# Faculty of Engineering

**Department Of Textile Engineering**

# PROJECT (THESIS) REPORT ON

Study on the Impact of Stitch Length on the Quality Parameters of Knitted Fabrics Produced on a V-Bed Knitting Machine

**Course Title: Project (Thesis)**

**Course Code: TE-400**

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This Report presented in partial fulfillment of the Requirement for the Degree of

**Bachelor of Science in Textile Engineering.**

**Advanced in Fabric Manufacturing Technology**

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# Declaration:

It is further testified herewith that the thesis titled as "Study on the impact of stitch length on the quality parameters of knitted fabrics produced on a V-Bed knitting machine" is authentic and duly awarded to the candidate.

submitted to the Department of Textile engineering, Faculty of engineering, is a document of original work, conducted by us as a part of our course requirement towards completion of degree in Bachelor of science in textile engineering.

We also state that this thesis has not before been submitted into any other university or institution, in whole or in part, for any degree or diploma. The information and data utilized in this thesis have been credited to all the sources of information.

The study has been carried out under the guidance of **Md. Farhad Hossain**, Lecturer, Department of Textile engineering, faculty of engineering.

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# LETTER OF APPROVAL

The Project titles "Study on the Impact of Stitch Length on the Quality Parameters of Knitted Fabrics Produced on a V-Bed Knitting Machine" has been submitted to the Board of Examiners of the Faculty of Engineering by the following students on June 2025 in partial completion of the prerequisites for the degree of Bachelor of Textile Engineering and has been approved as satisfactory.

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# ACKNOWLEDGEMENT

Glory to the Almighty Allah, the most Gracious and the most Merciful who gave us the strength, courage, and patience in order to finish with the help of Him this thesis work with the title:

Research on Effect of Stitch Length on Quality Parameters of Knitted Fabric Produced on V-Bed Knitting Machine.

We heartily acknowledge our grateful thanks to our respected supervisor **Md. Farhad Hossain**, Lecturer, Department of Textile Engineering, Faculty of Engineering, upon his constant encouragement, guidance, useful suggestions, and constructive comments during the entire duration of research work. In aid of completing this paper, his contributions towards its completion and precious suggestions have been instrumental.

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And last but not least, we also thank our families and friends on whose moral support, patience and inspiration we further worked through this whole time.

# Dedication

With submission we present this thesis titled Study on the effect of stitch length on the Quality parameters of knitted fabric on V-Bed knitting machine.

to our lovely parents, whose love to us without any conditions and sacrifice as well as never-ending supports have been the main source of our success and strength.

We would also like to pay tribute to our honorable teachers, and above all our honorable Supervisor **Md. Farhad Hossain**, Lecturer, Department of Textile Engineering, Faculty of Engineering, in giving us advice and inspirations during this research.

This piece of writing is also committed in memory of all of them who have factored in our academic pursuit and supported us throughout the period of our study.

# Statement of Contributions

The joint work of both group members led to the development of this thesis as a collaborating effort of the two with an equal contribution to the planning, implementation, analysis, and documentation of this research as indicated in this sub-section. The experimental work was carried out in unison concentrating on the effects of variations in stitch length on other important quality factors like Stitch Length (S.L), Wales per Inch (WPI) and Courses per Inch (CPI), GSM, Ball Bursting and Single Yarn Strength. We took part in machine setting, sample preparation, data recording, test, and analysis together and had an equal distribution of labor and understanding why things were done in the particular way.

We had non-ending suggestions, tutoring, and comments under the good guidance of **Md. Farhad Hossain**, Lecturer, Department of Textile Engineering, Faculty of Engineering, whose guidance supported us throughout.

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This is our joint effort to academic perfection and know-how in the subject of textile engineering.

# Abstract:

The proposed study is research on the effects of stitch length on the quality parameters of knitted fabrics knitted on a V-bed flat knitting machine. The intent is to know how different stitch length affects physical and mechanical characteristics of the fabric generated. Three stitch lengths were used to create fabric sample using 100 percent acrylic yarn. Pertinent testing's have been carried out in the laboratory involving stitch length, Wales per Inch (WPI) and Courses per Inch (CPI), weight of the fabric in grams per square meter (GSM), and ball bursting strength and single yarn strength tests. Findings provided that stitch length also influences density of fabric, weight, and mechanical strength to a significant extent. To be specific the yarn strength and bursting improved with short stitch lengths and there was also more compactness in the fabrics produced but when the stitch lengths were long there was a lighter more flexible fabric. This research can be helpful to the optimization of the length of stitch in the knitted fabric production in order to get the required performance and quality of the fabric.

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# Chapter 1: Introduction

## 1.1 Background of the Study:

The knitted materials now form a major constituent of textile industry since they possess better stretchability, comfort, and versatility when compared to their counterparts the woven fabrics. Different knitting technologies make it possible to produce knitted articles of various structures, e.g., V-bed flat knitting machine is mostly applied in producing structured knitwear (e.g., rib, interlock, or different textured structures), mainly in fashion, sportswear, and technical knitwear. Various knitting parameters control the quality and performance of knitted fabrics that are produced on such machines with stitch length being one of the most important parameters.

The length of yarn to one stitch is tagged as stitch length, which directly affects various fabric characteristics like GSM (grams per square meter), WPI & CPI, Ball Bursting strength, Single yarn strength. The longer the chain the looser and more breathable fabric with a low GSM is more likely, the shorter the chain the denser and stronger and less extensible fabric is the result. Thus, correlating the stitch length and the quality parameters of the fabrics is vital to the improvement of the process as well as to attain wanted characteristics that the fabrics must possess in order to be used in their end-uses.

The impact of machine type, yarn count, and fabric structure in relation to the knitted fabric properties is widely investigated by previous researches, however, the quantitative analysis of the impact of varying stitch lengths with the use of V-bed flat knitting machine is not researched extensively. The V-bed machines are precise in loop forming and customizable making up of fabrics and this characteristic makes the V-bed machines ideal in doing the experimental studies where the effects of one process variable at a time are isolated.

This research paper is intended to address this area of gap in knowledge by overcoming it, through a scientific study of the influence of various stitch lengths, on important quality parameters of knitted fabrics, in a systematic way that standards of testing methodology may be used to analyze the results. It can be said that the above findings will bring a useful contribution to the area of fabric design, manufacturing engineers and researchers into the object of knitting technology.

## 1.2 Problem Statement:

1) The knitting industry prerequisite is the manufacturing of high quality and uniform fabrics; this is because the parameters of the machine involved must be controlled accurately with length of stitch being very important. Stitch length is directly related to some of the most important values of the fabric GSM (grams per square meter), Bursting strength, WPI & CPI, Single yarn strength. Although this is important, the influence of stitch length on the quality of knitted fabrics especially on V-bed flat knitting machines has not been really and systematically examined. [1]
2) Most manufacturers use trial and error approach to adjust stitch length to attain required performance of the fabric, this causes variation in quality, production waste, and inefficiency in production. Also, due to the lack of definite instructions and unified data, knitting operators and engineers are not able to have clear ideas on how to approximate the effects of alterations in stitch length on particular fabric parameters.
3) Hence there is the requirement of a detailed study that can determine how to measure the relationship between the stitch length and the fabric qualities of characteristics through controlled experimentation in V-bed flat knitting machine. This will allow the manufacturers to make informed choices regarding the configuration of machine parameters in addition to increasing quality of products and efficiency of the production. [1]

## 1.3 Objectives of the Study:

The main aim of this research work is to explore how the stitch length variation would affect the physical and mechanical properties of knitted fabrics made on a V-bed flat knitting machine. Its specific objectives are the following:

1. To analyze the effect of different stitch lengths on key quality parameters such as:
    - Fabric weight (GSM)
    - Ball Bursting strength
    - Stich Length
    - WPI & CPI
    - Single Yarn strength test
2. To manufacture some samples of knitted fabrics with different lengths of stitches in a V-bed flat knitting machine under controlled circumstances the rest of the variables being constant that is, the type of yarn, tension, and the gauge of the machine.

