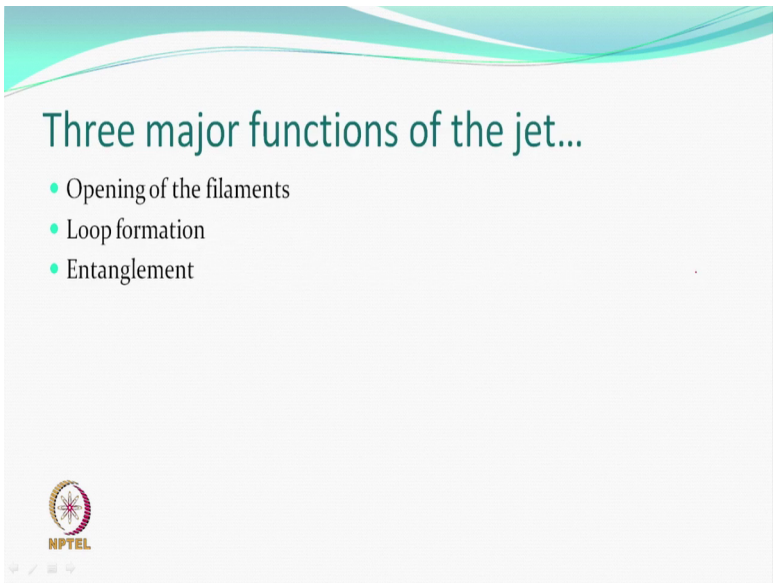

One is the opening of the filaments. So, bundle is coming which is to be open because each filament must make loops individually not as a bundle, if they make the loops as a

bundle it will open also very easily. Then you require entanglement these are the three things which have been done in which part of the jet all these things happen.

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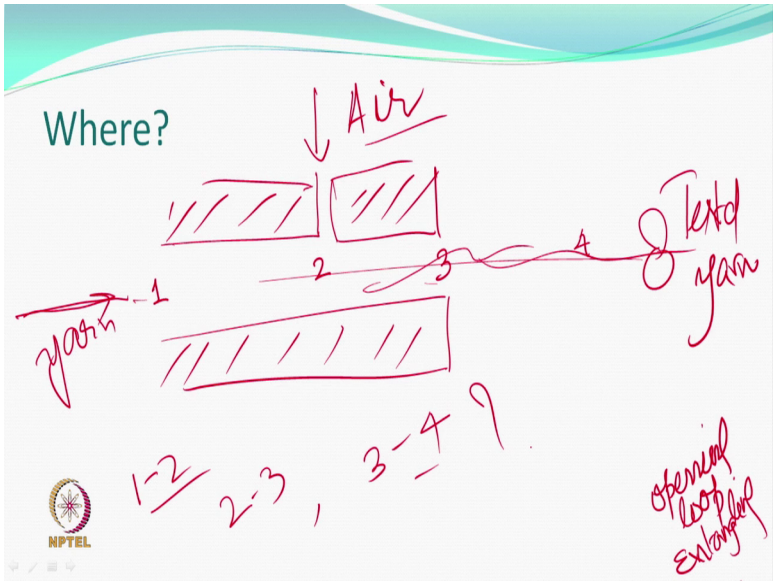

Let us say roughly this is some kind of a jet simple the air is entering from this side the yarn is entering from here let us say and then they will get a textured yarn at the end. So, all these three things that is opening loop formation and entanglement at what point do they happen ? Will they happen let us say we define point 1 entry, point 2 where the air is likely to meet, point 3 exit, point 4 outside the jet.

Where do you think the opening of the filament would take place the filament is coming from one side between 1 to 2 opening or between 2 and 3 or between 3 and 4 where, these questions are there a lot of people; obviously, we are looking at designs, turbulences, velocity is being high and all change of design this understanding is important where all these things happen. It is quite possible we can easily accepted that loop formation will not take place before opening and entanglement; obviously, will not take place before loop formation, if this kind of thing happen then; obviously, we do not know what kind of material we produce.

So, although the exact timing may not be the same for the every filament, but overall we can approximately assume that opening of loops opening of the filaments should proceed before loop formation and entanglement must happen after loop formation. So, let us say

if somebody asked this question. So, where exactly the opening of the filament takes place, where exactly the loop formation takes place and entanglement.

So, these are some of the zones that we have described where do you think it will form between 1 to 2 opening possibly no because entanglement opening can take place only when there is interaction. So, maybe between 2 3 the loop formation could be also similar what is your opinion can everything happens somewhere else.

