Reducing fly contamination in single jersey circular knitting machine

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Abstract

The aim of this is to reduce Fly contamination from knitted fabric and increase the quality of the fabric. Fly contamination problem was found on dyed fabric which were being produced in three machines of the JFL floor. From the quality team data of fly contamination of 10 days was taken of those three machines. At first some procedures were applied to find out the causes of the problem (Matrix, Pareto Chart,5W1H). After find out the major causes, their solutions were also found and being applied on the machines. Such as maintaining proper polyethene on the machine as separator, making duster and proper use of it, counselling and giving training to the helpers. The costs were being noted while the solutions were applied in order to do so. Besides helpers and operators were being monitored time to time as they remain idle and were shown gossiping with each other's whereas they had to clean the dusts from the machines. After doing all the things it was seen fly contamination reduced in an approximate range. These things were monitored about 12 days and the data of 10 days after implementation was also taken. The data of 10 days before implementation and 10 days after implementation was compared. When it became confirmed that fly contamination reduced, then the cost benefit was calculated. Doing all the things, it became clear that the aims of the project were achieved.

Keywords

Fly Contamination, quality improvement, machine maintenance, cost-benefit analysis. Fly Contamination, quality improvement, machine maintenance, cost-benefit analysis.

1. Introduction

In recent years, the knitting sector of the textile industry has experienced rapid growth, driven by an increasing demand for weft-knitted garments in both domestic and export markets. However, one of the most critical quality concerns in this sector is fly contamination in knitted fabrics. This issue has been widely discussed in both industrial and research settings due to its significant impact on product quality and production efficiency [1]-[6].

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Fly contamination occurs when loose fibers detach due to friction between yarns or between yarns and machine components. These detached fibers combine to form entanglements known as fly, which, when introduced into the fabric, lead to defects. Contamination can originate from dyed and mélange fibers, dead fibers, foreign fibers, plastic particles, and dust from other machines. The presence of fly in knitted fabric results in serious production challenges, including yarn breakages, clogged yarn guides and feeders, fabric defects such as holes and thick spots, and mechanical failures such as broken needles. These issues not only reduce production efficiency but also lead to substantial economic losses [7].

The increasing prevalence of high-speed knitting machines has exacerbated the fly contamination problem. These machines generate more fly than traditional ones, thereby increasing the risk of defects and making quality control more complex. Additionally, fly contamination poses health hazards to workers, contributes to an unhealthy work environment, and increases the likelihood of fire hazards. Studies have shown that fly contamination is responsible for 60–80% of fabric defects, accounting for 15% of all machine faults, 15% of maintenance-related downtime, and fabric weight losses ranging from 0.5% to 1%. These statistics underscore the critical importance of addressing fly contamination in the knitting industry [7]-[11].

The objective of the research is to investigate the root causes of fly contamination in knitted textiles and offer workable remedies to lessen its effects. The following are the main goals of this study:
-to determine the elements influencing fabric quality.
-to identify the underlying reasons for fly pollution.
-to create methods for resolving issues in order to lessen fly pollution.
-to improve production and fabric quality in order to satisfy customer requests.
-to maximize manufacturing time, eliminate fabric rejects, and cut expenses.
-to investigate creative methods for effectively using idle materials.
In an attempt reach these objectives, the study seeks to increase production efficiency, improve knitted fabric quality, and support a more economical and sustainable knitting sector.

2. Theoretical Background

In the year 2009 Mehmet E. Yuksekkaya has studied a fly generation during manufacturing has attracted the attention of many workers for decades. In this study, it was noticed that the length of the fiber has the biggest impact on how much fly is produced throughout the raising process out of all the fiber characteristics [1]. Such as due to an increase in fiber mean length, blending with a synthetic fiber type also lowers the fly generation. Moreover, other factors that have a big impact on fly creation

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include yarn moisture content, weaving pattern, fabric speed, input tension, and the number of rollers on the machine. (E. Yuksekkaya, Pages 169-176 | Received 16 Feb 2007, Accepted 10Apr2007, Publishedonline:28Jan2008) [1].

In the year 2008 Yeong Seok Koo has done research on waxing effect on fly contamination. In the research, the frictional characteristics and Fly contamination during the knitting process were studied using cotton yarn with a wax finish. Here a designed test rig used the measured yarn tensions to determine the coefficient of friction, and the test rig was also used to measure the amount of lint produced throughout the test. Also, when compared to yarn that wasn't waxed, the wax treatment had a positive effect on reducing frictional forces. Finally, the results, however, indicated a detrimental impact on wax particle-induced Fly contamination. (Yeong Seok Koo, Department of clothing and textile, Pusan national University, Busan, South Korea.609-735) [2].

