Science and Technology of Weft and Warp Knitting
Prof. Dr. Bipin Kumar
Department of Textile Technology
Indian Institute of Technology - Delhi

Module - 2
Lecture - 5
Automation in Loop Formation

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Welcome participants. Now we are going to move in week 2, the first lecture. We have named this lecture Automation in Loop Formation. Before I move, let's first revise what we covered so far in week 1. So, in week 1, we come up with the basic definition of knitting, which is process of inter-looping of yarns.

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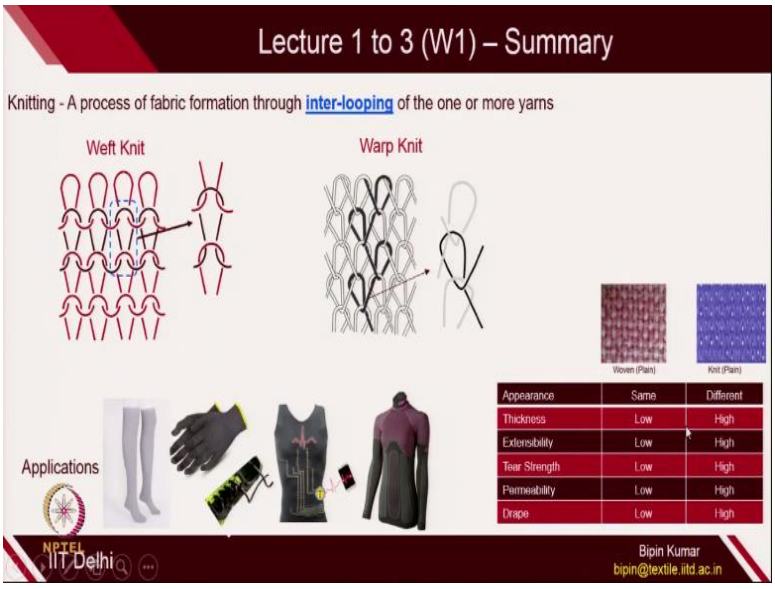

So, we saw what happened; how the loop interacts inside the fabric structure. We come across 2 categories of knitting, one is weft knit and another one is warp knits. So, warp knit, we will going to cover later in this course. We also saw some of the application potential of knitting, right from the hosiery and garment. We can also go for hi tech end applications like wearable technologies, protective gloves, agriculture, sports. Last week also, let you know what is the basic difference between a plain fabric and a knit fabric, some of the basic differences in these 2 structure.

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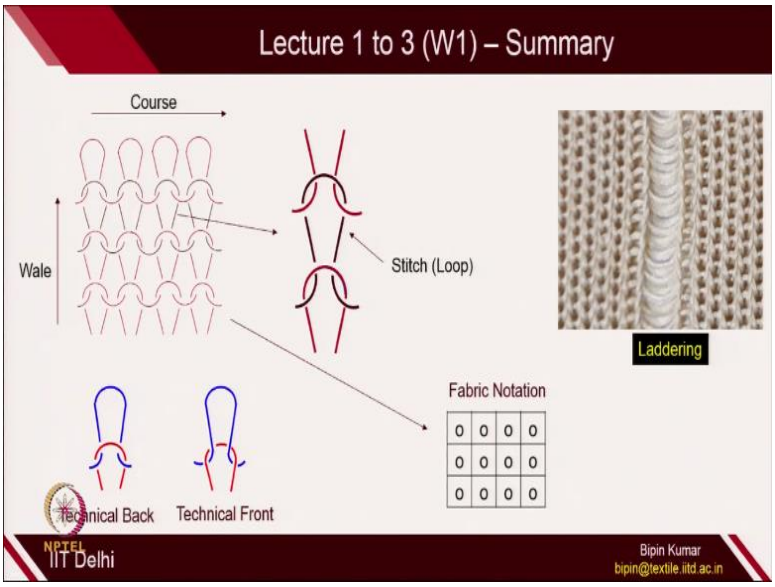

In last week also, I gave more emphasis on the intermeshing's. So, how loops are intermeshed inside a basic weft knit structure. So, you can see here, the head is interacting with the, loop is interacting 2 times at the head location and 2 times at the foot location with the old loop. We come across some of the basic terminologies which we used in knitting. The first one is the course, which is the series of loops in horizontal direction.

Wale, it is the column of loops in vertical direction. We also give more emphasis on technical back where you make the loop on the back side of old loop. Technical front, where you make the loops on the front side of the old loop. We also let you know about how we can denote the entire fabric structure by a simple table diagram. So, here you, all the loops are on the technical backside.

So, you can simply represent 0. There are 4 columns and you can represent this fabrics very simply with the help of table notation. We also let you know the importance of intermeshing. In case, if we lose any 2 interesting points of a particular loop, there could be problem of

laddering. The entire loops will just open up, if any loops break inside the fabric structure. So, laddering is the, one of the key issues in case of weft knit structure.

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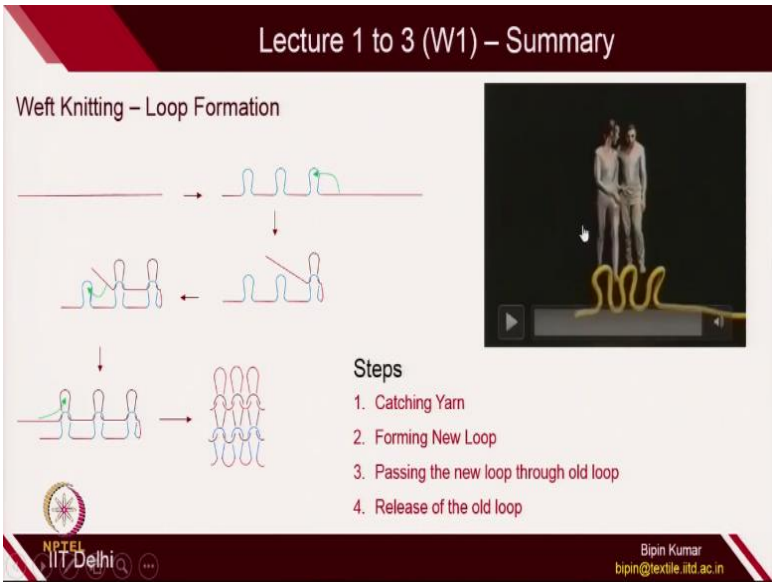

Apart from that, I also give you the indication of how we make a knit fabric structure. We start from the single yarn and then we create loops. And then, we start making new loops individually and adding to each of these columns one by one. A simple videos is very helpful in understanding what is exactly **(Video Starts: 03:24)** happening. So, you can see here. This, we first created a series of loops.

