Science and Technology of Weft and Warp Knitting
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Lecture - 31
Advancement in Knitting Technology

Welcome participant to week number 7. In this particular week we are going to see latest advancement in knitting technologies. We are also going to learn lot of complicated designs that you can create in weft knitting machines. Also we are going to learn little bit about design software where you can simulate the fabric structure before making knitting. So if you see what we have covered so far from week number 1 to week number 6, we have seen simple weft knitting technologies.
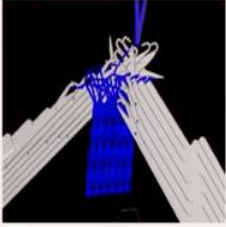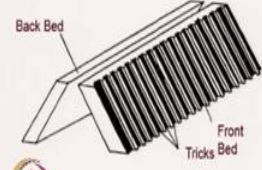
We have seen single bed, we have seen V bed, we have also seen circular bed. You also learned how to make tuck, float on V bed machine and single bed machine. You have also seen the engineering aspect, how you can control the fabric properties by controlling stitches. You have also done lot of calculations related to simple weft knitted structures. Now in this particular week we are moving towards the advancement.

So this particular week will be little bit complicated, so I request all of you to please pay attention because this is the most important week in weft knitting technologies. If you understand this particular week, hopefully you would be able to expect or learn any technologies are any weft knitted structure that you will encounter in your life.

So let's start with the advancement. So before we moved to advancement, we need to understand why there was a need to advance in knitting technologies. Our fabric was being produced on single bed and V bed machines which was manually operated. But why we need to have the advancement in these technologies?

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So let's see that what is the limitations that the V bed machine was giving to us. So if you see in one of the practical I demonstrated you the V bed machine. In the V bed machines, you actually operate the machine with hand. So the moment when you are operating the machine with hand, you cannot reach your hand up to more than 2 meter. So usually most of the manual machine where you are moving the carrier by hand the width is limited and it is up to 1.5 meter or maximum 2 meter.

The other big limitation with manual V bed machine is limited cam speed. Because you are operating by your hand and manually there is a limitation. We cannot move very fast because this is our biological problem. So definitely the speed of these machines are very low. So that's why the production capacity of this machine is limited. The other important thing which you can observe in manual V bed machine is the tension variation.

So whenever you are doing or making a course moving from left to right or right to left, there may be chances that you are doing it at different tension levels. So because it is done by the hand so naturally you can expect lot of tension variation on the machine because of the jerk which can be created because of your hand movement.

So because of the tension variations, the loop architectures might not be stable or you will not get the uniform length of loops in the entire fabric structures. So these are some of the limitations which manual V bed machines are facing in daily routine.

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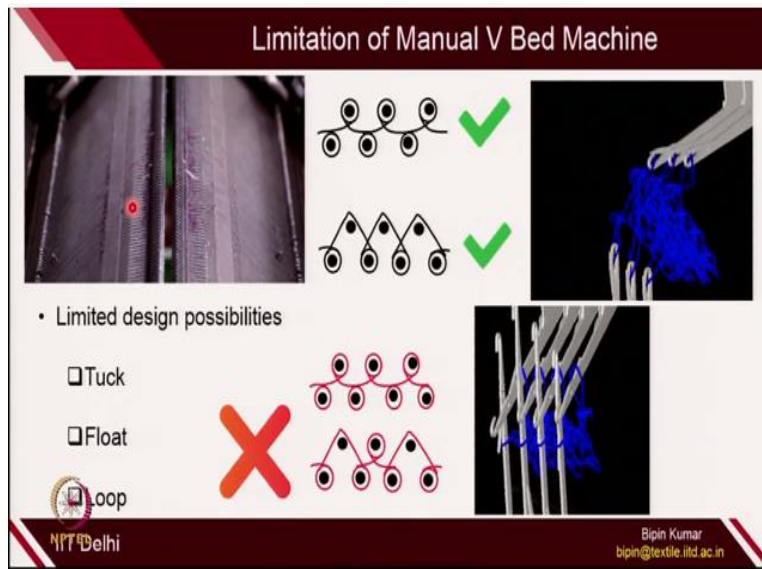
The other limitations which is the most fundamental limitation is when you see a V bed machine, you can make tuck, float and loop on either of the bed. But the problem on V bed machine is whenever you want to make tuck all the needles which is selected on 1 bed will make tuck. When you set the float all the needles of that particular bed will make floats. So it is not possible to create a course where you can have tuck, float as well as loop in the same course.

For example, if you see this machine, this particular course is possible where in this particular course you have loop being formed on the front side and back side. In this particular course loop is being formed on the front bed and tuck is form on the back bed. So if you see the animation in this the front bed is making loop and back bed is making tuck. So this is what you are doing. And in the next course both are making loops.

So these designs is possible where the entire needle of either of the bed can make tuck, float and loops. These are the simple designs. We have also seen Cardigan, double half Cardigan, rib based on the float structure, we have also seen Milano rib, rib ribble all those structures we have

already seen. But let's suppose if you want to create a structure where on the same bed you have tuck and loop, then that is not possible on these type of machine arrangements.

