Faculty of Engineering

Department of Textile Engineering

Thesis on

"Study on Factors Affecting Knit Productivity"

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Submitted By

Name	ID
Joy Sarker	191-23-686
Samiul Islam Himel	191-23-653
Muksedul Mumin Rabby	191-23-678

Supervised By

Prof. Dr. Md Mahbubul Haque, Ph.D. (UK), CTextFTI,

(A British Commonwealth Scholar)

Professor & Coordinator for Research and Industrial Collaboration

Dept. of Textile Engineering,

Daffodil International University

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Advance in Fabric Manufacturing Technology

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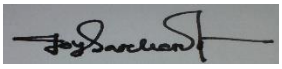
DECLARATION

We declare that we are the sole authors of this project. It is the actual copy of the project that was accepted by our supervisor including any necessary revisions. Neither this study nor any part of it has been submitted elsewhere for the award of any degree. We also grant Daffodil International University permission to reproduce and distribute electronic or paper copies of this Project.



Joy Sarker

ID: 191-23-686

Department of Textile Engineering
Daffodil International University

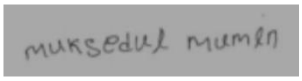
Email: joy23-686@diu.edu.bd

Samiul Islam Himel

ID: 191-23-653

Department of Textile Engineering
Daffodil International University

Email:samiul23-653@diu.edu.bd



Md. Muksedul Mumin

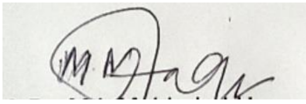
ID: 191-23-678

Department of Textile Engineering
Daffodil International University

Email: muksedul23-678@diu.edu.bd

LETTER OF APPROVAL

The Thesis Report entitled “Thesis on Study on Factors Affecting Knit Productivity” prepared by Joy Sarker (ID: 191-23-686), Samiul Islam Himel (ID: 191-23-653), & Md. Muksedul Mumin Rabby (ID: 191-23-678) is approved in Partial Fulfillment of the Requirements for the Bachelor of Science in Textile Engineering Degree. The said students have completed their thesis under my supervision.



Prof. Dr. Md Mahbubul Haque, Ph.D. (UK), CTextFTI,
(A British Commonwealth Scholar)
Professor & Coordinator for Research and Industrial Collaboration
Dept. of Textile Engineering,
Daffodil International University

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Dedicated To Our Beloved Parents

&

Honorable Teachers.

Abstract

Knit fabric is well known for its comfortability, better texture, comparatively good wrinkle resistance, well-breathability, a good fit for the wearer's body, more elasticity, lower labor cost for manufacturing, more elasticity & stretchability, and so on. The Quality parameter of knit fabric is greatly influenced by its Physical or Dimensional Properties, Mechanical & Chemical Properties. The thermal conductivity of knit fabric is influenced by Loop Shape Factor & Tightness Factor. If the loop shape factor and tightness factor both are similar, a minimum thermal conductivity can be obtained. But if the Tightness factor is constant, but the loop shape factor decreases, thermal conductivity increases, and if the loop shape factor is constant, the tightness factor decreases thermal conductivity decreases. The WPI, CPI, GSM, and Thickness factors are related to air permeability, stretchability, elasticity, and water absorbency. Stitch Length and Yarn Count help to control the GSM of the knit fabric. They are inversely proportional to the GSM. A Compressor, Motor, Aluminum Tubes, Yarn Guide, VDQ Pulley, Feeding Devices, Needle, Cam, Sinker, Oiling & Lubricating Pipe, Cylinder, take up roller & cloth roller are the basic parts of a knitting machine. The proper functioning of these parts helps to obtain the best outcome. Knitting productivity increases by increasing technical parameters i.e., Cylinder RPM, Cylinder Diameter, No of Feeders, No of Needles, Stitch length, & Fabric Width. And if the count of yarn increases, the thickness of the yarn reduces, and yarn breakage tendency increases due to yarn tension and machine speed. But Risk factors appear when mismatched knit programming and wrong technical parameters are set in the knitting machine. For example, If 30 count of yarn is allocated to 18 gauges machine, it will cause a disastrous situation in the machine, and production will be hampered. For required GSM fabric, the proper Count of yarn & Stitch length should have functioned in the machine otherwise production time will be loss for higher machine maintenance time due to several yarn breakage & tensioning of yarn. Even the mental stress of a worker & employee can affect the knitting productivity. Sustainability, Safety & Compliance is a must for better knit productivity. Non-compliance factory is underrated nowadays. So, Besides technically improving, worker training, workplace safety, overhead stress removed from employee & worker, fire safety, environment-friendly, worker-friendly, and supportive action is must necessary at this moment to improve the quality of goods and enhance productivity.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Knitting is the process of producing fabrics from continuous strands of threads by transforming yarn into a series of loops, and each series of loops are knocked over through an immediately preceding series of loops. Loop intermeshing is considered the basic element of knit fabric structure, where loops are intermeshed with adjacent loops on both left and right sides and above and below. Knit fabric can easily be differed from woven fabrics, as the woven fabric is produced by the interlacing of two sets of threads, where lengthwise threads are known as Warp threads and widthwise threads are known as Weft threads, on the other hand, knit fabrics are produced by interloping of a single set of continuous thread.