And then, you catch new yarn, make a new loop and pass through the old loop. So, you are catching new yarn, making new loops, passing through the old loop. Catching the yarn, making loop, passing through the old loop. Now, the same process is repeated from the other side. So, you catch the yarn, you make the loop and pass through the old loop. Then again, you do the same process. You catch the yarn, make the loop and pass through the old one. This is how, in general, the loops are being created inside a knit fabric structure. **(Video Ends: 04:07)** Okay.

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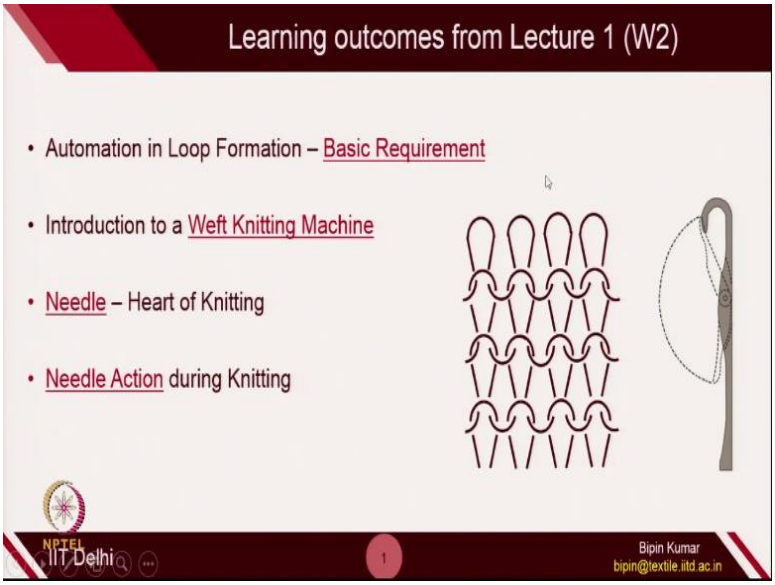

Now, comes to the today's lecture; what we are going to learn in today's class. First of all, we want to learn about the automation; why there is a need for automation; how we can automate the process of hand knitting. I am going to introduce to you the basic weft knitting machines which is widely used across the world. And also, we are going to learn about the most important element on a knitting machine, which is the needle. So, needle is called the heart of the knitting. So, I will give more emphasis on understanding the needle functions and the actions during the loop formation inside the knit structure. Okay.

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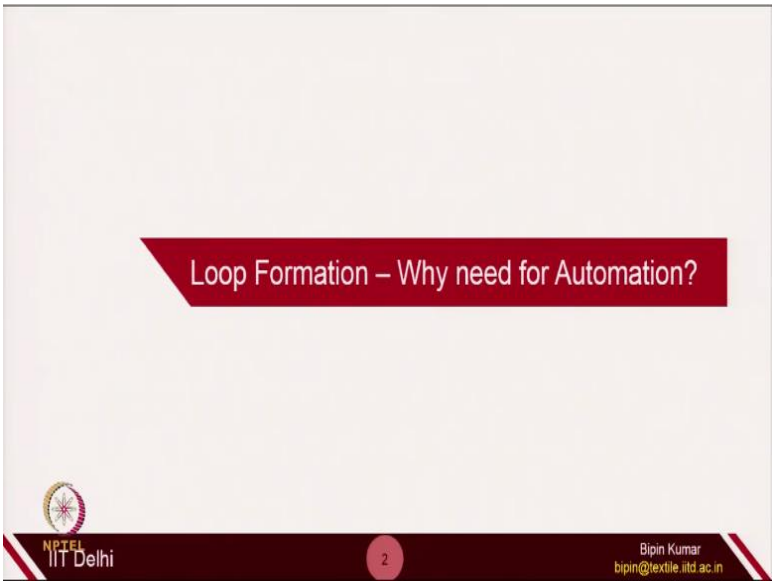

Let's start with the first fundamental questions. Why there is a need for automation of loop formation? Why we want to automate this process and why there is a need? What is the problem with the existing hand knitting process? So, before we move to that, there is one

fundamental aspects we need to understand. If you remember, I showed you 2 videos in the week 1, where you can create a column of loops.

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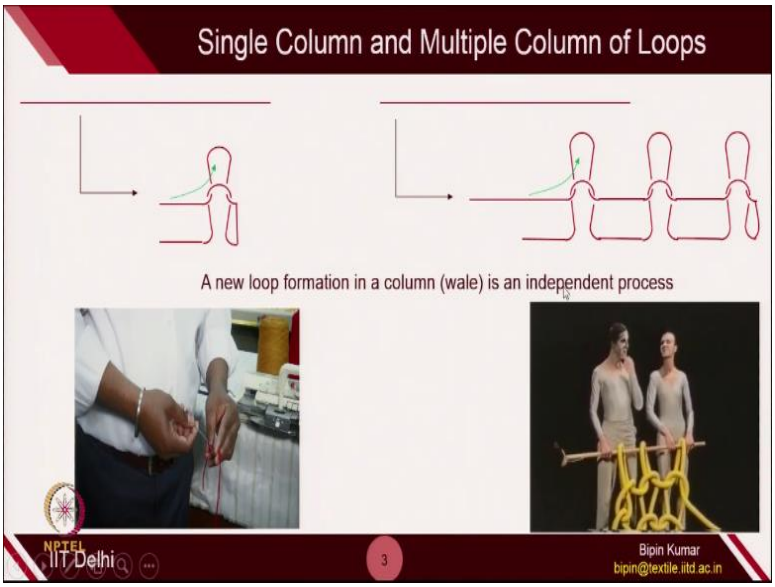

So, **(Video Starts: 05:16)** the first videos, our technicians were showing you how we were creating the loops in the same column. Okay. And the second videos which is the showed in detail in the last few slides, where you were creating loops one by one in each of these individual columns. So, the take away from these 2 videos are: whenever we are creating new loops, that new loop is only getting added with that particular column.

