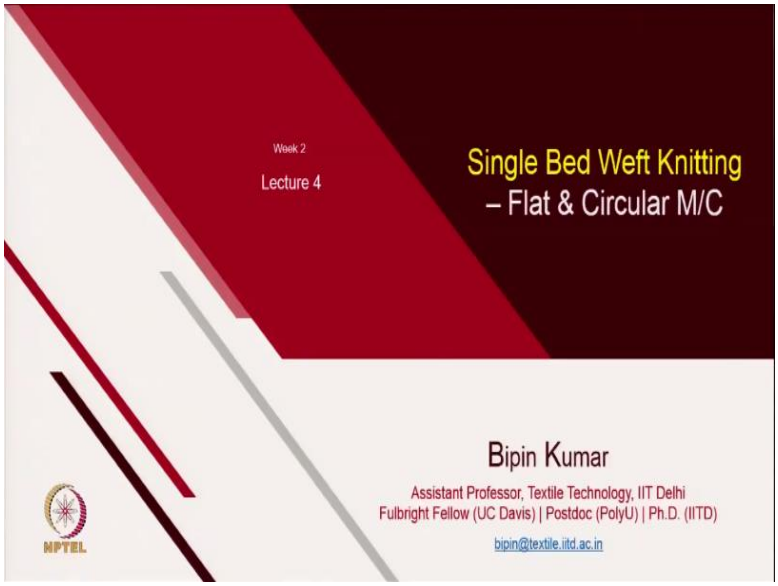
Science and Technology of Weft and Warp Knitting
Prof. Dr. Bipin Kumar
Department of Textile Technology
Indian Institute of Technology - Delhi

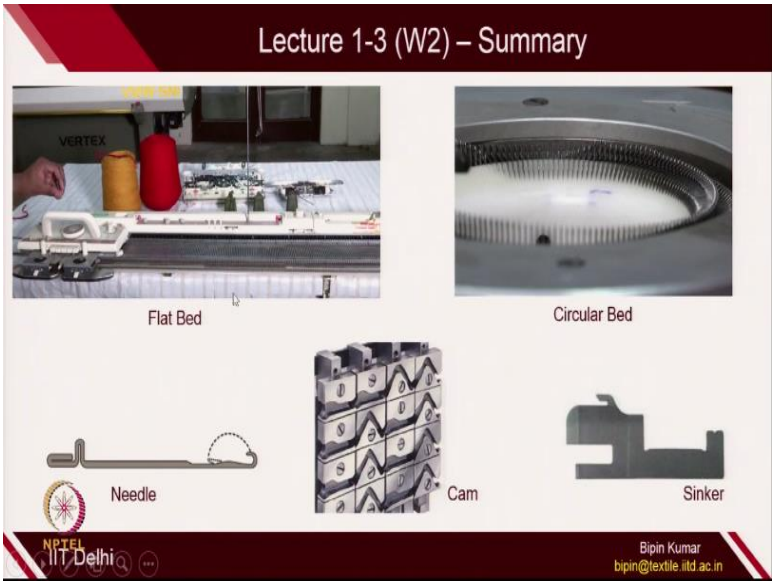
Module - 2
Lecture - 8
Single Bed Weft Knitting - Flat and Circular Machine

(Refer Slide Time: 00:17)



Good morning participants. Now we are moving to last lecture of week 2, lecture 4. The topic of this particular lecture is Single Bed Weft Knitting Machines. We are still continuing the same topic, flat bed and circular bed machines. But some of the topics I have missed. So, that is what some of these additional topics I am going to cover in this weft knitting. So, these all are related to technological developments which was happened in last 50, 60 years in flat and circular machines. So, before I move to this section, let's have a quick recap of what we have covered so far.

(Refer Slide Time: 00:57)



So, the first thing we started in this week was automation of loop formation. So, I introduced to you the importance of needle and how the needle was responsible for making loops. Needle interacts with the cam and it follows the path of cam which was created by multiple cams by placing in a certain sequence. And the needle butt actually follows the path of this cam track, due to which it continues its loop formation process.

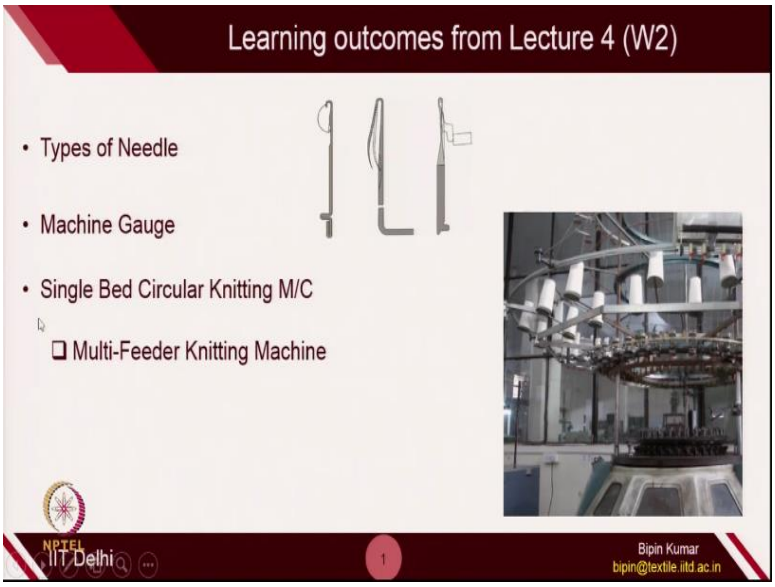
And these needles are actually placed on the bed. So, a series of needles are placed in the slot that is created on needle beds. And that needle bed can be divided into 2 categories. One is flat bed. You can see here, the machine is flat one. And the other one is the circular bed where the cylinder is used where the slots was created on the curved part of the cylinder and needles are placed in a curved section.

So, these 2 categories are wildly popular in weft knitting. And in case of flat bed, we also have seen how needles and cams are the only responsible element which helps in knitting actions. But in case of circular bed, there was additional element that was introduced, that is needed for loop formation is the sinker. So, in case of fabric formation in a circular bed, it is the needle and sinker that has to work together with the help of cam profile to make the loop possible.

Obviously, sinker also has the butt part and needle also has the butt part. So, naturally, there is a 2 cam system on a circular bed, one for needle movement, needle reciprocative movement and the another one for sinker reciprocative movement. So, in some sense, circular knitting is different from flat knitting, not only by the nature of its architecture, but also the nature of

functioning. Because we need additional elements such as sinker and its additional cam for making fabric on a circular bed.

(Refer Slide Time: 03:10)

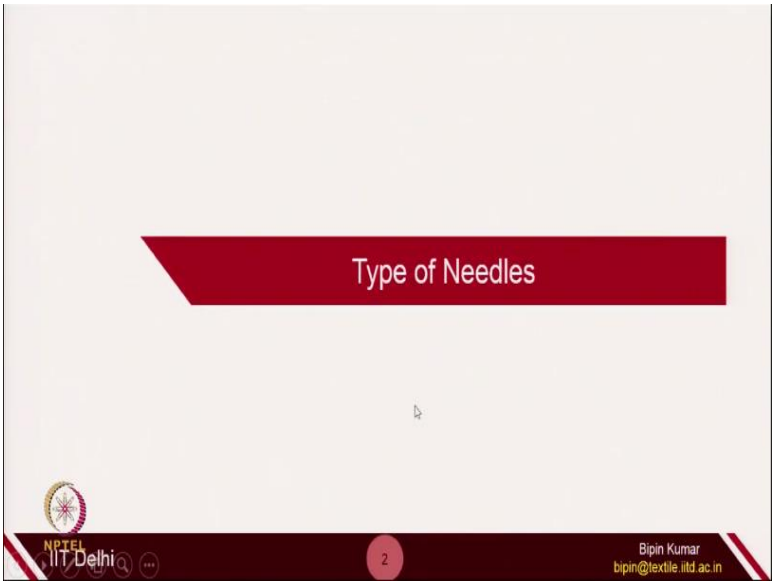


Now, let's move to some of related topics on single bed. The first topic is types of needles. So, I already introduced to you latch needle. But there are some other needles also popular in the world, one is beard needle and compound needles. The other relevant topic is machine gauge which is very very important because, it determines the fabric densities, loop densities inside the fabrics.

So, I am going to give more emphasis on this. The third thing is the most popular single bed circular knitting machine. So, there are so many circular knitting machines. We categorize these or we classify these machines by different means. And one of these classification includes multi-feeder knitting machines. So, this is the most popular one in the industry, because it helps in vest formation, t-shirt formation, undergarment formation.

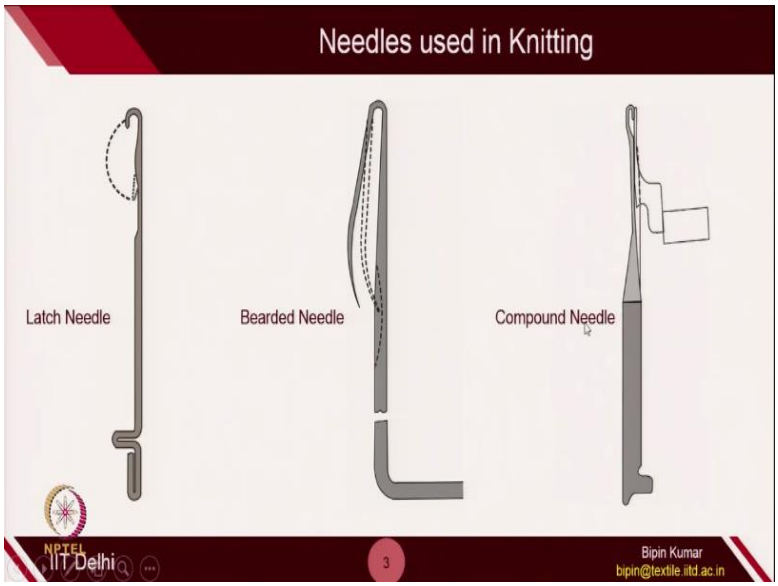
So, I am going to give a introduction to multi-feeder knitting machines. Please note that all of these machines are related to single bed machines. So, the bed remains single; placements of needles is also same, but some changes are, has been done on the machines to make the production as per the requirement. Let's start with the type of needle which is used in knitting industry.

