Science and Technology of Weft and Warp Knitting
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Module - 1
Lecture - 4
Analysis of a Weft Knit Fabric

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Welcome participants. Now, I am going to do the lab demonstration 1. This time, we are going to demonstrate you the basic analysis of a weft knitted fabric structure. So, fabric analysis is one of the key elements that every students in textile engineering should know. So, in a analysis of a weft knitted fabric structure thus, there are many things which you need to understand whenever you see a fabric in your life.

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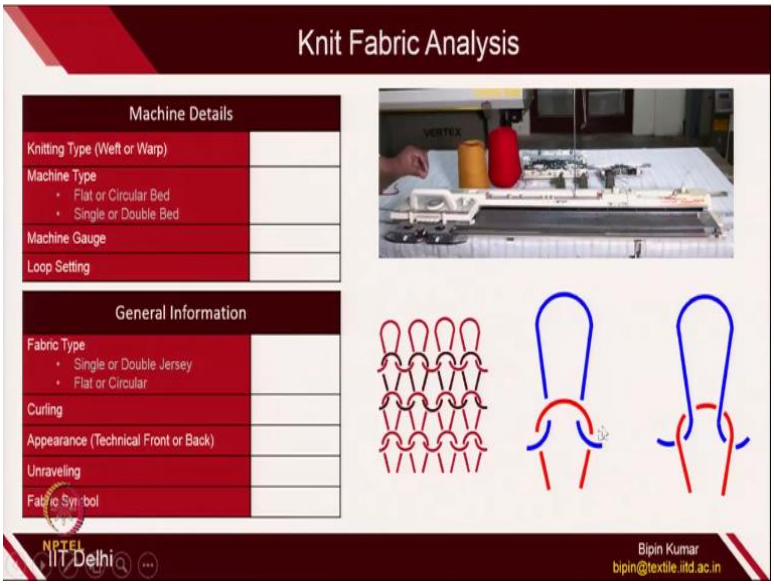

So, the first thing, when you are doing the analysis, you should be knowing the machine details. Like, on which machine the fabric is being formed; what are the type of the machines; what is the gauge of the machine; so, machine gauge is the number of needles which are being used per unit inch on the machine; and the loop setting, what loop settings has been used to make the, to produce the fabrics.

Also, you need to, also give some brief idea of what is the type of the fabric, whether it is a single jersey or double jersey; whether it is being formed on a single bed, then it is called single jersey, when it is being formed on a double bed, then it is called double jersey. Weather the fabric is flat or circular; whether the fabric is doing curling; what is the appearance of the fabric; can you identify technical front or back; what is the unravelling conditions of the fabrics; can you unravel the yarn from the fabric from both the ends; how you can symbolize these fabrics.

Although many of these things, we have not covered so far, but some of this, I am going to demonstrate you how you can identify some of these general informations of the weft knit fabric structure. So, you have a weft knit fabric here. This is the common machines which is used for making weft knit fabrics. We will cover this in week number 2. We have also introduced to you the technical back side when the loop is being formed on the back side.

In this case, you can only see the head part and the sinker part. And this is the technical front side of the loop. We can see, the loop is being formed on the front side of the back old loop. Here legs are visible. So, this is technical back loop and this is technical front loop.

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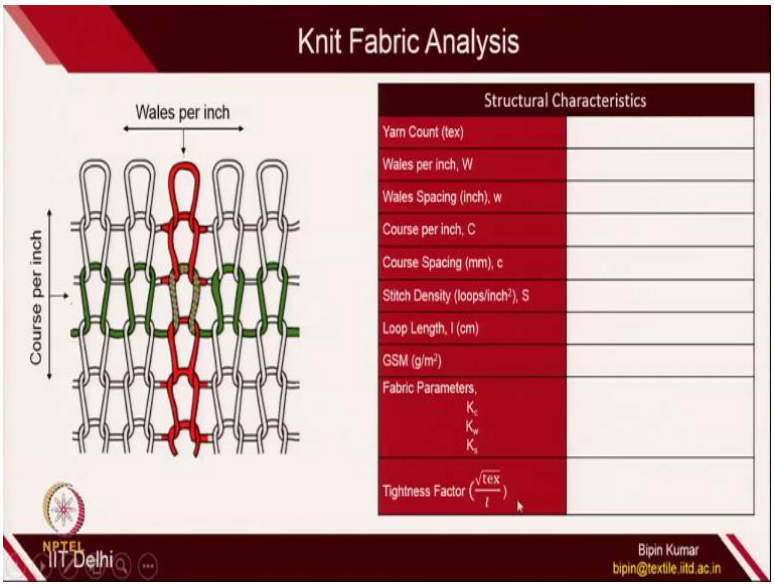