So, a new loop formation in a column is completely an independent process. So, I really want to give more emphasis on this particular word, a independent process. So, whenever we create loops in a column, other loops are not interacting with that loop. So, they remain idle. So, the process of loop formation in a column is a purely independent **(Video Ends: 06:14)** process.

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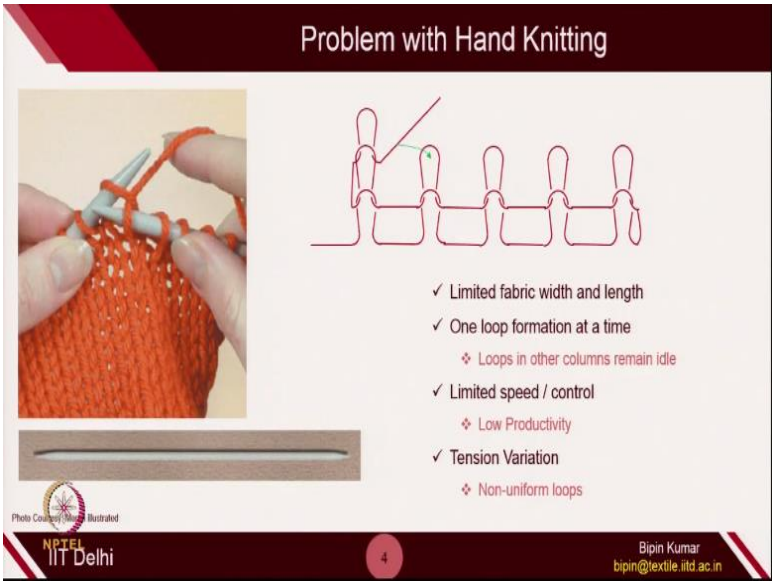

So, now comes to the problem of hand knitting. So, you have seen many ladies used to do weft knitting in Asian countries, where they use needle bars and they create loops from left to right and right to left, one by one. The process is almost similar what you have seen in the video. So, you create loop and then add in a particular column. The big problem with this hand knitting is, it has limited fabric width and length capabilities, because our hand is very limited, right.

So, we cannot create a fabric more than 2 meter of length, because it is very difficult to work or control the entire bigger length or width of the fabrics. Both, we cannot create bigger length, we cannot play with wide fabric; that is the big limitations of the weft knitting using hand. The other big problem is, we are doing loop formation one at a time. So, for example, in this photos, you can see; once the loop is being formed in the first column, now the second loop is getting formed in the second column in this series.

So, ideally speaking, the columns of loops remain ideally except the one which is being used. So, because of this, the production speed is extremely limited. So, we cannot have very high productivity, because we only interacts with one column at a time. Other big problem with hand knitting is tension variation. So, since we are doing it by hand, for any reason, if you do not give sufficient tension to the yarn, we can have different length of the loops.

For example, if you do not pull the yarn properly, then that loop length will become low. If you, let's suppose, if you pull the yarn too much, then that loop will become very big. So, in this case, there is a high chance, because we are doing it manually. And there could be

problem of tension variation in the yarn during fabric making process. So, the surface of fabric could be disturbed because of tension variation. So, to overcome these challenges, there is a need for mechanization.

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So, automations, we call it automations. So, how we can achieve this automations? In the last 2 slides, we also give more emphasis on, like each of the loop formation is highly independent. So, what we can do for the automation is, we can control the loop formation in each columns by separate entity. And that entity is called a needle. So, instead of controlling the fabric formation by 2 bars, we can have multiple number of needles for the number of columns which is there in the fabric structure.

How this will be helpful? Because, each needles will support each column. Obviously, if you have 1000 needles, 1000 needles will support in 1000 columns. In this way, we can achieve very high width of the fabric. Also, movements of needles are independent. So, if we can control the movement of each needle precisely, there is a less chances of any tension variations and we can get more uniform fabric structure.

So, this entire process of knitting will become more and more simpler, if we play and start controlling the individual columns of the fabric. Apart from these tension control and controlling each column, the big advantage of this process is: Now, since each of needles is independent, their movements are independent; so, we can, we do not have to make any particular needle idle all the times.

It is possible that all the needles can operate simultaneously. Apart from, like contrast to the hand knitting where you were just making one loop at a time, other columns are not doing anything, but in this process, it is possible that all needles can operate simultaneously. So, naturally, the production will go multi-folds.

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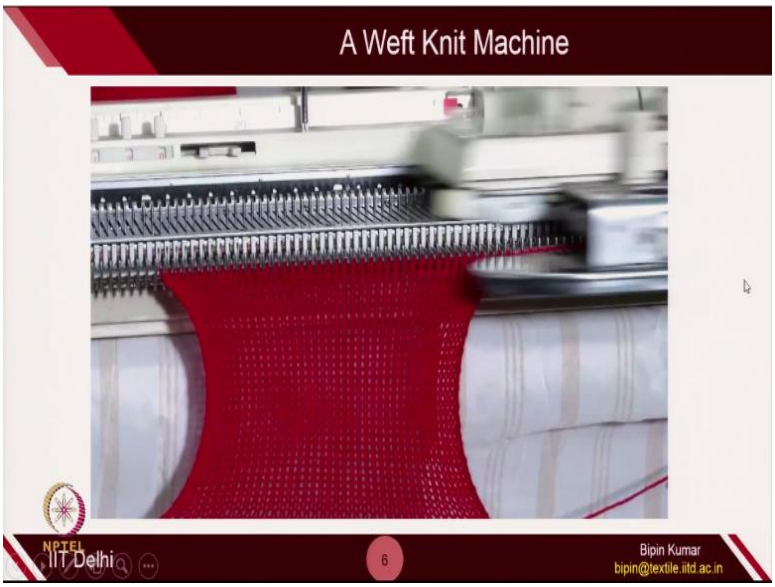

This is the simple video of a weft knitting machine which is there in our lab. **(Video Starts: 10:35)** Let's see how it is being used. So, you can see in within a second, you are generating like more than 20, 30 loops. So, this is the fabric which is being pulled out from the bed. And you can see all of these columns of loops are being controlled by each individual needles. So, this is the simple machines on which we make knit fabrics. Let's go detail on the machine **(Video Ends: 11:05)** elements; what exactly is there on this particular machines.