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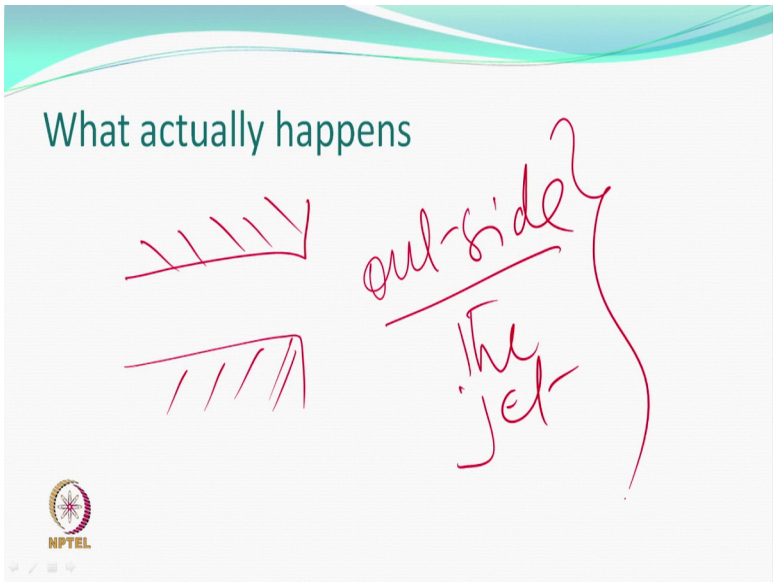

What actually happens is interestingly outside the jet it was noticed by various kinds of things that the whole thing is happening outside the jet. So, what was this fuss about more interaction, more turbulence so, that a lot of things happen; this quite surprising, then why this old design business converging, diverging, air symmetry and everything else.

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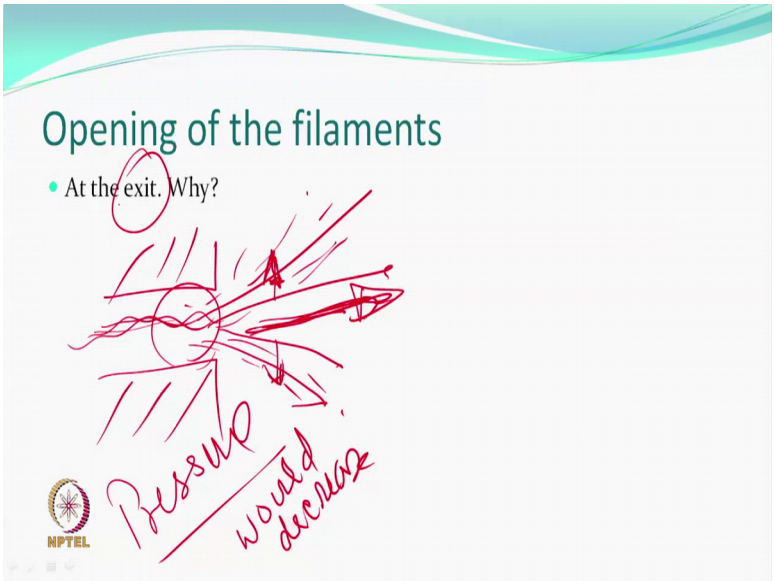

Majority of the filaments opened up at the exit why do you think so should happen? Why cannot they entangle while they are still in the inside the jet in the channel? Because for opening there has to be some force which is at an angle different to the motion of the yarn on the filament if yarn is moving like this and if all the forces are working in this direction why would any filament separate why should separate? It can only separate if there is some force which is acting in the direction which is different than the direction of motion of the yarn.

So, as the yarn is coming a filament bundle it may be fluttering because of some velocity being high some turbulence inside, but there is no real reason for it us to assume that would happen inside, why would happen outside? Here there is more pressure as it comes out what happens pressure will decrease or increase? As the air compressed air is coming through nozzle out into the open the pressure will decrease or not?

Yes the pressure would decrease, because the air can now go not just in front, but also in any other direction by this it means that you actually have some force which is taking the yarn in this direction and there is some force acting just in the direction which is maybe at right angles.

Now, this type of force if it is available then there is a reason for us to believe that the filaments can open; one filament can go like this, the other filament can go like, there the other filament can go. Based on the resultant force that they experience at the exit, so,

exit why it could happen? Because, there was not much space pressure very high if the pressure is high it is acting upon each filament it does not say that go somewhere, so its compressing actually.