In the year 2016 Muhammad Abu Taher, Md. Mostafizur Rahman, Muhammad Ashfak Jahangir, Md. Shipan Mia, Ashaduzzaman have done study on knit fabric faults and their causes [3]. It was seen, in the textile sector, errors are commonly made, and the stitch length directly affects these errors. Such as when it was changed the stitch length at the same count on three identical double jersey knitting machines with the same rib structure, they discovered how it affected common knit fabric flaws. Besides the amount of various serious knit industry flaws, such as holes/cracks, loops/drop stitches, Lycra out, knots, and so forth, steadily increases or decreases with changes in stitch length.

In the year 2011 Woodhead Publishing Series in Textiles published a research paper on Quality control in the knitting process and common knitting faults. Here the key criteria for knitted fabric quality control are outlined in this chapter. Moreover, the crucial elements are the stitch density and loop length. In order to manage knitting process variables including input tension, take-down tension, and raw material management, discussion focuses on high-speed production circular knitting. Besides the most recent technology created to stop the production of errors during knitting uses an online monitoring technique. Finally, the chapter ends with a description of typical circular knitting mistakes ((Advances in Knitting Technology, Woodhead Publishing [4]. A re-evaluation study highlighted that production efficiency in circular knitting is closely tied to yarn tension, machine maintenance, and operator skill (Rassel 2023) [5].

2.1. Knitting

Knitting is a technique to turn thread or yarn into a piece of cloth. Knitted fabric consists of horizontal parallel courses of yarn which is different from woven cloth. The courses of threads or yarn are joined

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to each other by interlocking loops in which a short loop of one course of yarn or thread is wrapped over another course. [D.J. Spencer].

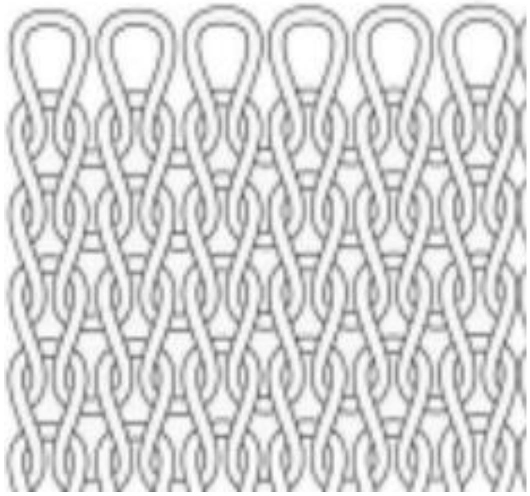

Fig.1 Knitting Structure. [D.J. Spencer].

2.2.1. Classification of Knitting

Knitting is primarily classified as weft knitting and weft knitting and weft knitting. This classification is based on the direction of movement of the yarn with respect to the direction of fabric formation. If the yarns run in the direction of fabric formation during knitting, then the process of knitting is called weft knitting. The yarn in the knitting structure are just like weft yarns in woven fabrics. Such structures are called weft-knitted fabrics and the machines in which such structures are produced are called weft knitting machine.

In case the yarns run in length direction, i.e., the direction of fabric formation knitting the process is called warp knitting. The yarns inside the knitting fabric are just like the warp yarns in woven fabrics. Such knitted fabrics are called warp knitted fabrics and the machine which produces such fabric is known as warp knitting machine[S.C.Ray]

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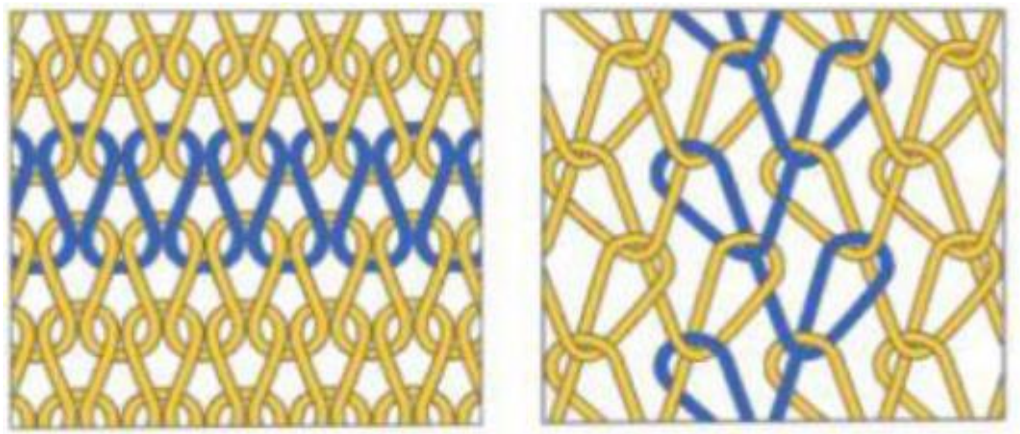