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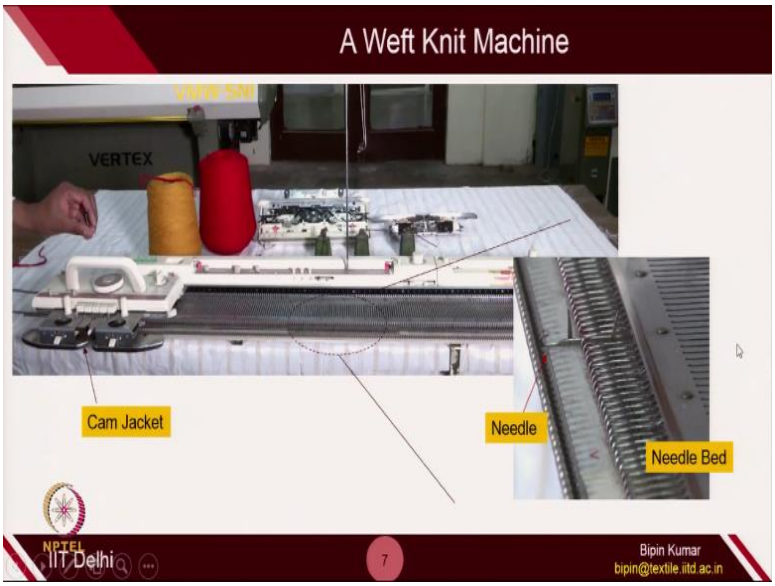

So, this is the weft knit machine and there are 2 primary elements which is very useful in knitting process. The first one is the needle bed. So, you have the needle bed here. So, you just enlarge this segment of the bed. So, you have the needle bed. On this needle bed, a needle is placed in sequence, in series. So, 1 needle I have projected out from, on, from this bed which you can see here.

This is the needle which is being placed on the slot which is there on this bed. So, this bed will have almost 200 slots. And on each slot, we are placing 1 needle at a time. So, we could place 200 needles. The other thing is the cam jacket. So, this cam jacket basically helps to pull out this needle, make this needle move forward or backward with respect to the needle bed. So, the cam jacket is the one which was doing the reciprocative movements from left to right and right to left. Okay. Because of this cam jackets, this needle was coming out and going inside in the needle bed.

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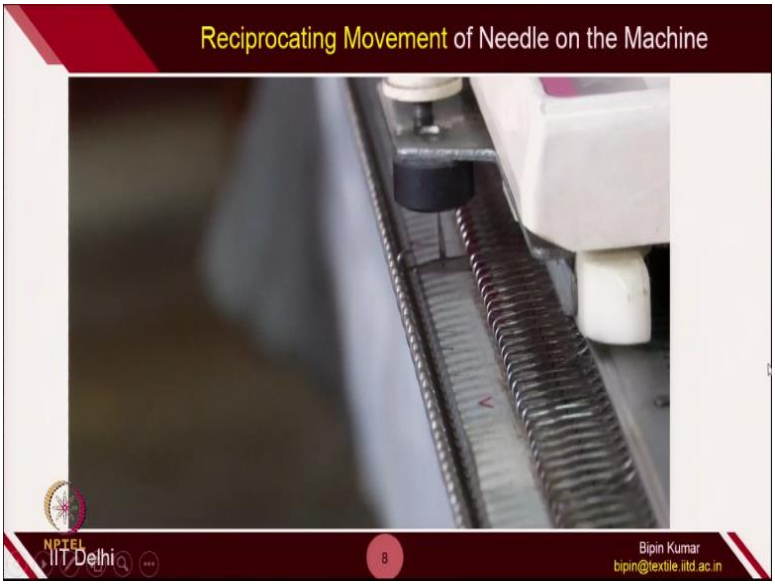

So, let's see what exactly is happening. So, here, this is the cam jacket and this is the needle; **(Video Starts: 12:21)** let's see what exactly. So, once the cam jacket move from left to right; you can see here, it interacts with the needle, with the help of grove inside. And this needles comes forward and goes backward. Again, once the cam jacket goes from left to right, the same process is repeated.

It goes forward and then it comes backward once the cam jacket completed the entire process. Okay. We can have multiple needles working together. So, here 3 needles are operating simultaneously. So, the moment the first needle from the left, it interacts, it goes

faster, then it goes down. Okay. So, while moving from left to right, the same process is repeated. And from right to left, now the cam jacket is moving from right to left.

You can see the same thing is happening again. The needle is going out and then coming inside. So, the motion is very precise and highly uniform. So, you can see here, more than 8 needles are working simultaneously. And the each movement of each needle is highly precised controlled. So, the tension variations will be **(Video Ends: 13:43)** extremely uniform. So, this is, the entire process of needle movement is controlled by this cam jacket. Okay.