3. To compare and test the physical properties and the mechanical properties of the samples of the fabric according to the standard textile tests.
4. To come up with the right stitch length which is a good hybridization of strength, comfort and fabric performance of stitches which fit in the end-use application.
5. To present the recommendation of the knitting machine operators and textile manufacturers, who can regulate the desired length of the stitches to make the required characteristics of the fabric and to be effective at work.

## 1.4 <u>Scope of the Study:</u>

In studying this, the variation in stitch length is targeted at the study of the impact on various quality parameters in knitted fabrics when using V-bed flat knitting machine. The evaluation is restricted to understanding the effect that variation in stitch length on important physical and mechanical properties of a fabric and this is done by maintaining constant the rest of the production factors i.e., yarn type, gauge, tension and environmental conditions.

The study involves:

- Creating fabric samples at varying length of stitches in the same machine, same knitting structure, and same yarn.
- Assessing the impact of stitch length on specific fabric quality parameters, including:
    - GSM (Grams per Square Meter)
    - Ball Bursting strength
    - Stitch Length
    - WPI & CPI
    - Single Yarn strength test

The experiment is narrowed to single jersey or rib-knit, and during the experiment only a single type of yarn (e.g., 100 per cent cotton or a given blend) is applied. Included are other factors that can influence the experiment like yarn twist, fiber blends, fabric finishing or the dyeing process, among others.

This controlled research work will give a numerical understanding on influence of stitch length only on the performance of the fabric and manufacturers as well as researchers and technicians will have quantitative knowledge on when to adjust stitch setting when knitting in V-beds.

## 1.5 Significance of the Study:

Sold fabric Knitted fabrics also enjoy enormous popularity when it comes to global textile industry with their excellent stretchiness, pleasantness and versatility. Stitch length is one of the most important factors which affect the quality of knitted fabrics because it has a direct influence on the fabric weight (GSM), dimensional stability, tensile strength, thickness, elasticity, and appearance [1]**.** Nevertheless, in the industrial setting, the choice of stitch length tends to deal not with the data-informed insight but with the experience-based intuition, and this approach leads to the scatter in the product quality, excessive use of material, and inefficient manufacturing.

The aim of the research to develop a scientific and quantitative insight into the effects of change in the length of stitches with regard to quality parameters of knitted fabrics contributed on a V-bed flat knitting machine. The operation of V-bed machines has become an extensively utilized element of contemporary knitwear manufacturing due to the device flexibility and accuracy, but little scholarly writing appears in regards to the relegation to stitch length optimization specific to the V-bed machine**.** [2]

The findings of this research will be valuable to:

- By assisting the manufacturers to fine-tune the machine settings to a particular quality requirement thus cutting down on the waste during the production process.
- By presenting uniform guidelines regarding controlling the stitch length in proportion to the fabric performance, textile engineers are in a position to provide.
- Scholars, through providing to the established base of knowledge in knitting technology and exposing the direction in which new studies can be made.
- The educational institutions, which provide the empirical data which can be used in the teaching process and during the laboratory classes in the textile and apparel engineering schools.

## 1.6 Limitations of the Study:

Although the study has important insights about the correlation of the length of stitches and the relevant measurement of Quality parameters of knitted fabrics of a V-bed knit machine, it is limited by few short comings:

1. **Machine Type Constraint**

   V-bed flat knitting machines is the only study considered. It could not be directly applicable to circular knitting machines, warp knitting machines or other knitting technologies functioning on other mechanical principles and other fabric formation dynamics.

2. **Limited Yarn Variety**

   Just a single or limited quantities of a kind of yarns (i.e., 100% cotton or certain combinations) were employed during the experiments. These data can change as the fiber composition or yarn count or level of twist or even the yarn structure (spun or filament) changes.

3. **Fixed Fabric Structure**

   During the study a particular knit construction (i.e., plain knit or 1 x 1 rib) was employed. Structures would react to a change in stitch length differently, i.e., interlock, tuck or float designs.

4. **Environmental Conditions Not Considered**

   The properties of fabrics can be affected by such external factors as temperature, humidity, and wear on the machine. The environment under which the study was performed is controlled laboratory environments, which fail to show differences there may be in industries.

5. **Manual vs. Automated Adjustments**

   Machine adjustment of stitch length was done by machine setting on the particular V-bed knitting machine used in study. There might be slight disparities brought about by variation in the calibration of machines and handling of operators.

# Chapter 2: Literature Review

## 2.1 Overview of Knitting Technology:

Knitting is the most versatile fabric manufacturing method that is largely practiced in textile industry. Knitting differs with weaving in that it does not involve the interweaving of two separate sets of yarn but involves interloping of one or more yarns to form a structure that is flexible and stretchable. Knitted fabrics are also superior in comfort, stretch and breathability, and drape, thus the use of knitted fabrics can span all the spectrum of garments as well as technical fabrics. [3]

Knitting has two broad categories; weft knitting and warp knitting. It is in weft knitting, the yarn is inserted horizontally and one loop is constructed above the other. The use of flatbed knitting machines, particularly V-bed knitting machines which as well as simple structure can produce sophisticated ones like rib, interlock and jacquard patterns with very great accuracy are widely used in weft knitting. V-bed knitting devices have two needle beds shaped like an inverted V, thus allowing the combination of intermeshing loops of the two beds, and thus allowing more complex, stable fabric structures. [4]

Stitch length, the length of yarn to get a single loop, is one of the most important variables in knitting, and it is critical in definition of the final characteristics of the fabric. The modification of stitch length has an effect on fabric weight (GSM), thickness, tensile strength, shrinkage and dimensional stability. Hence accurate control of stitch length is essential in enhancing the quality of products and provision of end use associated requirements. [1]

The growing interest in performance driven and custom knitted fabrics makes it apparent to comprehend the role played by machine parameters such as stitch length. The v-bed flat knitting technology offers a good platform to study the roles of technical modifications on the output of fabrics because it has high control and programmability levels. [1]

## 2.2 Stitch Length and Its Influence on Fabric Structure:

Stitch length is the core knitting parameter, which describes the length of the yarn composed to create 1 loop or stitch of knitted cloth. It has direct influence on the loop size, density of the fabric and the dimensional nature of the fabric. The shorter a stitch length, the smaller the loops will be, and heavier grouping of fabric, the denser and the heavier the fabric will be, the greater the thickness and the tensile strength. On the other hand, the greater length of stitches will create bigger loops usually producing a lighter material and more extensible with more air permeability and durability of softer hand feel. [1]

Variation in stitch length has some effects on physical dimension and mechanical behavior of knitted fabrics as well. As an example, shorter stitch length fabrics tend to have narrower elongation and greater bursting strength since shorter stitches form tight loops, longer stitch length can become stretched easily but have lower strength and stability. Also, alterations to stitch length may alter the appearance of the fabric, i.e., the smoothness or loop definition of the cloth, and that of knitwear is essential to the looks and its functional features. [1]

V-bed knitting machine]) Stitches lengths can be controlled precisely in V-bed knitting machines so that the manufacturer can adjust the properties of the fabric to meet the requirements of a particular end use. Nevertheless, the dependence of stitch length on the parameters of the fabric quality is different when changing the type of yarn, knitting structure and machine setting, and thus empirical assessment should be conducted in each case of production. [1]

## 2.3 Quality Parameters of Knitted Fabrics (S.L, WPI, CPI, GSM, Ball Bursting Strength, Single Yarn Strength):

When analyzing knitted fabrics, many parameters have to be considered regarding the quality related to the knitting fabric performance and the appropriateness of using them in a wide variety of applications. Major parameters which are affected by stitch length that are of interest in this study therefore include stitch length (S.L), Wales Per Inch (WPI), Courses Per Inch (CPI), Fabric weight or GSM, Bursting Strength and Yarn Strength. These parameters will allow one to get the complete picture of the physical and mechanical aspects of the behavior of the fabric.