In doing analysis, some of the keywords which you might encounter frequently. The first one is the yarn count. What is the yarn which is used for making this fabric? What was its linear density, tex. Tex is generally defined as the weight of the yarn in 1000 meter length of the yarn. Wales per inch, how many wales you can count per unit inch. Wales spacing: what is the distance between 2 wales in a series.

Course per inch: how many courses you can count in an inch. Course spacing: distance between 2 courses. Stitch density is how many loops you can count per unit area. So, we define this as a number of loops per inch square. Loop length is also one of the key things that you should also learn, how we can find the loop length. So, loop length is the actual length of the loop which is being used inside the fabric.

GSM: GSM is the gram per meter square. It is the weight of the fabric which is expressed per meter square. So, weight of the certain area, that is called GSM. We express this in gram per meter square. Some of the key fabric parameter is Kw, Kc and Ks. This I am not covering today's. But, probably in third or fourth week in geometrical model you will come across these fabric parameters.

The tightness factor which we define as $\mathbf{tex^{1/2}/\ l}$. So, this tightness factor is also one of the key parameter in fabric analysis. That will let you know whether the fabric is porous or not. So, it is, it somehow indicates the functional coverage of yarn inside the fabric structure. So,

tightness factor, if this factor is more, you can assume the fabric is very tight. So, obviously if the fabric is very tight, then the porosity or the permeability of the fabric will be hindered.

So, tightness factor is also sometimes useful when we are comparising different fabric structures. So, let's do the analysis of a simple fabrics. Before I start, I am also going to give you different types of fabrics that are being used in textile engineering. We start from some of the fabric samples. **(Video Starts: 04:54)** So, the first fabric sample you might have seen your real life is the woven fabrics which is made by the interlacements of warp threads and weft threads.

So, it goes up and down like this. The second fabric structures which you might have seen is the knitted fabric which we are going to analyze today. Okay. So, this is the normal knit fabric structures. Okay. So, in knitting, I have also introduced to you 2 types of knitting fabrics. One was weft knit fabrics. And the another one is mostly warp knit fabrics which is not that extensible.

So, you can see here. This is the warp knit fabrics. Okay. So, this also we are going to analyze after 3, 4 weeks. And the another one is the braided structures. You can see here. So, this is the structure mostly used in ropes or covering. This is also one of the key fabric which is used in textile engineering. Okay. So, each fabrics has different techniques to analyze, but today's we are going to focus mostly on weft knitted structure.

So, let's see 2 types of weft knitted structures. One is single jersey. So, this one on my left side is, this one is single jersey structure and the other one is double jersey structure. You can clearly see the structure has different nature. So, one is curling from the edges. And this structure looks much more stable. Okay. In coming weeks, I am going to let you understand why these structures are having different nature; why one is curling, why one is more stable.

But for the time being, you just assume that this structure is curling; mostly single jersey structure. This one is double jersey structure. If you try to see this fabric, so as I mentioned in technical front side, you can only see the technical front side of the loop. So, you can see, this is the leg part of the fabric. So, let me show you technical front part. So, each loop, this is your leg part. Okay.

So, this is your leg part. If you reverse this fabric, again it will look like similar. Technical front only you can see on both the surface. So, this is, on this side also technical front. But if you see a single jersey fabric structure which we are going to analyze today. The structure looks completely different. So, first of all you can see here, this is the technical front side where you can see the legs. Okay.