Because when you are selecting a bed for making tuck all the needles will make tuck or loop or float. For example, in this if you see this is the first course where both the loops are being created. In the second course if you see so 1 tuck and 2 rest are making loops. So this is not possible unfortunately on this particular course we cannot make it on manual V bed machines. Because in the manual V bed machine all the needles will do the same operation for a single bed. **(Refer Slide Time: 06:42)**


So ideally speaking if you see there is no possibility for individual needle selections. For example, if you want to create a course where first needle is making loop, second float, third loop, fourth tuck, and then again loop. So these type of arrangement is not possible on a manual V bed machine which is quite popular. Because we have no possibilities for individually control the needle movement.

So all the needles of the same bed will be doing the same functions. So unfortunately we would not be able to create this course. So which is shown in this figure. If you see this needle is not working and this needle is making tuck. So unfortunately this course we cannot make it on manual V bed machine. So this is a problem with manual V bed machine. Other limitation if you can observe on a manual V bed machine is feeder selections.

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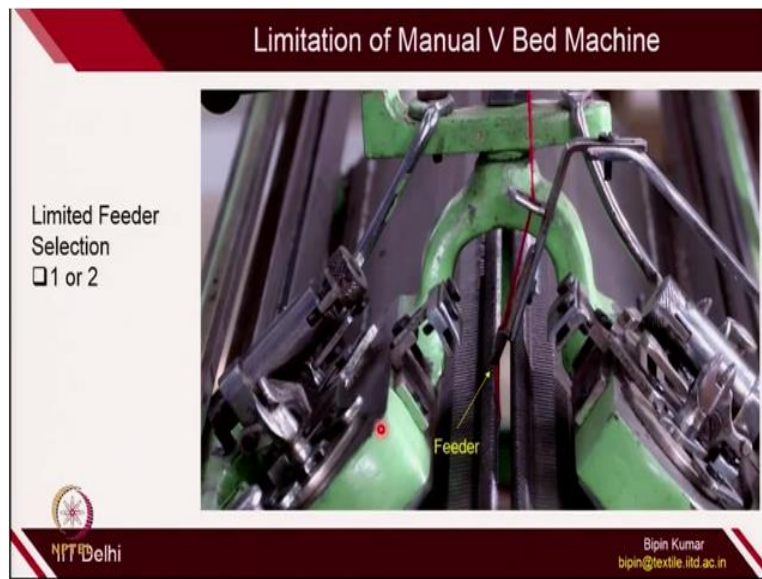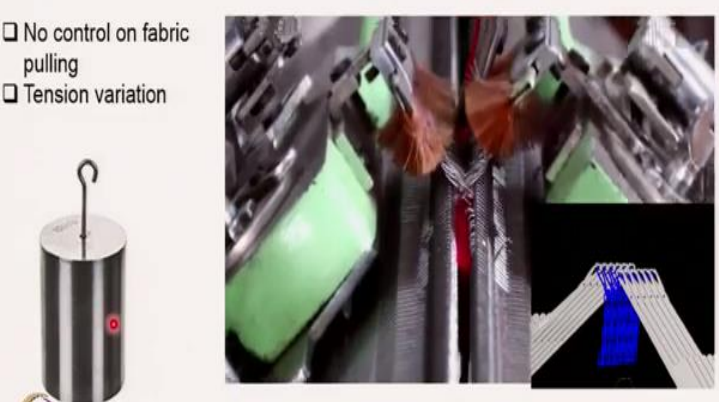
So you have seen the feeder is actually carried by the cam jacket where the feeder is coming and this is the feeder point. And this supplies the yarn in the noodles on the bed. And in normal machine manually operated you have maximum 1 or 2 feeders. So you can play with 2 or 3 colours at max. And we cannot have more than 2 or 3 feeders on the machine. This is again a problem.

Because when you want to play or make something which consists of multiple color of yarns then definitely more feeder is required and which is unfortunately not possible on manual V bed machine.

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The other big limitation is the fabric pulling. So if you see the machine when you are creating the fabric. The fabric is being pulled from the underneath between these 2 beds with the help of dead weight. So you put dead weight here and because of that the tension is pulling the fabric in downward directions. So since the dead weight is applied and obviously dead weight is not uniform.

Because there will be tension variation at different points when you are applying this dead weight in a certain loop. And because of that there may be non-uniform nature of loops on the fabric surface. So these are all limitations in a manual V bed machines.

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And because of that we need to do certain advancements where we can overcome these type of limitations. So in last 30, 40 years many advancement has been done in weft knitting technologies. I am going to list a few of those advancements which play a major role in creating very uniform and very complicated weft knitted structure. Let's focus on some of those advancement.