Knitting technology is practiced in the textile industry over the centuries. In the early sixteenth century, knitted goods are made by Hand knitting with the help of Pins, Hands & Fingers. But modern knitting technology is the complete work of an electrically powered motor, a multiplicity of needles, cams, sinkers, needle holders, and yarn feeders. Compared to hand knitting, high-speed circular knitting machines replaced 100 to 150 stitches per minute to several thousand stitches per minute. William Lee is known as the inventor of the mechanical stitch formation technique. Mathew Townsend obtains a patent for inventing Latch Needle in 1847. D. Griswold got a patent for a circular knitting machine that can produce tubular plain or rib fabrics in 1878. Robert Walter Scott was granted a patent for Interlock Fabrics in 1910.

Knit fabrics have different quality parameters for better productivity. Course density, Wales Density, Stitch Density, Stitch Length (SL), Count, GSM, Fabric Structure/Design, Needle & Cam Arrangement, Dimensional Stability, Spirality & Skewing-Bowing are well-known quality parameters. Besides that, types of needles, types of cams, yarn feeding systems, gauges, and rpm of the cylinder are considered as the knitting factors that affect the knitting productivity. Moreover, the mental stress of the operator directly influences the knitting productivity. All the mentioned factors have their own characteristics that can individually affect knit productivity. With the change of GSM, Yarn count & SL varies. Different structures have different types of needle & cam arrangements. Stitch densities are different for different GSM fabrics. Knit fabrics have the tendency of higher dimensional stability due to interloping. Spirality provides a great impact on knit fabrics. Skewness & Bowing, the distortion of pattern across the fabric width has an impact on knitted fabrics. So, every factor should be under consideration during knit fabric production as they all have a major impact on knit fabric productivity.

1.2 Objectives of this Study

- To know about the factors that affect knitting productivity.
- Comparison of productivity for different m/c speeds, different no of feeders, stitch length, and Gauge.
- To know about the relation of Count, GSM & Stitch Length.
- Comparison of Change of Count and Stitch Length based on GSM of knit fabrics.
- To get an idea about the techniques & idea implementation for the enhancement of knitting productivity.

CHAPTER 2

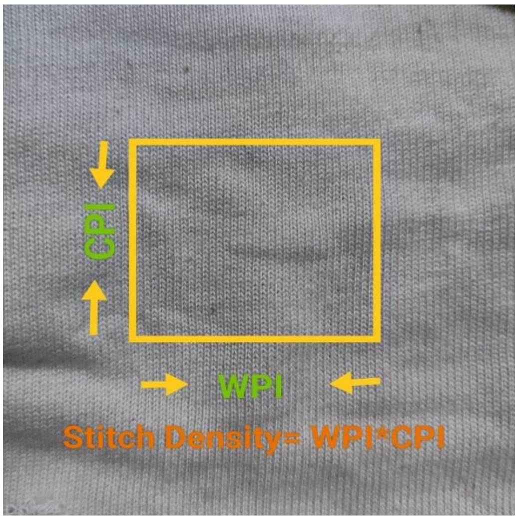
LITERATURE REVIEW

Fabric Quality can be defined as the assessment of predetermined specific characteristics or parameters of the fabric. Knit fabric is gaining popularity for its comfortability, better texture, comparatively good wrinkle resistance, well-breathability, good fit for the wearer's body, more elasticity, lower labor cost for manufacturing, more elasticity & stretchability, and so on. Different types of parameters have effects on knit productivity and its quality. Physical or dimensional properties of knit fabric can influence knit productivity.

2.1.1 Course per inch. The course is defined as the horizontal rows of loops. The total amount of horizontal rows of loops per inch is known as course per cm. No of feeder= no of cam box=no of course.

2.1.2 Wales per inch. Wales is defined as the vertical columns of loops. The total amount of vertical columns of loops per inch is known as Wales per inch. No of needles= no of Wales.

2.1.3 Stitch Density. The number of stitches per unit area is known as stitch density. It is obtained by multiplying Courses per inch with Wales per inch.



2.1.4 Loop Shape Factor: It can be obtained by dividing the course per inch by Wales per inch. To determine the dimension of the fabric, the loop shape factor helps. This shape basically depends on the types of yarn used and the finishing that is received.

Loop Shape Factor: CPI/WPI

2.1.5 Tightness Factor: The tightness factor is proportional to the yarn diameter and divided by the length of the yarn in a single stitch or loop.