So, it may go like this the filament may not go straight like this, but may flutter and go, but as it exits suddenly there is a pressure drop and because there is a pressure drop the molecules of air are going in direction which is not necessarily the direction in which they immediately exit. So, there is another force with another direction and that is the reason why filaments will start opening. So, when do the form the loop?

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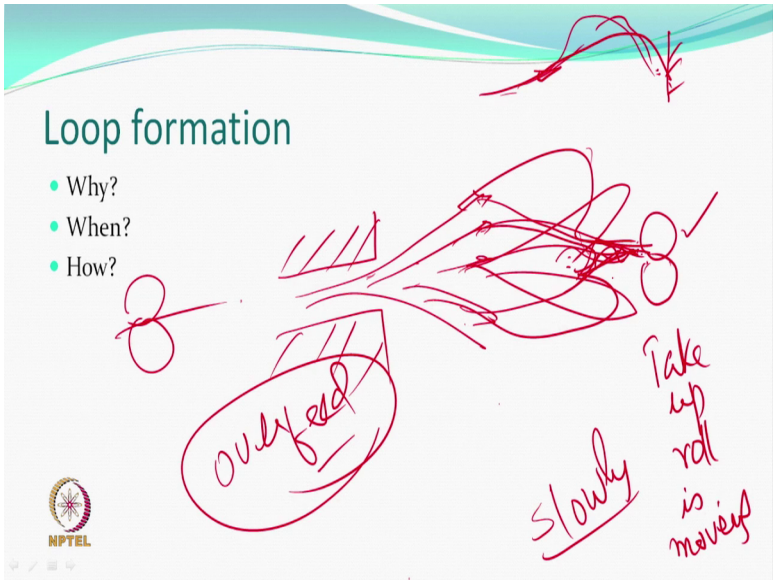

So, loop formation how does it happen, why does it happen actually, why would any filament make a loop? Obviously, we can now say with little more confidence that it will happen outside the jet; where some filaments are moving like this, some filaments are moving this some are like that. And so, they are now open why will the loop form loop would form only if one end is moving the other end is not moving.

If we create a situation that this does not move and the yarn is being pushed in this direction. So, it will start bending and that is how it will make loop. So, how does it stop? So, we have what we call as take up roll these filaments whatever they want they cannot go without interacting at this point or somewhere all of them have to come like this all of them must converge at this point.

So, how will they converge? So, this will probably make like this may make and then sort entanglement here this may do like this may make like that the other one may do think like this. So, loop formation will take place because, we hope that this which is a take up roll is moving slowly. Slowly means what? It cannot be slower than the feed roll, it is fast what is it slow it is slow because you are giving a overfeed. So, what is happening so, giving overfeed this anyway moving slow, but the filaments may be moving faster the cause of the over feed and therefore, one end is moving slowly the other end is moving fast and you make a loop and then sometimes happen. So, it is also happening outside, but individual filaments are bending.

Now, the question that comes all of them have been given over feed simultaneously if all of them go differently, but finally, converge make loops why would they entangle? That means, they just bent, so, they just come out of the take up roll and then the open again if they open its all useless the whole work is useless to ensure that it is not useless, but useful; that means, entangle miss must take place.

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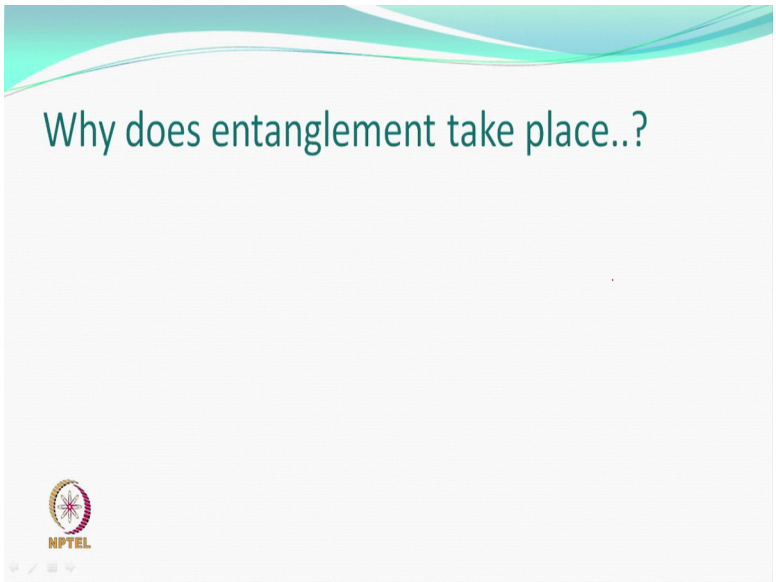

Now this question again comes why does the entanglement take place? If all the filaments make loops because they had over feed they were moving faster than the take up roll, so, they make loop together. So, these are happy making loops, but by entanglement.