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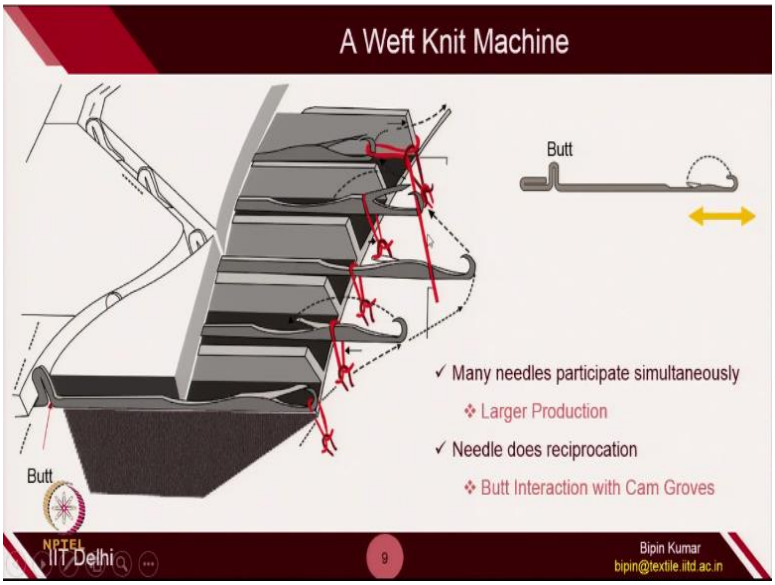

So, this is the cam jacket on which there was groves inside and the needle was doing reciprocative movements. So, it was going out from the bed and coming inside. So, this arrow indicates, the, it can move in left direction and right direction with respect to the bed. The other element of the needle was the butt which was engaging with the cam jacket. So, this is the cam jacket.

So, when the cam jacket was moving on the bed, this butt was engaged with the groves inside this cam jacket. So, this is the groves. So, you can see, this groves has a path. And the moment the butt interacts with the groves, it has to follow the path of grove. Okay. And the path is designed in such a way that will force this needle to move forward and then go inside. So, each needle has to follow the entire reciprocating movement.

And during this process, the loop is getting formed. So, we will come to that; how each steps was defined; how the loop was getting formed. First try to understand; the basic advantage is: Because many needles are participating simultaneously; so, for example, if you take the snapshot; the first needle is not doing anything, but the second, third and fourth. So, on the bed, these 3 needles are doing something.

So, they are operating simultaneously. They are not sitting idle. Like in hand knitting, when you are doing the loop formation, only one loop is getting formed. But here, multiple needles are helping in the formation of loops in their columns, in their respective columns. Because of this, higher productions can be achieved. The second thing is, butt is interact with the cam groves, because of which needle does the reciprocation.

And this motion has to be highly uniform. So, both cam jacket as well as needle is the 2 primary elements on this weft knitting machines which helps in the knitting formation. Let's try to understand each of these machine elements. **(Video Starts: 16:05)** This is the basic videos where you can see how both are interacting. So, this is the cam jacket, the needle is doing reciprocative movement. **(Video Ends: 16:14)**

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So, we start from the needle. Needle is the most fundamental part of the machine. We call this as the heart of knitting. Without needle, nothing is possible.

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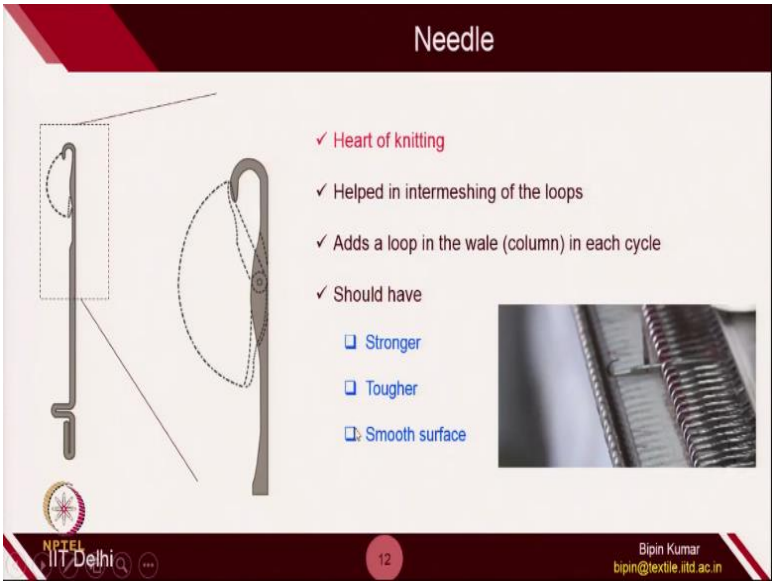

Needle is the heart of knitting and it actually help in intermeshing of the loops with the new loops. And each needles, as I emphasized again and again, each needles add a particular loop in that particular column. This needle is very important that it should survive multiple cycles. Because, when we are creating a fabric on the machine, it can have many courses. Its length can be more than 10 meter or 15 meters depending on the applications.

So, a needle has to continuously operates because of which, the first requirement of the needle is, it should be highly strong. Why it should be strong? Because you have seen in the video, the fabric was hanging from the front side. So, each needle was carrying the weight of the fabric. So, the moment the weight of the fabric will increased, there may be chances that the needle has to carry a high load because of which it should be stronger, so that it cannot break from the top part. Okay.

The other thing is, it should be highly tougher. Tougher in the sense, the moment whenever cam jacket interacts with the butt of the needle, there is a sharp force which is applied on this needles. So, that shock or that impact has to be absorbed by this needle. So, this needle has to be highly tougher. So, the material which is used for this needle should have sufficient toughness. The third thing which is primarily important for this needle is the smooth surface.

Because the needle interacts with the yarn and the yarn has to slide. For example, the loops has to slide on this surface of needle. So, if the surface of needle is rough, there is a high tension variations in the yarn can happen, because of that, the yarn can break. So, the surface

of the needle has to kept very smooth, so that a smooth running of the loops on the needles should be possible. Okay.