Tightness Factor= $Tex^{1/2+}/l$

- ✓ Loop Shape Factor and Tightness factor both have an effect on the thermal conductivity of knitted fabric. If the loop shape factor and tightness factor both are similar, a minimum thermal conductivity can be obtained. But if the

Tightness factor is constant, but the loop shape factor decreases, thermal conductivity increases, and if the loop shape factor is constant, the tightness factor decreases thermal conductivity decreases.

2.1.6 Stitch Length: The length of yarn required to produce a complete knit loop is known as the stitch length.

Stitch length= One needle loop + two half a sinker loops.

2.1.7 Loop length can be obtained by dividing the course length by the no of loops.

Loop length= Course length/no of loops.

2.1.8 Needle Gauge: The needle gauge is the number of needles per inch. It represents the knitting machine's Size & Fineness. The most popular gauge is 18G, 24G, and 28G. The needle gauge has a relation with the yarn count. Depending on yarn count, a Gauge is allocated. A higher gauge means the fabric is finer. The spacing between the loops and the thickness of the fabric can be determined by the needle gauge.

For single jersey, G= $1650^{1/2}$/Tex

For double jersey, G= $1400^{1/2}$/Tex

Table 1:Relation Between Count & Needle Gauge

Count	Needle Gauge
18~20	18
20~26	24
28~34	28

2.1.9 Fabric Weight (G.S.M): Fabric weight is an important parameter for knit fabric. The knit fabric production is calculated in the weight. There are two ways for expressing the fabric weight, one is "weight per unit area" and another one is "weight per unit length". For a particular size piece, it is expressed by "weight per unit area" i.e., grams per square meter or ounces per square meter. G.S.M is the most widely used fabric weight measurement method for a particular size piece. Knit Fabric's weight (G.S.M) depends on two factors

i. Yarn Count
ii. Loop Length.

If the yarn count is constant and the loop length is reduced, The G.S.M will be higher. If the stitch length increases, the WPI, CPI, Thickness Factor, GSM, & Tightness Factor will be decreased for every structure but comfort properties like air permeability, stretchability, elasticity, and water absorbency will increases.

2.2 Stitch length helps to control the GSM of the knit fabric. It is inversely proportional to the GSM. Altering the position of the tension pulley, proper adjustment of stitch length and uniform count of yarn can control the GSM of the fabric, although finishing has some involvement in controlling GSM. If the pulley moves in the positive direction, the stitch length will decrease & the GSM will increase.

Two Formulas for calculating the GSM of knit Fabric:

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

$$GSM = \frac{Course\ per\ inch \times Wales\ per\ inch \times Stitch\ length(mm)}{Ne} \times 0.9155$$

2.2.1 Dimensional Stability: Dimensional stability is the ability of a fabric to maintain its required or original shape or dimensional when they are washed or relaxed under pressure or usage for an intended purpose & the shrinkage is directly related to it. There is a contraction with the dimension of shrinkage of the fabric as the fabric shrinks after cutting. Yarn twisting or the degree of yarn twisting has a great impact on dimensional stability. That’s why the polyester fabric has better dimensional stability than cotton fabric. Shrinkage of knit fabric should be assessed after a relaxation process, drying them immediately after hand wash. Normally shrinkage up to 5% is ok.

2.2.2 Spirality: The angular displacement of the courses and Wales from the perpendicular angle is known as spirality. Spirality depends on the feeding system, cutting angle, and shape of loop, it can be induced by selecting yarn twist direction.

2.2.3 Fabric Width: Cuttable width is the actual width for cutting with proper marker making without selvage width. Fabric cuttable width tolerance up to 3% for knit fabric. Fabric width is measured by

- Fabric Width=$\frac{3.1416 \times D \times G \times SL}{kw}$
- D= Diameter of the machine
- G= Gauge of the m/c
- Kw= 38 for dry relaxed, 41 for wet relaxed, 42.2 for Finished relaxed.

2.3 Knitting Productivity: The factors that impact the knitting productivity

2.3.1 Proper Increase of Machine Speed: Increasing machine speed in higher grades, faster the movement of needles. Consequently, the production will increase. But there is a factor that should be maintained properly that is "Tension". Excessive tension should not impart to the machine, otherwise, higher-end breakage can happen & which will ultimately decrease the production.

2.3.2 Increasing No of Feeders (F): By increasing no of feeders, the cylinder circumference will increase, as a result, the number of courses will be increased per revolution at a glance. To increase production, we must use a higher no of feeders.

2.3.3 Increasing No of Gauge (G): The higher the gauge, the more in production. So, the production can be increased by using a higher no of gauges in the machine. Relatively, productivity will be lower for the lower no of gauges.

2.3.4 Increasing size of Diameter (D) of Cylinder: With the increased size of the diameter of the cylinder, production increases. The production will decrease if the diameter of the cylinder reduces.