Fig.2. Weft Knitting & Warp Knitting[S.C.Ray].

2.2.2. Basic Weft-Knitted Structures

Plain, rib, interlock and purl are four basic weft-knitted structures from which all other weft-knitted structures can be derived. The graphical and schematic representations of the four basic weft-knitted structures are shown in figure 2.5.1-a and 2.5.1-b, respectively.

Generally plain structure is made on single bed machine whereas the other three are made on double bed machines. But the arrangement the needles in the two beds are different for obtaining rib, interlock and purl structures.

2.2.3. Single Jersey Knitting

Single jersey horizontal knitting farm was first made in 1589 by William Lee. Single jersey machine can only produce plain. Plain is the simplest type of structure practiced since the inception of knitting technology. It can be done in hand knitting as well as machine knitting. Although stockings, gloves and caps were the main plain hand knitting structures in the past, now it has wide application in the manufacture of inner and outer garments.

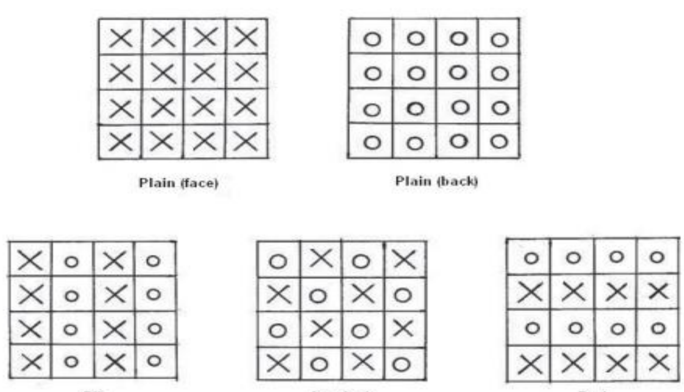

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Fig.3. Graphical notation of four basic weft knitted structure [S.C Ray].

2.2.4. Double Jersey Knitting

The double jersey machine is made with two set of needles. The second set of needles were first incorporated in the knitting from by Jedediah Strutt in 1755 for producing a knitted structure with both face loops and back loops. Double jersey machine with rib gaiting produces rib structure only. But double jersey machine with interlock gaiting can be converted to rib gaiting.[S.C.Ray].

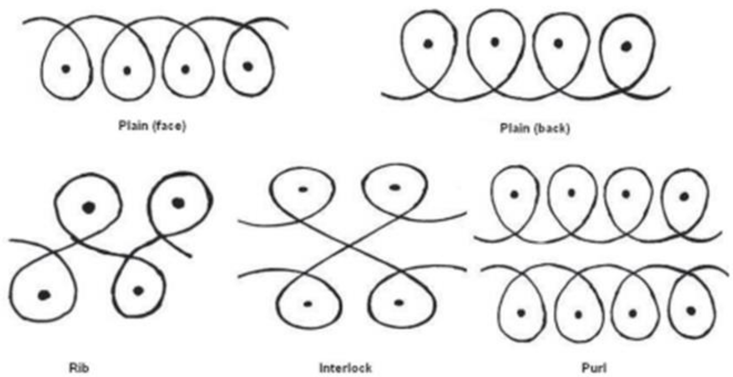

Fig.4. Schematic notation of four basic weft-knitted structures[S.C.Ray]

2.2.5. Feature of Plain(single jersey) knitting

- Machine has only one bed which may be flat or circular.
- There is only one set of needles and one cam system in the machine.
- Minimum one yarn is needed to produce a fabric.
- Single-faced structure, i.e., only one type of loops – Face or Back – are visible on the surface.
- Loops are V-shaped on technical face and semi-circular on technical back of the fabric.
- Because of side limbs of the loops on the face side, it feels smoother on face side than back side.
- Yarn /course can be un-roved from starting and ending end of knitting.
- Stitch length can be varied with stitch cam setting.
- Courses per inch and Wales per inch in the fabric inversely vary with loop length.
- Properties like rigidity, air permeability, bursting strength, etc. and GSM of the fabric change with change in loop length.
- Fabric thickness is approximately two times the diameter of the yarn used.
- Common gauge is 16–28 for circular machines and 5–12 for flat machines.