1. **Stitch Length (S.L)**

   Stitch length; the amount of yarn per loop or stitch within the knitted material. It has a direct impact on the density, elasticity and dimensional stability of fabrics. The longer the stitch length, the looser and more extensible the fabrics will be, and the lesser their fabric weight, and the shorter the stitch length, the denser and tighter it will be, higher the strength and stretches it will have. The control of stitch length is by setting a machine and yarn tension used in the knitting process.

**2. Wales Per Inch (WPI)**

Wales signify the verticals of loops that go on the length of the fabric. Wales per inch (abbreviated WPI) is an indication of the number of Wales per inch of fabric, and is a measure of fabric fineness along the wale direction. The higher the WPI, the finer the fabric with the greater number of loops per unit of length leading to the strength and the look of a fabric.

**3. Courses Per Inch (CPI)**

Courses are the horizontal series of loops over the width of the fabrics. CPI refers to the number of courses per inch and describes tightness of the fabric along the course. CPI with WPI can be used to control the loop density of the fabric and influence this properties as stretch, recovery and porosity.

**4. Fabric Weight (GSM)**

Grams per square meter (GSM) is a unit of measurement of a fabric weighed per area. It is a very important quality parameter that influences the life of the fabric, handle as well as usability in the end-use. The GSM is affected by the stitch length and loop density since close stitches add to the mass and to the thickness of the fabric.

**5. Ball Bursting Strength**

The bursting strength gives the resistance of the fabric against breaking apart in multiple directions and resilience of the structure. This parameter particularly applies to knits, in sportswear and technical textile constructions. The use of shorter stitches normally increases bursting strength through more interlocked loops and made fabric tighter.

**6. Yarn Strength**

The tensile strength of the knitting yarns applied is called yarn strength, as it influences directly the mechanical properties of the fabric. Better yarns contribute to better holding up of fabrics and breaking resistance by processing and actual use. In this study the strength of the yarn is maintained because the type of yarn was constrained and therefore concentrated testing of the length of stitches could be done.

## 2.4 Research Gaps and Justification:

Though stitch length is considered as a very critical step in establishing the quality and the performance of knitted fabrics, the literature has various gaps that may lead into conducting this study. In the vast majority of past works, the effect of the knitting parameters on fabrics has been discussed in a very general way with little or no emphasis on the quantitative significance of change in stitch length on the fabrics manufactured through V- bed flat knitting machines.

To start with, numerous studies are devoted mostly to circular knitting or other knitting technology, whereas the V-bed knitting process, which has even another structure of loops and a fabric, is considered much less intensively. It creates a vacuum of knowledge on how variation in stitch length can be used to specifically come up with different effects on fabrics that are manufactured on v-bed machine.

Second, the correlation between stitch length with various quality factors like Fabric Weight (GSM), WPI & CPI, Bursting Strength and Single yarn strength is yet to be carried out under standardizable conditions. In numerous studies, a single property is examined or stitch length is not kept as an independent variable, thus, it is hard to prove a direct causality.

## 2.5 Basic Principles of Knitting:

Knitting is a spinning process of forming fabrics where elastic and stretchable textile structures are made by means of interloping the yarns. As opposed to weaving, which is the interlacing of two sets of yarns (warp and weft) at right angles, in knitting, a looping called stitches is created either vertically or horizontally. These stitches are joined together to form an endless stretchable fabric that resistant’s special mechanical and aesthetic qualities, turning knitted textiles as the quality choice to make fashion clothes, sportswear and technical fabrications.

A loop is the basic building block of any piece of knitting, made by the movement of a needle by which previously existing yarn loop through a new loop is pulled which results in the formation of a new loop. Stitch geometry, loop density, yarn type and most importantly, stitch length which varies according to how long the yarn will have to be used to make just a single stitch are the main factors of fabric build and characteristics. The length of the stitches regulates the tightness of the textile: the shorter it is, the denser and tighter (with a larger GSM and millimeters per square) the textile obtains, and longer stitches produce lighter and more open textiles with more extensibility and air permeability.

Knitting can be grouped into two categories which include weft knitting and warp knitting. The paper examines weft knitting, and specifically V- bed flat knitting. It is also common to make shaped garments, or give structure to knit fabrics. In a V-bed knitting machine the two needle beds are positioned in a reverse V shape. This arrangement provides greater control of the manner in which the loops are achieved, produces more regular stitches and enables complex wove patterns such as ribs, cables and jacquards to be produced.

We should have a way of relating to the simple concept of knitting so as to realize how variation in settings of the machine particularly the length of the stitch alters the quality of the end product. Producers can model the strength and other strengths of a fabric by carefully varying the length of the stitches used.

## 2.6 Types of Loops and Their Mechanism:

Knitting is a manufacturing technique of making fabrics whereby yarns are looped together by knitting needles. The loop structure can be taken as the basic building block of knitted fabrics and it is very important in deciding the physical and mechanical properties of the fabric including elasticity, dimensional stability, thickness, air permeability and GSM etc. On V-bed flat knits machines, a large amount of control and repeatability in the manufacture of the loops means that stitch length and other parameters can be tightly controlled to change the fabric and stitch characteristics.

1. **Types of Loops in Knitted Fabrics**

In general, knitted fabrics consist of three primary types of loops:

**a. Knit Loop**

The knit loop is the one in which a loop is brought through previously constructed loop on the same wale (vertical column). This is the core of the weft knitted fabrics which gives the fabric elasticity, stretch, and softness. Knit loops are typical in fabrics such as plain jersey, rib and interlock.

**b. Tuck Loop**

A tuck loop occurs when a needle keeps an earlier made loop and is given out a new yarn without throwing away an older one. This makes a tuck stitch creating a bigger loop and an open fabric structure. Tuck stitches add width to fabric and make it thicker and more porous, it is common to see the tuck in textured or decorative knits.

**c. Miss (Float) Loop**

Miss loops, also float loops When a needle fails to accept a yarn in a knitting cycle the yarn floats behind the existing loops: this is called a miss loop or float loop. This makes the loop density lower and results in a close fitting non extensible fabric. Float loops are applied to insert color motifs or organizational effects, or to enlarge GSM in particular area.

**2. Loop Formation Mechanism in V-Bed Knitting Machines**

The V-bed flat knitting machines have two needle beds that face not one another but rather the form a V-shape. The beds-maintained latch needles which travel in a reciprocating fashion. Mechanism of loop formation entails the following steps:

**a. Yarn Feeding**

The yarn carrier directs the yarn into the needles along the needle beds and on the basis of the programmed design feeds the yarn to the needles.

**b. Needle Movement**

Each latch needle goes through a coordinated vertical motion:

- **Clearing**: The needle rises, and the old loop slides down to the stem.

- **Feeding**: Yarn is laid into the hook of the needle.
- **Knocking-over**: The old loop is pushed over the closed latch and cast off.
- **Drawing-down**: The new loop is formed and pulled into the fabric structure.

Such an exact mechanism of loop formation allows having uniform stoichiometry and changing the length of stitches, which is done by changing the settings of the stitch cam, directly affecting loop size and cloth responses.

