To study the impact on process parameter of knitted fabric

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Abstract

At first collected some of knitted fabric samples along with required data which are needed to commence project work with effective analysis. And also separate the fabrics according to their class so that it will help to carry out further activities depending on the established form of work.

During our industrial attachment we manage and to watch carefully and effectively the knitted fabric specification along with machine specification and the major factors which are necessary to calculate different types of variation and variable on which the whole fabric construction depends where carried out. Our efforts were to develop a dependable way so that we can easily visualize or can forecast the resulting fabric specification with required configuration.

We have tried our best to emphasize on the adjustable points on which fabric GSM. Stitch length, fabric width, & compactness directly or indirectly depend. The theoretical as well as the practical knowledge that we gathered from our classes and the industry has helped us to perform our project with credit and for this we specially convey thanks to our honorable teachers.

Introduction

Fabric is a manufactured assembly of fibres and yarns that has substantial surface area in relation to its thickness and sufficient cohesion to give the assembly useful mechanical strength. Fabrics are most commonly woven or knitted but the term includes assemblies produced by felting, lace making, net making, non woven processes and tufting. Our project basically is on knitted fabric specification and machines which are related to knitted fabric production. A precise statement of a set of requirement to be satisfied by a materials, product, and system or service that indicates the procedures for determining whether each of the requirements is satisfied. In the analysis of woven fabric specification we consider ends per inch, picks per inch, yarn count (warp & weft), and fabric width but in case of knitted fabric specification GSM, stitch length are mainly considered. The title of our project work is Analysis of knitted fabric specification and other related machine specification. There are problem in our industries to produce knitted fabrics of required G.S.M. Other specification like fabric width, fabric thickness is generally maintained in industries by previous data sheet. For this reason there are problem if any order comes which didn't produced in previous. Our target is to find out the easy process to get decision about yarn count selection, loop length selection, machine Diameter selection & machine gauge selection. We strongly think that by this process we can get decision about yarn count, loop length, machine gauge, and machine diameter for the single jersey, Rib and interlock fabric.

Aims of the project work are the following:

- Find out relation between yarn count and GSM.
- Find out the logic of selection of stitch length selection.
- Selection of machine diameter and machine gauge to get specific width of fabric.
- Find out the fabric width.

Direct system: In this system the count lf yarn express the no. wt. units in one length unit. In direct system "higher the count, coarser the yarn" This system is used for thrown silk, artificial silk, jute etc and count calculation formula is the following:

Count=Here,

$W \times l / w \times L$

W = weight of sample.
L = length of sample.
w = unit weight in system.
l = unit length in system.

Indirect system: In this system the count of yarn express the no of unit length per unit weight. In this system higher the yarn counts finer the yarn. It is generally used for cotton, worsted, woolen, linen etc and the yarn count calculation formula is the following:

Count = $L \times w / W \times l$

Here,

W = weight of sample.

L = length of sample.

w = unit weight in system.

l = unit length in system.

GSM: GSM means the weight in gram per square meter of fabric. Fabric area density: Fabric area density can be calculated by the following formula,

Area density = $(S \times l \times T \div 100) \times gm/m2$

Here, T = Tex,
S = Stitch density,
l = Stitch length.

Fabric width: Fabric width can be calculated by the following formula:

Fabric width = course length × Stitch length/ Kw

π × d × G × Stitch length / Kw

Where, Stitch length is in cm

D = Machine diameter,

G = Machine Gauge and

Kw = 38 (for dry relaxed state) = 41 (for wet relaxed state) = 42.2 (for finished relaxed state)

GSM: There are two formulas for calculating the GSM of a knitted fabric. i.e. First formula is

$$GSM = \frac{Course\ per\ inch \times Stitch\ length \times 39.37 \times 39.37 \times Tex}{1000 \times 1000}$$

$$GSM = \frac{WPI \times CPI \times SL(mm) \times 0.9155}{Count\ (Ne)}$$

Calculation of weles per inch:

We calculated the number of wales in 10 inch fabric unraveling the yarn. Then we divide the no of total wales by 10 inch to getting the wales per inch.