(Refer Slide Time: 04:28)



I already introduced to you the latch needle, each of it parts that help in knitting process.

(Refer Slide Time: 04:31)



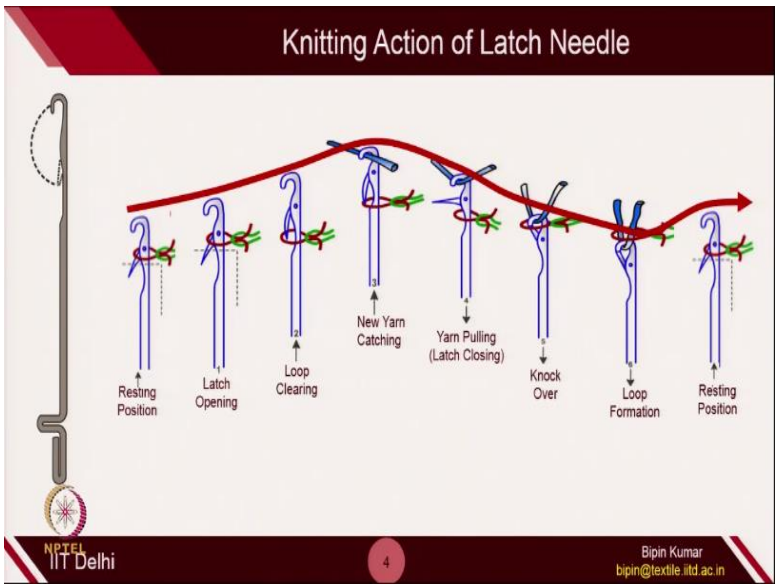
Latch needles, the main important part is the latch itself. That's why this needle is named latch needle. Latch is actually helping in closing the hook and opening the hook. And this action of opening and closing of latch, is self-sustained, because we don't need additional motor or motions to open or close this latch. We have seen already, how the latch is opened by the yarn itself.

We have already seen how the old loop actually goes underneath this latch and closes it with the hook and then knock over from the surface. Latch needle is the most important one, mostly popular in weft knitting. But, apart from latch needle, there are 2 other categories of needles

that is used in knitting. The first one is the beard needle. So, the name comes from the beard part.

So, we are going to introduce you these needles and their functioning. The other one is the compound needles which has 2 different segments and they are completely different. The nature of movement of compound needle is also different from latch and beard needles. So, in this particular section, we are going to understand the functioning of beard needle and compound needle in a while. So, let's start first with the loop formation process.

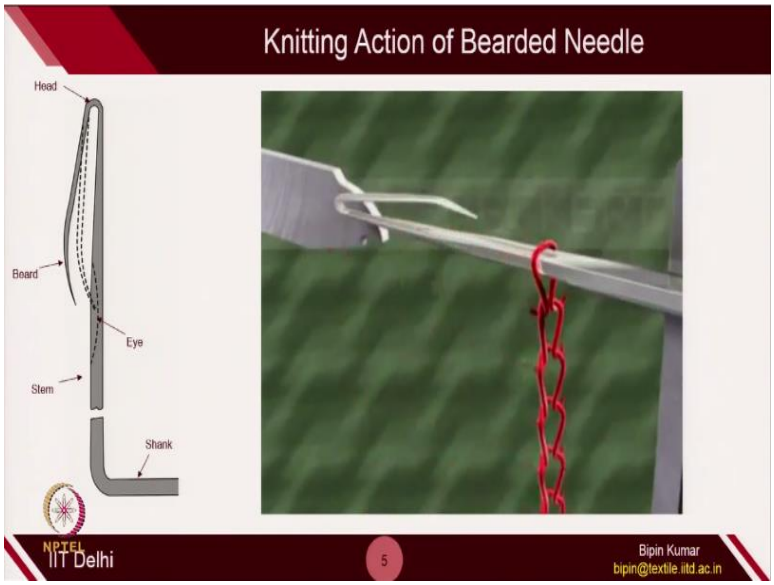
(Refer Slide Time: 05:54)



Just a quick recap, we have already introduced you how the reciprocative movement of needle was done with the help of cam track. So, okay, the butt was engaged with the cam track. And because of this, certain sequence was followed by the needle. And due to this sequence, it was forming the loop. So, it started with the latch opening, because the needle starts raising. And then, the loop was cleared.

Then new yarn was catched. And then, yarn was pulled. And once the latch get closed, the old loop was knocked out. And then, the needle descends to create the loop. In this way, after the job is done, it goes back to its resting positions. So, the sequence was actually properly timed and the cam track was also designed depending on the amount of reciprocative movements that has to be given to latch needle. Okay. So, you can see here, it was raising and then closing. Then it was descending and then again going back to its original positions. So, this, we have already covered in the previous lecture.

(Refer Slide Time: 07:05)



Now, move to the beard needle; how the knitting action is possible with the help of beard needle. So, in, if you see the structure of beard needle, it is not look like a latch. It has the head part similar to latch needle, but it do not have latch, but it has the beard. Okay. So, you can see here, this is the beard part and this beard part is flexible. Okay. So, this beard part can go inside the slot. And this slot is eye.

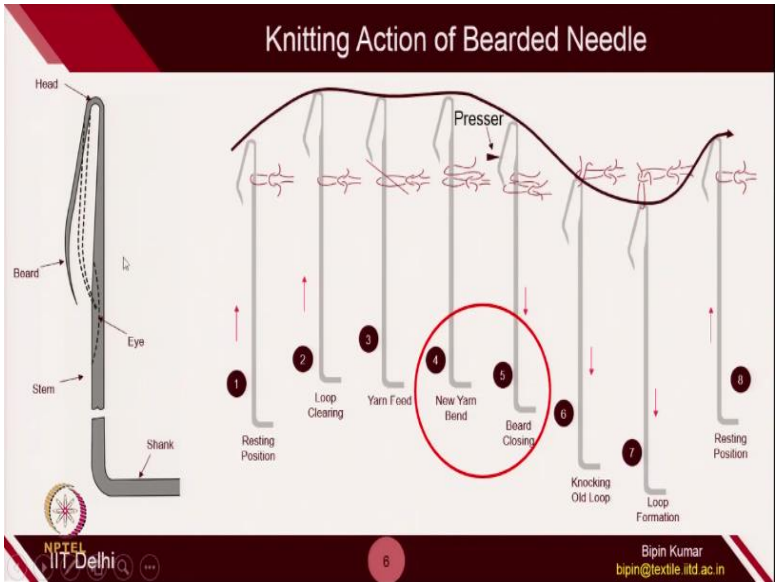
So, once it has to close the head, this beard part; if you press this beard part, it can go inside this slot. In this way, it can hold the old loop or new loop depending on the position of the needle. Once job is done, if the old loop has to come out, this beard will come out and the old loop can slide on this segment. So, this segment remains same as per the latch needle, which is the stem part on which old loop slides.

So, it remains same. After that, there is no butt part which you can see here, it is only the shank. So, shank is the part which helps to fix this beard needle on the machine bed. Instead of bed, we have the bar here, on which this shank is placed. So, here is a small animation. Just have a quick look how the loop is getting created with the beard needle. And then, we will try to understand each of these steps in detail.

(Video Starts: 08:36) You can see here, how there was additional element which was helping in loop formation. Then this beard was down. And then, old loop was raised. So, the first thing, yarn catched, then loop was formed, then this element was pressing this beard; and then sliding was done. Once again, have a quick recap. So, you can see here, it was pressing and then the loop was sliding.

So, you can see here, the beard was raised; and then, knocking was done. **(Video Ends: 09:10)** So, if you try to differentiate each of these steps, then you will be able to understand how each of these steps is important and how these was created on the machine.

(Refer Slide Time: 09:20)



Similar to latch needle, the reciprocation has to be done, but in a certain fashion. We again have the resting position similar to latch needle where it is holding the old loop. Okay. So, the first thing, to catch a new loop or new yarn, this old loop has to come out from the beard and head segment. Okay. So, this head and beard segments, this old loop has to come out. To do so, there is a step of loop clearing in which this particular needle raises upward.

So, in this case, you can see the old loops comes out from the interaction of beard and head. So, now the old loop position is on the stem part. Once the old loop is cleared, now this segment is free to catch the yarn. So now, you can see here, this, the new yarn is feed to the needle at this particular location. And the only difference here is, you can see this, now the new yarn is bent.

So, once the yarn is present, the new yarn is actually bent in the loop form. This is done by a different elements. It is not done by the needle itself. But if you see the actioning of latch needle, it was the latch which was bending the yarn. But here, the new yarn bending was done by a different element. Okay. So, once this new yarn is bend, then this new yarn is slide inside and simultaneously this beard part was pressed.

So, this beard was pressed with the stem part, so that it can close. So, the fifth step is the beard closing. After the beard is closed, this old loop slides over the beard and then knocked out. Okay. So, this is how the step was done. And after that, the needle still goes down to bend the yarn, to create sufficient length of the loop. Once job is done, it goes back to its original position.