2.2.6. Feature of Rib(Double jersey) knitting

- Machine has two beds – may be flat or circular.

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- There are two sets of needles – one in each bed.
- There are two cam systems – one in each bed.
- Rib fabrics are double-faced structures as well as balanced structures.
- Both face loops and back loops are visible on both the sides of the fabric, and fabric has identical appearance in face and back.
- Each course is made of face loop and back loop in alternative order, the order may be 1×1, 2×2, 3×3, 6×3, etc.
- Face loops are made by the needles in front or bottom bed and back loops are made by needles in the back or top bed.
- Fabric is much thicker, generally double, than single jersey fabric.

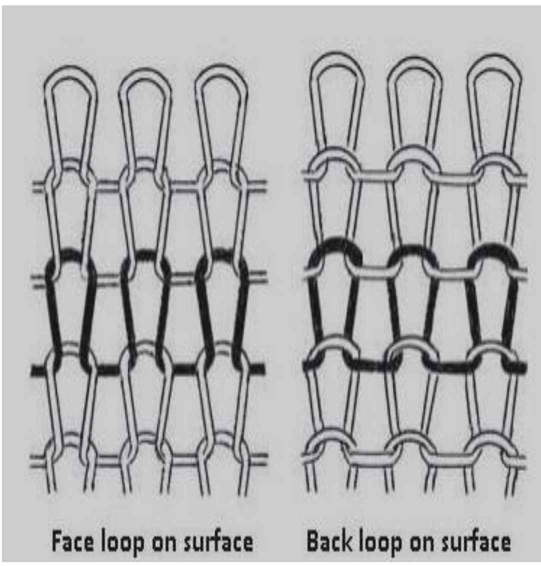

Fig.5. Plain Structure

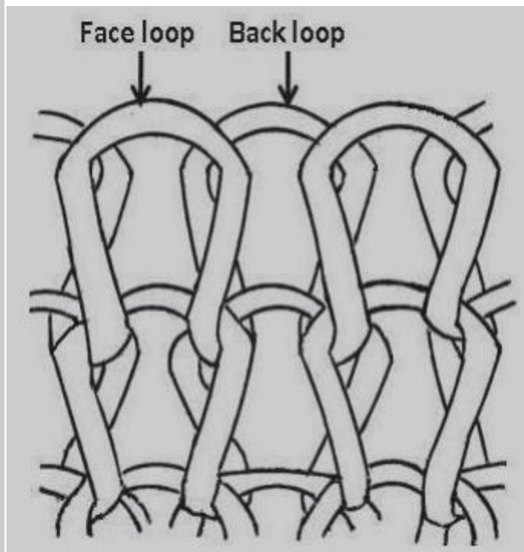

Fig.6. Rib Structure

2.2. Some Knitting Terms

2.2.1. Machine Pitch & Gauge

Both these terms are related to the density of needles in each bed of the machine. Machine pitch (needle pitch) is defined as the distance between the centers of two neighboring needles in one needle set measured on the nominal machine diameter or width.

Machine gauge is also defined in various units (systems) in various countries. Definition of gauge also depends on the types of knitting machines. Most popularly, it is defined in English system as the number of needles per inch[S.C.Ray].

2.2.2. Loop

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Loop means a shape produced by a curve that bends round and crosses itself. In knitting it is the basic unit of a knitted structure. It is produced by bending yarn with the help of some knitting elements, namely needle and sinker. According to the knitting element, which is forcing the yarn to bend, loops may be termed as needle loop and sinker loop.

Face Loop

If the new loops passed from the back to the front of the previous loop made by the same needle during inter-looping, the loop is called face loop.