Calculation of course per inch:

We calculated the number of course in five inch with the help of counting glass and needle. Then we divide the total no of course by five inch to getting the course per inch.

Measurement of stitch length:

Stitch length is theoretically a single length of yarn which includes one needle loop and adjacent needle loops on either side of it. Loop exits coarse in length and it is that which influence fabric dimension and other properties including weight. In order to determine the stitch length, we count 100 no wales or stitch and count its length by hanging the yarn on the stitch counter. The reading is found in mm unit.

Measurement of yarn count

We have fallowed a different way to find out the count of the yarn. At first we unravel a considerable no yarn from the fabric. Then we measured the total length of the yarn and measured the weight of that no of yarn. From these weights, we find out the count of the yarn. The equation we followed is as follow:

Count = n × l × 453.6÷ wt × 36 × 840
Where,
n= number of yarn in bundle.

L= length of yarn.
Wt= weight of yarn.

Measurement of GSM: GSM is a very important parameter for specified a certain quality of knitted fabric. The production of knitted fabric is calculated in weight. The GSM cutter is very popular and easy usable GSM testing instrument used in most knitted factory. But the construction of this cutter is very simple. It is circular disk of 100 square cm area with sharp blade attached to its edge. So 100 square cm of fabric can easily cut by it and weighted at the electric balance to get GSM reading.

Another formula is the following:

GSM = (Ks × Tex)/ Stitch length (mm)

Where, Ks is a constant.

Its value is different for different fabric structure and fabric type. Ks is calculated and estimated as below:

Ks = (GSM× Stitch length) /Tex

Comment: It is very convenient to determine the stitch length against the required GSM by using the value of Ks. We could not determine the value of Ks for other decorative fabric. It requires large time and industry.

Gsm depends on:

1. Type of yarn: The main material for knitting process is yarn. The quality of knitted yarn should be like as follows:

2. Yarn count: The following counts of yarn that are widely used for knitting process are given:

a) Cotton: 20/1, 24/1, 26/1, 28/1, 30/1, 34/1, 40/1 Ne.

b) Terylene cotton: 20/1, 24/1, 26/1, 28/1, 30/1 Ne.
c) CVC: 26/1, 28/1, 30/1, 34/1 Ne.
d) Melange: 20/1, 22/1, 26/1, 30/1 Ne.
e) Spandex: 40D, 70D.
f) Polyester: 75D, 150D.
g) Sewing thread: 40/2, 150D etc.

Other parameters are:

- Stitch length
- Fabric Structure
- Finishing process.
- Depth of shade.
- Stitch density.
- Machine gauge

Fabric Type	Yarn count	Stitch length (mm)	Color	D×G	Finished diameter (inch)	Finished GSM
Plain S/j	16s/1	3.32	White	30×20	32-33	205-240
Plain S/j	20s/1	3.20	White	30×20	32-34	180-200
Plain S/j	24s/1	2.90	White	30×24	32-33	165-180
Plain S/j	30s/1	2.66	White	30×24	31-32	130-155
Plain S/j	40s/1	2.50	Avg	30×24	29-30	100-120
Plain S/j	50s/1	2.30	Avg	30×28	29	90-100
Plain S/j	60s/1	2.20	Avg	30×28	27	75-85

Table No. Relation between yarn count, fabric type, stitch length and finish GSM:

N.B: If the fabric is to be Enzyme washed, the stitch length should be kept (10%) less than the normal range. Because, enzyme wash reduces the total weight of the fabric by removing the floating fiber and hairy fiber. For light color, the finished GSM varies 1-2% from grey GSM.

For average color, the finished GSM varies 2-4% If the GSM varies 25-30%, it is not only necessary to control the VDQ pulley dia. but also yarn tension & take-up roller.

Comment (Reference 1):

1. It is very distinct from these tables that there is no proof that these values are true, as they are not actual or experimental and they have taken these values from the mill and factory.