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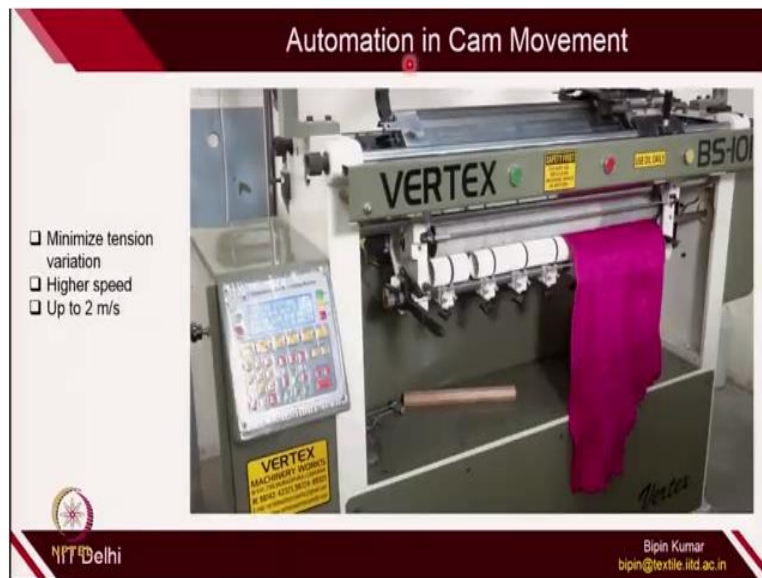
So the first advancement was automation in cam movement. So every manufacture wants limited interference with the operators. Because when there is operator operating the machines, there could be tension variations because of the carriage movement by the hand. First advancement in the machine was done in the automation of the cam movement or the carriage movement. So here you can see the carriage is moving with the help of electronic motors.

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Automation in Cam Movement

□ Minimize tension variation
□ Higher speed
□ Up to 2 m/s

And because of that you have minimum tension variation. And the carriage speed can also be controlled and we can reach up to 2 meter per second. So many thing can be solved because of simple advancement. First of all, this movement will always be uniform. So the tension variations will be minimized the second because it is motor controlled, so you can increase the speed of the motor depending on the requirement. And you can go from slow speed to higher speed.

So the production rate can also be manipulated in the reality. So automation in the cam movement is really important from the production point of view and from observing uniform fabric production. So automation is very-very needed.

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Multiple Feeder Selection

❑ Up to 30 carriers

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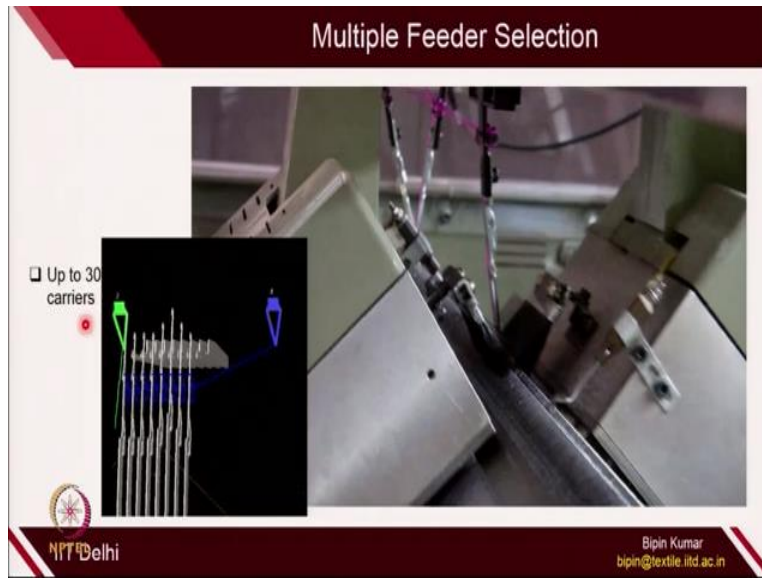
The second big innovation was done because the automation is already there. The carriage can move left to right and right to left with the help of motors. The other advancement that which could be very useful in daily routine is the feeder selection. So the carriage can automatically select any feeders depending on the design of the fabrics. So you can have up to 30 carriers which could be standing either on the left side or right side of the machine and the carriage can pick any of the carrier depending on the requirement of the fabrics.

So here I am in a simple video you can show here it is catching the yellow yarn which is being formed here. The course is being formed with the yellow yarn. Now it is carrying the purple yarn. So you can see anytime any carrier can be choosing by the cam jacket or the carrier. And you can play with the design. So multiple feeder selection is another big advancement in this weft knitting technologies which was not possible on the manual bed.

Because on the manual bed hardly 1 or 2 feeders was there and every time operator has to choose which feeder has to operate. So here also you can see the animations you can the feeder is green one. Next course feeder is the blue one. So blue yarn is being provided again green yarn will be provided. So any course, any feeders can be selected from left side or right side of the machine depending on that fabric design.

So lot of flexibility will come in the designing aspects using this type of technologies. And you can have up to 30 carrier. So you can imagine you can play with 30 different colours of the yarn at the same time and you can give the command to the machine and the machine will automatically choose the respective color in the respective course. So which is shown here.

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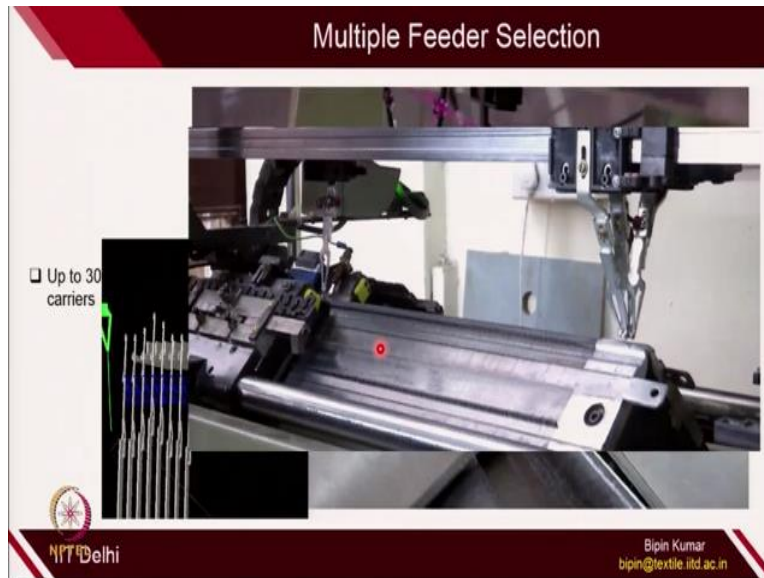
So you can see here on the machine, this is a simple photo of the machine which is there in our lab. And you can see there 4, 5 feeders on 1 side and this is the cam jacket. So the cam jacket can come this side and it can pick any of these feeders and it can carry the yarn for the course development. So definitely feeder selection was also very important. It gives you lot of flexibilities in making coloured fabric samples okay.