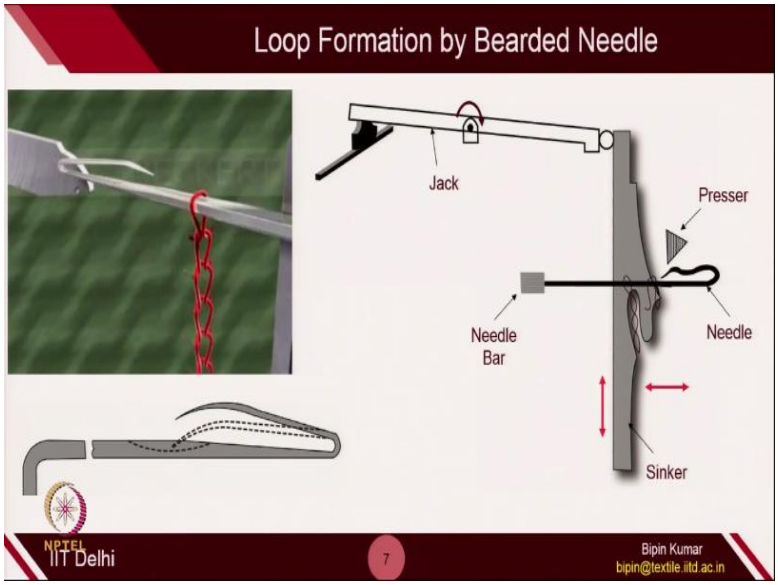
Naturally, if you try to differentiate the functioning of latch needle and beard needle, these 2 steps are slightly different, which was not happening when the loop was getting formed with the help of latch needle. The first different was the yarn bending. So, once the straight yarn segment is present, it was a different element which was bending this yarn so that it can slide inside.

So, new yarn bending was done by a different element. And the second thing was the pressure. Because beard closing was done by a different element which is shown here by the rectangle. This is called pressure which presses this beard so that it can close with the stem segment. Okay. So, these 2 steps are slightly different in the sense that the latch do not require the additional elements when it is interacting with the yarn.

But in case of beard needles, we need 2 different machine elements for doing this function. Otherwise, if you try to observe the path of the reciprocation of the needle it remains same. It rises, then it descends; and then it goes back to its original position. So, the path or the reciprocative movements of needle remains same. It is only the 2 additional elements which is required, because the beard segment is not self-actuating.

It cannot automatically close itself and open itself. So, we need to press it by certain element which is called the pressure. And the second thing is, once the yarn is being present here, it cannot automatically slides down inside. So, we need another slider or you can say another element which bends the yarn and slide it inside beard and head segments. Okay.

(Refer Slide Time: 13:15)



If you see the machine, so the machine looks like this. So, apart from this beard needle, it has 2 segments. One is the sinker part and the another one is the pressure part. If you now see carefully this animation, **(Video Starts: 13:32)** it is the sinker part which is taking the loop inside the beard segment. Okay. If you see again, this is the sinker part which is taking the loop inside the beard part and also making the sinker segments.

(Video Ends: 13:49) So, this sinker, with the help of this portion, it bends the yarn. And then, it goes forward. This is the reciprocative movement of sinker. It takes that new yarn, once the beard is open, inside this beard and head segments. Okay. And the other thing which is required is the pressure. So, you can see, this is the pressure element. So, if you see this animation, there was a small disc which was coming and closing this beard part.

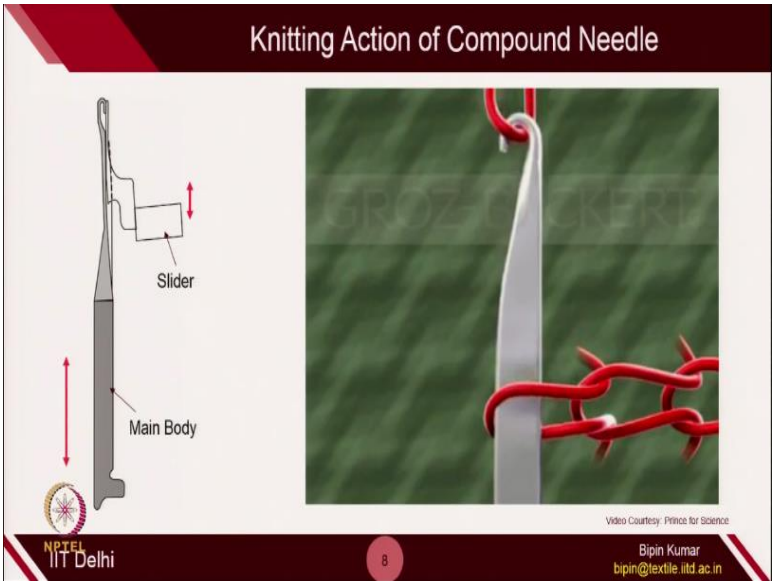
(Video Starts: 14:18) So, you can see here, this is the disc, this is the pressure part which is closing this beard. So, you can see here, this is the pressure. So, this pressure elements is needed to close the beard **(Video Ends: 14:34)** and push this beard part into the eye, so that the old loop and new loop is separated. So, once this beard segment is closed, the old loop which is on the stem part, it can goes over the beard segment and knocked out from the needle.

This is how the knitting is taken place in case of beard needle. In terms of simplicity, if you see latch needle do not require additional elements like pressure or sinker on the flat bed. But in case of operation with beard needle, we need additional elements. So naturally, the space for knitting is reduced and it causes very limited productivity. This is the reason why beard needle is not now popular in knitting industries.

Although, if you see the knitting automation, it started with the beard needle. It was the first beard needle that was invented prior to latch needle. But once latch needle was introduced, beard needle reduces its popularities, because of additional elements like sinker or pressure which is required during loop formations. So obviously, if you need more and more machine element parts in loop formation, more complexities on the machines and limited productivity.

Now, the beard needle is not so much popular in weft knitting, but still, beard needle is popular in warp knitting which we will going to see once we will introduce the, you the warp knitting technologies.

(Refer Slide Time: 16:09)



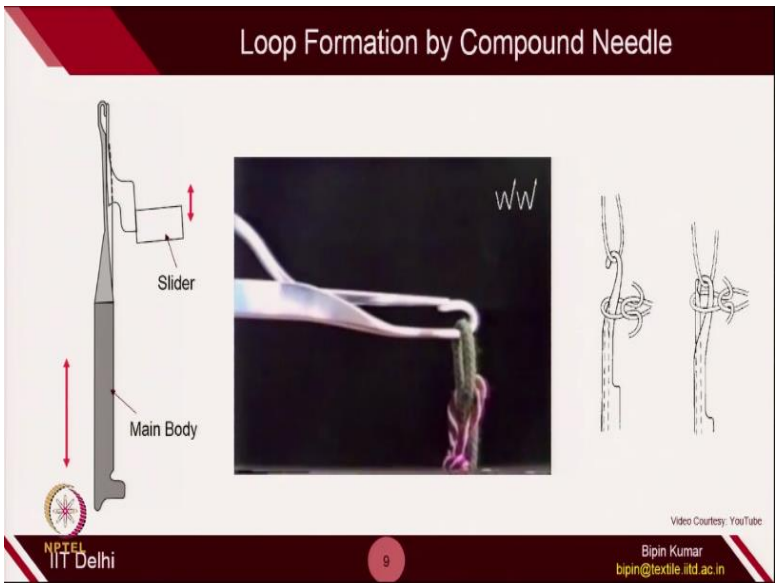
This is how it works. Now the other type of needle is compound needle. So, apart from latch needle and compound needle, compound needle has also different structure, different characteristics. So, in compound needle, actually it has 2 segments, 2 different segments. One is the main body on which head is attached. This is the main body. And the other part is the slider body.

And the slider body, the latch is attached. And these 2 bodies has different amount of reciprocative movement. So, if you see the latch needle and beard needle, the latch and beard was the part of the main body and it was closing with the head and opening with the head. But in case of compound needle, different segments was needed for the closing and opening. So, the slider is a completely different segment and the main body was a completely different.

So, obviously the design is much more complicated compared to latch and beard needle. It also has different way and different style in which it does the knitting. So, let's have a quick recap on the animations, how it creates the loop. **(Video Starts: 17:24)** So, you can see, it is catching the yarn, going inside. So, you can see here, it is; so, the latch is there on the stem. **(Video Ends: 17:36)**

And once the needle is descending, there was, this latch was there, which was closing with this head part, so that this old loop was slides through the head part. So, knocking was taking place and the latch closing was also taking place simultaneously as soon as the needle was descending. **(Video Starts: 17:55)** So, you can see here. So, this was standing on the stem part. And this latch was coming out and closing with the hook part. **(Video Ends: 18:10)**

(Refer Slide Time: 18:12)



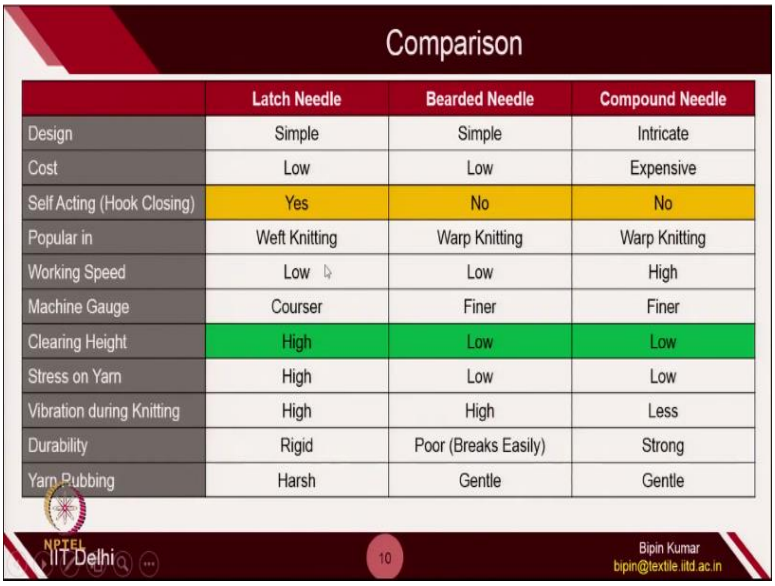
Here is a another small video from YouTube which you can see and observe how the loop formation was done. So, initially the old loop is on the stem segment and the latch or the slider part is inside. So, this slider part is inside the slot of this main body. So, you can see here, it is inside the slot. Once the head part of the needle, from the main body; this is the head part. This head part catches the yarn.

And once it start pulling through the old loop, this latch comes out from the slot and closes with the hook. Okay. And in this way, this helps the latch needles to slide through this slider part and knock from the needle and get attached with the leg segments of this new yarn. So, here you, is a small animations, how you can see. So, the first thing, it is catching the old loop. You can see here.