And this is the technical back side where you can see only the head and sinker part. So, this is, you can see, so this is head part and this is the sinker part. Okay. Certain things which we need to analyze for any fabrics. So, since, the first thing which we are going to do is the regarding the machine details. Like, what type of knitting we used for making this fabrics. So, the first one is weft and warp.

So obviously, the fabric which we are dealing is weft knitting. So, this is the weft knit machine. Okay. So, this is the weft knit fabrics which we are analyzing. Machine type flat end circular; so, the fabric is mostly a flat panel. So, it's not circular like your hosiery or stockings. So, definitely it is a flat bed. So, flat bed; I am going to give more information about these technologies in coming weeks.

But for the time being, this fabric is produced on a flat bed. Single or double bed: So, more, it is being formed by a single bed and that's why it is curling. This also, I am going to describe you in couple of weeks. So, for the time being, you can just assume this is a single bed fabrics. And the fabric which was not curling, here, this was basically formed on a double bed machine. Machine gauge: So, machine gauge is a, it is defined as number of needles per unit inch.

So, in a 1 inch, how many needles are being placed. So, this, again when we describe the machine, I will go, let you know the machine gauge. It generally varies from 2 to 50. So, it means, 2 means, **2 needles/inch**; 50 means, **50 needles/inch**. Different technologies are being there, but in reality, this particular fabric is being formed on a machine needles per unit inch was around 6.

So, 6 needle per inch. Loop setting also, this is one of the technical terms we use on the machine. So, we, if you want to create a bigger size of loops and smaller size of loops; so, at that time we use this word, loop settings. So, at this moment, we have set the loops setting of

10. So, these, all of these things might be new to you. Definitely in second or third weeks we are going to cover more about this.

But the general information. You might have some understanding. The first one is the fabric type: single or double jersey. So, naturally, this fabric is a single jersey fabrics, because it is being formed on a single bed, because you can see only one type of loops on the surface. So, this is a single jersey. More details; in week number 3, you would be able to understand what is a single jersey fabric and double jersey fabrics.

Curling: So, curling naturally, you can by looking to the fabric itself, you can see it is curling from the edges, you can see here. The moment you are leaving this fabric, it is making, it is curled from the edges. So, yes, it was curling from the edges. A more interesting part is, when you try to understand this curling, you can see, the curling is, this is the technical back side and this is technical front side.

So, on one side you can see, it was curling from the front to back. So, it is curling this way. Okay. So, front is visible. But if you see the curling from the other edge, so if you open the fabric, other side will start to curl. So, here you can see the back side is curling. So, naturally, the tendency is on one side, on this side, it is curling from front to back side, but on this side, it is curling from back to front side. Okay.

So, this is some interesting nature of this fabrics. I am going to give more details in subsequent weeks. But for the time being, you can understand, this is yes, this is curling. And the nature of curling is evident. But if you see other fabric, for example, this fabric, it is not curling. So, this is the basic difference between a single and double jersey structures. So, one will curl; definitely, if it is a single jersey it will curl.

And if it is a double jersey it will not curl. The third thing which you need to understand is the appearance. So, can you identify technical front and back. In the lecture also, I have showed you what do you mean by technical front. So, in technical front, you can only see the leg side. So, this is your technical front. And technical back. If you see this, you can only see the head and sinker part.

So, this is head and sinker. So, this is your technical back side, and this is your technical front side. This is technical front side, and this is your technical back side. So, I hope you would be able to understand and identify. So, let's look at the unravelling part. So, unravelling basically indicates whether you can take out the yarn from the fabric. So, when you realize the fabric production on the machine, you have seen the first course is formed at the bottom and the last course at the top.

So, if you start pulling the yarn from the last course, you will realize the loops are coming out. So, this is called unravelling. So, loops will just come out and the fabric will collapse, and yarns will be released. If you take the other side also, and if you will try to pull the yarn, the same thing will happen. So, you can see here. The unravelling is happening from the other course also.