### 3. Relation of Loop Type to Fabric Quality Parameters

Each loop type and its geometry significantly affect fabric characteristics:

- **Knit loops** enhance stretch and flexibility.
- **Tuck loops** increase thickness, texture, and air permeability.
- **Miss loops** reduce stretch but contribute to tightness and GSM.

Indeed, when the stitch length is adjusted, the loop size is modified and the tightness factor thus the whole range of parameters related to this quality including bursting strength, dimensional stability, and fabric weight. It is thus important to unravel the types of loops and how they are formed to control the performance of fabric, in V-bed knitting.

# Chapter 3: Methodology

## 3.1 Materials:

### 3.1.1 Yarns:

- **Yarn:** Material-Acrylic

## 3.2 Machine Description (V-Bed Knitting Machine):

The knitted fabric samples to be used in this study were created using a V-bed flat knitting machine which is very appropriate in the production of structured knitted fabrics that are dimensionally stable. The study aimed at analyzing the effect of the alterations in the length of stitches on parameters of fabric quality under the conditions of maintenance of all other knitting conditions.

The knitting machine V-bed which is used in the study is made in China and works with 2 beds of flat needles set in V-shape. This enables the machine to knit complicated patterns, produce a rib or interlock structure and to make fabric uniform. The machine is a 7G gauge or 7 needles per inch gauge suitable to medium to coarse knitted goods production.

Key specifications of the machine are as follows:

- **Machine Type**: V-Bed Knitting Machine
- **Brand**: China
- **Machine Width**: 42 Inch
- **Gauge**: 7G
- **Number of Needles**: 294
- **Needle Type**: Latch needles
- **Needle Bed Type**: Double bed (V-formation)
- **Stitch Length Control**: Adjustable via mechanical cam system

The carriage system of the machine travels over the needle beds picking needles and advancing yarn through regulated cam systems. Stitch length is controllable by regulating the stitch cam and this checks the amount of yarn to feed to form a loop. This versatility formed a major part of the study because various lengths of the stitches were assigned to each piece of the fabrics.

In the experiment, the length of stitch was changed, and the rest of the parameters e.g., yarn tension, carriage speed, and machine settings were kept constant. This made sure that the differences noted in quality parameters, including Wales per Inch (WPI), Courses per Inch (CPI), GSM, ball bursting strength, single yarn strength, were credited only to the variation with the length of the stitch.

The constant performance and control of the formation of stitch produced by this machine is what made it fit to be used to conduct the comparative study on the impact of stitch length on the quality of knitted fabrics.

*Figure 1:V-Bed Knitting Machine*

### 3.2.1 Main Parts:

- Yarn package
- Yarn guide
- Tension spring
- Cymbal tension
- Yarn take-up

- Fabric comb
- Yarn carrier
- Back needle bed
- Front needle bed
- Needle spring
- Fabric
- Dead weighting system
- Latch needle

#### 3.2.2 Process:

Fabric samples in this study were created by the use of a V-bed flat knitting machine (7G, 294 needles, 42-inch width), in which the length of the stitches was varied by the option of settings on the stitch cam. As the carriage was swung over the V shaped beds of the two needles, needles were chosen and the yarn was fed through the latch needles into loops. Yarn tension, carriage speed, needle set-up, etc. were all not altered. This was done under control in such a way that any alteration made on the fabric (WPI, CPI, GSM, bursting strength, and single yarn strength) was only through the change in stitch length.

## 3.3 Fabric Sample Production:

- ❖ **Knitting of Samples :** Number of Samples: 5

## 3.4 Test Methods and Testing Instruments:

#### 3.4.1 Stitch Length Measurement (S.L):

Stitch length is the length of yarn in one loop of knitted fabric.

To determine (S.L):

1. **Sample Selection**

   Select a sample of the knitted fabric from the middle portion to ensure uniformity and avoid edge distortion.

2. **Unravel the Yarn**

   Carefully unravel one complete course (row of loops) of the fabric using a seam ripper or fine needle without stretching the yarn.

3. **Measure Yarn Length**

   Use a precise measuring tape or scale to measure the total yarn length used in one course. Ensure the yarn is laid flat without tension while measuring.

4. **Count the Number of Loops**

   Count the number of loops (stitches) present in that course. This count represents the number of stitches made using the measured yarn length.

5. **Calculate Stitch Length (S.L)**

   Divide the total yarn length by the number of stitches to get the average Stitch Length (S.L) in cm: S.L =Total Yarn Length /10

### 3.4.2 WPI & CPI Measurement:

WPI (Wales per inch) and CPI (courses per inch) were measured using a counting glass. WPI was counted across the width and CPI along the length of the fabric within 1 inch. Multiple readings were averaged to ensure accuracy. These values were used to assess the effect of stitch length on fabric density.

**Machine Name:** Counting Glass

To determine WPI & CPI:

1. A counting glass (pick glass) was used for visual measurement.
2. For WPI**,** the fabric was placed flat and the number of vertical loops (Wales) within 1 inch across the width was counted.
3. For CPI**,** the number of horizontal loops (courses) within 1 inch along the length was counted.
4. Measurements were taken from multiple areas of each sample to ensure accuracy.
5. The average values were calculated for each fabric sample.
6. These values helped analyze how stitch length variations affected fabric density and structure**.**

### 3.4.3 Fabric Weight (GSM) Determination:

GSM (grams per square meter) measures the weight of fabric and indicates its thickness or heaviness. A circular sample was cut using a GSM cutter**,** then weighed on a digital balance. The GSM was calculated using the standard formula. This helped assess how stitch length affects fabric mass and density.

**Machine Name:** GSM Cutter

*Figure 2: GSM Cutter*

*Figure 3: Weight Balance Machine*

**To Determine GSM:**

1. A GSM cutter was used to cut a circular sample.
2. The sample was then weighed using a digital balance with high precision.
3. GSM was calculated using the formula:
4. Samples were conditioned under standard atmospheric conditions (20 ± 2°C, 65 ± 2% RH) before testing.
5. The process was repeated for multiple samples, and the average value was taken for each fabric.
6. The results helped assess how stitch length variations influenced the weight and density of the fabric.

### 3.4.4 Determination of Ball Bursting Strength Test:

**Machine name:** James Heal (Universal Strength Tester)

**Standards:** ISO 3303-1

*Figure 4: James Heal (Universal Strength Tester)*

**Method of Determine Ball Bursting Strength Test:**

1. To measure the bursting strength of knitted fabrics by applying pressure with a ball until the fabric ruptures.
2. Test follows ISO 3303-1 standard for ball bursting strength of textile fabrics.
3. Fabric specimens are cut to a specified size, ensuring uniformity and conditioning under standard atmospheric conditions before testing.
4. Uses a ball bursting tester where a steel ball applies pressure perpendicularly to the fabric surface.
5. The ball is pushed against the fabric at a constant rate until the fabric bursts, recording the maximum force applied.
6. Bursting force (in Newtons) and deformation at burst point are noted to assess fabric strength.

7. Variation in stitch length affects fabric density and structure, influencing the bursting strength results in this test.

### 3.4.5 Determination of Single Yarn Strength Test:

**Machine name:** James Heal (Universal Strength Tester)

**Standards:** ISO 3303-1


*Figure 5: James Heal (Universal Strength Tester)*

**Method of Determine Single Yarn Strength:**

1. To measure the tensile strength and elongation of single yarns extracted from knitted fabrics produced on a V-Bed knitting machine.

2. Individual yarns are carefully removed from the fabric without damage and conditioned at standard temperature and humidity before testing.
3. A universal tensile testing machine compliant with ISO 3303-1 is used, equipped with appropriate grips to hold the yarn securely.
4. The yarn is stretched at a constant rate until it breaks; the machine records the maximum force (strength) and elongation at break.
5. Different stitch lengths alter yarn tension and fabric tightness, affecting the mechanical properties of the yarn tested in this method.