(Video Starts: 19:14) The first part is the latch is open, okay, by this different movement. And then, this old loop was cleared. Okay. And then, this new yarn was present. And then, the latch was closed with the head and the old loop was slide through the latch and knocked from the needle segment. So, this is how the loop formation was done **(Video Ends: 19:49)** on a compound needles.

Obviously, the process is little bit complicated, because we had to ensure different amount of reciprocative movement for the main body as well as the slider part. So, the design is very complicated and integrate compared to latch needle machines and beard needle machine.

(Refer Slide Time: 20:11)



Here is this table by which you can compare the functioning of these 3 types of needles which is popular in knitting industry. And the first one is latch, beard and compound. So, in terms of design, the latch is the most simple one. Beard is also, comes under the simple design categories. But compound needle, because it has different parts which is involved in different movements; so that's why the design is very integrate, very complicated.

Cost if you see, latch needle is comparatively low and beard needle also low cost. But compound needle is very very expensive. The main difference among these 3 needles is self-acting. So, the hook closing which you can observe by looking to the knitting principle of all these 3 needles, it is the latch needle, it was self-acting. The closing of latch and opening of latch was done by the loop itself.

But in case of beard needle, you need the pressure elements that, that disc on the animations which was pressing that beard segments. So, the beard needle, you need additional elements during the loop formation. Also, if you see the compound needle, the closing of the latch part or is done by the slider itself. So, they are not self-acting. So, this is why, because of the simplicity in terms of knitting, latch needles become more and more popular in last 50, 60 years.

And it has almost obsolete this beard and compound needle. It has replaced these 2 types of needles from the knitting industries, especially in case of weft knitting machines. In terms of popularity if you see, in weft knitting, mostly latch needle is used. And beard needle and compound needle is still popular on in warp knitting. Once we will cover the topic of warp knitting, you will come to know about these type of needles.

Working speed: Latch needle is very in delicates, because latch has to open. We have to give some time to pull the yarn by the needle itself. So, that's why, the working speed of latch needle is very very low compared to compound needle which is very high. Beard needle, also because there are so many elements involved, so; and each process takes some time. So, that's why the speed of beard needle is also low compared to compound needle.

So, in terms of productivity the compound needle is, can give you very high production rate. Machine gauge actually indicates how many needles you have placed per unit length. So, it is defined as number of needles per inch. The next topic in this particular lecture is related to machine gauge. Latch needle is actually used in courser gauge, where you need limited number of needles to be placed on the bed.

Courser in the sense like 2 gauge to almost 24 gauges will be used latch needle. So, more courser bed. Beard needle is very fine and compound is also very fine. You can place these needle in a needle bar. And then, you can place that bar on the machines. So, very fine placements of needles is possible when you are using beard needle and compound needle. So, the distance between 2 needles can made as minimum as possible with the help of beard needle and compound needle.

So, finer gauge machines, actually they use these type of needles. Clearing height: so, how much the needle rises? In case of latch needle, this is the maximum distance that the latch needle covered, because it has to raise completely to clear the old loop. In case of beard needle,

since you have the sinker elements which was helping in sliding the loop inside the beard part, the amount of reciprocation; actually the amplitude of reciprocation is much much lower compared to latch needle.

And in compound needle, since there is 2 parts, slider and the main body. So, if they move in opposite direction, it can very fastly closes the latch and head parts. So, that's why the amount of distance which is covered by the compound needle is much lower compared to the latch needle. Yarn stress: you have seen like how the latch needle was actually pulling the yarn strongly.

Because, once it catches the yarn, it is the head part which was interacting with the yarn. And it was pulling it. So, that's why high amount of force is generated on the yarn itself. So, yarn is under high stress conditions when you are using latch needle. So, there is a more chances of breakages in case of machine using latch needle. While in case of beard needle, you have seen how the sinker element was helping in loop bend formation.

So, comparatively, yarn stress was much much lower. In compound needle also, the yarn stress was much much lower. Vibration during knitting: Since the maximum stroke or maximum reciprocation amount was done by the latch needle; so, that's why high vibration was observed in case of latch needle. In case of beard needle, since the beard segment is much more flexible and longer length of metal is there; so, there is high chance of vibration when it is doing the knitting action.

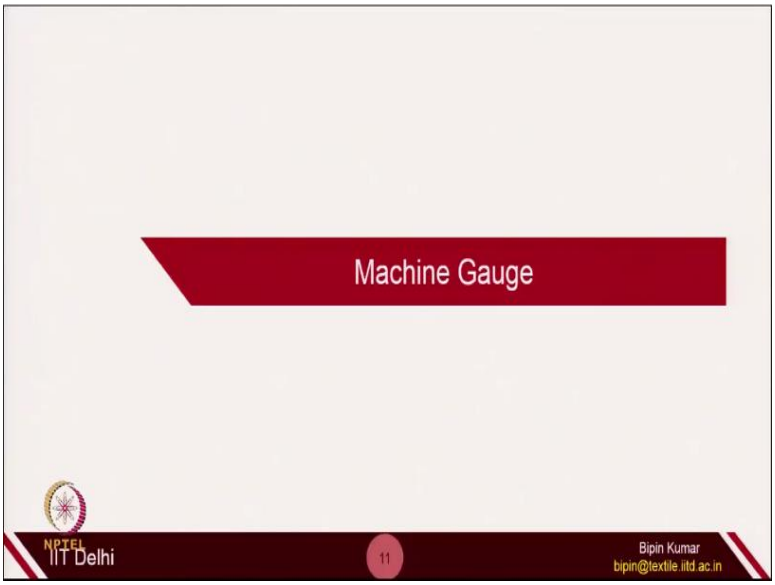
But in case of compound needle, since the design is so robust and the metallic part is also very strong. And also the stroke amount or the reciprocation or the amount of clearing height done by the compound needle is less, the vibration is less observed in case of compound needle. If you see the durability, latch needle is rigid. It can run for 6 to 8 months depending on how simply you are running the machine.

And but in case of beard needle, it is very poor and very flexible design. So, that's why it breaks very easily, because the beard segment is very very flexible. So, even a small amount of jerk, it can breaks. And if you see the compound needle is the most strong and robust design. So, compound needle, there are less chances of breakages. Yarn rubbing: since the yarn was interacting with the latch needle a lot; so, very harsh treatment was done on the yarn.

So, there is a chances of lint formation, fly formation during high speed running of this machines. In case of beard needle, it was the very gentle treatment, because the sinker part was bending the yarn in a very gentle fashion. Also in case of compound needle, very gentle treatment of the yarn. So, if you are running with very delicate yarn, it is advised to use beard needle and compound needle.

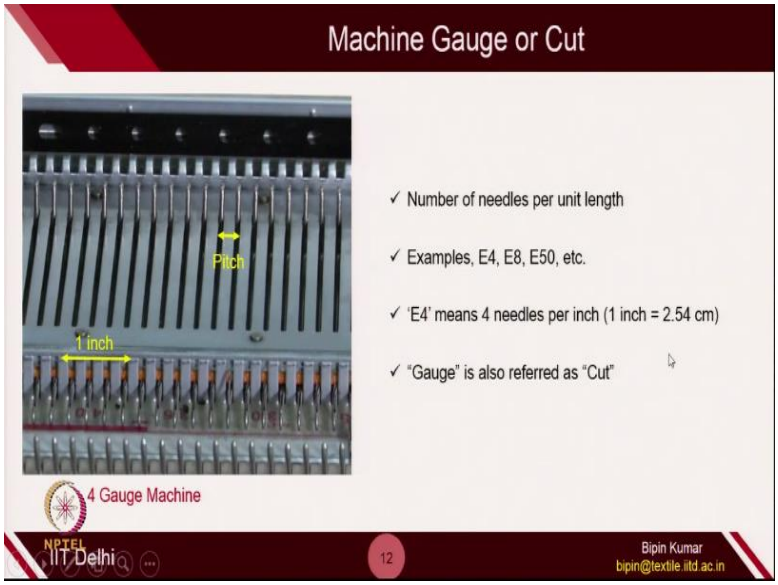
But latch needle is more popular in the sense because it is very simple design and self-actuating. So, this is some of the basic differences in these 3 needles. So, in the industry, if you go, 90% of the time you might be observing only the latch needle is used in the bed. And these 2 are also a popular, but not so much. Though it was popular 50, 60 years before, but latch needle is replacing these types of needles day by day. Okay.

(Refer Slide Time: 27:39)



Now, we are moving to next topic which is the machine gauge. Also, this is related to each bed which is used in knitting.

(Refer Slide Time: 27:53)



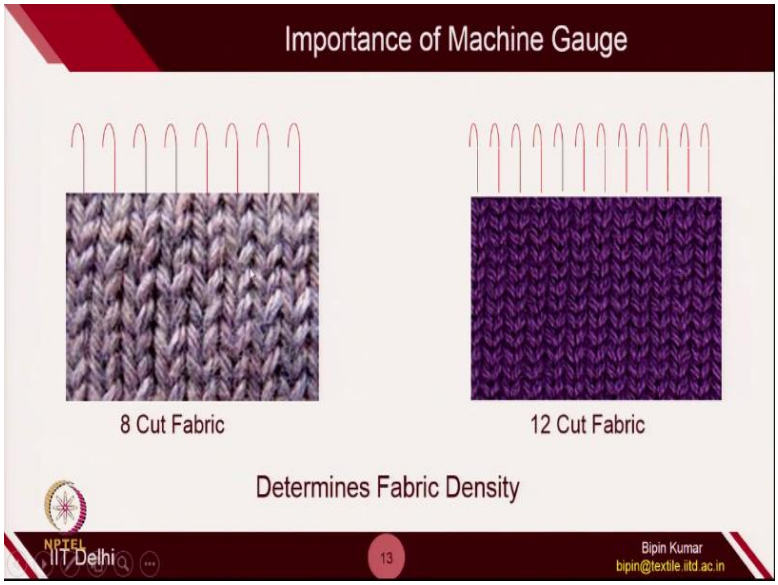
So, machine gauge in simply it is defined as number of needles per unit length. So, you have seen how the needle was placed on the trick or the slot inside the bed. So, here is this bed. And in each of these slot, a needle is placed. So, this is the butt segment of the needle and they are placed on the bed. Naturally the placement of these slots can be made very very finer, depending on what type of tooling machines you are using.