2.3.5 Stitch Length (SL): If we increase the stitch length, the production will be better. Stitch length is directly related to the VDQ pulley. VDQ stands for Variable Día for Quality. VDQ pulley controls the knitted fabric quality by maintaining the GSM & SL. If the yarn feeding is increased, the stitch length will increase, to do that, we should increase the diameter of the VDQ pulley, to increase the diameter of the VDQ pulley, the pulley should turn towards the reverse direction and GSM will be reduced.

2.3.6 Increasing Efficiency of Machine: Productivity can be increased by increasing the efficiency of the knitting machine. Higher machine efficiency brings more production.

2.3.7 Yarn Count: Count is the numerical expression of yarn's coarseness or fineness. It may be defined as "Weight per unit Length" or "Length per unit Weight". In an indirect count system, which is defined as the length per unit weight, by increasing this count, productivity will decrease. There is less chance of yarn breakage if the thickness of the yarn is increased. But breakage will increase for thin yarn. As a result, more knotting time will be required for several yarn breakage moments. Ultimately, it will reduce production.

An overview is mentioned below:

Table 2: An overview of the productivity

Cyl. RPM	No of Feeders	Cyl. Dia.	Gauge	SL. (mm)	Efficiency	Count (Ne)	Production(kg/shift)
15	96	30	24	2.5	75%	30	57.68
20	96	30	24	2.5	75%	30	76.9
15	104	30	24	2.5	75%	30	62.48
15	96	35	24	2.5	75%	30	67.28
15	96	30	28	2.5	75%	30	67.28
15	96	30	24	2.7	75%	30	62.29
15	96	30	24	2.5	80%	30	61.52
15	96	30	24	2.5	75%	34	54.28

2.4 There are some other factors that can influence the productivity of knitting:

2.4.1 Machine Maintenance: Machine maintenance is an important parameter for better productivity. Weekly machine maintenance and servicing are must necessary. Every part of the machine should be properly cleaned. For better productivity, proper utilization of the machine is a must. If the machine runs well, stoppage time will be reduced, less fault will be found in the fabric. Needle, Sinkers, Cams, Positive feeder storage, guides, needle tricks, sensors, oil and lubricating pipe, take-up roller, cloth rollers & motor should be serviced under a pre-determined timeline. Suppose, the oil pipe is not cleaned for a long time, some oil spots will definitely appear in the fabric & this is one kind of fabric fault. If the needle is not checked properly, short fiber will jampack the hook, as a result, the hook can't receive the new yarn properly, Needle mark, star mark, and a hole will be created in the fabric. This will reduce the fabric quality & production will hamper. If the sensor does not work properly, after yarn breakage operator will not be able to rectify the problem, as a result, more time will be taken to find out the issue and solve the problem. If the positive feeder does not work properly, loop length variation and tension variation, un-uniform feeding will happen. If the needle tricks are well not cleaned, fluffs will be adjusted in the tricks, which will create fabric defects. All this reduces the fabric quality as well as production.

2.4.2 Quality-full Knitting yarn: better quality means better productivity. Low-quality yarns have a higher breakage tendency. On the other hand, the better spinning yarn has fewer short fibers and a low breakage tendency. If the no of breakage is high, machine stoppage time will be higher, and consequently, production will decrease.

2.4.3 The skill of Workers: A skilled worker knows better. He always deals with the mechanical & technical parts of the machine. He can easily find out the problem and solve the issues. Operating skill is much better than others. Run time operation is good. By justifying the problems, it imparts better solutions to the machine. Efficiency is better. Worker's efficiency increases the machine's efficiency and production improves.

2.4.4 Machine Program: Each machine should be associated with one program. Because, of several changes in structural design, needle & cam arrangement takes a long time to run the new program. But if the machine is associated with a single program, that idle team can be reduced as well as production will be higher. So, the no of programs should be reduced for a single machine.

2.4.5 Overhead Remove from Employee & Workers: Mental satisfaction does matter in higher productivity. Workers should be motivated all the time, and provide necessary medical and proper economic support. Health safety is a must. Overstress directly affects the employee and workers' mental stability. Every employee and worker should be associated with a particular job description. Otherwise, stress ultimately affects the quality and production of the industry.

2.5 Other Developments to improve knitting productivity:

- Use aluminum tubes to eliminate the possibility of yarn damage.
- Use auto lint removal.
- Dry & Cool compressed air of 120-145 pounds per square inch for oiling and cleaning.
- Needles & Sinkers compatibility with the desired machine.
- Lifters for movement of fabric.

CHAPTER 3

METHODOLOGY

The following steps are carried out during the whole project for identifying knit productivity.

3.1 Knitting productivity based on different Machine RPM

- ❖ Requesting for approval of two machine allocations for the project.
- ❖ Requesting for Servicing & Maintenance of machines.
- ❖ Set our desired knitting program (Except RPM of m/c, all the parameters i.e., machine brand, machine specifications, machine efficiency, count of yarn, cylinder diameter, gauge, stitch length, no of feeder, and fabric structure) was identical in both machines.
- ❖ Requesting approval of yarn requisition for our project.
- ❖ Took help from the supervisor, feeder man & operator.
- ❖ Hourly production follow-up.
- ❖ Keep noting our desired findings.
- ❖ Comparison between the results of two machines.