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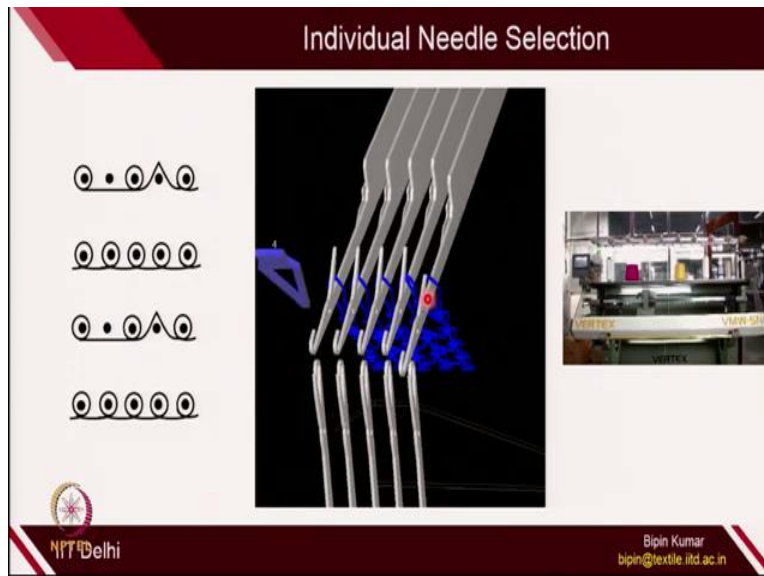
Now the most important one is the individual needle selections. So you have seen in a manual V bed machine or single bed machine which we have demonstrated in lab demo 1 and lab demo 3 where you can either set the needles in loop position, tuck position and float positions. So all the needles of a particular bed will do only 1 operation at a time in a entire course. But if there is a provision of individual needle selection, so you can choose whatever stitch you want to create in any particular needle then there will be unlimited design possibilities.

For example, here you can see the first course is making all loops on the bed. The second course, the first noodle is making loop, the second float, third loop, fourth tuck, fifth again loop. Third course all needle are making loops. Fifth course 1 needle loop, 1 float, loop, tuck and loop. So on the same bed in the same course all stiches is possible. So this is only possible because of individual needle selection.

So you can see here on this machine you can see the first course all loops has been formed. In the second course you can see the second one is not raised. So it is making float and this one is making tuck. And in the third course all are making loop. In the fourth course you can see here again the second needle is making float and this needle is making tuck. So on the same bed any needle can be selected for making any type of stitches.

So this is really very smart and innovative achievements in the field of weft knitting technologies. And this gives you lot of freedom to the fabric manufacturer to play with any designs at any location.

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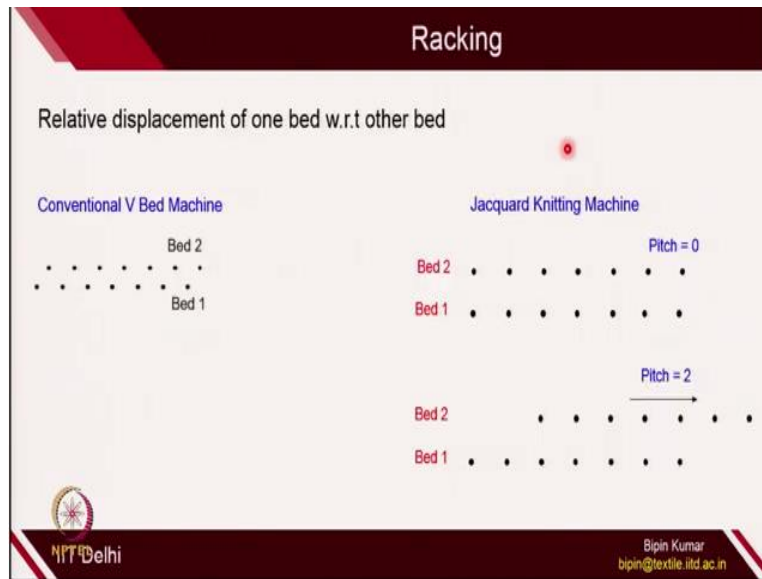
So the other big advancement in weft knitting was racking. So racking is actually relative displacement of 1 bed with respect to other bed. So if you see manual V bed machine conventional V bed machine, your needles are placed in the form of rib gating. If you remember the gating, gating represents the placement of 1 bed with respect to other. So here the bed number 1 and bed number 2 are placed in such a way that they are half pitch.