Back Loop

When the new loop passes to the back from the front of the previous loop during inter-looping, the loop is called back loop

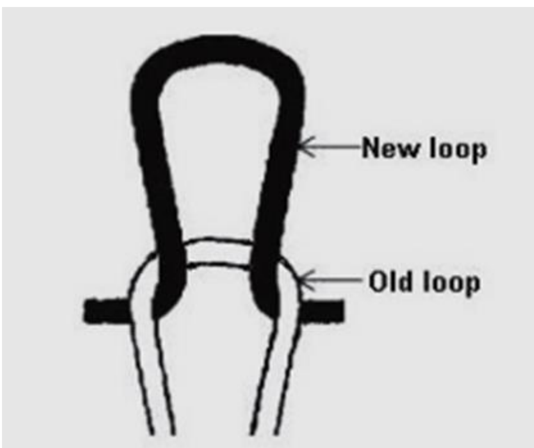

Fig.7. Face Loop[S.C.Ray]

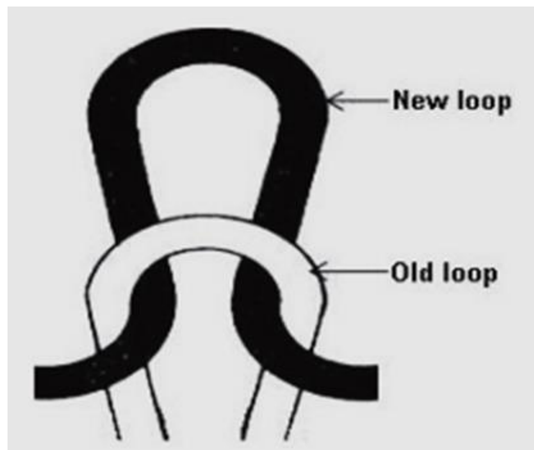

Fig.8.Back Loops.

Held Loop

When an old loop is not released in due time but retained in the hook for two or more knitting cycles, then the old loop is called held loop. A held loop can only be retained by a needle for a limited number of knitting cycles before it is cast-off and a new loop is drawn through.

Tuck Loop

If during rising, needle reaches to such a height that the old loop is not cleared but needle hook can catch new yarn during downward movement, then the old loop is not cast-off but retained in the hook as well as a new loop is formed. This situation is called tucking and the new loop is called tuck loop.

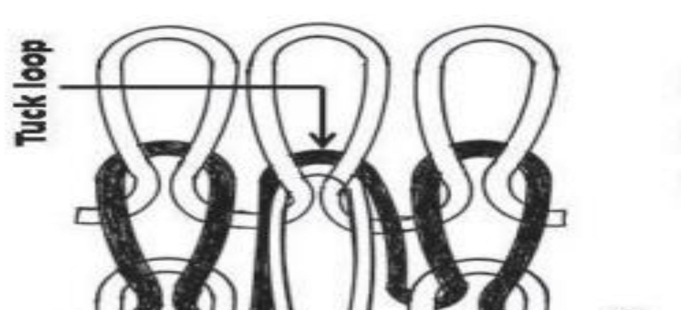

Fig.9. Tuck & Held Loops[S.C.Ray]

Miss Loop

If during rising, needle reaches to such a height that neither the old loop is cleared nor the needle hook can catch new yarn during downward movement, then the old loop is not cast-off but retained in the hook as well as no new loop is formed. This situation is called floating loop.

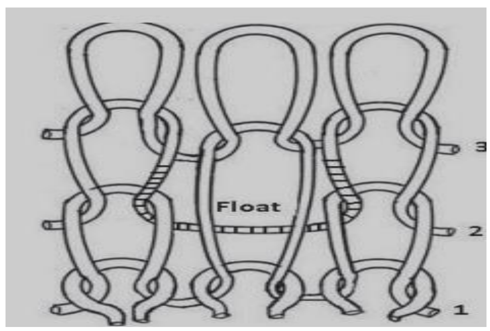

Fig.10. Float or Miss loop[S.C.Ray].

2.2.3. Course & Wales

Course

Horizontal rows of stitches are called courses which run widthwise from side to side of the cloth, and in the sense are similar to the weft or filling in a woven fabric [I.A.S]

Wales

Vertical columns of stitches in a knitted fabric are called Wales. Wales run lengthwise through the entire fabric, and is that sense are to the warp in a woven fabric. [I.A.S]

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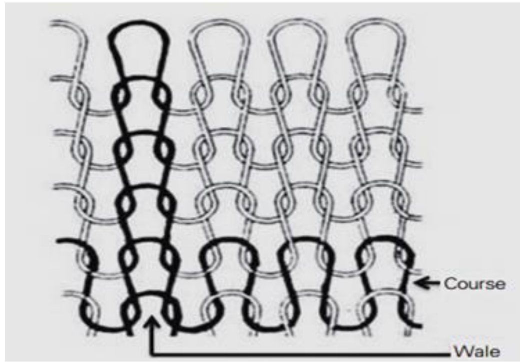