3.2 Knitting productivity based on different No of Feeders

- → Requesting for approval of two machine allocations for the project.
- → Requesting for Servicing & Maintenance of machines.
- → Set our desired knitting program (Except no of feeders of m/c, all the parameters i.e., machine brand, machine efficiency, machine specifications, count of yarn, stitch length, cylinder diameter, gauge, machine rpm, and fabric structure) was identical in both machines.
- → Requesting for approval of yarn requisition for our project.
- → Took help from the supervisor, feeder man & operator.
- → Hourly production follow-up.
- → Keep noting our desired findings.
- → Comparison between the results of two machines.

3.3 Knitting productivity based on different Machine diameter

- Requesting for approval of two machine allocations for the project.
- Requesting for Servicing & Maintenance of machines.
- Set our desired knitting program (Except machine diameter, all the parameters i.e., machine brand, machine specifications, machine efficiency, count of yarn, stitch length, no of feeders, gauge, machine rpm, and fabric structure) was identical in both machines.
- Requesting for approval of yarn requisition for our project.

- Took help from the supervisor, feeder man & operator.
- Hourly production follow-up.
- Keep noting our desired findings.
- Comparison between the results of two machines.

3.4 Knitting productivity based on different Needle Gauge

- Requesting for approval of two machine allocations for the project.
- Requesting for Servicing & Maintenance of machines.
- Set our desired knitting program (Except needle gauge, all the parameters i.e., machine brand, machine specifications, machine efficiency, count of yarn, stitch length, no of feeders, cylinder diameter, machine rpm, and fabric structure) was identical in both machines.
- Requesting for approval of yarn requisition for our project.
- Took help from the supervisor, feeder man & operator.
- Hourly production follow-up.
- Keep noting our desired findings.
- Comparison between the results of two machines.

3.5 Knitting productivity based on different Stitch Length

- Requesting for approval of two machine allocations for the project.
- Requesting for Servicing & Maintenance of machines.
- Set our desired knitting program (Except stitch length, all the parameters i.e., machine brand, machine specifications, machine efficiency, count of yarn, no of feeders, needle gauge, cylinder diameter, machine rpm, and fabric structure) was identical in both machines.
- Requesting for approval of yarn requisition for our project.
- Took help from the supervisor, feeder man & operator.
- Hourly production follow-up.
- Keep noting our desired findings.
- Comparison between the results of two machines.

3.6 Knitting productivity based on different Yarn Count, Yarn Quality, & Breakage Ratio

→ Requesting for approval of two machine allocations for the project.

→ Requesting for Servicing & Maintenance of machines.

→ Set our desired knitting program (Except yarn count, all the parameters i.e., machine brand, machine specifications, machine efficiency, stitch length, no of feeders, needle gauge, cylinder diameter, machine rpm, and fabric structure) was identical in both machines.

→ Requesting approval of yarn requisition for our project.

→ Took help from the supervisor, feeder man & operator.

→ Hourly production follow-up.

→ Keep noting our desired findings.

→ Comparison between the results of two machines.

3.7 Knitting productivity based on Machine Efficiency

- Requesting for approval of two machine allocations for the project.
- Requesting for Servicing & Maintenance of machines.
- Set our desired knitting program (all the parameters i.e., machine brand, machine specifications, yarn count, stitch length, no of feeders, needle gauge, cylinder diameter, machine rpm, and fabric structure) was identical in both machines.
- Requesting for approval of yarn requisition for our project.
- Took help from the supervisor, feeder man & operator.
- Hourly production follow-up.
- Keep noting our desired findings.
- Comparison between the results of two machines.

3.8 For Comparison of Change of Count and Stitch Length based on GSM of knit fabrics.

We did some technical job in knit fabric. We do research for different GSM of grey knit fabric. We checked the variation of the yarn count and stitch length for different GSM of grey fabric. To do that, we observed different knitting knit programs running on the machine. During this project, we have found a relationship the Count & GSM-

$$\text{GSM} \propto \frac{1}{Yarn\ Count\ (Ne) \times Stitch\ Length}$$

$$\text{Stitch Length} = \frac{k}{Yarn\ Count\ (Ne) \times GSM}$$

Where, K = 12068.51 (Single Jersey), 14855.2(Double Lacoste), 16431.497(1*1 Rib), 19005.333(2*1 Rib), 24013.8 (Interlock).