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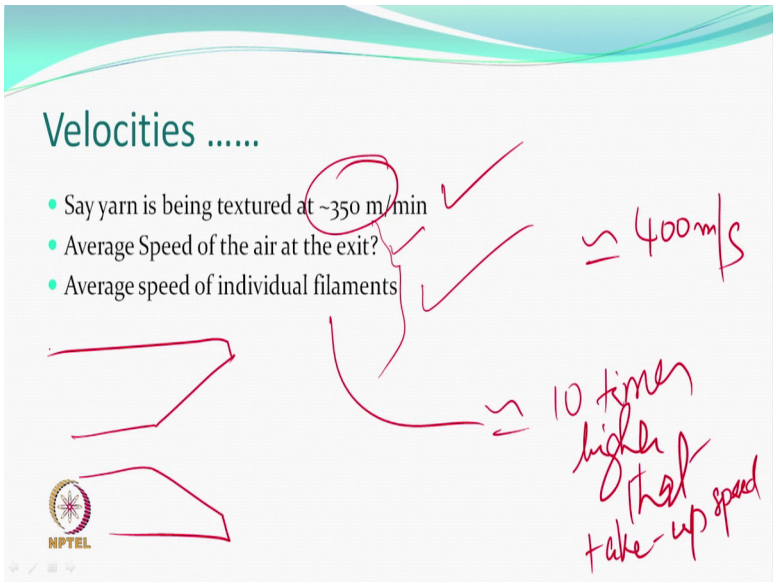

You must understand let us say the yarn is moving some average speed at about 350 meters per minute let us say at the take up. And we do understand just because the loop has been formed the average speed of the individual filament must be higher than this, then the loop will form there is a pressure or there. And we can also assume that the average speed of the air at the exit will be more than the speed of the filament because there is a slip also the air is not gripping the filament like a roller, but its moving fast.

And so, it is taking the filaments along with it, but we can assume that the speed of the individual filaments would be higher than this and the speed of the air every speed of the air should be higher than that of the filament. Can there be any confusion in this? What if somebody asks? If the yarn is being texturized or is being taken up by a roll at about 350 meters what is likely to be the average speed of the air at the exit. Any guesses 500 600 1000 what interestingly the air actually is moving at a supersonic speed and what is supersonic? Obviously, it may be close to 400 meters per second not minute.

So, this converging of a jet creates this high velocity supersonic and so, you would have lot of drag filaments going to be pulled through the jet of course, they are open. But let us say somebody again asked this question what would be the average speed of an individual filament? More than 350 definitely 350 meters per minute; will it be close to 400 meters per second?

May not be because going to be slipping it is not a fun trip, but interestingly the speed every speed or the filaments could be 10 times higher than take up speed. If it this is 350 the filament may be doing 3500 meters per minute what a speed and all this is happening in very short period of time, you already understood what how much less time is spent of inside the jet. Although now we know almost everything is happening outside yet, but jet is important creating high velocity and also opening.

Now, you can probably appreciate why they are diverging why cannot they just have this thing a straight cut non divergent exit. So, if it is straight non divergent the pressure drop will be immediate the filament may be flying all over. So, you can control if you have the exit little controlled then it will pressure will drop, but at a rate at which you want. So, a lot of work was done also on what could be the angle and the length of this exit which is a conical diverging. But without much difficulty it will be easy to it is easy to understand that this expansion will be controlled that is one converging of the jet vents and will increase the velocity. So, more drag will be there and filaments are going to move at a faster pace

Now, because the difference is there between the take up velocities or speed and that of the filament average speed loop formation takes place. So, these two thing have been explained why entanglement? This is just good enough to open the filaments and move them faster.