2. They have determined the value of count by Beasley's balance. We never give the value of count in fraction but by our method we find that the value of count is most of the time is fraction.

From our project work we manage to find the following equations for the selection of yarn count to get required GSM. equations vary for fabric types, fabric construction. List of equations are tabulated below:

Name of the Fabric	Equation
Plain Single Jersey	Yarn Count = 86-0.28GSM
Single Jersey Pique	Yarn Count = 87-0.30GSM
1x1 Rib	Yarn Count = 85-0.25GSM
2x2 Rib	Yarn Count = 76-0.20GSM
2x1 Lycra Rib	Yarn Count = 55-0.11GSM
2 Thread Fleece	Yarn Count = 62-0.17GSM
3 Thread Fleece	Yarn Count = 272-GSM
Interlock	Yarn Count = 81-0.20GSM

EQUAION FOR GATTING REQUIRED GSM FROM THE SPECIFIC YARN COUNT:

EQUATION FOR DETERMINING FABRIC WIDTH:

Fabric width = No. of wales X Wales space
. =No. of needle X Wales space.
= Π dg X Wales space

Where,

d = Cylinder diameter.
g = Gauge.

FOR CALCULATING YARN DIAMETER: $= da \propto \sqrt{Tex}$

Name Of The Fabric	Equation
Plain Single Jersey	**GSM** = 296-3.52Yarn Count
Single Jersey Pique	**GSM** = 290-3.33Yarn Count
1x1 Rib	**GSM** = 340-4.00Yarn Count
2x2 Rib	**GSM** = 380-5.00Yarn Count
2x1 Lycra Rib	**GSM** = 493-9.00Yarn Count
2 Thread Fleece	**GSM** = 370-6.00Yarn Count
3 Thread Fleece	**GSM** = 272-Yarn Count
Interlock	**GSM** = 389-4.77Yarn Count

$$d = \frac{Tex}{26.7} \; For\ cotton$$

$$da = \frac{1}{\sqrt{Ne}}$$

$$da = \frac{0.91}{\sqrt{Ne}}$$

Relation among GSM, stitch length and yarn count can be derived from the following equation:

$$GSM \alpha \frac{1}{\text{Yarn count} \times \text{Stitch length}}$$

(When count and Stitch length both Yarn are variable)

- **Yarn count** × **Loop length** × GSM = **K**

Where K is a Constant.
Wales space = 4d; [where d is the yarn diameter]
Minimum stitch length = 14d
Fabric Thickness:
In the fully relaxed state the fabric thickness for double jersey, t= 4d
For single jersey, t = 2d
Comment (Reference 2):

1. It is understandable that gauge is an important factor for fabric width but actually the width of fabric is dependent upon the number of needle present in the machine. Often the number of needle present in the machine is not equal to Π dg. So the equation should only be like following:

Comment (Reference 3):

Different properties were found in Different knit structures according to stitch length, stitch density that means wales per inch, course per inch. Shortly they told loose structure that means higher loop length gives less GSM on fabric & compact structure that means shorter loop length gives high GSM on fabric. In their project analysis, they observed that single jersey plain structure & 1×1 plain rib structure variation of calculated GSM with respect to actual GSM is too small. But in single lactose & polo-pique structure variation of calculated GSM with respect to actual GSM is high. Because single lactose & polo-pique structure are made by combination of knit & tuck loops. They also analyzed that one knit loop consumes 30% more yarn than tuck loop. So calculated GSM is higher in single lacoste & polo-pique structure than single jersey plain structure & 1×1 plain rib structure. In general, the angle of spirality values decreases when the tightness factor values gets higher that is decrease of loop length in all knitted samples. In slack knitted fabric structures, the loop can easily find an area to rotate & spirality increases. The spirality angle of the fabrics knitted with ring yarns are very high comparing with the knitted with open end yarns. This shows the effect of the spirality on twist liveliness. Fabric shrinkage depends on different fabric structure i.e.; single jersey, rib, interlock & their derivatives, yarn composition i.e.; 100% cotton, cotton & polyester & synthetic yarn.