The 1 bed is moved relatively half pitch with respect to the opposite bed. So which you can see it here. In this way you can make the rib design. In advance knitting machine there is a possibilities that you can shift any of the bed with respect to the opposite bed and you can create whatever design you want. So for example if you see here the beds are facing each other. In this particular point, the bed 2 are actually shifted by 2 pitch. It means it has shifted by 2 needle points.

So this is pitch number 2. So these type of arrangement was unfortunately not possible on manual V bed machine. But in advanced jacquard knitting machines there is a possibilities that we can shift any of the bed especially back bed is shifted most of the times with respect to front or back bed. So this is called racking.
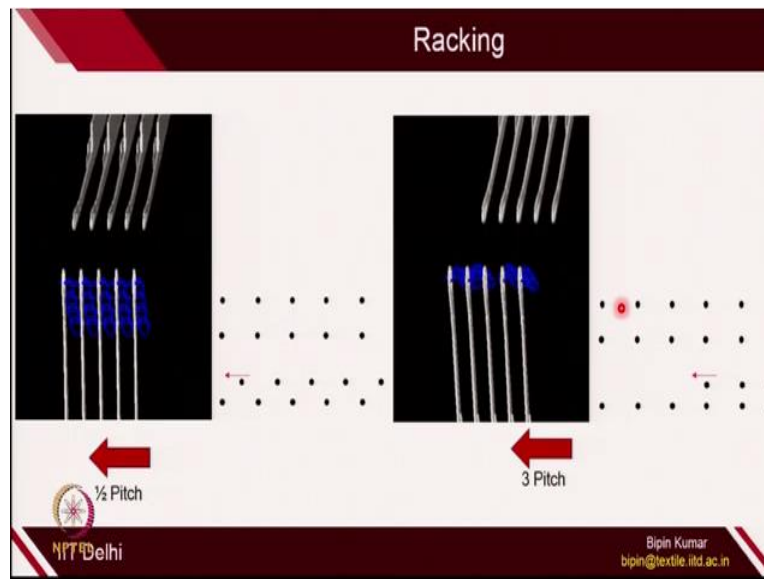
You can see here there is a small videos where you can understand what do you mean by racking. So here if you see this needles have placed in the rib position. So this is half pitch. So you can see here the bed are shifting half pitch on the left direction. So first course the beds are needles are placed in with respect to half pitch. And in the second course the back bed is shifted by half pitch.

So at this point the needles start facing each other for both the beds. If you see the other video here the needles are moving 3 pitch. So you can see here the bed is actually shifting 3 pitch. So on the left direction. So here the back bed is away from the front bed up to 3 needles position. And in the second course the back bed is actually moved from right to left and it is facing each other. So the racking is possible on some advanced machines especially jacquard knitting machines is the most popular where racking function is already given for the fabric development.

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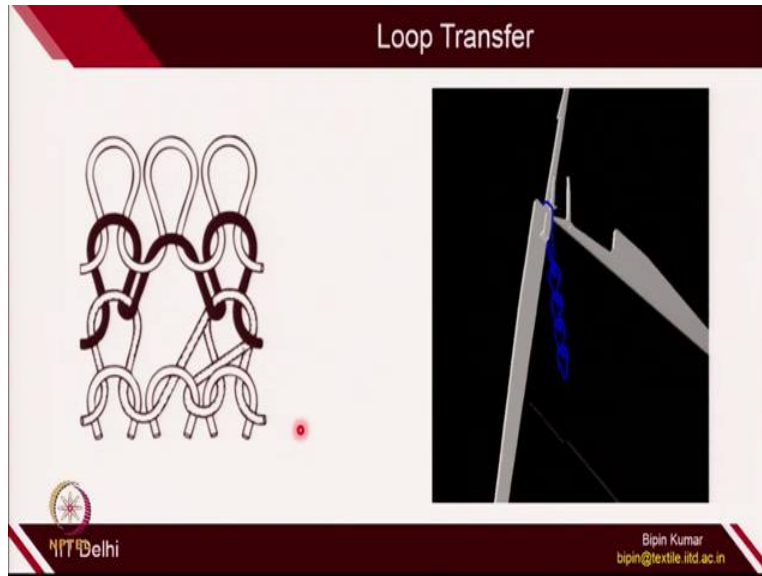
The other innovation was the possibility of loop transfer. So loop transfer is nothing but when you are transferring the loop from 1 bed to other bed. So here you can see 1 of the needle from front bed is shown to you and back bed is having no loops. So you can transfer the loop from 1 bed to other bed. So you can see here. So the needle raised and then the loop has been shifted from front bed to back bed.

So this is how loops can be transferred. So in 1 of the lecture especially when I was discussing about purl fabric development. I introduced you this functions loop transfer where you can transfer the loop from front bed to back bed and then you can make the loop. Again you can transfer the loops from back bed to front bed. And if you can continue doing that you can create purl fabrics on V bed machine.

Also loop transfer can be very useful when you want to shift a loop from 1 column to other columns. If you see here the second column loops which were supposed, so this loop was supposed to make interlacements with the top loop. But unfortunately this loops has been shifted from second column to third column. So loop transfer is very fundamental function which gives you lot of design possibilities. So for example if you want to actually see the animation of how these loops has been created.