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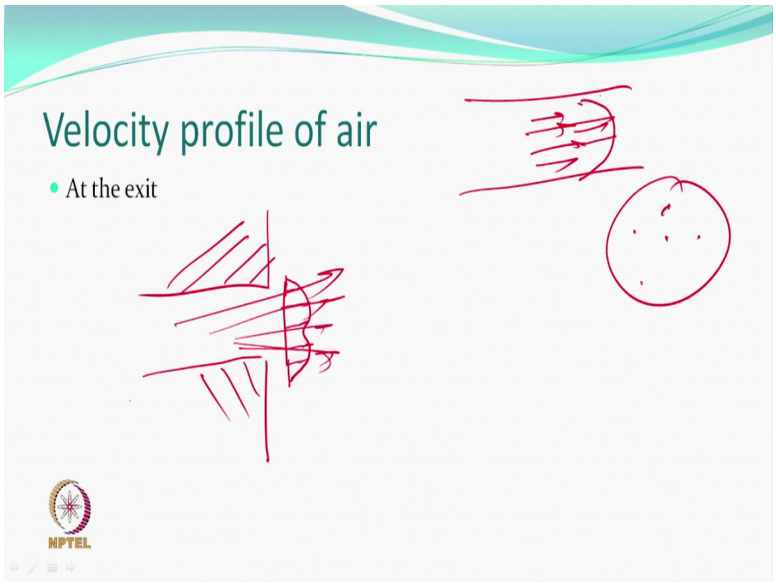

If entanglement has to take place the speed of different filaments at any given point of time must not be same, if they are same then opening will take place together of course and loop formation will also take place together entanglement will not take place.

So, if somebody says what would be the profile of the air velocity if it was low velocity situation like a Newtonian flow through any tube the profile would be like this? The fluid which is moving and is close to the walls will move slowly. The ones which is the center will move faster true; that means, if the filament happens to be let us say near the wall it may be moving slowly ok.

But because of turbulent velocity situation the profile which has been measured is at the exit something like that at the center it is not necessarily the highest velocity, because of the molecules in turbulence they may be hitting each other in the center more of course, they will hit everything else also. So, maybe part of it is true that near the wall the velocity will be the lowest somewhere you have in the center velocity higher, but not exactly the highest.

And the two halves there will be velocity which may be higher, but this is a good thing for us why is it good thing? Because now filaments will be moving out based on their position in the jet whether they are here they are here, they are here, they are here, they are here. Already the way based on their position they will be moving out at different velocities.

Now why is it important to us that is important because the overfeed which we are giving is constant same for each filament, but if the velocity are different velocities speeds are different. Then this overfeed will be consumed first by such filaments which are moving faster and they will form the loop and after because they were wherever they were and the movement they make a loop the tension in the filament will increase.

So, this filament will try to come to the center of the jet exit because now tense when it is free it moves along with the direction of the flow of air, but when the loop has been formed because whatever overfeed was there for that particular filament has been consumed because move has made a loop. The tailing portion will if it was let us say at this point because its consumed it will push itself down almost to the center.

So, this filament is moved down other filament which has still not consumed its overfeed; obviously, and a much less tension it will flow the air direction of the airflow and maybe move out. So, some filaments which consume their overfeed at given point time there are some other which have not consumed because they were moving at a slower speed. And so, they would start moving out the one which becomes which is consumed completely the overfeed will start coming in the center. So, this thing will happen which we call as a migration.

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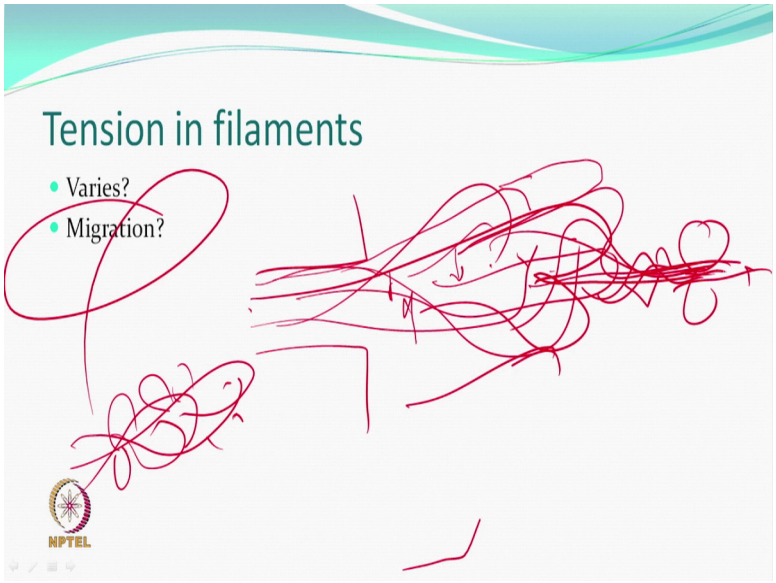

So, tension in the filament will vary because at different point of time different filaments would be consuming their part of the or feed. And so, after consuming the over feed they would become tense and so, they will migrate by mode the mode you migrate entanglement starts happening. So, this filament let us say is moving faster has made the loop, this filament was moving slowly is still there this will like to come down this is still going up.