So, you can see here, unravelling is happening from the both sides. So, if you see the fabric, the yarn can be pulled from both the courses; from the first course and from the last course. So, it means, this fabric, unravelling can be done from both the sides. There are certain other fabrics where especially in rib fabrics, you will realize the unravelling is only happening from the last course.

That we will discuss in the subsequent lectures. You can do the unravelling. So, yes, from both ends. Now, the fabric symbol, it is always better to represent this fabric with some kind of symbol. So, if I am going to represent this side of the fabric, so you can, simply you can have all the loops in the back side. Okay. And in all courses, it is the same. And you can count number of columns.

So, the repeat unit, if you just want to repeat, this is technical back side and the other part is technical front. In technical front side, the other part is technical front. So, if you want to find out technical front side; so, this is your technical front side. And we denote technical front side by cross. Okay. So, fabric symbol also the key things which I hope you would be able to do that.

So, this is the basic general information, general nature of the fabric; what is the, whether is the fabric single jersey; weather it is curling, from which side; what is the curling nature; what is technical front; what is technical back; unravelling, whether it is doing unraveling,

yes or no; fabric symbol. So, these are the some things which you should be knowing how to represent this fabric structure.

Now, come to the most important part which is fabric analysis, especially the structural characteristics. So, structural characters, the first thing is, we need to find out each of these things individually. So, the first thing is the yarn which is being used to make the fabric structure. So, the yarn which is used here in making this particular fabric, the tex was around 194. Okay.

You can, the finding yarn count is very easy. You can follow any standards in textile. In reality, you just take the weight and you find the length, take their ratio. So, the yarn tex was one 194.4 tex. **Tex = gram/1000 meter** of yarn. The second thing is wales per inch, wales per inch, it means how many columns you can count in this fabric. So, wales per inch, so this is your fabric.

So, how many columns you can count in your per unit length. So, you can count right now from here itself. I have a scale with me. Okay. So, I can count from here to here. Okay. So, in 1 centimeter, this is 1-centimeter scale. So, you can count 1, 2, 3, 3 and half. Okay. So, 1, 2, 3 and half. So, how many columns you can count per unit length. And that length is inch. So, sometimes we use pick glass.

This is the pick glass, so this is the normal pick glass, and this is automatically 1 inch. So, you can put the pick glass, you can put the lens here and you can count how many wales are there. So, this process is very simple, so right now number of **wales/inch = 8**. Okay. Wales spacing is nothing but the ratio of wales per inch. So, w you can, wales spacing is the distance between 2 wales.

So, you can easily find **w = 1/W = 1/8.** Okay. So, this is 8 wales per inch. So, 1/8 = 0.125 inch. So, distance between 2 loops, this is 0.125 along the course. This is 0.125 inch. Similarly, course per inch, to find out the course per inch, you can put the pick glass and you can count; so, this time or may be from the scale also you can count. How many courses you can count?

So, for example, here, you can see here. So, in this length, in 1 centimeter length, how many courses you can count? 1, 2, 3, 4, 5; around 5. Okay. So, 1, 2, 3, 4, 4 and half, something like that. So, but if you use pick glass you would be able to differentiate more easily. Because it gives you more enlarged view. So, right now, the **courses / inch = 11**.

You can definitely convert inch into centimeter. You can convert in courses in inch. Course spacing again **c = 1/C = 1/11**. **Distance between 2 courses= 0.091 inch**. This is nothing but the distance between 2 loops along the column. Stitch density: stitch density is number of loops per inch square. To find out stitch density, either you can take out the area and you can count number of loops in that particular area.

Otherwise, the most easy way to find the stitch density is; stitch density is nothing but the multiplication of wales per inch and course per inch. So, **8*11 = 88 loops/inch^2**. Okay. The other thing which is there is loop length. So, to find the loop length; so, what is the length of the loop? So, in loop length, we have to include the sinker part as well, the 2 legs and head part.

So, to find the loop length, as I showed you the unravelling part; so, you can unravel the yarn, you can count how many columns are there. And then, you can just divide it. So, **total length/number of loops**. So, you can take out the length of a entire course, you measure that length, you count number of loops. So, number of loops you can count by number of needles that have been used on the machine.