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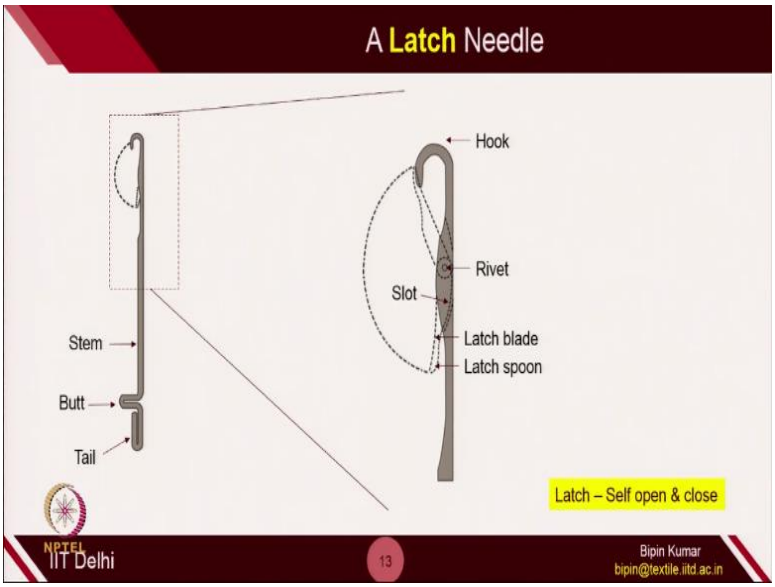

The other thing, let's try to understand is the latch needle. This needle, we call this as a latch needle because it has certain elements. And the most important element of this particular needle is the latch. Let's try to see some of the parts of this needle. So, we start from the hook. So, hook is the top part. Then we have the rivet. With this rivet, this latch is fixed. And because this rivets allow this latch to move and go into different location.

So, this is the latch which can go and close the hooks and it also can come out. Then we have the slot. In this slot, the latch blade can enter. So, this slot is grooved in the column of this particular needle on which the blade can sit. Apart from this, the top part, you have the stem part, you can see, this is the stem part. This stem part is also important because the loop slides on this portions.

The butt, you have already seen the importance of butt. And the last one is the tail. The beauty of this latch needle is, the latch actually does the opening and closing by itself. So, I will show you what do you mean by this self opening and closing. First try to see the actual needles. So, I have the needle with me and I am going to show you needle. **(Video Starts: 20:01)** I have the needle with me.

And this needle is had several parts. So, we start from the first. This is the head part on the top, you can see here, this is the head part. This has sharp edges, curvature, so that it can hold

the yarn. And this is the latch. Okay. So, you can see here, latch can slide. Okay. So, it can close the hook, it can open the hook. Okay. This has some significance. I will show you in a minute. And this is the location where the rivet is there.

So, this is the rivet, along the rivet, this can slide. And the other part is, the grove. So, you have the grove here. So, between the walls of this needle, this latch can sit in this grove. So, you can see here, we have this slot inside the needle wall on which the latch can easily sit when it is open. Okay. When this is open, the most important part is the spacing here. You can see here this spacing.

So, when the latch is completely open, it is not going completely inside the wall of this needle. Rather it is, the maximum penetration which is going inside up to this point. Okay. So, once the yarn slides from the back side, it helps to close the latch automatically. This has some importance. I will show you in couple of minutes. So, now go to the bottom side of the needle. So, this is the stem, okay; this surface on which the loop slides.

And this is the butt. And this is the tail. Okay. Using the tail, we fix it inside the needle bed. Okay. So, let me show you how the loop is being formed by this needle. **(Video Ends: 22:16)** Each of these machine elements is extremely important. Okay. So, let me show you the video. **(Video Starts: 22:26)** So, this is how it is happening. So, the latch is getting open and closed. Okay. So, once again. So, you can see the latch is getting open by the loop itself and then it is getting closed by loop itself. **(Video Ends: 22:41)** Okay.

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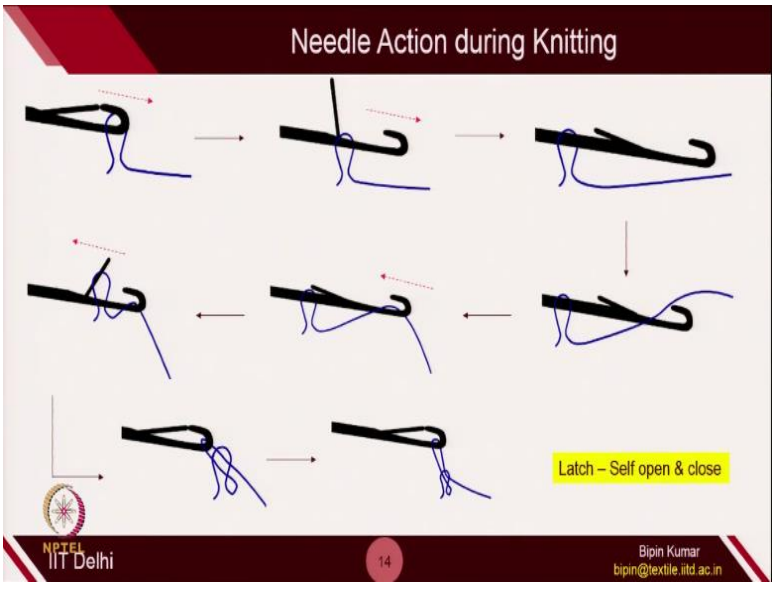

So, I have summarized in these photos that animation part. So, you can see here, initially, the latch and the hook are closed and it is securing the old loop. Okay. And the moment the needle moves start forwarding the old loop starts to open the latch. Okay. And there will be, the needle moves sufficiently forward, the old loops come out from the latch and hook interaction. So, this position, you call it the clearing. Okay.

After the clearing is done, the needle is presented the yarn. The yarn is getting presented. And that new yarn is getting interacted with the hook. The moment it interacts with the hook and the needle starts going in the backward direction, it means it is going inside the bed. So, once it is, it starts moving inside the bed, the old loop is still sliding on this stem part. And since, it comes now underneath this latch.

Because of this, the latch is automatically closed with the interaction of old loop. And old loop is helping this latch to close the hook part. You can see here, this hook part. And once this needle moves sufficiently backward or inside the bed, the old loop it comes out from the needle. This is called knocking over. And finally, we create the new loops. So, the key point here is, the latch which you see here, the motion of latch is itself. We are not providing any motion to the latch. The loop itself is helping the latch to open the hook and close the hook.