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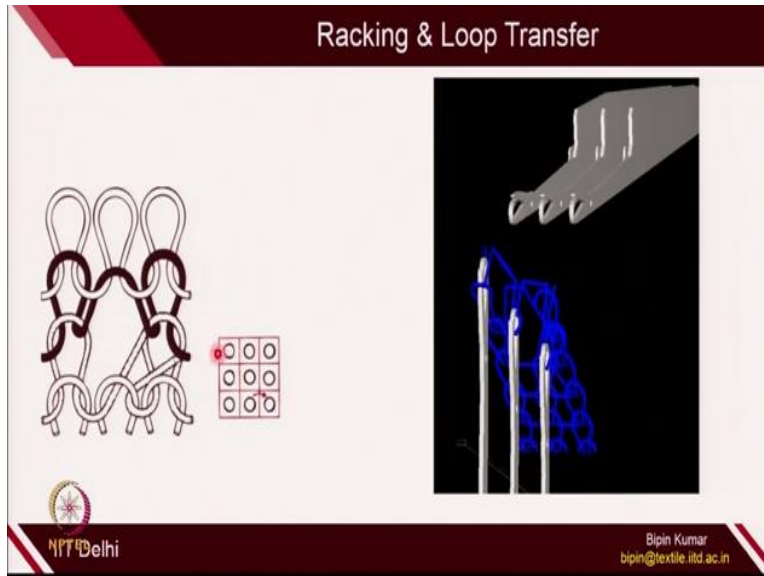
You can see it here. So in this first course if you see, so the second loop is actually transferred to the next column okay. And then you have created another 3 back loops and another 3 back loops. So this animation is shown here, so you can see on this. So first the front this loop is transferred to the opposite bed and this bed is actually racked.

So racking is the sifting of bed. And then this loop is transferred again to the next column. And next you are making this black row. So you can see here and again you are making another course. So in this way you can see a very beautiful hole is created in the fabric. So once I will cover the design aspect. I will talk about more loop transfer property on a particular machines. But at this moment you can imagine this loop transfer is very-very important from design perspective.

Unfortunately, on a manual V bed machine these type of function is not there. So in advanced knitting machines you can have the possibility of both racking and loop transfer together to create whatever design.

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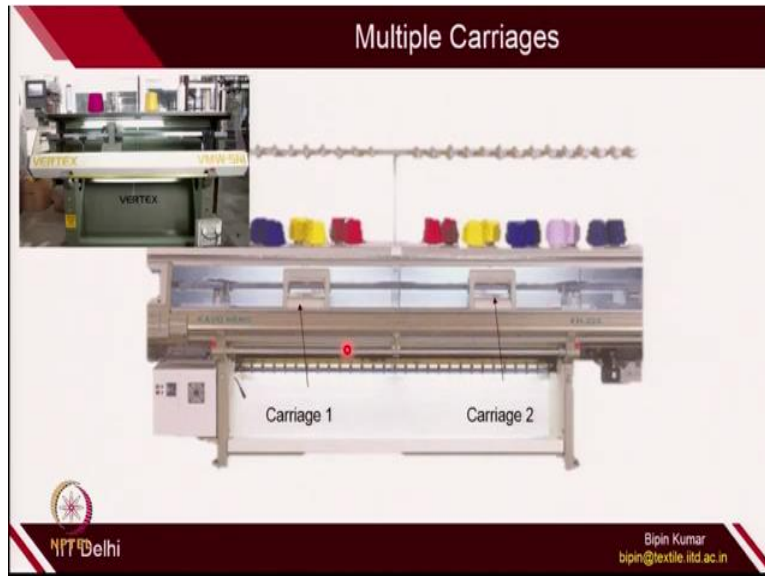
The other innovation from the productivity point of view is the number of carriages. So on 1 of the machine I just showed you the videos. So here 1 carriage is moving okay. Some portion of the bed is not working at all. So if you want to increase the productivity, you can play with multiple carriage on the same bed. So 1 carriage will be making 1 set of the fabrics, other carriage will be making other set of the fabric.

So in this way the same machine the productivity can be doubled. Because you are having possibilities of 2 carriages. So up to 3 carriages you can observe some of the machines in realities the most popular one is the single carriage machines but double is machine is also getting more and more popular when productivity is very important from company point of view.
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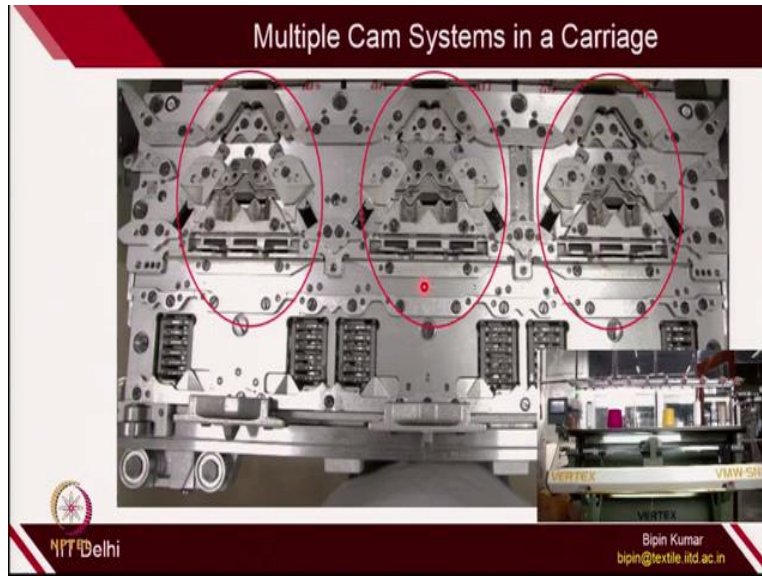
Now let's move to the multiple cam system in a carriage. So if you see this particular bed you have 1 carriage and in 1 carriage you can have 3 cams. So if you carefully see this cams looks like similar arrangement as I have shown you the V bed machine. So 1 cam system so once the carriage is moving, this can be activated into loop, tuck and float position. The other carriage system can also do that.