Fig.11. Courses & Wale

2.2.4. Stitch Density

Stitch density is the total number of loops in a unit area such as a square inch or a square centimeter. It is obtained by multiplying the number of courses and Wales per inch or centimeter together[S.C.Ray]

2.2.5. Course length& Loop length

Length of yarn contained in a loop is called loop length or stitch length. Course length is length of yarn required in the production of a course. It can be measured at a yarn feed during knitting or by un-roving the yarn from the knitted fabric[S.C.Ray]

2.3. Weft Knitting Elements

2.3.1. Needle

The main element used in knitting is the needle which actually makes the loop. Needles are may be arranged on the needle bed at regular interval in such a way so that needles may move freely along the axis without any lateral tilting. For the purpose cuts or groves, technically known as tricks, are made on the needle bed[S.C.Ray]

Latch needle

- Hook, which draws the yarn, makes the loop and retains the same. The top of the hook is called crown.
- Slot or saw cut on the stem which receives the latch blade.
- Latch which moves around its fulcrum for opening and closing of the hook.
- Latch has a spoon or cup at the end which imparts better closing of the hook.

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- Butt which receives the motion from cam system needed for loop formation.
- Tail, which is an extension of the stem below the butt, is used for giving support to the needle inside the trick.

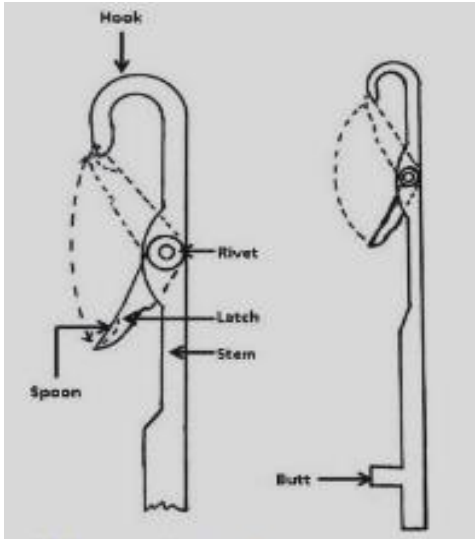

Fig.12. Latch Needle[S.C.Ray]

Bearded needle

- Stem the body of the needle.
- Head where the stem has been bent to make the hook.
- Beard, the flexible hook which can be pushed to the stem for hook closure.
- Groove or eye cut into the stem to accommodate the tip of the beard.
- Shank, the bent bottom portion of the needle for connecting with a separate machine part

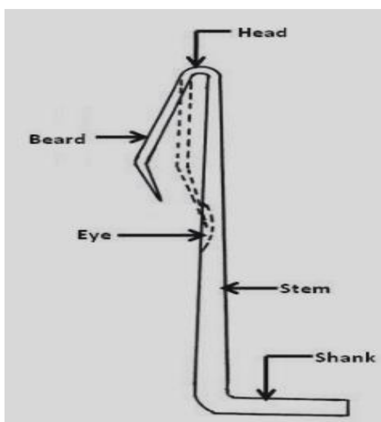

Fig.13. Bearded needle[S.C.Ray]

Compound needle

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Compound needles are more versatile and suitable for both weft and warp knitting. It is a modified latch needle. These needles are very robust and durable but can't be made of finer variety. Moreover, motions are to be given separately on the needle and the hook closer; and hence compound needles have very limited applications[S.C.Ray]

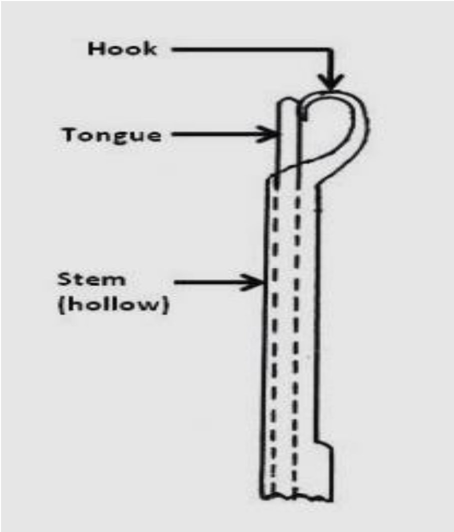

Fig.14. Compound Needle[S.C.Ray]

2.3.2. Sinker

- The primary knitting element next to needle is the sinker.
- . It is a thin metal plate positioned in between the needles.
- The sinkers generally move to and for in horizontal, i.e., at 90° to the direction of movement of needles and maintain a fixed height.
- Sinker is used in both weft and warp knitting in combination with latch needle as well bearded needle.