# Chapter 4: Result and Discussion

## 4.1 Test Results

The test results are shown here following the completion of testing (Stitch Length, WPI & CPI, GSM, Ball Bursting Test & Single Yarn Strength Test) in accordance with the previously discussed standards.

### 4.1.1 Stitch Length

*Table 1: Stitch Length Result*

| SL No | Stitch Length |
|---|---|
| 1 | 12.3 |
| 2 | 10.3 |
| 3 | 9.2 |
| 4 | 8.4 |
| 5 | 6.6 |

### 4.1.2 WPI & CPI

*Table 2: WPI & CPI Test Result*

| SL No | WPI | CPI |
|---|---|---|
| 1 | 7 | 10 |
| 2 | 8 | 12 |
| 3 | 90 | 14 |
| 4 | 10 | 18 |
| 5 | 11 | 23 |

### 4.1.3 GSM

*Table 3: GSM Test Result*

| SL No | Fabric Type | GSM |
|---|---|---|
| 1 | Knit | 223 |
| 2 | Knit | 266 |
| 3 | Knit | 318 |
| 4 | Knit | 395 |
| 5 | Knit | 477 |

### 4.1.4 Single Yarn Strength

*Table 4: Single Yarn Strength Test Result*

| Specimen | Skein Breaking Strength (N) | Skein Break Factor (CSP) (NeC × lbf) | Time to Break (s) |
|---|---|---|---|
| 1 | 3.681 | – | n/a |
| 2 | 3.669 | – | n/a |
| 3 | 3.482 | – | n/a |

| | | | |
|---|---|---|---|
| **Mean** | **3.611** | – | n/a |
| **Confidence Limits** | **±0.277** | – | n/a |
| **Coefficient of Variation** | **3.087%** | – | n/a |

### 4.1.5 Ball Bursting Strength Test

**SL No: 1**

*Table 5: Ball Bursting Strength Test SL No.1 Result*

| Specimen | Rupturing Force (N) | Extension at Break (mm) | Observations |
|---|---|---|---|
| 1 | 118.82 | 126.61 | - |
| 2 | 133.67 | 124.67 | - |
| 3 | 111.37 | 121.92 | - |
| **Mean** | **121.29** | **124.40** | |

**SL No: 2**

*Table 6: Ball Bursting Strength Test SL No.2 Result*

| Specimen | Rupturing Force (N) | Extension at Break (mm) | Observations |
|---|---|---|---|
| 1 | 160.20 | 128.18 | - |
| 2 | 155.72 | 128.68 | - |
| 3 | 105.18 | 140.42 | - |
| **Mean** | **140.36** | **132.42** | |

**SL No: 3**

*Table 7: Ball Bursting Strength Test SL No.3 Result*

| Specimen | Rupturing Force (N) | Extension at Break (mm) | Observations |
|---|---|---|---|
| 1 | 215.20 | 131.66 | - |
| 2 | 185.14 | 130.68 | - |
| 3 | 171.58 | 120.17 | - |
| **Mean** | **190.64** | **127.50** | |

**SL No: 4**

*Table 8: Ball Bursting Strength Test SL No.4 Result*

| Specimen | Rupturing Force (N) | Extension at Break (mm) | Observations |
|---|---|---|---|
| 1 | 226.73 | 130.41 | - |
| 2 | 249.33 | 127.42 | - |
| 3 | 204.46 | 117.67 | - |
| **Mean** | **226.84** | **125.16** | |

**SL No: 5**

*Table 9: Ball Bursting Strength Test SL No.5 Result*

| Specimen | Rupturing Force (N) | Extension at Break (mm) | Observations |
|---|---|---|---|
| 1 | 275.97 | 127.42 | - |
| 2 | 268.31 | 135.41 | - |
| 3 | 279.65 | 124.18 | - |
| **Mean** | **274.64** | **129.00** | |

## 4.2 Discussion Based on Test Results

### 4.2.1 Stitch Length:

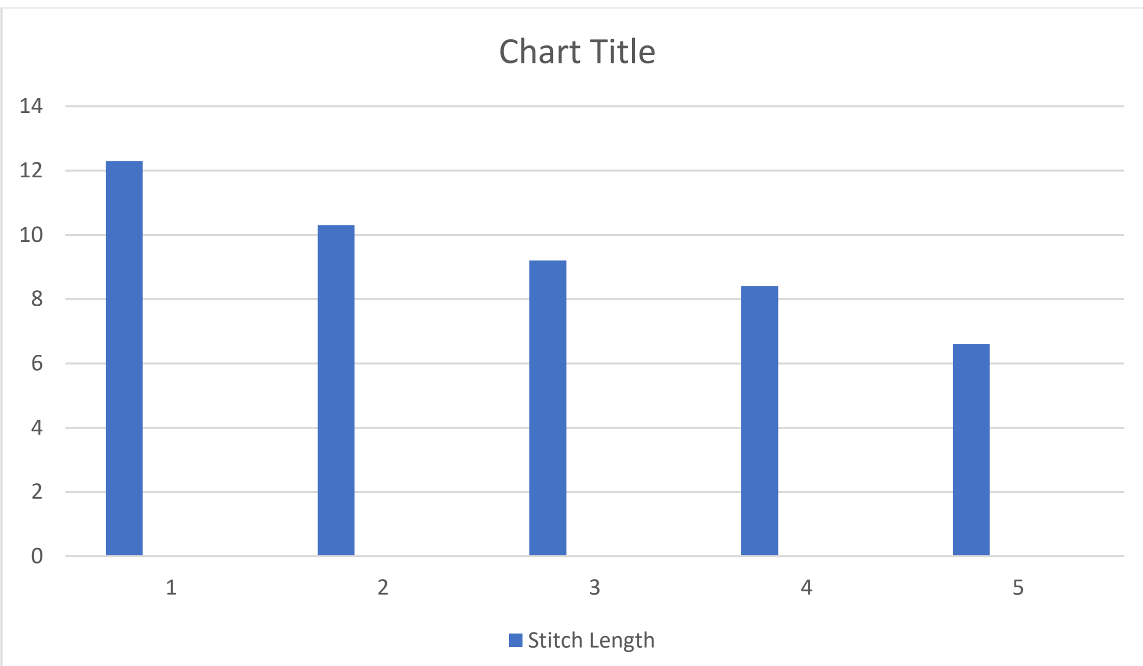


*Figure 6: Stitch Length Result graph*

**Discussion:** The data shows a decreasing trend in stitch length from 12.3 mm to 6.6 mm across five samples. A higher stitch length (e.g., 12.3 mm) indicates longer loops, which typically produce lighter, more extensible fabrics. Conversely, lower stitch lengths (e.g., 6.6 mm) suggest tighter, denser fabrics with higher GSM and strength. This variation is crucial for evaluating how stitch length affects fabric quality parameters like weight, thickness, and durability. The range in values allows for comparative analysis to identify the optimal stitch length for specific performance or comfort requirements.