And the other cam system is also doing in the same course. So basically in 1 go there are possibilities of 3 cam system in a single carriage. So what is the benefit of having 3 cam system on a same carriage. This will increase you the productivity and this will also gives you lot of flexibility in terms of design. I will show you some of those videos.

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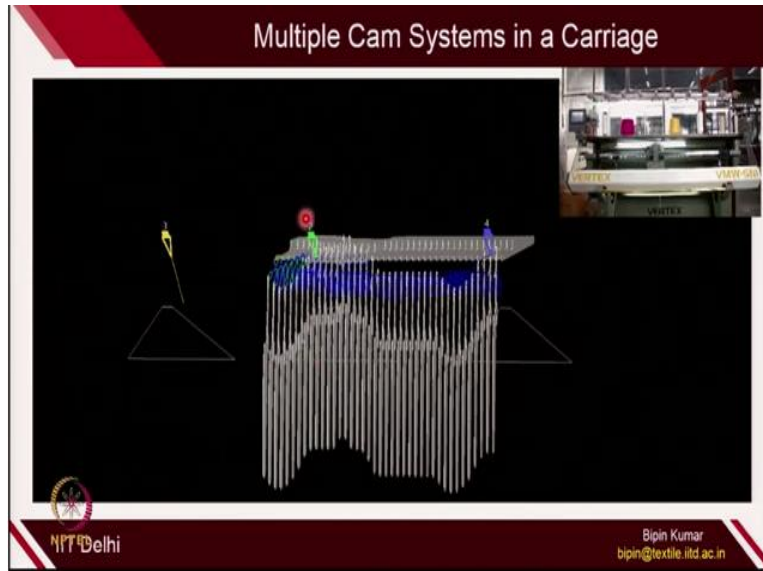
For example, when you have 3 carriage candidates system in 1 go, when you are going or taking the carriage from 1 side to other side you can simultaneously create up to 3 courses which you can saw it in this video. So the first carriage is carrying the blue yarn, second cam is carrying the green yarn, third cam is carrying the yellow yarn. So each cam has the flexibility to play with any of feeder arrangement.

Because it can operate or do the needle functions depending on what setting you have done on this cam system. So in 1 go when you are going from left to right you are actually creating 3 course simultaneously. Because you have 3 cam system and each cam system can make loop, tuck and float. So once the blue cam system completed its function, the needles are free and then the second cam system starts making the loop, 1 second done.

Then those needles become free for the third cam system and then this way you can create multiple courses by 1 traverse movement. So once you go from left to right simultaneously you can create 3 courses. So in this way you can imagine the productivity can go 3 times with the same time interval. For example, if you see this video the carrier is moving from left to right or right to left.

But ideally speaking this carrier is making 3 courses in 1 go so because of 3 cam system. This was some latest developments in the knitting machine. So whenever you go and check the

specifications at least you can imagine and relate what are the possibilities and what are the potential of that particular machines.

So I am going to list some of those specifications. So this is very important if someone wants to start a company or if you, if someone wants to learn the technologies, you should be knowing what is the potential of these functions and what actually it indicates. So I am listing one of those specifications from 1 of the jacquard machine. So I found this in one of the exhibition when I visited.

They were giving these types of specification. So initially it was difficult for me to understand these specifications. But once you have understood all those videos which I have just showed you. You can relate what those specifications mean for a particular knitting machine.

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	Machine Specifications	
GAUGE	3G, 3.5G, 4G, 5G, 7G, 10G, 12G, 14G,	
KNITTING WIDTH	90" (37" X 2), 100" (42" X 2).	
CAM SYSTEM	Double System, Twin Carriage. (2 + 2) Knitting System Three-Way Technique And Transfer With Split Stitch Function.	
KNITTING SPEED	Max. 1.2m/Sec. Knitting Speed Varies According To Gauge And Knitting Condition.	
YARN CARRIERS	32 Yarn Carriers On 8 Double Rails.	
NEEDLE SELECTION	Full Jacquard Selection Via Special Solenoids.	

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So let's start with the machine specification. So when you go and meet any supplier who sell knitting machines, you can look at those specifications. So its very important that you understand these specifications and their meaning. So the first specification is the gauge which I have already introduced you. So when you go, the supplier can have multiple options for you. It can provide you 3 gauge, 3.5 gauge, 7 gauge, 10 gauge, 14 gauge.

In some machines we can also go up to 50 gauge. So this gauge means number of needles per inch which I have already introduced in one of the lecture in previous weeks. Knitting width depending on the productivity you can decide what should be the size of the bed whether it is 90 inch or whether it is 100 inch. You can also go for 50 inch if you want a sample size machine. So that possibility is also there.