Function of sinker

- Loop formation.
- Holding down.
- Knocking over

Main part of sinker

- Throat which holds the yarn during loop formation.
- Belly is the projected portion on which the old loops or fabric rests.
- Butt which receives motion from a cam system.

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- Neb which prevents the yarns and fabric from moving up.

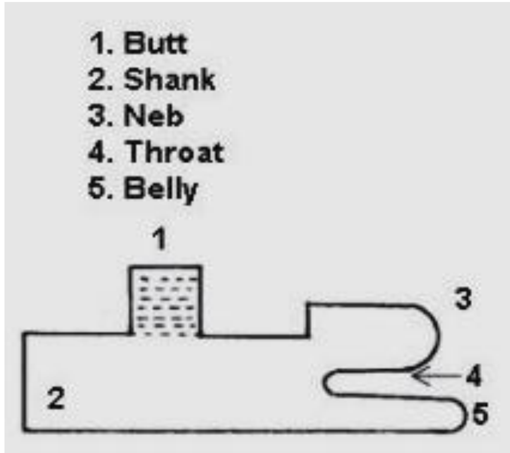


Fig.15.Sinker [S.C.Ray]

2.3.3. Knitting cam System

For the purpose of loop formation, needles are to move along the needle axis inside the trick. This axial movement of the needles is produced by means a cam system or cam profile. Generally, a few pieces of cams (metallic plates) make a groove or channel. The butts of the needles are placed inside the channel and the relative displacement of the two forces the needles to follow the profile of the cam system.

The cam system found in circular double jersey (cylinder and dial) interlock knitting machine is shown in Figure 17. There are two cam tracks in both the cam jackets. The butts of short and long needles pass through the upper and lower cam tracks respectively during interlock knitting[S.C.Ray].

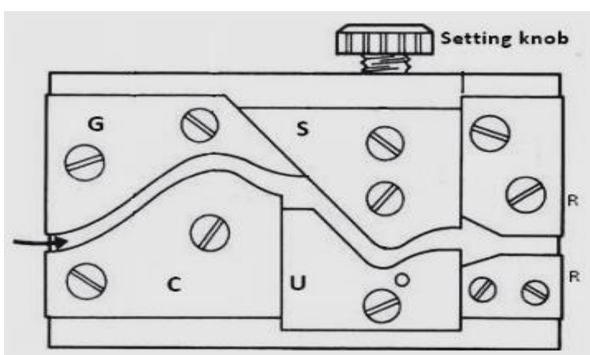
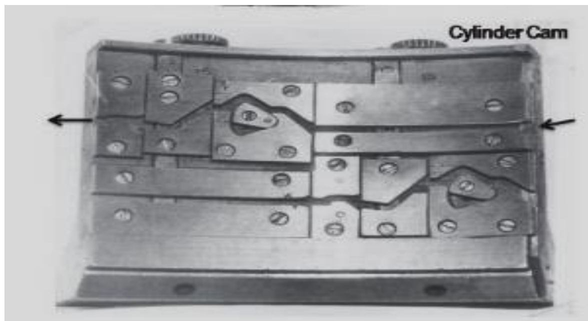


Fig.16. Knitting cam in circular knitting machine

Fig.17. Diagram of dial cam



Fiig.18. Diagram of cylinder cam[S.C.Ray]

2.4. Yarn Count

The number of fibers per unite length of yarn can very, finally this variation, along with the yarn production parameter, lead to the fact the also the yarn cross-section is not constant. Thus, it is difficult to precisely measure the physical dimensions of a yarn needed to derive a unite for expression the fineness or count. A ratio of mass to length of a fibers, yarn or ply is used to express to count. [Layer,Mammel,Schach]

There are two systems of yarn numbering –

1. Direct system
2. Indirect system

2.4.1. Indirect System

Where weight is fixed and, in this system, count is the number of units of length per unite of weight.

The following counting system is employed under indirect system:

- English Cotton System or Count: The number of 840-yard hanks that weigh 1 lb.
- Worsted System or Count: The number of 560-yard hanks that weigh 1 lb.
- Metric System or Count: The number of 1000 meter hanks that weigh 1000 g (1 kg)

We used in our project English cotton system or count.