Table 3: Relation Between GSM & Count

Name of Fabrics	Relation Between GSM & Count
Single Jersey	**Ne = -0.141 GSM + 50.22**
Pique	**Ne = 0.146 GSM + 57.16**
Double Lacoste	**Ne = -0.167 GSM + 64.36**
1*1 Rib	**Ne = -0.123 GSM + 54.57**
Lycra 1*1 Rib	**Ne = -0.119 GSM + 59.12**
Lycra 2*2 Rib	**Ne= 0.206 GSM + 80.56**

CHAPTER 4

RESULT & DISCUSSION

We got around 10 days to complete our thesis work in the industry. Two Machine was allocated for us. Our findings and result are discussed through the following table of comparison.

4.1 Knitting productivity calculation due to change in Machine RPM:

Table 4: Knitting productivity calculation due to change in Machine RPM

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (mm)	Efficiency	Count(Ne)	Production(kg/shift)	Prod^{n} Changes in kg	Changes Variation %
15	96	30	24	2.5	75%	30	57.68	Fixed	Fixed
20	96	30	24	2.5	75%	30	76.9	19.22	33.33%
10	96	30	24	2.5	75%	30	38.45	-19.22	-33.33%

In the table, we have calculated the changes in productivity and its percentage for every 5 rpm increase or decrease. And the result shows that for increasing the 5 rpm of machine, 19.22 kg extra fabric per shift is produced, 33.33% productivity increases similarly for decreasing 5 rpm of machine, 33.33% production decreases.

4.2 Knitting productivity calculation due to change in No of Feeders:

Table 5:Knitting productivity calculation due to change in No of feeders

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (cm)	Efficiency%	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.6770803	Fixed	Fixed
15	120	30	24	0.25	75	30	72.0963504	14.42	25.00%
15	72	30	24	0.25	75	30	43.2578102	-14.42	-25.00%

In the table, we have calculated the changes in productivity and its percentage for every 24 feeders increase or decrease. And the result shows that for increasing 24 feeders of a machine, 14.42 kg extra fabric per shift is produced, and 25% productivity increases similarly for decreasing 24 feeders of a machine, 25% production decreases.

4.3 Knitting productivity calculation due to change in Machine Diameter:

Table 6: Knitting Productivity calculation due to change in Machine Diameter

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (cm)	Efficiency%	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	34	24	0.25	75	30	65.37	7.69	13.33%
15	96	26	24	0.25	75	30	49.99	-7.69	-13.33%

In the table, we have calculated the changes in productivity and its percentage for every 4-inch dia. of machine increase or decrease. And the result shows that for increasing 4-inch dia. of machine, 7.69 kg extra fabric per shift is produced, 13.33% productivity increases similarly for decreasing 4-inch dia. of machine, 13.33% production decreases.

4.4 Knitting productivity calculation due to change in Needle Gauge:

Table 7: Knitting Productivity calculation due to change in Needle Gauge

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (cm)	Efficiency%	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	18	0.25	75	30	43.26	-14.42	-25.00%
15	96	30	28	0.25	75	30	67.29	9.61	16.67%

In the table, we have calculated the changes in productivity and its percentage for every 6 gauge variation in the machine. And the result shows that for increasing 6 gauge in the machine, 14.42 kg extra fabric per shift is produced, and 25.00% productivity increases similarly for decreasing 6 gauge in a machine, 25.00% production decreases.

4.5 Knitting productivity calculation due to change in Stitch Length:

Table 8: Knitting Productivity calculation due to change in Stitch Length

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (cm)	Efficiency%	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	24	0.3	75	30	69.21	11.54	20.00%
15	96	30	24	0.2	75	30	46.14	-11.54	-20.00%

In the table, we have calculated the changes in productivity and its percentage for every 5 mm stitch length variation in the machine. And the result shows that for increasing 5 mm stitch length in the machine, 11.54 kg extra fabric per shift is produced, 20% productivity increases similarly for decreasing 5 mm stitch length in machine, 20.00% production decreases.

4.6 Knitting productivity calculation due to changes in Yarn Count & Yarn Quality, & Breakage Ratio:

Table 9: Knitting Productivity Calculation Due to changes in Yarn Count, Yarn Quality & Breakage ratio

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (cm)	Efficiency%	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	24	0.25	75	32	54.07	-3.60	-6.25%
15	96	30	24	0.25	75	28	61.80	4.12	7.14%

Production(kg/shift)	Count(Ne)	Yarn Breakage/Hour	Knotting time for Each Breakage in sec	Production loss time in min	Production loss in yds in hour	Production loss per shift in yds	Production loss % per shift
		2	40	1.33	0.16		
57.68	30	2	35	1.17	0.21	1.76	3.05%
		4	38	2.53	0.3		
		2	43	1.43	0.16		
54.07	32	1	40	0.67	0.075	1.92	3.55%
		7	38	4.43	0.49		
		0	37	0	0.00		
61.80	28	3	32	1.6	0.206	1.6	2.59%
		6	31	3.1	0.4		

From the table, we can see that lower the no of count of yarn means higher the thickness of yarn & lower the possibility of yarn breakage. Consequently, it will reduce the production loss time due to knotting & production loss % per shift.