In reality, machine gauge is used to indicate how finer or courser is the machine. So, number of needles which is used per unit length of the bed is defined as machine gauge. It is also called as cut. It is indicated by a alphabet E and by a number. So, E4 means 4 needles per inch. So, this is indicated by number of needles per inch. So, here if you can see, this is the distance 1 inch.

And if you count how many needles; so, 1, 2, 3, 4. So, in 1 inch, there are 4 needles are present. So, that's why this is called 4 gauge machine. And we call it E4. So, whenever you are interacting with the machines, the first thing obviously need to absorb is, what is the gauge of the machine. Whether it is E4, E8; E60 is also there. Like 60 needles per inch. So, you can imagine, in the same length, there 60 needles are placed.

So, in that case, how finer is the distance between 2 needles. That is also very important in terms of fabric quality. A gauge is also referred as cut. Cut is used mostly in western countries especially in U.S., they use cut. They also indicate the same thing, how many needles are used per unit length.

(Refer Slide Time: 29:47)

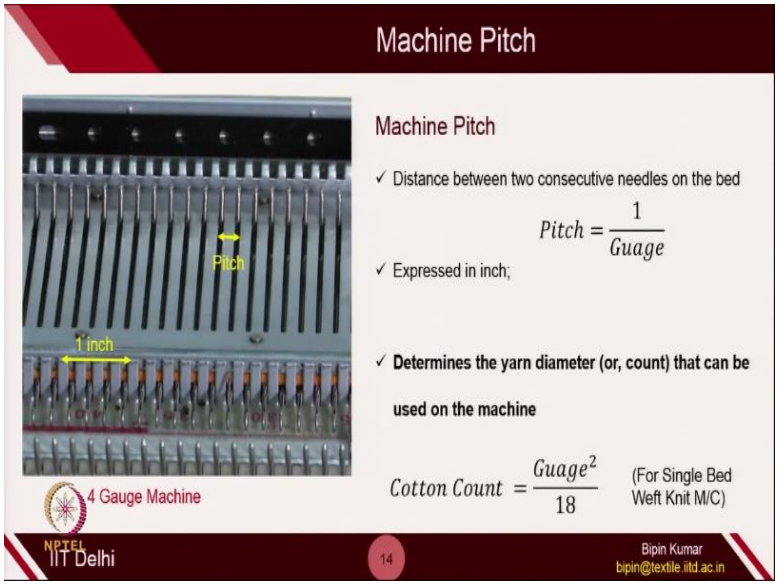


Why this machine gauge is so important? Because, depending on what type of machines you are using for the fabric production the fabric quality or fabric density will be decided. For example: Here, this is 8 cut fabric, so here you can see; for making 8 wales, 1, 2, 3, 4, 5, 6, 7, 8. So, 8 needles was used in the same area. But for the same area, you can see here, in 12 cut fabric, 12 needles was used for the same width of the machine.

So, naturally if you see this fabric and this fabric, this fabric number of loops in the per unit area is much much lower compared to this one where you, the number of loops is much denser. So, you can count many number of loops here. So, fabric density is decided by the machine gauge itself. So, if we use finer gauge machine means, it means more number of needles per unit length. Then you will observe denser fabric.

If you use courser gauge machine, where the number of needles per unit length is lesser, like 4, 6; then you will observe less number of loops, so courser fabric. So, this 2 fabrics, one is courser fabric, this one is finer fabrics. So, courser and finer depends on what type of gauge you are using on the machine itself. Whether the machine is finer gauge, then it will create finer fabric. Whether the machine is courser gauge, then it will create a courser fabric. So, fabric density is determined by the machine gauge. Let's see the other part, the pitch.

(Refer Slide Time: 31:29)



It is actually the distance between 2 consecutive needles on the bed. So, you see, the needles are placed on the bed. And distance between 2 consecutive needles is called pitch. So, if you calculate the distance; here you can see, in 1 inch, there are 4 needles are placed. So, distance between 2 needles naturally will become 1 by 4. So, there is a small relation where pitch is actually one by gauge.

So, if you know the machine gauge, you can find out the pitch. So, pitch is expressed in the distance unit. It is expressed in inch. For this particular machine, the pitch is, the distance between 2 needle is 1 by 4. So, 0.25 inch. Why pitch is important? Because, depending on what is the distance or the allowance which is given between 2 needles, the yarn selection has to be decided for a particular machine.

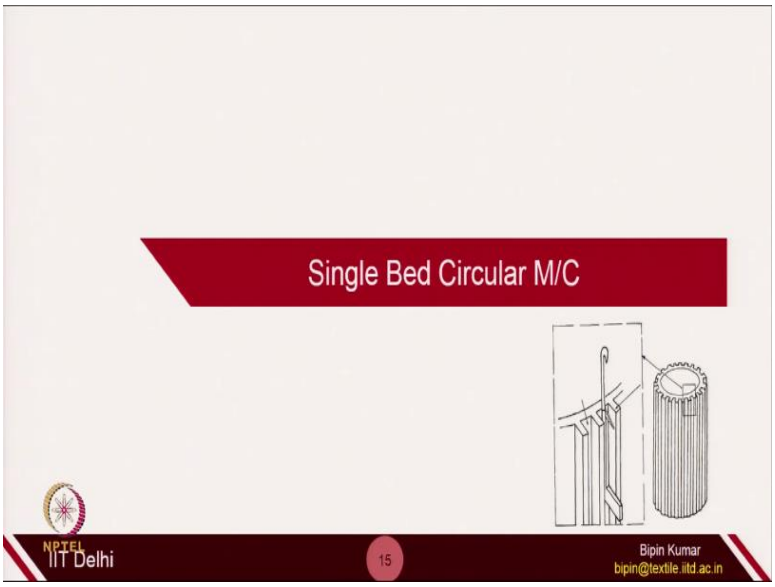
So, what diameter or what count of the yarn one should use on a particular machine, this is decided by the pitch itself. So, if the pitch distance is higher, you can use much thicker yarn, because the distance between 2 needles is too much. But if the distance is narrow, especially in finer gauge machine, then you cannot use much thicker yarn. And there is a small relation which you can use to determine what type of count is suitable for a particular machine.

For a single bed weft knitting machine, the cotton yarn is expressed in any English count. The cotton count which is used for a particular single bed weft knitting machine is, it depends on gauge squared. So, machine gauge, if it is 4 gauge, then 4 into 4 divided by 18. So, this is a small relationship. So, depending on machine and depending on the fiber type, a small relations

is already provided by the manufacturer itself like what type of count you can run on the, on a particular machine without breaking the yarn.

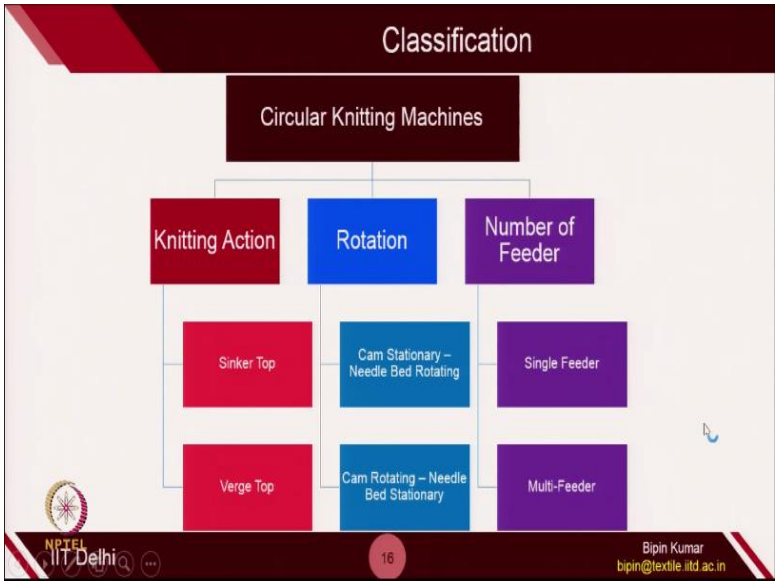
If it is very finer yarn and let's suppose we are running very thicker yarn, then obviously there will be difficulty in the loop formation. So, the selection of yarn, the quality of fabric, it all depends on the placement and the slot size or the pitch or the gauge of the machine. So, that's why this particular topic is very very important from the production and quality point of view.

(Refer Slide Time: 34:03)



Now, move to the last segment which is the, related to circular machine. We have already seen circular machines where needles was placed on a cylinder in the slot. That slot is called trick. And but, there are, in the market there are so many types of circular machines you can observe. And their functionings are also completely different. So, I thought, maybe I should classify some of these machines and at least you should be knowing these machines whenever you interact with any circular machine in future.

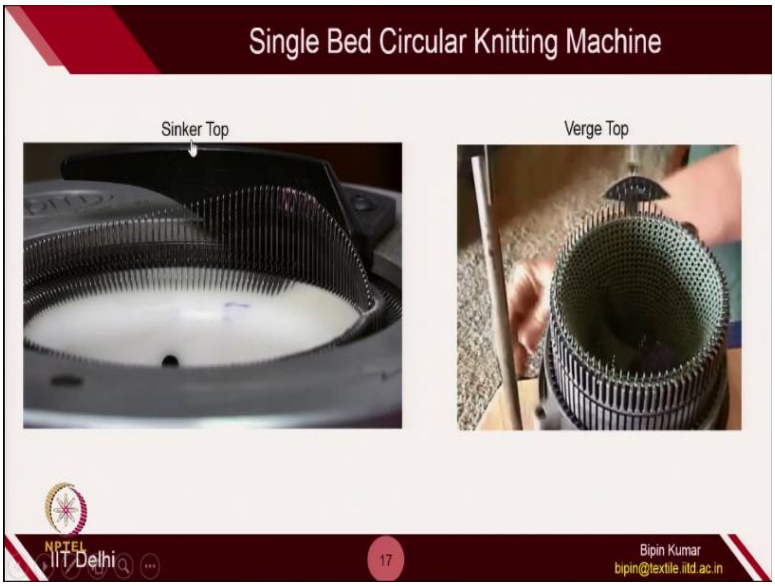
(Refer Slide Time: 34:34)



When you see circular knitting machines, it can be divided into by 3 categories, by knitting actions which I already covered in the last class. The classification is done by sinker top and verge top machines. Rotation: so, how the rotation is done on the circular machine. It can be further categorized by 2 ways. One is cam stationery and needle bed rotating. So, here the cam is stationery and needle is rotating and the butt is interacting with stationary cam.