But maybe at a point of time it will make a loop somewhere there and similarly and so, they will move up, they will go down as the loop formation takes place and so, its quite possible at some stage this exactly moving like this the other one is going up. And so, they are moving and migrating and because they are moving and migrating therefore, you will have entanglement. Some will go to the surface some will be in the core the one off sometime in the core will move out the one which is in the surface will move in and

so, loops also will just be formed where one filament is like this the other one went like that this one goes down.

And so, you will get loops of various types being formed. And everything is happening here because all of them finally, must make a loop and then go from here make a loop and then with the loop go it out of this take a problem it is clear.

Outside the jet the pressure drops the filaments separate filaments are moving at a very high speed compared to the take up roller and therefore, they make loops filaments are not moving at the same speed. And therefore, migration will take place and therefore, entangle will take place; remember now all the three important things are happening outside the jet.

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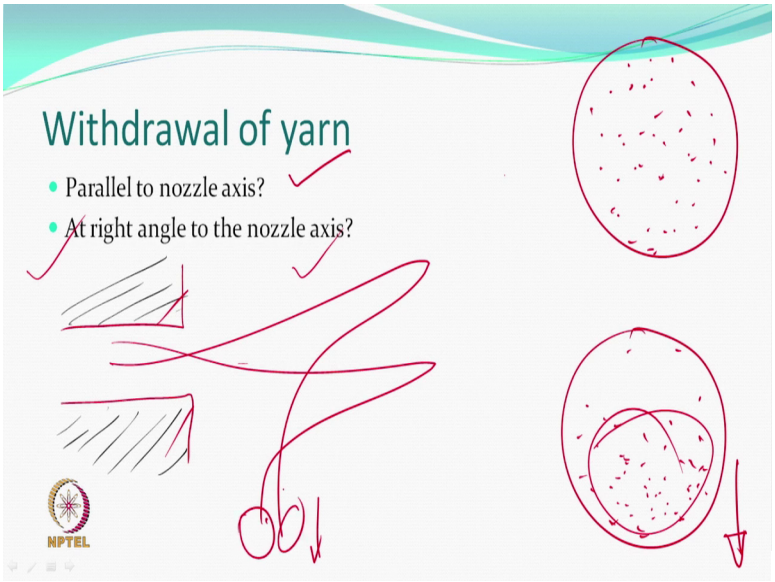

So, as the designs are being discussed people wanted to know is it necessary that the yarn which is coming out at the exit passes through a take up roll which is aligned with the center of this nozzle. This is what is being done the loop still form entanglement we still happen because there is this one is moving slowly. But suppose we change this and make a simple change and say that this is not in a line, but it is actually almost at right angles to the path of the yarn motion.

What happens this one goes like this, but still has to come back some migration may take place this one goes like this and has to come back this one goes up and has to come

back. And obviously, remember this happening in 3 dimensions is not that in 2 dimension is saying either here or there the loop can form whichever waveforms, but the more important thing is the moment you change the direction something wants to move in that direction suddenly pull it down the tension here will be more

Remember we just discussed somewhere if the tension is higher entanglements will be tighter and they could find that if you have the take up at right angles to the nozzle the withdrawal is at right angles to the nozzle exes.

Then you just produce yarns which are of better quality and there is hardly any cost yarn does not mind you take up from user direction you want to make sense simple innovation. So, this is how one can think of let me see if we can do something. So, if we are moving parallel to the nozzle axis withdrawing and if you look at the cross section of a jet then you find the all the filaments have a equal probability of being found in the cross section of the jet without any bias.

Of course, they will be changing their positions and they will be migrating, but I read given point of time you see well there are every part of the thing is approximately filled up with some filament or the other right. But if you do at right angles, so, there will be a bias more filaments will be if you are withdrawing in this direction will be at this point. Some of course, will be here and one or two may be there as well based on what has happened to them, but majority will fall in this region.