Result and Discussion

Fabric Specification

Elements of Specification:

1. GSM:

The weight of fabric in gm per square meter is called GSM.

Factors Considered For Required GSM:

Yarn Count (English count):

Through our project work we manage to find out the following relation between yarn count and GSM: i.e.

GSM α 1/ Yarn count (When Stitch length is same) ……(1)

GSM α 1/ Loop length (When Yarn count is same)
…….(2)
From the equation (1) & (2) we get,

GSM α 1/ Yarn count × Stitch length (When Yarn count and Stitch length both are variable)

Yarn count × Loop length × GSM = K

Where, K = Constant.

K varies for the single jersey with different gsm, count, and loop length.

S/N	GSM	SL	COUNT	EQUATION	AVERAGE	STD DEV	CV%
1	220	3.3	16s	11616			
2	200	3.2	20s	12800			
3	180	3.0	24s	12960			
4	150	2.9	30s	13050	83486	933.30	7.82
5	110	2.5	40s	11000			
6	100	2.3	50s	11500			
7	80	2.2	60s	10560			

Table No. 3.1 Constant for single jersey from collect fabric

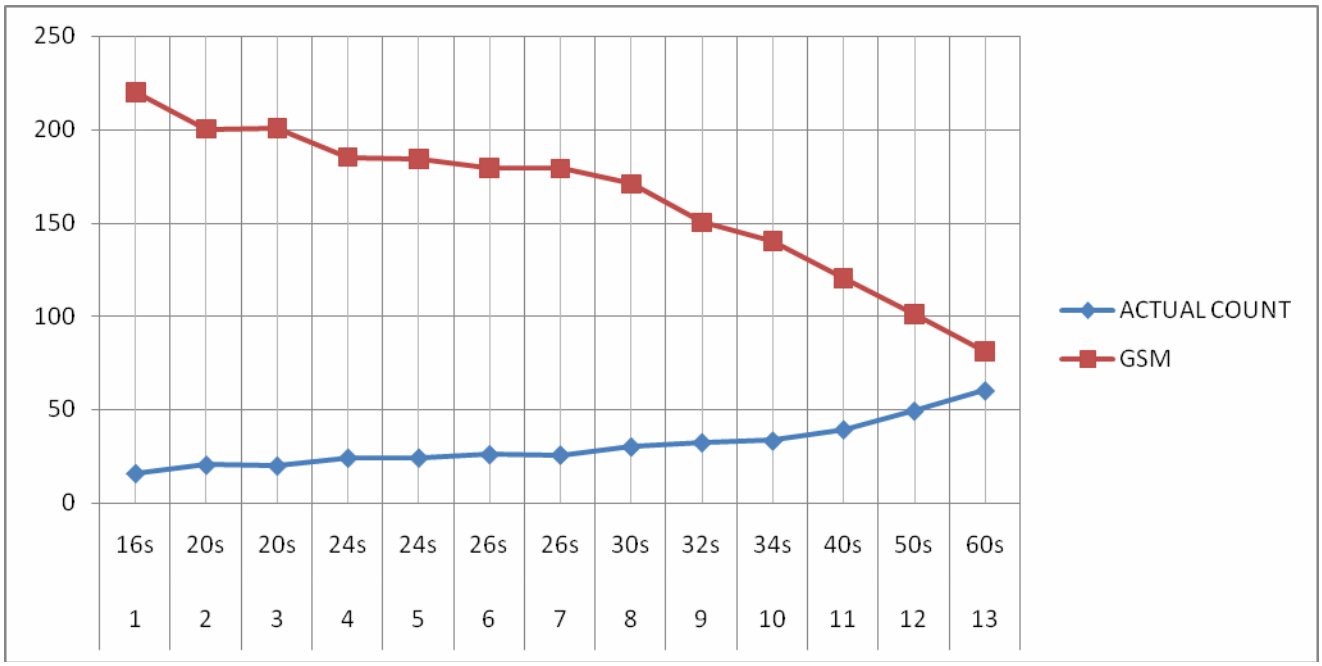
Type	Ne	Max GSM	Min GSM	GSM	S/L (mm)	Constant K	AVG	SD	CV%
S/J	16s	240	205	240	3.00	11520			
				230	3.30	12144			
				210	3.35	11256			
	20s	200	180	200	2.90	11600			
				190	3.02	11476			
				180	3.20	11520			
	24s	180	165	180	2.95	12744			
				170	2.90	11832			
				160	2.80	10752	11506.05	705.52	6.13
	30s	155	130	150	2.75	12375			
				140	2.90	12180			
				130	2.60	10140			
	40s	120	110	120	2.55	12240			
				110	2.50	11000			
	50s	100	90	100	2.35	11750			
				90	2.30	10350			
	60s	85	75	80	2.25	10800			