4.7 Knitting productivity calculation due to change in Machine & Operator Efficiency:

Table 10: Knitting Productivity Calculation due to change in Machine & Operator efficiency

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (cm)	Efficiency%	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	24	0.25	77	30	59.22	1.54	2.67%
15	96	30	24	0.25	80	30	61.52	3.85	6.67%

In the table, we have calculated machine efficiency & operator efficiency for observing knitting productivity. The result shows that obviously better efficiency will increase the production. A skilled worker took less time in knotting, find out the problem quickly, production loss time reduces. On the other hand, If machine runs well & properly utilized nearly 2.67% of production increases for every 2% better efficiency.

4.8 An overview for Changes in Count & Stitch Length based on GSM for better productivity:

Table 11: Allocation of yarn count & Stitch length based on GSM of fabrics

	Single Jersey				
FABRIC	**GSM**	**Yarn Count**	**SL**	**M/C Dia**	**F/Dia**
Slub S/J	160	30s Slub	2.7	30*24	60
S/J Slub	160	28's slub	2.7	36*24	74T
Slub S/J	275	24s co	3.93	42*14	78 OP
Slub S/J	275	24s slub com	3.88	42*18	80 N OP
S/J	140	32s E.M 2%	2.62	36*24	74" T
S/J	150	30s argon	2.76	36*24	72T
S/J	155	28s Com	2.7	34*24	72" T
S/J	175	26/s	2.7f5	36*24	78" K op
S/J	155	28/s com	2.7	34*24	72" T
S/J	160	28s cotton 75/25 recycle	2.65	34*24	72" T
S/J	155	28s Com	2.7	34*24	72" T
S/J	160	30s cvc 60/40	2.6	34*24	70T
S/J	260	12/1 Kh Rotor	3.6	30*20	62 K. OP
S/J	160	24/1 com	2.85	30*24	66T
S/J	160	28/1 com	2.6	30*24	62T
S/J	150	34/1 K.H.	2.55	30*24	56T
S/J	340	16/1 KH 2ply	4.4	36*16	N.OP

S/J	140	34/1 Feru 1%	2.55	30*24	56T
S/J	320	10/l mell 5%	3.7	30*20	62 K.OP
S/J	155	28s com	2.68	34*24	70T
S/J	240	16s Rotor	3	34*20	74" k op
S/J	155	28's com	2.85	34*24	70
S/J	160	28/S KH	2.75	36*24	76T
S/J	160	28/s kh	2.65	36*24	76T
S/J	170	26/s com	2.75	36*24	78 N OP
S/J	200	24/s com	2.8	26*24	74 N OP
S/J	200	24/S com	2.77	26*24	72 N OP
S/J	175	26s com	1.75	34*24	78 OP
S/J	140	30's com	2.7	30*28	74 T
S/J	275	24s com	3.93	32*14	78 OP
S/J	140	34/1 cvc (60+40)	2.55	26*28	56T
S/J	140	34/1 com	2.55	30*24	56T
S/J	140	30/1 cvc (60+40)	2.75	30*24	60T
S/J	140	34/1 cvc (60+40)	2.55	26*28	56T
S/J	140	34/1 com	2.55	56*28	56t
S/J	150	30/1 com	2.6	28*28	64T
S/J	140	34/1 cvc (60+40)	2.75	30*24	56T
s/J	145	30s com	2.85	36*24	74" T
S/J	250	34s 2ply com	3.1	30*20	60 N OP
S/J	210	16s Rotor	3.1	34*20	74" K oP
S/J	140	34s com	2.55	36*24	74
S/J	160	28s com	2.7	34*24	70" N OP
S/J	175	26s	2.75	36*24	78" K OP
S/J	140	32s cvc 60/40	2.65	34*24	70" T
Lyc S/J	170	34s cvc & 20D Lyc	3	30*24	68" K op
S/J Lyc	160	40/s com + 20D Lyc	2.85	30*28	67 K OP
Lyc S/J	180	34s com+20D Lyc	3	28*28	65 OP
Lyc S/J	160	40s com & 20D lyc	2.85	30*28	67" K OP
Lyc S/J	150	40s Com & 20D Lyc	3	32*28	70" K OP

St. S/J	180	24s Y/D	2.82	28*24	62" K OP
Stv S/J	160	28s YD	2.72	32*24	66 OP
STV S/J	180	24S YD	2.82	28*24	62 OP
Auto Stv. S/J	140	32/s Y/D	2.6	34*24	66" N OP
Auto Lyc St.S/J	180	34/s y/d + 20D Lyc	2.9	34*24	66" K oP
Lyc Stv S/J	210	28s YD+20D Lyc	3	32*24	66 OP
F F Ly S/J Stp Auto	200	30/s Y/D & 30D Lyc	3	36/24	70 K op