### 4.2.2 WPI & CPI

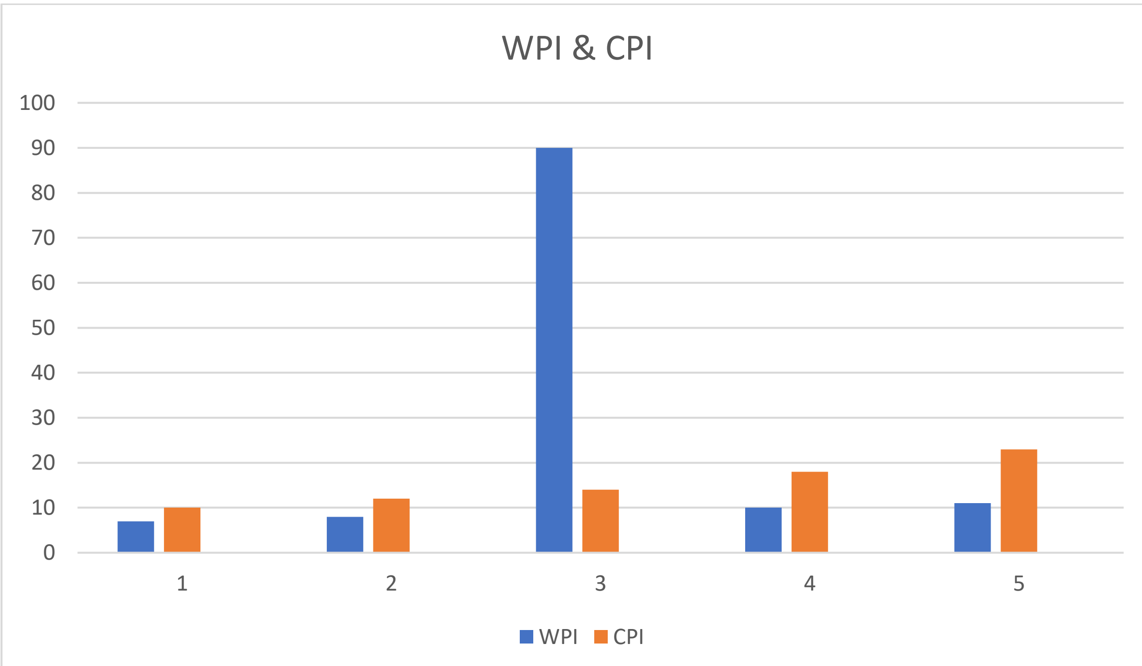


*Figure 7: WPI & CPI Graph Discussion*

**Discussion:** From the data, WPI (Wales per Inch) values range from 7 to 11, except for an outlier value of 90 at SL No. 3, which seems unusually high and likely erroneous. CPI (Courses per Inch) values show a gradual increase from 10 to 23 across specimens, indicating a consistent rise in fabric density. This suggests improved loop formation and tighter knitting, though the abnormal WPI at SL No. 3 should be rechecked or excluded from analysis.

### 4.2.3 GSM

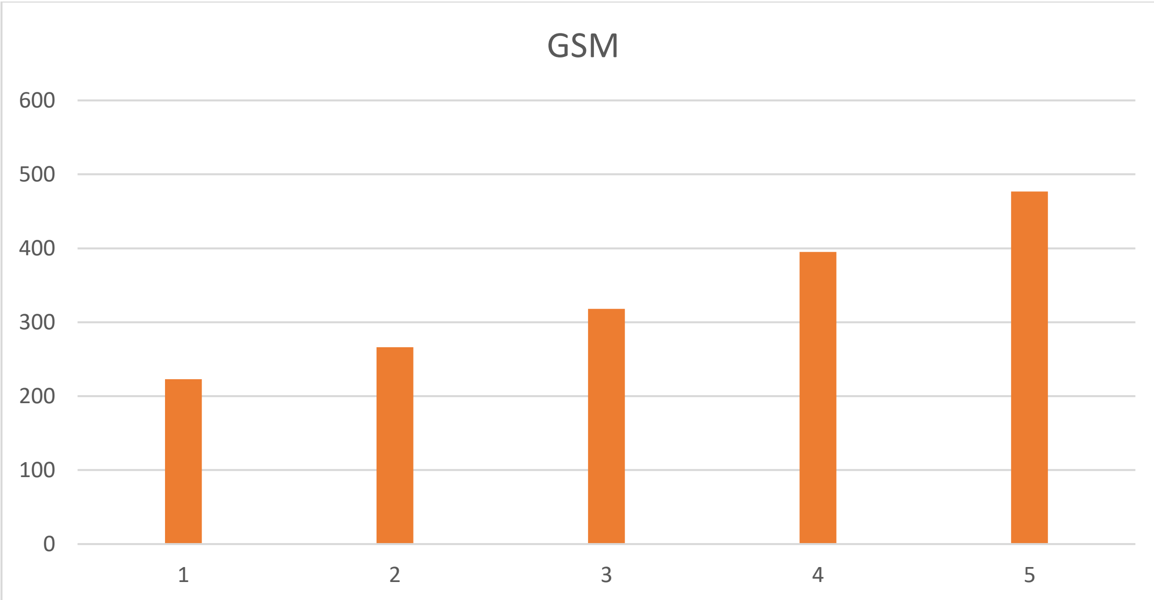


*Figure 8: GSM Graph Discussion*

**Discussion on GSM:** The GSM (grams per square meter) values of the knit fabrics show a steady increase from 223 to 477, indicating progressively heavier and denser fabrics. This suggests variations in loop length, stitch density, or yarn count. Higher GSM fabrics are likely thicker and more durable, suitable for winter or outerwear, while lower GSM fabrics are lighter and more breathable, ideal for summer or undergarments.

### 4.2.4 Single Yarn Strength

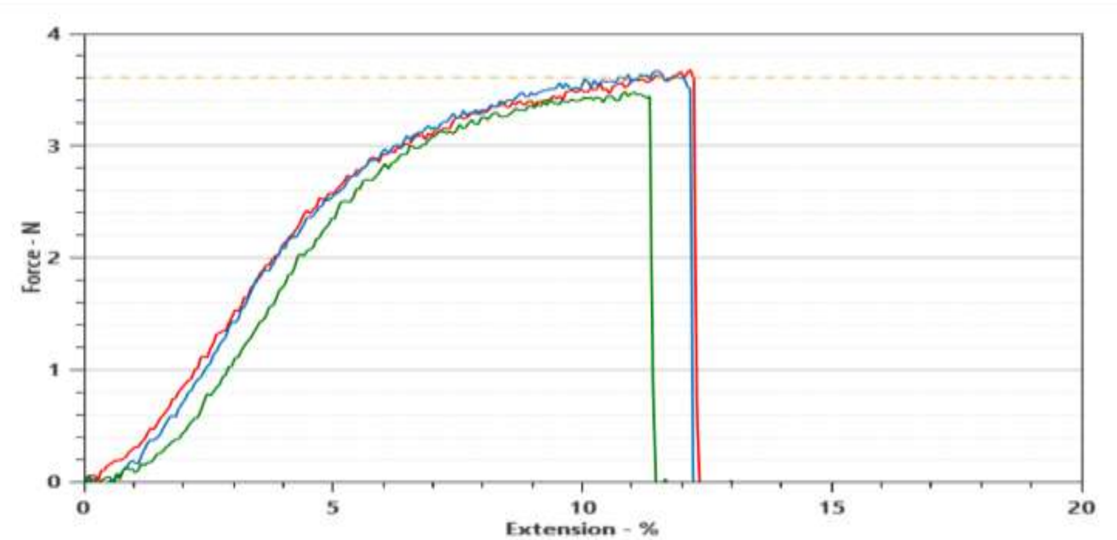


*Figure 9:Single Yarn Strength Test Graph Discussion*

**Discussion:** The average skein breaking strength of the yarn is 3.611 N, with a low coefficient of variation (3.087%), indicating consistent yarn quality across specimens. The confidence limit (±0.277 N) suggests minor variation in test results. However, the Skein Break Factor (CSP) and Time to Break data are unavailable, which limits a more comprehensive analysis. Overall, the yarn shows stable tensile strength within acceptable variation.