Table No.3.2 Actual practicing of constant value in industries:

S/N	COUNT	ACTUAL COUNT	GSM

1	16s	15.76	220.00
2	20s	20.25	200.23
3	20s	19.84	200.47
4	24s	24.07	185.11
5	24s	24.11	184.17
6	26s	25.91	179.22
7	26s	25.67	179.00
8	30s	30.02	170.77
9	32s	32.34	150.10
10	34s	33.22	140.00
11	40s	39.30	120.07
12	50s	49.29	100.77
13	60s	60.21	80.786

Table No. 3.3 Actual determination of fabric gsm & yarn count of collect fabric



Graph No. 3.1 Graph shows the relation between the count & the GSM

By taking two points from the straight line, we can find the following equation:

(80, 60.21) (220, 15.76)
X=GSM Y=COUNT
= x-80/80-220 = y-60.21/60.21-15.76
= x-80/-140 = y-60.21/44.45
= x = (y-60.21) (-140)/44.45 + 80
= x = (-3.149y + 190 + 80)

From, (1)
= y = (x-80) 44.45/ (-140) + 60.21
= y = (x-80) (-0.137) + 60.21
= y = (-0.317x) + 25.4 + 60.21
= y = (85.6-0.317x)
Example: Count, y = 30

= x = (270-3.149y)

GSM = 270 – 3.149 × 30
= 175.5

2. Fabric Width:
Along the fabric width there presents the Wales. The total no. of needle is fixed for the same cylinder having the equal gauge as well as diameter.

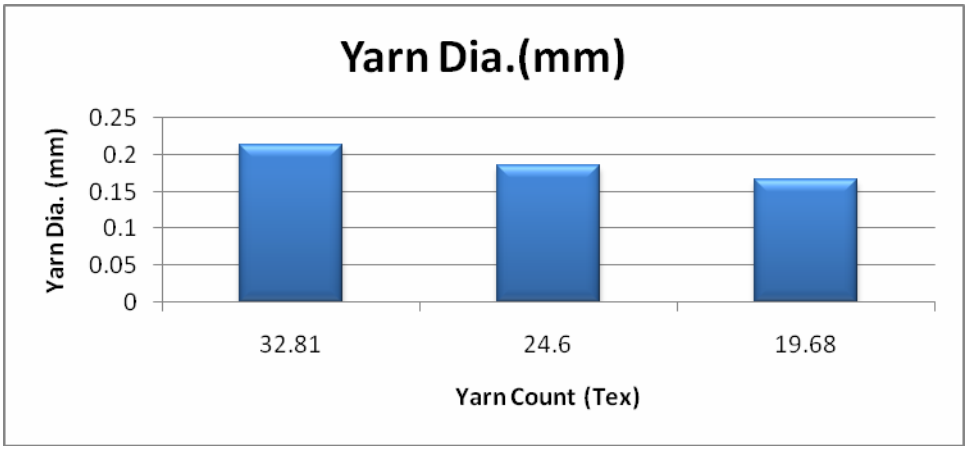
Fabric width = No. of Wales × Wales space.

=Total no of needle in the machine × Wales space.