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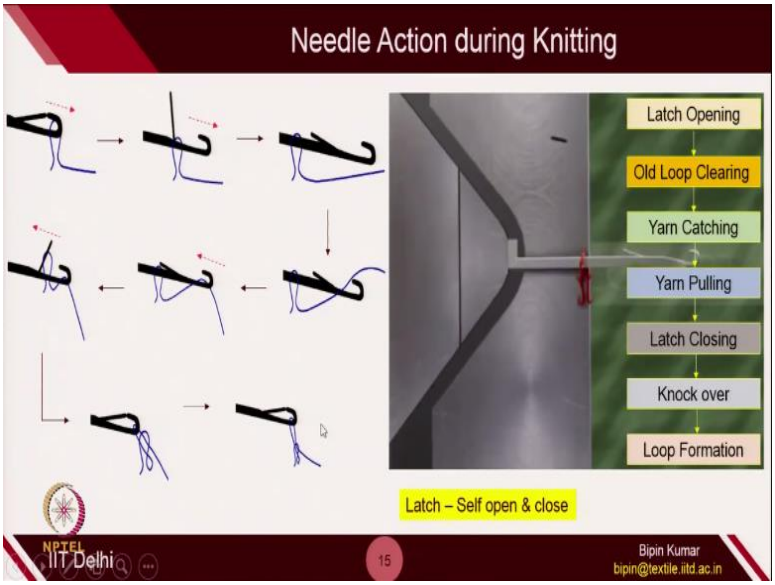

(Video Starts: 24:36) This animations also help you to understand. So, you can see here, the latch is getting slide. So, this is now the clearing position. And now, the latch is getting open and the old loop is getting knocked over. So, these are the series of process which happens on

the machine when the cam jacket moves. So, you can see here, this is the cam jacket which is moving and this is the grove the needle has to follow.

So, the first part it has to do is the latch opening. So you, the latch is getting open. The second one is the old loop clearing. So, you can see here, the loop is getting cleared. Once the loop is getting cleared, now the head part is free. And this head part is now catching the yarn. The yarn is getting catched. And this needle now starts moving backward, inside the bed. So, during this, the yarn is getting pulled. So, yarn which is fixed inside the head, it is getting pulled.

Because of this downward motion of this needle inside the bed, you can see the old loop is now closing the latch. Okay. So, latch is getting closed. And finally, the old loop is getting knocked over. And once the old loop is getting knocked over, it automatically generates the new loop. And that new loop is hold by the head and latch itself. So, this is the starting position. So, we start from here and we; now, the next loop is being formed. And again, we can do the same process for creation of new loops. **(Video Ends: 26:20)** Okay.

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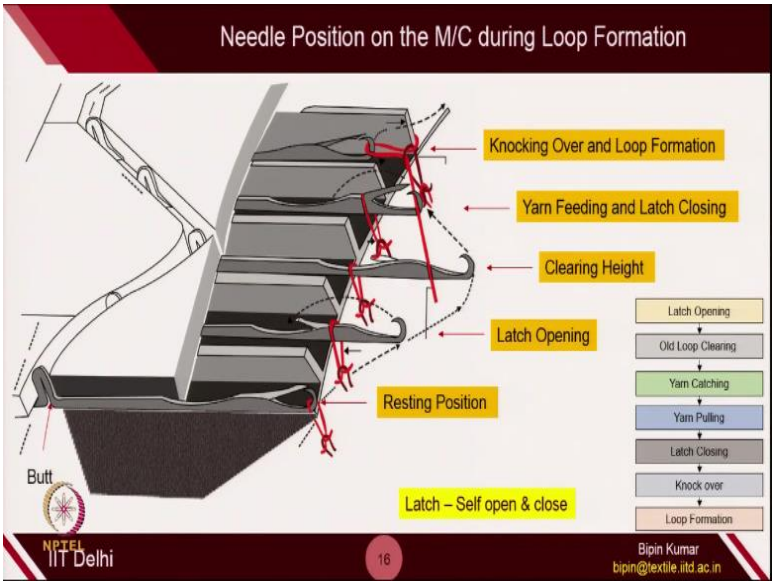

So, let's try to understand the position of needle with respect to bed, in each of these process. So, the first part is, the moment cam jacket interacts with the butt; at this particular position, we call this as a resting position. Resting position in the sense, in this position, the hook and latch is in closed position. And they are holding the loop inside. Okay. Now, the but is getting interact with the cam jacket and it has to follow the groves.

So, naturally, the next position is, it has to move forward. So, it will move forward. So, you can see here, this arrow. So, it is moving forward with respect to bed. Since the old loop is still hanging and the needle is moving forward, so old loop now gets interacted with the latch near the rivet point. Because of this, since the latch can slide, so old loop, it starts to open the latch. So, this process is called latch opening. Okay.

The moment the needle starts moving sufficiently further, the old loop slides completely out from the latch and go to the stem part. So, this is the stem part and you can see the old loop is getting, comes out. So, this is called clearing height. So, this is the position where the needle has come maximum distance from the bed. Okay. And latch is completely open position. So, once the old loop is cleared completely, the next yarn is getting presented to the hook.

So, you can see, the next yarn is coming now. And now, the needle starts retracting back to the bed. So, during this process, the hook get engaged with the yarn. And simultaneously during this retractive path, you can see the old loop is now getting underneath this latch. So, because of this, the latch starts sliding in opposite direction. Now, the latch starts closing. Latch closing is going to happen here.

After that, once the needle moves sufficiently back inside this bed, old loop slides completely from the latch, because latch close the head completely. And this old loop slides over. And this new loop's yarn is there, which is being formed because the needle goes inside. And old loops interacts with the leg of the new loop. So, knocking over and loop formation are both the simultaneously process.

So, these are the entire process of loop formation. First, the latch is getting opened. And then, old loop is cleared. So, this is the 2 points where the latch opening and clearing is happening. Then yarn closing, yarn pulling and latch closing. They are doing simultaneously when the needle is moving backward inside the bed. So, yarn feeding and latch closing. They are doing simultaneously.

Once the latch is getting closed, then knocking over and loop formation is done simultaneously. So, these 2 processes. So, in the entire process you can see easily that latch is getting open and closed by itself with the help of loops. And this is why this is, needle is

called latch needle, because latch becomes so important segment in the needle in the loop formation.