So width indicates what is the operating area on which you can develop the fabric on the machine. The third one is the cam system which I just introduced you. Double system means it has 2 cam. So at a time 2 feeder can be taken by each of these cam system and twin carriage I have already shown you this twin carriage system. So where if the bed size is much bigger so you can have 1 carriage operating on 1 side of the machine and the other carriage operating on other side of the machine.

And in each of these carriage you can have 1 system, 2 system, 3 system. So 3 system I showed you the video. Single system you have already seen. So and twin carriage so if a machine is having twin carriage with 3 system it means in 1 go you can produce 6 courses. So that is the benefit of having multiple system and multiple carriage. The other thing is knitting system with 3 way techniques.

So 3 way technique means like each of these cam system can be set into loop or tuck and float setting also transfer with split stitches. So also there is a possibility to transfer the loop from 1 side to other sites. This is the meaning of loop transfer. Knitting is speed, we can have the speed from 0 to 1.2 meters per second. We have also seeing this machine, which is going up to 1.5 meter, 2 meter per second.

Knitting speed definitely varies with the gauge and knitting conditions. But naturally this whenever you go for automation in the knitting technologies the speed will be always higher than the manual speed. So this is also you need to take care. If you want very high productivity you must check what is the maximum speed of the machine. Yarn carriers, so 32 yarn carriers on 8 double railings.

So railing is there on which the feeder rails actually moves and you can in each of these feeder you can fit up to 32 yarn carriers. So you can imagine you can play with 32 different colours of the yarns at the same time. Needle selection, full jacquard selections with special solenoids. So I have also shown you like in some of the machines you can expect like you can play and set individual needles to any setting.

So in the same course you can set some needle in the tuck, some needles on the front, some needles on the loop, some needles will be doing transfers, so anything can be selected. So any design on a particular needles can be set on these type of machines. Transfer, the other specification is transfer.

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	Machine Specifications
TRANSFER	Simultaneous Transfer, Front Or Back, Independent Of Carriage Direction.
STITCH DENSITY	30 Levels Independent Selection, Electronic Control With Stepping Motor 00-230 Steps On Each Level.
RACKING	Racked By Servo Motor And High Precision Ball Screw System (up to 5 pitch) Racking 1/2 Pitch Also Available From Any Position.
FABRIC TAKE DOWN	Main Roller / Sub Roller : 32 Levels Changeable Speed, Automatically Adjustable On Each Level. Sub Roller With Automatic Opening And Closing.
STOP MOTION	Yarn Break, Knot, Press Off, Needle Break, Shock, Over Torque, Piece Count, Over Run, Program Error Etc.
TOP TENSIONS	Electronic Top Tensions Easy To Thread The Yarn Through. Large Knots Cause Machine Stop. Small Knots Cause Slow Speed Then Automatically Resume At Set Speed.
YARN FEED UNIT	Auto. Positive Feeding Device On Each Left And Right Side.

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You can also see whether it is having the transfer functions whether you can transfer the loop from front to back or back to front. That is independent of whether you are moving from left to right or right to left. Stitch density in manual V bed machine, I have shown you a stitch density level from 0 to 10. In some machines especially in jacquard knitting machines, you can have 30 levels of independent selectors.

So you play with the stitch density and you can control with the loop length. Racking, racking already I have introduced up to 5 pitch so you can shift the 1 bed with respect to other bed up to 5 pitch. That is really wonderful. Also there is a possibility to rack half pitch and we will come to

design aspect and you can see how racking was very important when you are transferring the loop from 1 column to other column.

So racking is definitely one of the very important functions. Fabric take down, so instead of putting the dead weight, you can have roller controlled, mechanically controlled, fabric pooling. So this is a positively controlled fabric pooling. In this way you can expect very uniform tension in the fabric and the surface appearance of the fabric will be very uniform. Because all loop is experiencing the same level of tensions.

Stop motion, there are lot of stop motion. For example, if the yarn breaks the machine will automatically stop. If there is a knotting in a yarn it can take care, press off. Needle break, if the needle breaks the automatically the machine will stop. So all those things there are a lot of stop motion and auxiliary emotions are provided on advanced knitting machines. Tension control, so the next one is tension control because the yarn is being pulled from the bobbin.

So you can control the tension. Also there are lot of tensioners which is there on the machines which take cares of the unwinding zone. So that the yarn whenever you pull from the bobbin, the tension in the yarn remain same. So that you can observe the same level of loop formation. Yarn feed unit, so also you can positively control the yarn feeding to the machine during course development.

So these are the some of the specification. There are almost 30, 40 specifications are there. But these are the some important one. So whenever you go whenever you encountered any machines, you can relate these specifications and you can expect what is the potential of that machines. So that is the main goal of this particular lectures. Advancements are unlimited and in just 1 lecture I would not be able to complete all the advancements.

But these are some crunch of the specifications which is always there. And if you want to buy any particular machines, you first fix whatever specifications you need and then you can go and negotiate with the dealer. So with this I stop here. In next class, I am going to take you to the

knitting world where you can play with any design which is possible on advanced knitting machine.

So I have in my lab one of the advanced machines from SHIMA SEIKI where you can actually play with any designs. And in that machines I have the fulfilment of most of these specifications. So once I have all the specifications on the machines, I can make any fabric design. So which I am going to introduce you in next lecture. So stay tuned. Thank you very much for the listening.