### 4.2.5 Ball Bursting Strength Test

**SL No: 1**

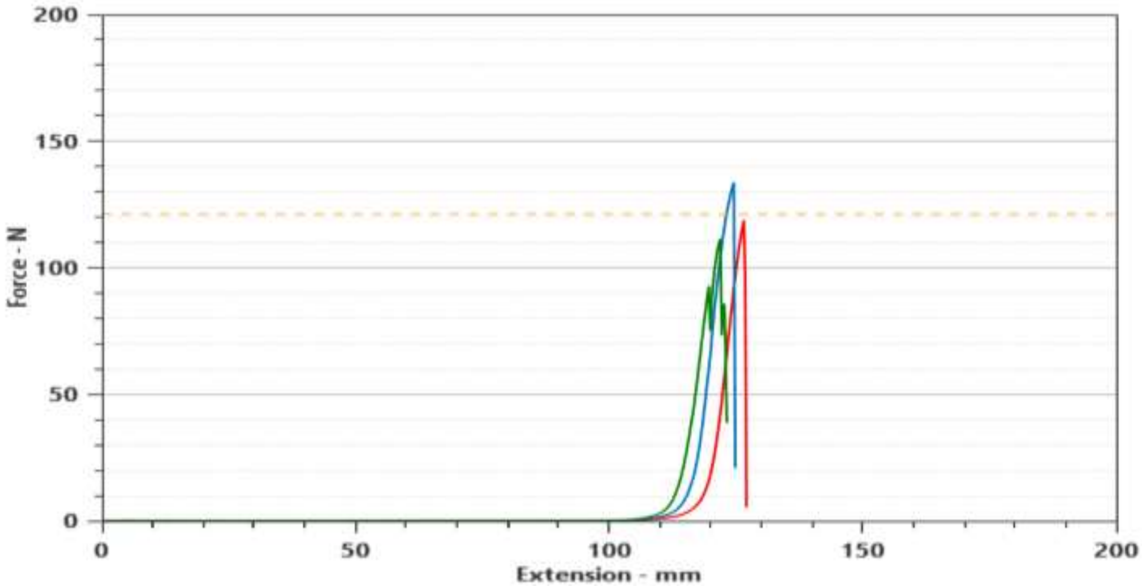


*Figure 10: Ball Bursting Strength Test Result SL No.1 Discussion*

**Discussion:** The ball bursting strength test results show an average rupturing force of 121.29 N and an average extension at break of 124.40 mm. The values indicate moderate strength and flexibility of the fabric. Slight variations among specimens suggest consistent performance. The fabric demonstrates good resistance to multidirectional stress, suitable for applications requiring stretch and durability.

## SL No 2

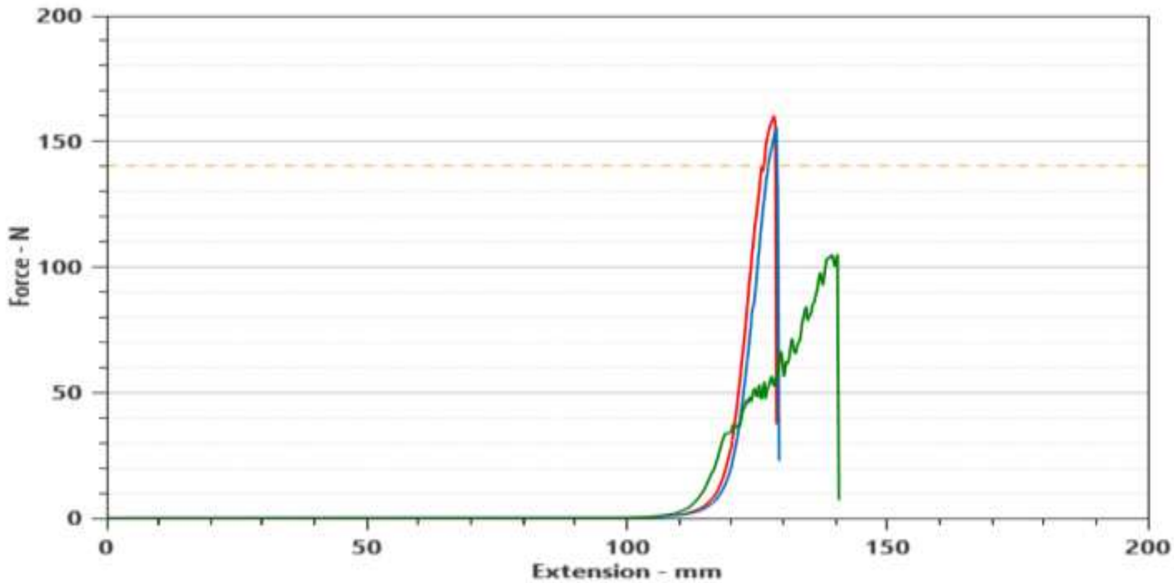


*Figure 11:  Ball Bursting Strength Test Result SL No.2 Discussion*

**Discussion:** The average rupturing force is 140.36 N, and the average extension at break is 132.42 mm, indicating improved bursting strength and flexibility compared to SL No.1. However, Specimen 3 shows a significantly lower force (105.18 N) but higher extension (140.42 mm), suggesting variability in fabric uniformity or possible weakness in that sample. Overall, the fabric exhibits good multidirectional strength with slight inconsistencies.

## SL No 3

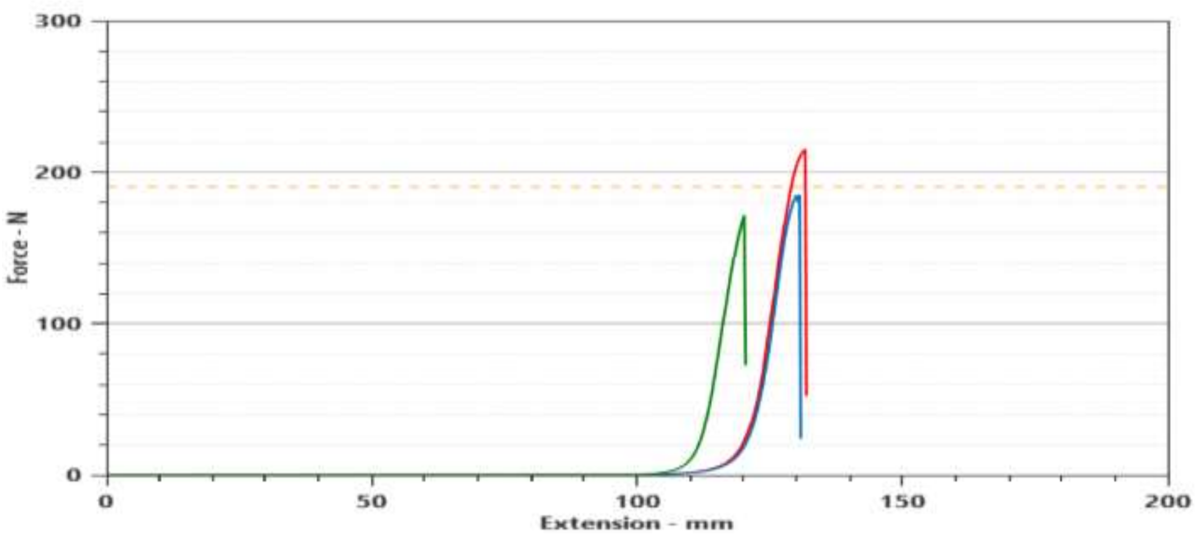


*Figure 12: Ball Bursting Strength Test Result SL No.3 Discussion*

**Discussion:** The average rupturing force is 190.64 N and the average extension at break is 127.50 mm, indicating a significant improvement in bursting strength compared to SL No.1 and SL No.2. All specimens show high resistance to force, suggesting strong fabric integrity and good durability. The relatively stable extension values also reflect consistent elasticity. This fabric sample appears suitable for high-stress applications where both strength and flexibility are essential.