And the second one is, cam is rotating and but needle bed is stationary. So, the cam rotates and needle bed is stationary. The third category is through number of needles. So, when, depending on number of needles, the machines can be divided into 2 categories; one is single feeder machines and the other one is multi-feeder machine. Okay.

(Refer Slide Time: 35:26)



Now see, some of these, the same classifications we can see here. So, the first one is sinker top. So, in last class also I discussed how one machine uses sinker but the other machine uses verge. So, verge is the end part of this trick wall, which helps in the loop formations. **(Video Starts: 35:45)** So, we have already seen, like in one type of circular machines, we need sinker element during loop formations.

Because sinker was holding, sinker was helping in knocking, sinker was also helping in holding the fabric. But in case of verge top, it is the most simple one, where you do not need additional elements. So, the design is much much simpler. And the fabric is being formed. **(Video Ends: 36:11)** So, the circular machines definitely can be divided into 2 categories with, one with sinker top and verge top.

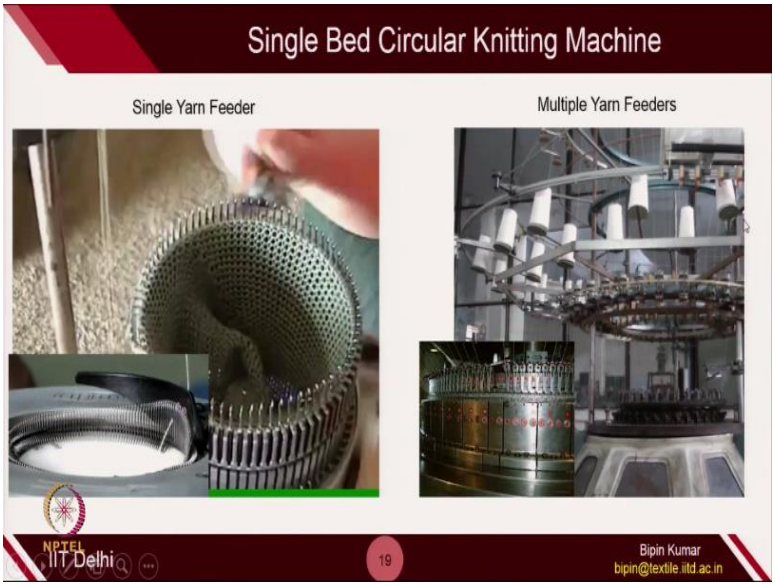
(Refer Slide Time: 36:21)

The other way we can divide this circular knitting machine is, how the rotation is taking place. So, in first case, the cam is rotating but the needle is just doing reciprocating movement in the same vertical line. Okay. So, the needle is not rotating on the curved surface, rather cam is rotating. So, let's see this video. **(Video Starts: 36:42)** So, here you can see, this cam plate, this is rotating.

And needle, it just doing reciprocative movements. Okay. And in the other case, the cam is stationary but the needle is rotating. So, here you can see, the cams are placed. These are the cam system. And the needle, the entire cylinder itself is rotating. Okay. So, you can see here, the cam is not moving, rather, you can see here, the cylinder is moving. **(Video Ends: 37:22)** So, here the needle is revolving but the cam is stationary.

In this case, needle is stationary, the cylinder is stationary and the cam is actually in this particular jacket, this circular one. In this way, these circular machines are also divided. The last one is by the amount of yarn which is consumed by the machine.

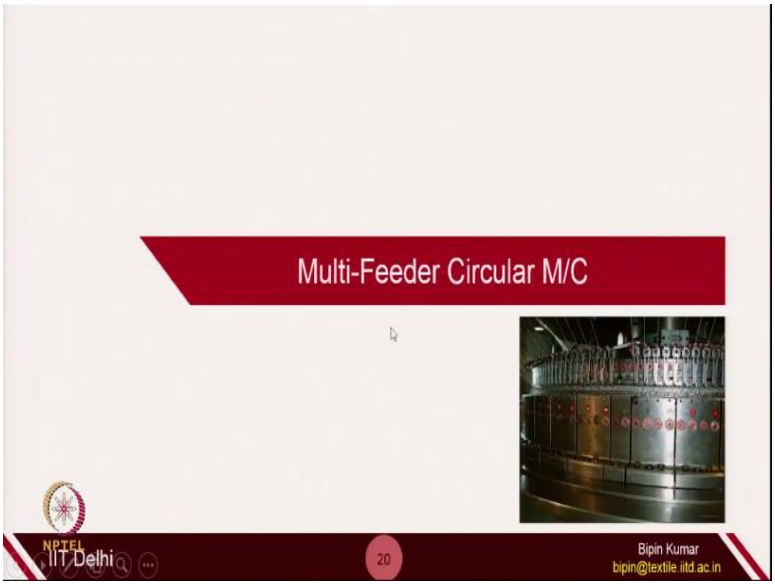
(Refer Slide Time: 37:39)



So, in one case single yarn feeder. So, you can see here, this is only one yarn is being used during knitting. But in case of multi-feeder yarn, you can see so many yarn bobbins are placed on the top of the machine. And at the same rotation, all of these yarn ends are used inside this cylinder. In industry, mostly it depends on the, how fast you can produce the fabric.

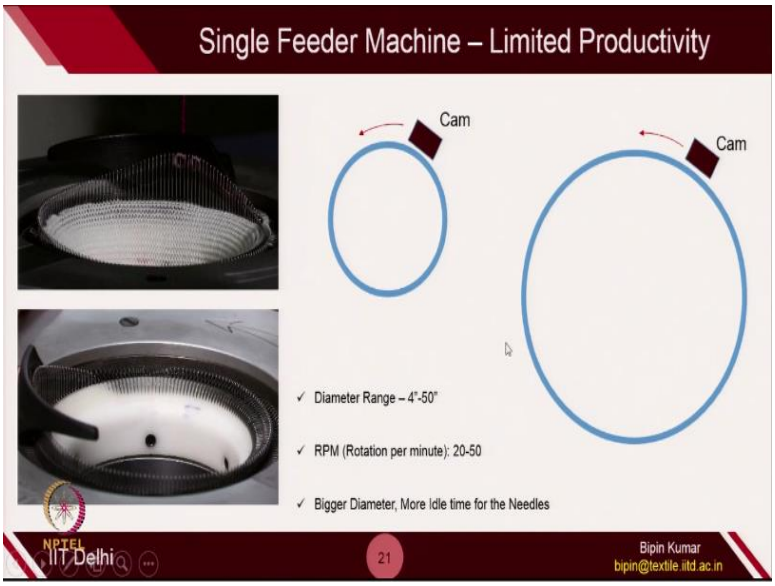
So, multiple yarn feeder machines are quite popular in case of circular knitting machines. So, I am going to give more introduction or more description of these type of machines which is used in the market.

(Refer Slide Time: 38:25)



Let's see multi-feeder circular machine. Why there was a need for a multi-feeder circular machine? What was the science? Why this machines become so popular compared to single feeder machines?

(Refer Slide Time: 38:38)

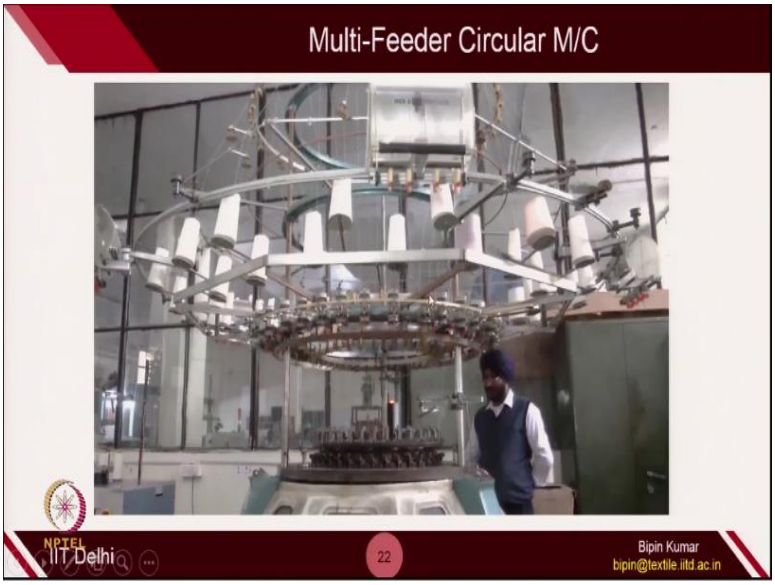


So, if you see single feeder machines from lecture 3, the cam was rotating and this was the cam. **(Video Starts: 38:47)** If you see this, the cam was rotating and the fabric was formed. Then you can see this vertical yarn which was feed in the fabric forming zone. Okay. And if you see, if you slow down this process, what you can realize is, whenever the cam is interacting you can see the needle is either raising or the sinker is going inside, depending on the position of the butt.

But other parts are not doing anything. So, along the circumference, wherever the cam is located, only the needles and sinkers interacted in that cam areas are participating in knitting actions. **(Video Ends: 39:30)** But rest other areas are not doing anything. They are idle. They are waiting for the cam to go to that particular locations. If you increase the diameter, because if you see single bed machines, the diameter can go from 4 inch to 50 inch.