So, we have calculated the **loop length = 1.2 centimeter** so far. Already done this. GSM again; **fabric weight/meter^2**. You can cut the fabric and you measure the length, you measure the width, you measure the weight. So, **GSM = weight/area.** So, **gram/meter^2**; so, right now, we have calculated this. We are around 320 **gram/meter^2**. Okay.

Fabric parameters: the formulas are already given. Kc, to find the Kc: If you know the course spacing, you know the loop length. You can easily find Kc. Or if you know the wales spacing; so, the **Kc = l/c**. You have already loop length you have find out 1.2. So, your **c=0.091 inch** and **loop length = 1.2 centimeter**. So, first you convert 0.091 into centimeter. **0.091* 2.54 = 0.23**.

So, **1.2 centimeter/0.23 centimeter**. So, **1.2/0.23=5.217.** Okay. This is your Kc. **Kw = l/w**. Again 1.2 centimeter. The value of w is 0.125. So, you first convert into centimeter, so 0.3175. **1.2/0.317=3.78**. And **Ks = Kc* Kw**. These are some fabric structure parameters. I will come with these structural parameters in, most probably in fifth and sixth week.

But for the time being, the calculation is very simple, just try to understand the calculation part. So, the case **Ks = Kc* Kw = 5.217*3.78 = 19.72**. Okay. And the last part is tightness factor. So, **tightness factor** is nothing but **= tex$^{1/2}$/loop length**. So, **tex$^{1/2}$**. Tex, we have already calculated here, 194.4. So, square root of 194.4.

And loop length is 1.2 centimeter. So, 1.2 centimeter. So**, 194.4$^{1/2}$ = 13.9 , 13.9/1.2=11.6 tex$^{1/2}$/centimeter**. Okay. So, this is how we do the calculation. Okay. Some of the things which you might able to absorb at this moment, but especially the fabric parameters and tightness factors. This is some, have some significance. I am going to cover this in detail may be in third and fourth week.

But for the time being, this is the whole analysis you, everyone must do whenever they play with a knitted structures. And we can make the comparison when you have many fabric structures. The other thing which is very interesting is like, if you, let's suppose if you have done some mistakes here, if you have done some mistakes for some reasons, you would be able to easily check the corrections.

So, for example GSM theoreticals. So, we have already calculated GSM, **320 gram/meter^2**. Okay. So, that GSM you can also calculate theoretically by using
yarn tex*loop length(meter) *stitch density (loops/meter^2)/1000. So, let's try to calculate this and see if we are reaching around 320. So, yarn tex is 194.4. Loop length is 1.2 centimeter.

So, it means **1.2*10^{-2}*stitch density**. So, stitch density we have already calculated **88 loops/ inch^2**. So, we have to convert this into meter square. So, **88*1/(2.54*2.54)** These are in centimeter. And **88*1*10000/(2.54*2.54)**. This is a per meter square, and divided by 1000. So, let's try to find out how much we are getting. So, **194.4*1.2*88/2.54/ 2.54.**

And then, you have so many zeros; so 1, 2, 3; 3 and this, this, $\mathbf{10^{-1}}$. So, this is around 318.19 gram/meter^2. Okay. So, 318.19. But the actual value was 320. So, you can see how close we are. So, it means our calculation is completely okay. Because, the variation in calculated and theoretical, experimental and theoretical is almost similar. So, this is how we do the fabric analysis.

So, the key take from this lab is, you should be able to first identify what structure you are dealing; you should be able to understand on which machines we are making these fabrics; also, you should be able to understand the general nature or behavior of the fabric: curling, appearance, its symbol and also the basic structural characteristics, like thread spacing, GSM, tightness factors.

So, these are the things you must try to analyze. So, we are stopping the lab demo right now. **(Video Ends: 30:49)** In the next week, we are going to start with the machines; how we make loops on flat bed machines. So, I hope to see you very soon in the next week. Thank you. Thank you very much for watching.