The above concepts clarify that Fabric width closely depends on total no. of needle not directly related to machine diameter or machine gauge.

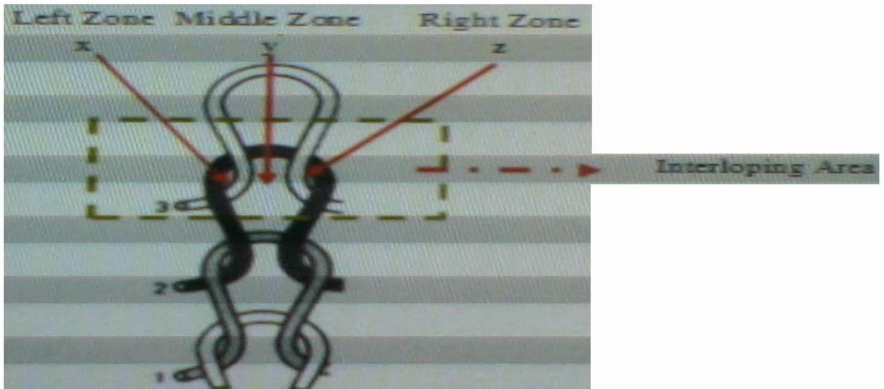
Wales Space:

The space covered by a wale is called wale space for that wale. Wales's space depends on: a. Yarn diameter. b. Loop length. They are described below:



Graph No. 3.2 Yarn diameter

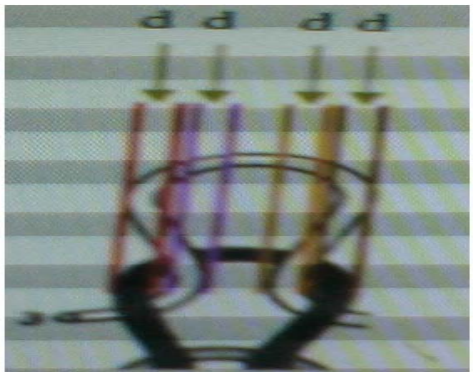
From the experiment it is seen that yarn diameter decreases with the increases of yarn count. The count which are generally used in circular knitting machine (20 to 60) the rate of decrease is generally slow than that of below 20 count in which the rate of increase of yarn count is higher or it increase rapidly. When the loop length is minimum, the leg of loop comes in close contact with each other and there is no free space among



left, middle and right zone of interloping area.

Interloping Area

Fig 1.: Impact of yarn diameter on free space in inter looping area Under the circumstance the wales space will be less than four times of yarn diameter.



Wales space = d+d+d+d = 4d When loop length is minimum

Comment: In case of minimum loop length there is no space left in interloping area. I.e. stretched due to tension the Wales space become less than 4d (d is the yarn diameter) When loop length is increased the space into the interloping area i.e. the zone a, b & c are increased as a result wales space becomes wider. It may be up to 5.2d (depending on the collected data)

Count	Wales Space (mm)	Yarn Dia (inch)	Yarn Dia (mm)	Ratio	Avg
30s	0.6604	0.006520	0.1656	3.9877	
30s	0.6224	0.006520	0.1656	3.7581	
18s	0.8380	0.008417	0.2138	3.8367	
18s	0.8380	0.008417	0.2138	3.8367	
24s	0.7362	0.007290	0.1851	3.9762	
24s	0.7362	0.007290	0.1851	3.9762	3.998
24s	0.7584	0.007290	0.1851	4.0957	
24s	0.7584	0.007290	0.1851	4.0957	

Table Actual value of ratio of Wales space and dia of yarn:

Comment:

It's clear from the chart that, the ratio of yarn dia to wales space is very near of 4. So we can say that one wales occupy 4d space, where d is the yarn diameter. So, from the above chart, we found the relation between the yarn count and the WPI as follow,

$$WPI = 28 \times \sqrt{Ne} \div 4$$

Count	Wales Space (mm)	Wale Space (inch)	WPI	AVG	SD	CV%
18s	0.8203	0.0322	30.96			
18s	0.8203	0.0322	30.96	30.63	0.33	1.077
18s	0.8380	0.0329	30.30			
18s	0.8380	0.0329	30.30			
24s	0.7362	0.0289	34.50			
24s	0.7362	0.0289	34.50	34.00	0.50	1.470
24s	0.7584	0.0298	33.50			
24s	0.7584	0.0298	33.50			
30s	0.6604	0.0260	38.46			
30s	0.6604	0.0260	38.46			
30s	0.6224	0.0245	40.81	39.63	1.175	2.964
30s	0.6224	0.0245	40.81			

Table No. 3.5 shows the actual WPI in accordance to the count:

Comment: From the above chart, we came to the decision that WPI the equation as follows:

$$WPI = 28 \times \sqrt{Ne} \div 4$$

Machine Specification:

1. Machine Gauge:

No. of needles per inch present in a needle bed of a knitting machine is called machine gauge for that knitting machine. A term giving a notational indication of the no. of needles per unit length along a needle bed or needle bar of a knitting machine in current practice, a common unit length of one English inch (25.4mm) is used for all types of warp and weft knitting machine. Selection of machine gauge depends upon yarn diameter. Yarn diameter depends upon the following:

1. Yarn count 2. Fiber type 3. Yarn twist 4. Yarn finished

General practice of yarn count and machine gauge in different industries is given below:

M/C Gauge	Count
18	14.0/1-23.5/1
20	18.0/1-26.0/1
22	21.5/1-29.5/1
24	23.5/1-35.5/1
26	26.0/1-41.5/1
28	29.5/1-47.5/1
30	35.5/1-59.0/1
32	41.5/1-70.0/1

Table No. 3.6 Typical selection of m/c gauge for different count yarn:

2. Machine Diameter: Machine diameter is mainly diameter of cylinder. It is important for fabric width. Only diameter does not determine the fabric width. It needs helps machine gauge and wales space which is depending upon yarn count and loop length.

S/N	Count (Ne)	Gauge	WPI	Fabric Found From 1 inch M/C Perimeter	Percentage Of Fabric Found X%
1	18	18	29	0.6206	62.06
2	18	20	30	0.6666	66.66
3	20	18	31	0.5806	58.06
4	20	20	32	0.6350	63.50
5	22	20	32	0.6250	62.50

6	22	24	33	0.7272	72.72
7	24	20	34	0.5882	58.82
8	24	24	34	0.7058	70.58
9	26	24	35	0.6857	68.57
10	26	28	35	0.8000	80.00
11	28	24	36	0.6666	66.66
12	28	28	36	0.7777	77.77
13	30	24	37	0.6486	64.86
14	30	28	37	0.7567	75.67
15	32	24	38	0.6315	63.15
16	32	28	38	0.7368	73,68
17	34	24	39	0.6153	61.53
18	34	28	39	0.7179	71.79
19	36	24	40	0.6000	60.00
20	36	28	40	0.7000	70.00
21	38	24	42	0.5714	57.14
22	38	28	42	0.6666	66.66
23	40	24	43	0.5581	55.81
24	40	28	43	0.6511	65.11
25	50	24	44	0.5454	54.54
26	50	28	44	0.6363	63.63
27	60	24	45	0.5333	53.33
28	60	28	45	0.6222	62.22

Table No. 3.7 Machine Diameter Selection

So, the machine dia for particular fabric dia is = Fabric dia / X% ×100

X = percentage of fabric found in relation to the m/c perimeter.