So, they are because you are pulling in their one direction. So, in the same direction more filaments will be there because everything is being pulled down. So, migration will still take place because, if they have to first cross and then come if you are moving in this direction is it clear.

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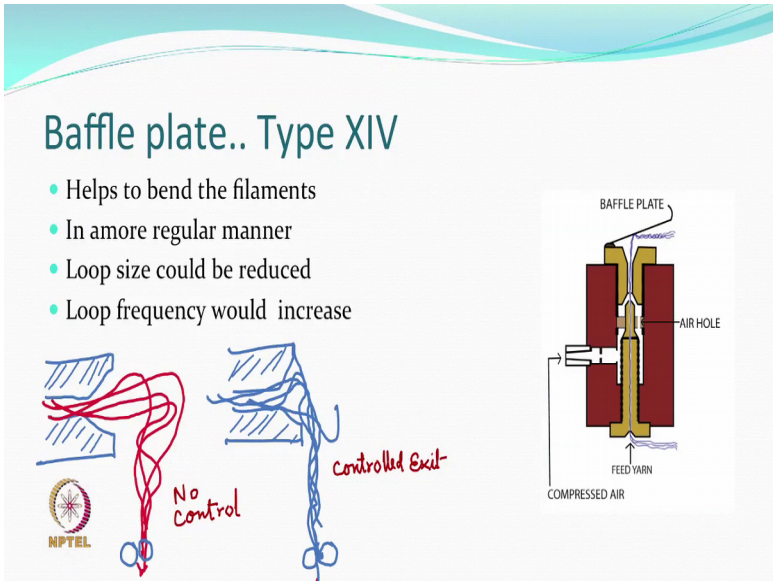

So, if one uses a baffle plate at the end of the exit free hanging let us say a baffle plate what happens of course, the yarn is being withdrawn at right angle. Now if we understand it will strike everything that is there it will strike and has to come down cannot go further it must strike because a hard rigid body.

So, whatever moves goes out this is happening and then it angles. So, it helps to bend the filaments instead of in general earlier the filament was first flying to whichever length and then come back, now it is going to be controlled. So, this plate will filaments will strike the plate and then bend. So, because you see in the direction and also now we have a control. So, if you do this control then it works better, loop frequency will increase loop size could reduce. So, you have higher bulk more entanglement and regular loop size is always good you know you got to have lot of variation in loop size its not such a good idea in any case.

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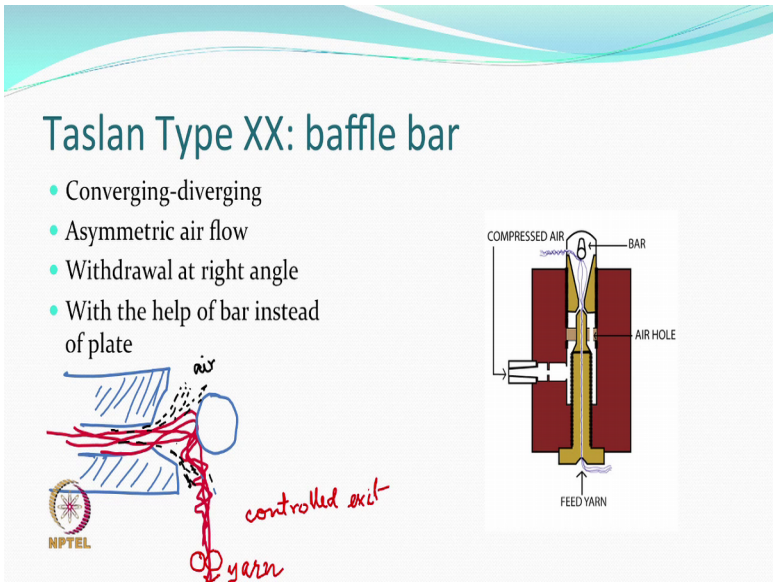

A Taslan XX instead of using a plate at the exit they had a bar which is. So, the air can the one which is excess air is not really doing much the filament you can go strike and obviously, is being pulled down. So, it will come down this one goes it works out; obviously, based on the size look; however, the air will keep moving in this direction or in this direction without any obstruction unlike the one air would be finding it difficult to move in up in this direction it has to follow this path.