4.9 Final Summary of Findings:

Table 12: Final Summary of Findings

Cyl. RPM	No of Feeders	Cyl. Dia	Gauge	SL. (mm)	Efficiency	Count(Ne)	Production(kg/shift)	Productivity Changes	Productivity Variation %
15	96	30	24	0.25	75	30	57.67708	Fixed	Fixed
16	96	30	24	0.25	75	30	61.522219	3.8451387	6.67%
20	96	30	24	0.25	75	30	76.902774	19.225693	33.33%
15	96	30	24	0.25	75	30	57.67708	Fixed	Fixed
15	98	30	24	0.25	75	30	58.878686	1.20	2.08%
15	120	30	24	0.25	75	30	72.09635	14.42	25.00%
15	72	30	24	0.25	75	30	43.25781	-14.42	-25.00%
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	32	24	0.25	75	30	61.52	3.85	6.67%
15	96	34	24	0.25	75	30	65.37	7.69	13.33%
15	96	26	24	0.25	75	30	49.99	-7.69	-13.33%
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	18	0.25	75	30	43.26	-14.42	-25.00%
15	96	30	28	0.25	75	30	67.29	9.61	16.67%
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	24	0.26	75	30	59.98	2.31	4.00%
15	96	30	24	0.3	75	30	69.21	11.54	20.00%
15	96	30	24	0.2	75	30	46.14	-11.54	-20.00%
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	24	0.25	77	30	59.22	1.54	2.67%
15	96	30	24	0.25	80	30	61.52	3.85	6.67%
15	96	30	24	0.25	75	30	57.68	Fixed	Fixed
15	96	30	24	0.25	75	32	54.07	-3.60	-6.25%

15	96	30	24	0.25	75	28	61.80	4.12	7.14%

Yarn Breakage/Hour	Knotting time for Each Breakage in sec	Production loss time in min	Production loss in yds in an hour	Production loss per shift in yds	Production loss % per shift
2	40	1.33	0.16	1.76	3.05%
2	35	1.17	0.21		
4	38	2.53	0.3		
2	43	1.43	0.16	1.92	3.55%
1	40	0.67	0.075		
7	38	4.43	0.49		
0	37	0	0.00	1.6	2.59%
3	32	1.6	0.206		
6	31	3.1	0.4		

By increasing, the 1 rpm of the machine, 0.83% production increases per hour.

By increasing, 2 feeders in the machine, 0.26% production increases per hour.

With the change of 2” dia. of a cylinder, 0.83% production variation happens per hour.

The needle Gauge must be compatible with the yarn count, otherwise, yarn breakage increases & by increasing the needle gauge the production increases by 3.12% per hour for increasing every 6 gauge.

By increasing the diameter of the VDQ pulley, the stitch length increases & the production will increase by 0.5% for increasing 1 mm.

By increasing, 2 counts of yarn, yarn breakage tendency increases for higher tension and speed of the machine & the production variation rate is 0.44 %, and the production loss is 0.78%.

And if the 2 counts are decreased, the breakage tendency reduces, & the production increases % is 0.89% and the production lose is reduced by 0.32%.

If the efficiency of the knitting machine 2% increases, the production will increase by 0.33% per hour.

Besides that, proper training of workers, proper servicing of the machine, ensuring proper compressed air & electricity, cleaning machine properly, excessive stress remove from the worker & employee, better safety & compliance, proper knit program run, operator awareness,

Will increase the knit productivity.

CHAPTER 5

CONCLUSION

Bangladesh's knit industry is doing a remarkable job of increasing the growth of the economy of Bangladesh. It witnessed a prestigious exporting sector over the years. Contribution in Gross Domestic Production, Export Earnings, Generational employment, Women Empowerment, and Reduction of poverty, in every matter this sector did top-notch outstanding work. In FY22 $11.16 billion, but in FY23, July-December it is $12.66 billion which is 13.4% greater than the previous year. It has now become a dominating sector in Bangladesh.

To continue its growth, its overflow, to attain its reputation, we all should take necessary steps for further improvement. Product Quality is the main concern thing nowadays & productivity must have to be higher also. Combining higher production with the desired quality is a tough matter. Customer expectations are too high now. To fulfill the requirements, by ensuring product quality we need to increase productivity as the demand for knitted goods is increasing.

To pertain the best outcome of productivity, the Mental satisfaction of workers & the working environment must need to be up to the mark. Knitting technical parameters like knitting method, fabric structure, needle & cam arrangement, gauge, stitch length, dia., count of yarn, feeding mechanism, and yarn guide all those things must be properly utilized. Each & every part of the knitting machine is directly involved with the mechanism of better productivity. Reduced Machine idle time, daily checking of breakage sensor & operator awareness is necessary to reduce the production loss time. After combining all the technical parameters, development parameters, psychological parameters together, we will able to bring out the best outcome from the knitting industry.

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