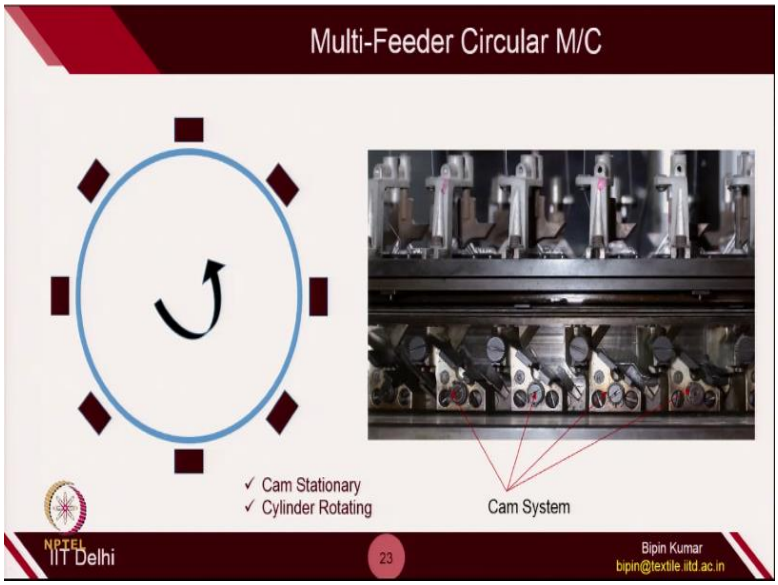
So, the more and more bigger diameter, you can see, the cam takes sufficient times to reach to each needle sections. So, in one rotation, hardly only segment of time is being used by a particular needle. And rest of the time, the needle is just sitting idle. Bigger the diameter, more idle time for the needle. So, more idle time for the needle means, needle is not doing anything and the fabric will not being formed. So, there is a chance of very limited productivity when you are utilizing a single feeder circular knitting machines.

(Refer Slide Time: 40:33)



But to increase the productivity, we can go for multi-feeder circular knitting machines. So, in terms of knitting principal it remains same, the only difference is, here we are providing more and more yarns to different segments on the same periphery of the machine. So, because of this, very high productivity of circular fabrics is achieved. This is why it is more popular in industries. And they use such type of machines to produce vests, t-shirts, undergarments, sports wears at a very very fast rate. So, let's see how this particular machine works in reality.

(Refer Slide Time: 41:14)



In case of single feeder, only one cam was there and the feeder was also moving with the cam. But in case of multi-feeder machines, many cams was located along the circumference. So, if you see the actual photo, so here these cams are placed on the cylinders. So, across this curved part of this cylinder, many small small cams was placed. So, these are all cam system that is placed on the cylinder.

And this particular machines, all of these cams which is placed around this circumference, they are stationary, but the cylinder is rotating. So, the entire cylinder rotates. So, the beauty of this particular machine is, the moment a particular needle; let's suppose if it interacts with the first cam, it does its knitting cycle, it makes one loop. Immediately it interacts with second cam in the same rotation.

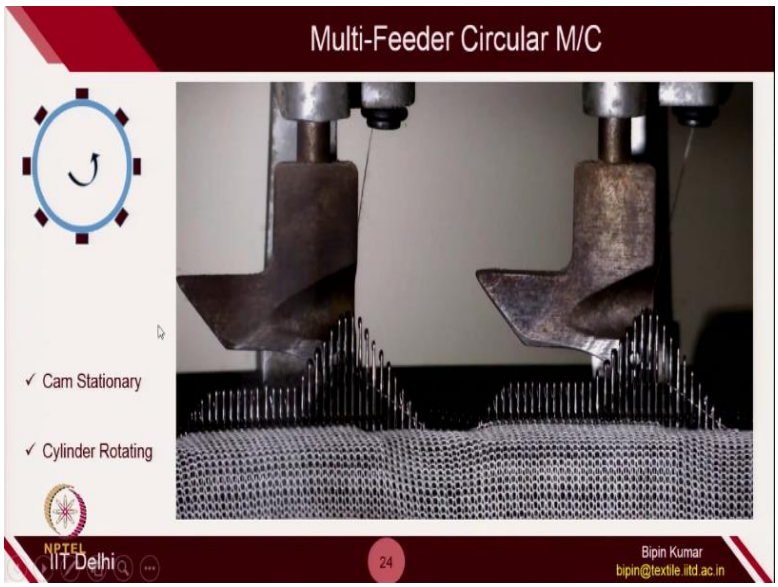
Once it makes the loop, after the interaction with this particular cam, it again interacts with the third cam in the same cycle. So, within one rotation, instead of making just one loop by a particular needle, each needle make multiple loops in one rotations, depending on how many cams it is interacting. Okay. Let's see this video. **(Video Starts: 42:47)** So, here is this cam. So, this cam is stationary, you can see the cam is not moving but the cylinder is rotating.

So, this cylinder is rotating. Okay. The moment this needle interacts with this cam, it makes one loop. After that, when it interacts with this particular cam, it will create another loop. **(Video Ends: 43:09)** So, within one revolution, it will create not just one loop, but multiple loops depending on how many cams are placed on the cylinder. So, if you have a much bigger

cylinder, you can place multiple cams even 20, 24 or maybe even 50 cams depending on the size of the cylinder.

So, you can, in just one revolution, you can create 50 loops by just one needle. Okay. This is the beauty of multi-feeder circular machines. And the productivity increases multi-folds because of this type of arrangement.

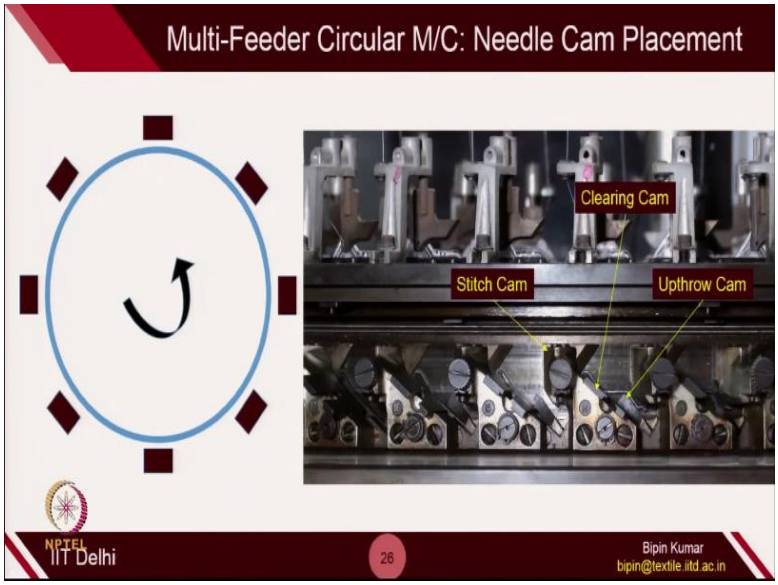
(Refer Slide Time: 43:50)



So, let's see how it works. So, you can here there is another video here, actual running of the fabric on this machine. **(Video Starts: 43:58)** So, the needle is revolving, so you can see here, the needle is revolving. So, needle is first making loops interaction with the cam placed here. Once this needle make the loop here, it is carrying and interacting with the second cam in the same circle.

(Video Ends: 44:15) And then it is making loops. So, in the same sequence, depending on how many cams are placed along the circumference, it interacts and it makes the loop according to that.

(Refer Slide Time: 44:15)



Now, let's try to observe the needle cam profile. So, each of these cams which is placed along the circumference, they do the same, some kind of reciprocative movements to the needle butt to make the knitting happening. **(Video Starts: 44:43)** And is a small video you can see here. So, the needle butt first interacts here. And it starts rising. Then again it hits this particular cam, then it rise.

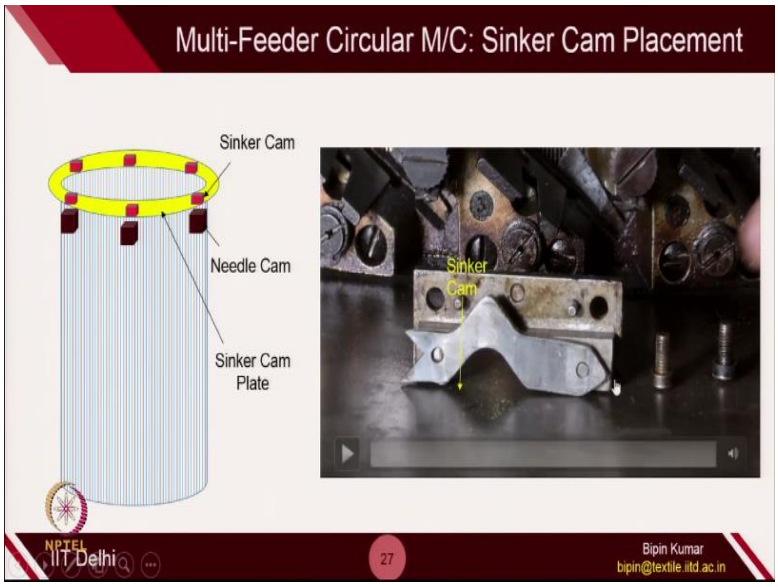
And then, it goes. This is, **(Video Ends: 45:04)** the metallic part, the small metallic part in each slots which you are looking at, they are butt. This particular cam segments is actually doing raising, clearing and stitching. So, these are the 3 cams which is located on the machine. So, the first one is the upthrow cam or the raising cam. It makes the butt to raise to certain heights. And then, it is hitting the clearing cam.

So, this is the resting position. Then it is hitting the clearing cam. Because of this, it is rising. And after that, you can see, here is the downward movement, the moment it interacts with this particular cam which is the stitch cam. It is start descending and it goes back to its bottom most positions. Once the job is done by this cam, immediately, the needle is free to interact with the second cam system.