So, this additional advantage you can say is aware. So, that is one of the type XX for example, at this kind of a baffle bar this type of a jet was type XIV everything else I mean exam converging diverging asymmetric entry of the air right angle withdrawal and a plate what more.

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After all this research of having too many pieces something which is at the exit that could be changed the feed tube could go in and out. So, that velocities could be change the volume of chamber could be decreased or increased. Finally, some set the all this is not required where you are having everything you having outside the jet, so, why are you doing such a complex design.

So, the concept of single core jet no different pieces is a how would be advantage one of the difficulty levels was in optimizing the parameter is that all these elements in the Taslan could be adjusted like the one who is an operator could adjust a bit change the volume where the interaction is taking place of a chamber and probably the properties could also be changed.

But then depending upon who whether this person is smart or not a little change could make more differences they said why not have a jet where no change is required. So, what do you do if the yarn are differentieren disable you define that if the linear range is this you use this jet if the linear range is this use this type of jet number different numbers.

So, the operator does not have to do any manipulation if operator does not have to do any manipulation then; obviously, its a good idea no change will take place as long as the jet is same one parameter has just been taken care off. And if everything has to take place

outside the jet then why do all the fuss interesting with all this design research this happened.

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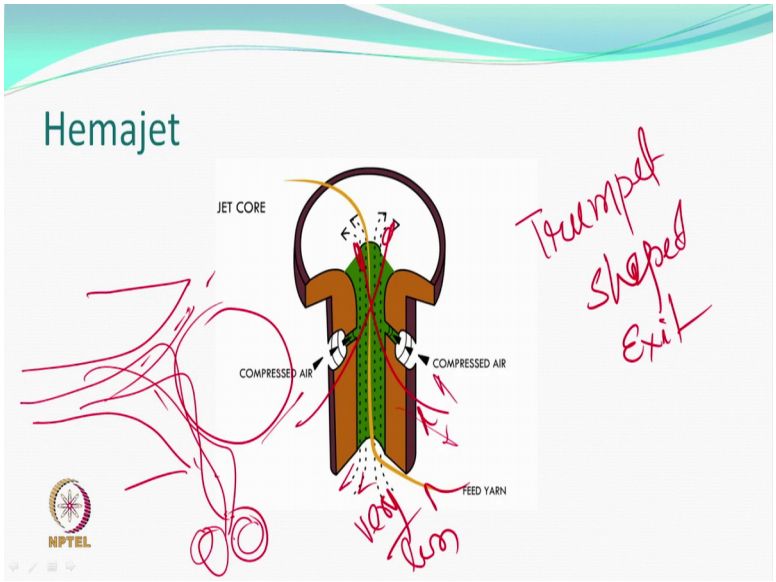

So, one of the interesting jet which came into existence was called the Hemajet. So, a trumpet shape exit air can pass not from one nozzle inside, but can go from two or three, these need not be meeting at the same point another one could be somewhere here also.

So, single core no converging just parallel increase in velocity by more pressures, more nozzles higher denier more nozzle, lesser denier single nozzle and expand in a trumpet shape why trumpet, why this kind of a shape instead of the other one ? Its again controlling the decrease in pressure, but no serious reasons available except well the other conical thing were all patented all angles.

So, you got to have something else, but definitely if you change the shape the length the angle of this trumpet things are going to obviously, be different, but importantly this became very popular because, now you had pressure control systems nozzle could be going 1 2 3 different angles could actually also have a possibility of giving twist or swirling motion also if it helped in any manner. So, yarn could be fed from here a multi filament yarn the air will go from here to here the chances of this going backwards is very less because the angles are pointing in the direction of the exit.

It will also open the loops and then at the end for example, if you have a spear or a blob in front and the take up is here. The filament will strike and come to this take a position and like the other baffle bar other air can go from all sides right instead of a barrio blob or a spare in front of it. So, some change in designs that we had last. So, what have we learnt?

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We have learned the mechanism of bulk development air jet texturing how all the three phenomena happened. The jet design features and importance of converging diverging asymmetric flow, withdrawal at right angles, role of baffle plate or a buffer bar and single core jets, wetting we have understood and this role. So, how these design features have helped in reducing the instability and also consumption affair as we earlier mentioned that compressed air is not cheap you do need to spend money and energy to compress the air. So, the modern jets as we know now have higher speeds at which you can process them at the same time consumption of air also is reduced because you could create higher turbulence higher velocity by changing the jet exit or entry of the air we stop here meet next time.

Thank you.