So, the relation between the machine dia and the machine dia is

= 7 × (Fabric dia ×√ Ne ÷ M/C Gauge)

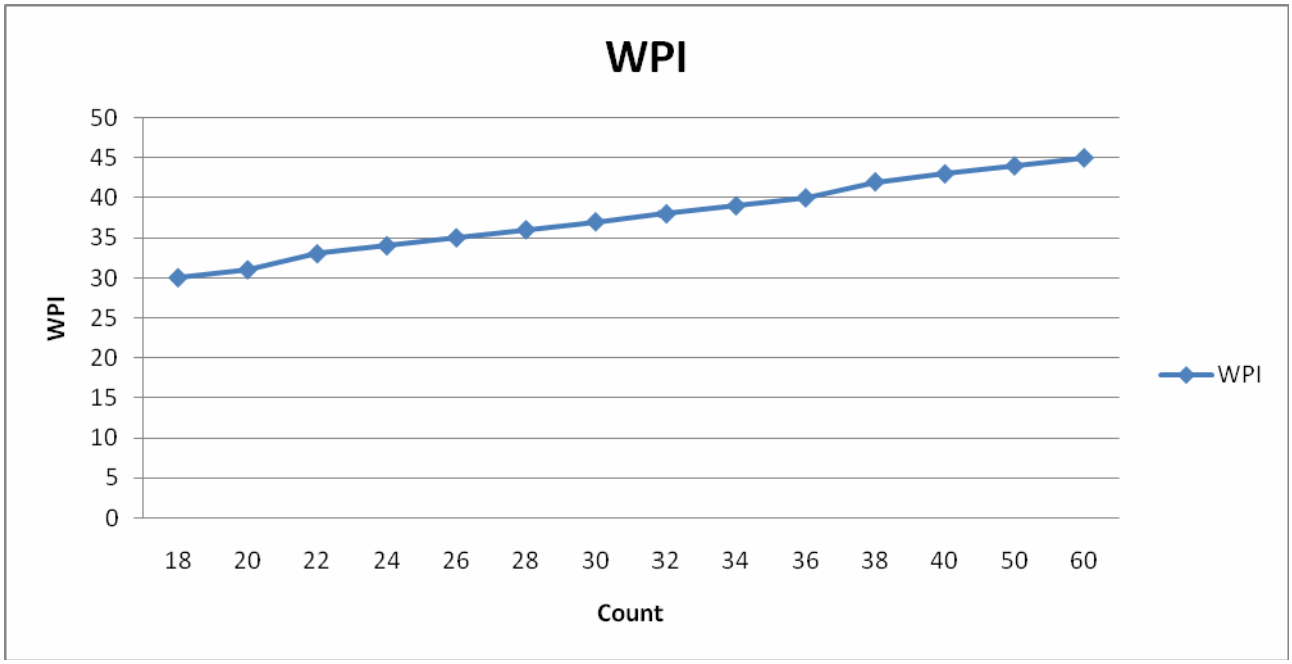
Again, the relation can be inversely shown that,

Fabric dia (Tubular) = Machine dia × M/C Gauge ÷ 7 × √Ne

For example, if the machine dia is 32", yarn count 24Ne, and the machine gauge is 24 then the fabric dia will be

=32 × 24 ÷ 7 × √24

= 22.4 inch



Graph 3.3 Shown the Relation between the Count and the Wpi

3. Needle gauge: Thickness of needle express by the needle gauge. It is important for selection of machine gauge. Needle gauge is different for the different gauge and different Brand. Some needle gauge found in industries is given below:

Machine Gauge	Needle Thickness in (mm)
24	0.52
28	0.41

Table. Shows needle gauge and thickness

CONCLUSION

From our project work we manage to find the following equations for the selection of yarn count to get required GSM equations vary for fabric types, fabric construction. List of equations are below:

The constant for the plain single jersey is as follow:

K (Yarn count × stitch length × GSM) = 11506.05

Relation between the fabric GSM and the yarn count: if the GSM of the fabric is "x" and the count of yarn is "y", then the equation for determining GSM and the Yarn count is as follows:

GSM, x = 270 – 3.15y & Yarn count (Ne), y = 86 – 0.32x

Machine diameter selection: The relation between the Fabric dia and the Machine dia is

= 7 × Fabric dia × Ne M/C Gauge

Again, the relation can be inversely shown that,

Fabric dia (Tubular) = Machine dia × M/C Gauge 7 × Ne