And once it makes the loop with the second cam system, again it interacts with the third, and so on. This is the beauty, how within a short span, a multiple loops are being created by the same needle. So, let's see this video. **(Video Starts: 46:18)** So, you can see here, you can see here, this the needle is raising, **(Video Ends: 46:26)** then going down. So, needle is raising, then this is the resting position, this is raising and the clearing point. And then it is going down.

Again raising, resting position, clearing, then go down. So, in this sequence, it is making the knitting.

(Refer Slide Time: 46:45)

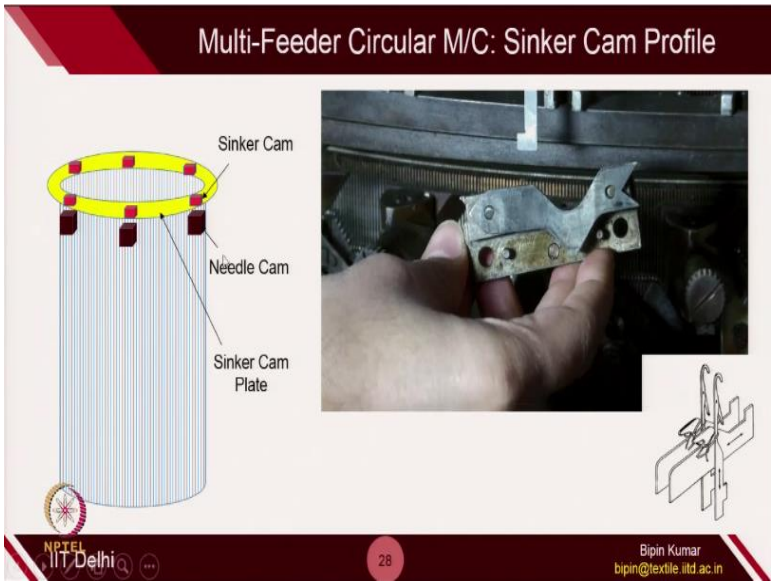


Now, let's see how the sinker is placed. So, if you try to observe, there is a sinker elements is also there on the machine. So, needle cam is placed on the cylinder's curved section and which is stationary and cylinder is rotating. The sinker cam is placed in this plate. So, this is the plate on which sinker cam is placed. So, these 2 cams works together at the time of knitting loop. So, I am showing you how the sinker is placed.

This is the same sinker which we covered in the third lecture. **(Video Starts: 47:27)** So, here, this is the sinker which you can remove. So, there are so many sinkers, depending on how needles cams are placed on the circumference same, the same number of sinker cam is also placed. So, you can see here, this is the sinker. So, it also creates a kind of profile for sinker reciprocative movement.

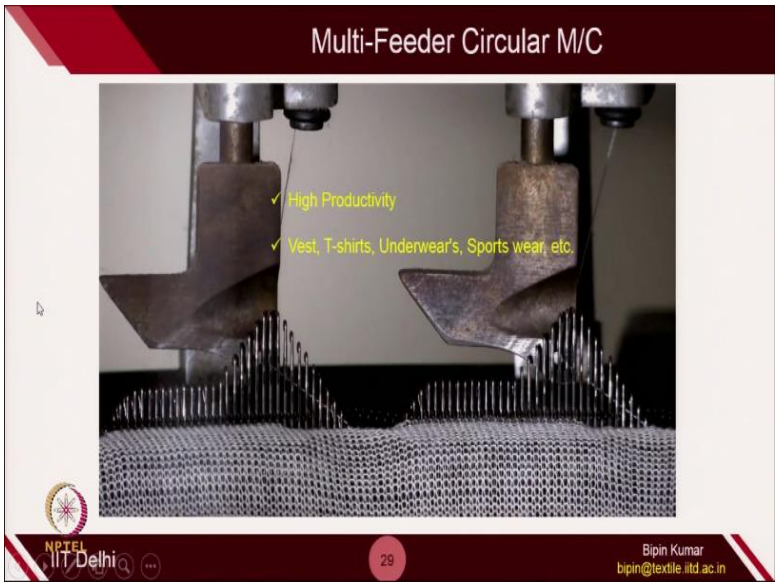
(Video Ends: 47:55) So, once the needle butt interacts, here this is the raising or upthrow cam. Then it, this is the resting position. And then, this is the clearing or raising position. Then it descends. So, this is how the sinker cam is placed on the machines.

(Refer Slide Time: 48:13)



Let's see how the sinker does the movement. So, I hope you remember this interaction of needle and sinker. **(Video Starts: 48:20)** So, this is the sinker part. So, sinker butt is here. And the sinker butt interacts with this cam profile and it follows the path of the cam. **(Video Ends: 48:32)** Okay. And the placement of sinker cam is like this. So, just on the top of the needle cam, the sinker cam is placed on the circular rim. Okay. So, this is, the yellow one is the sinker cam plate. And on each sinker cam plate a slots was created to place this sinker cam with the help of nut and bolt.

(Refer Slide Time: 48:56)



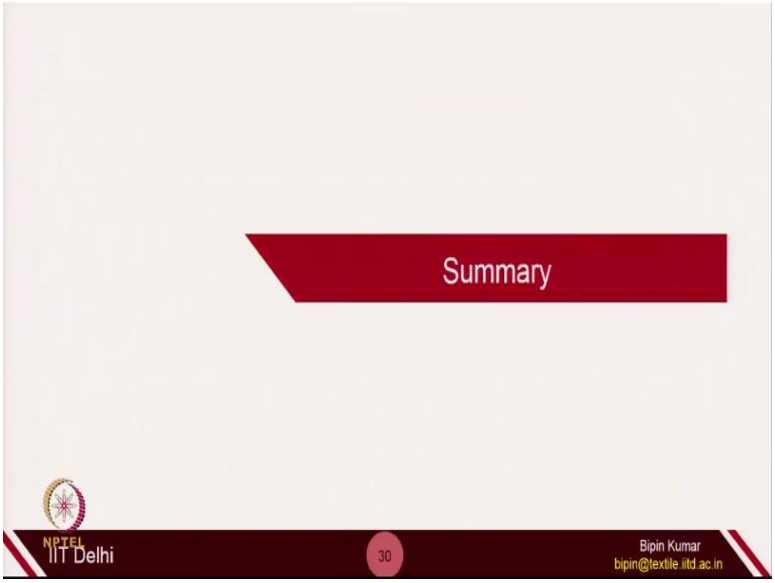
This is the actual machine which involves the functioning of both needle sinker and the fabric. So, you can see here, **(Video Starts: 49:05)** how the fabric is produced. So, at this location, the needle is going down. This location, knitting is at the clear most position. **(Video Ends:**

49:18) This is the resting position. The horizontal part, this is the rising position. The needle is raised and this is the clearing position. And then, it is going down by the help of stitch cam.

The beauty of this multi-feeder circular machine is, none of the needle is remaining idle for longer time. The moment it completes one knitting cycle with one cam interaction, it immediately follow the cam profile for the second cam which is placed on the circumference. So, multiple courses are formed in the same rotation due to which very high productivity is achieved.

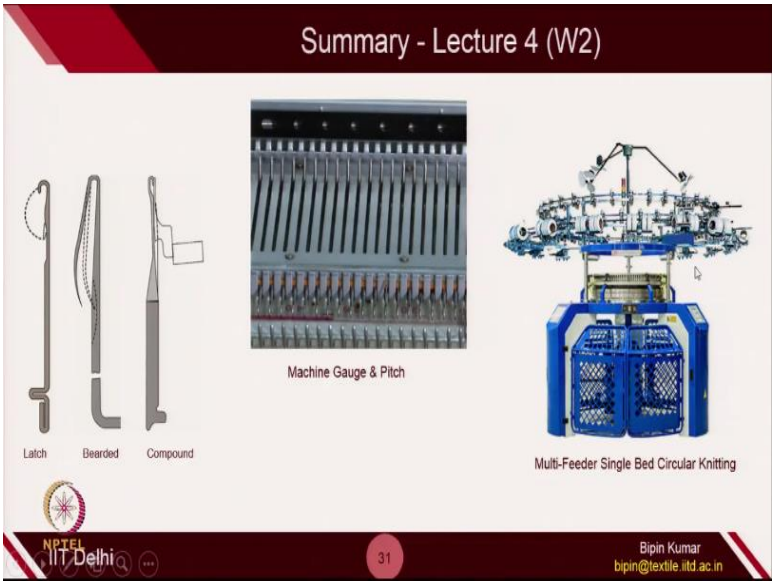
And this is very important from company point of view. They can achieve very high productivity. And these types of machines are used in vest development, t-shirt making, undergarments making, sportswear.

(Refer Slide Time: 50:11)



Let’s summarize this particular lecture. So, in this lecture, we still covered the single bed machines, flat and circular.

(Refer Slide Time: 50:22)



But we given more emphasis on the different types of needles that are used in this knitting machines. We given some importance to machine gauge and pitch, because this determines the fabric quality, fabric density. And the pitch decides what type of yarn you can used for fabric development on a particular machines. And also, I have given more emphasis from the company point of view to use a multiple feeder single bed circular knitting machine, because the production rate is much much higher.

So, compared to single feeder which creates just one course in one rotations, here you can create multiple course by one rotation of cylinders. So, this is why this type of machines are most popular. Latch, beard and compound: latch is the most popular one in weft knitting. But beard and compound needles are not so much populars; only they are used in warp knitting type of machines.

Although, 50, 60 years before, these 2 types of needles were used, but latch become very simple and it is a self-actuating needle. So, that's why this needle become more popular in knitting industries. We are going to stop this single bed knitting machines. In the next week, we are going to start a new type of knitting technologies where we used 2 beds in the fabric productions.

So, why there was a need for 2 beds? That we are going to discuss first. And then, we will see what type of designs and what type of technologies are there in those type of machines. So, with this I am going to stop this particular week. I have designed 2 demos for this particular week for running flat bed machines and for running circular bed machines. So, I hope you will

enjoy that lab demo where I am going to demonstrate you how in the lab we use or we run this machine in the fabric development. So, stay tuned. Thank you. Thank you very much.