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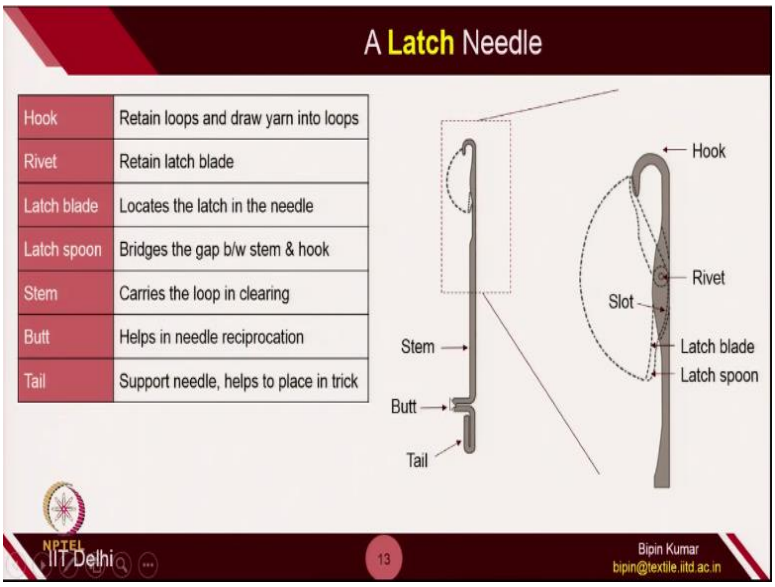

Now, let's see the functioning of each of these parts of the needle. I hope you can understand this now. So, you have the hook part which retains loop and draw yarns into the loop. Then rivet, this is the rivet part. With the help of rivet, the latch can slide. So, it can close the hook, it can open the hook. Then the latch blade and latch spoon is also one of the important segments. So, latch spoon, basically it helps to close the hooks securely, so that the old loop do not go again inside this hook once it comes out.

And the blade is important because it goes inside the slot so that it remain stable during the opening process, clearing process. And then, there is a stem, butt and tail. So, stem is the point where the old loop is sliding. And butt is the element of the needle which interacts with the cam jacket. And tail is the supporting part which helps you to fix the needle inside the bed.

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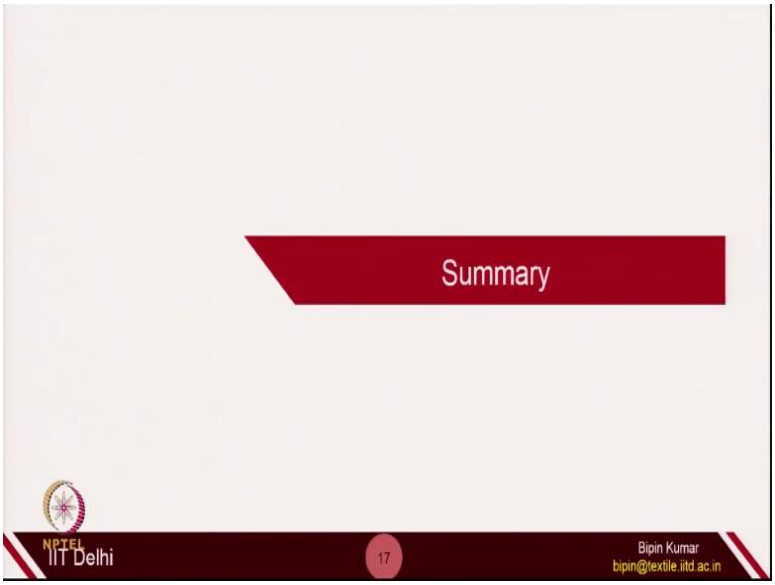

So, now let's do the summary. So, today what we covered so far is like:

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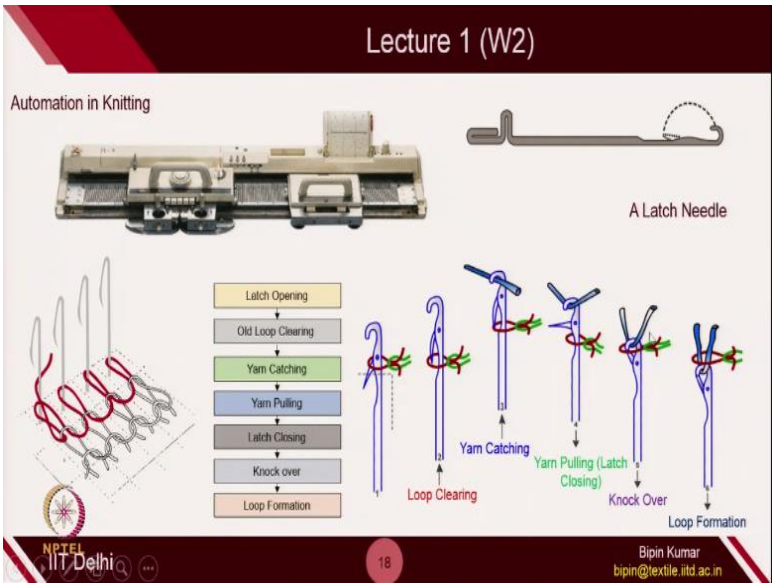

Why the importance of automation in the knitting. So, we come across that, to make the automation process, we need to control the loop formation in each column by a separate entity. And that entity is a needle. We also looked at one of the basic needle which is the latch needle. It is called latch needle because a latch is the most important segments which are doing closing and opening by itself and helps in loop formation and loop clearing.

So, there are certain processes which has to synchronize properly for the loop formation in a column. First is, old loop has to clear. Then yarn has to catched. And then, yarn pulling and latch closing has to done simultaneously. Then old loop has to knock over. And finally, the

loop is getting formed. So, I hope in today's lecture, you would be able to understand how the loop is being formed in the needle bed with the help of latch needle.

In the next class, we are going to understand the role of this cam jacket. So, what exactly is inside this cam jacket? How it helps in the loop formations? That is, we are going to cover in the next class. See you then. Thank you.