## SL No 4

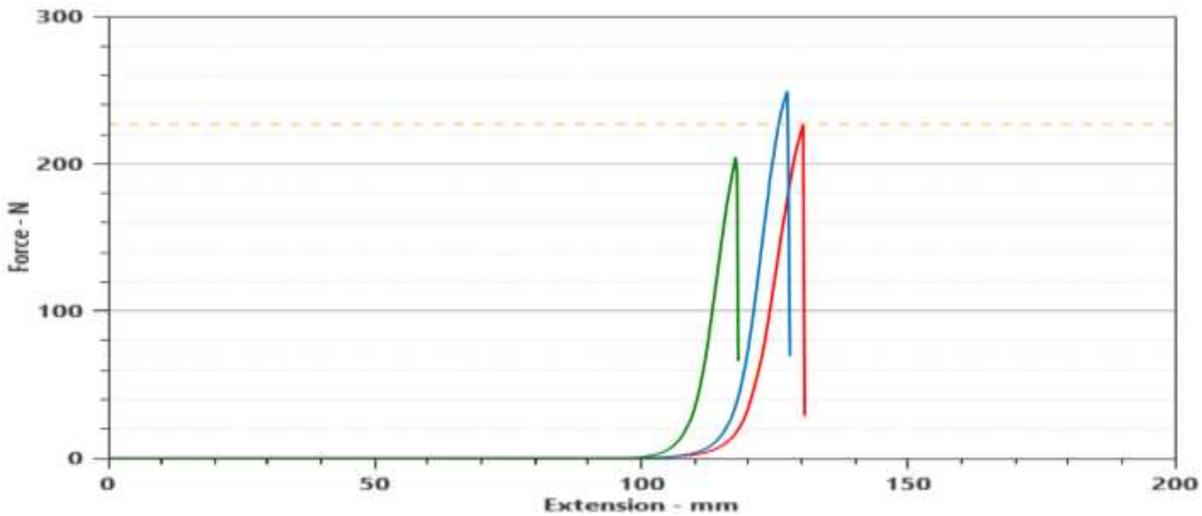


*Figure 13: Ball Bursting Strength Test Result SL No.4 Discussion*

**Discussion:** The fabric shows a high average rupturing force of 226.84 N and an average extension at break of 125.16 mm, indicating excellent strength and good flexibility. Among the specimens, force values vary moderately but remain consistently high, reflecting reliable structural integrity. This suggests that the fabric can withstand significant multidirectional pressure, making it well-suited for demanding end uses such as protective or performance wear.

**SL NO. 5**

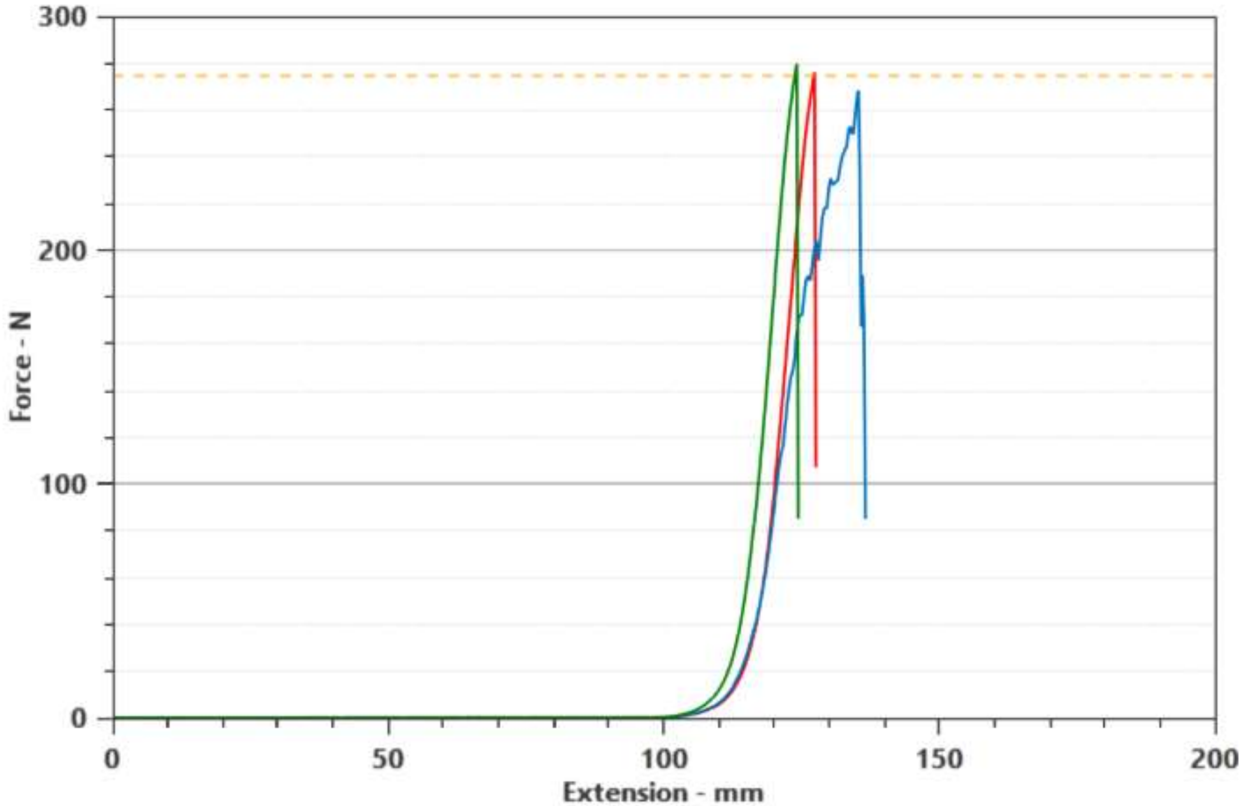


*Figure 14: Ball Bursting Strength Test Result SL No.5 Discussion*

**Discussion:** This sample shows the highest average rupturing force of 274.64 N among all tested sets, indicating superior bursting strength. The extension at break averages 129.00 mm, showing balanced flexibility alongside strength. The close range of values across all specimens reflects excellent consistency and fabric durability. This fabric is ideal for applications requiring maximum resistance to pressure and deformation.

# Chapter 5: Conclusion

## 5.1 Conclusion:

This study showed that stitch length significantly affects the quality of knitted fabrics produced on a V-bed flat knitting machine. As stitch length decreased, GSM, WPI, CPI, and ball bursting strength increased, resulting in denser, stronger fabrics. Longer stitch lengths produced lighter, more stretchable fabrics. The yarn strength remained consistent across samples, confirming reliable yarn quality. Thus, stitch length is a key factor in achieving desired fabric performance.

## 5.2 Recommendation:

1. Use shorter stitch lengths for stronger, heavier fabrics (winter or outerwear).
2. Use longer stitch lengths for softer, more breathable fabrics (summer wear).
3. Future research can study different yarns and structures or use computerized machines for greater accuracy.

## 5.3 References:

[1] L. &. G. D. Karthikeyan, "Effect of stitch length on the properties of single jersey fabrics," *International Journal of Textile and Fashion Technology (IJTFT)*, vol. 4, no. 2, p. 1–6, 2014.

[2] D. B. Ajgaonkar, Knitting Technology, Mumbai, India: Universal Publishing Corporation, 2004.

[3] S. J. Kadolph, Textiles, Upper Saddle River, NJ: Pearson Prentice Hall, 2010.

[4] J. E. Booth, Principles of textile testing: An introduction to physical methods of testing textile fibres, yarns and fabrics, Cambridge, UK: Woodhead Publishing, 2001.