2.5. Knitted fabric defect and their Types

2.5.1. Knitted fabric faults

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A fabric defect is any abnormal in the fabric that hinders its acceptability by the customer. A defect of the knitted fabric is an abnormality which spoils the aesthetics i.e., the clean & uniform appearance of the fabric & effects the performance parameters, like; dimensional stability etc.

2.5.2. Types of Knitted fabric defect

Drop stitch (Holes)

Drop Stitches are randomly appearing small or big holes of the, same or different size, which appear as defects, same or different size, in the knitted fabric. It occurs high yarn tension, high fabric take down tension, defects like; slubs, naps, knots etc., incorrect gap between the dial & cylinder rings.
Needle Lines: It occurs bent Latches, needle hooks & needle stems, tight needles in the grooves, wrong needle selection (Wrong sequence of needles, put in the Cylinder or Dial)
Barriness: It occurs high yarn tension, Count variation, Mixing of the yarn lots, Package hardness variation.

- Oil Lines: It occurs fibers & fluff accumulated in the needle tricks, which remain soaked with oil. excessive oiling of the, needle beds.
- Sinker Lines: It occurs bent or worn-out Sinkers. Sinkers being tight in, the sinker ring grooves
- Patta: It occurs yarn count variation, yarn tension variation.
- Slub: It occurs Thick or heavy place in yarn
- Contaminations:

Causes:

- Presence of dead fibers & other foreign materials, such as; dyed fibers, husk & synthetic fibers etc.
- Dead Fibers appear in the fabric, as a result of the, presence of excessive immature Cotton fibers, in the Cotton fiber crop .
- Dead fibers do not pick up color during Dyeing.
- Presence of the foreign materials, in the, staple fiber mixing
- (Kitty, Husk, Broken Seeds, dyed fibers & fibers like Poly Propylene, Polyester, Viscose etc)
- Dyed & other types of fibers flying from the adjacent Knitting machines cling, to the yarn being used for knitting & get, embedded in the Grey Fabric.

2.5.3. Fly Contaminations

A yarn is made of fiber, the fiber becomes loose due to friction between yarn & yarn, Yarn & Machine parts etc. These loose detached fibers then combined together & form entanglement of fibers. This

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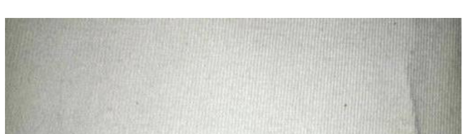

entanglement is called Fly. Fly from other machine classified as contamination. When dead fibers and foreign material such as dyed fibers husk, and synthetic fibers are knitted in fabric, then it considered as a fly contamination.

Fig.19. Fly contamination.

Fly comes from:

- Dyed & mélange fibres
- Dead fibres
- Foreign fibre
- Plastic particle
- Other machine dust

2.6. Some Tools used to Reduce Fly contamination

2.6.1. Cause effect diagram (Fishbone analysis)

The fishbone analysis is a tool for analyzing the business process and its effectiveness.it is also commonly referred as'' Ishikawa Diagram" because it was invented and incorporated by Mr. Kaoru Ishika, a Japanese quality control statistician. It is defined as a fishbone because of its structure outlook and appearance. In normal stature it looks like a skeleton of a fish. The fishbone diagram and analysis typically evaluates the causes and sub-causes of one particular problem and therefore assists to uncover all the symptoms of any business problem (American society for Quality,2005).For the particular reason it is also termed as "Cause-Effect analysis" .In a typical fishbone diagram the main problem which is required to be resolved has been put on the head of the diagram and the causes are put as the bones and then smaller bones created as resemblances of the sub-causes.[Tarun Kanti Bose].

2.6.2. Pareto Chart

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Pareto Analysis is a simple technique for prioritizing problem- solving work so that the first piece of work you do resolve the greatest number of problems. It's based on the Pareto Principle (also known as the 80/20 Rule) – the idea that 80 percent of problems may be caused by as few as 20 percent of causes.

To use Pareto Analysis, identify and list problems and their causes. Then score each problem and group them together by their cause. Then add up the score for each group. Finally, work on finding a solution to the cause of the problems in the group with the highest score. Pareto Analysis not only shows you the most important problem to solve, it also gives you a score showing how severe the problem.

2.6.3. 5W-1H

The 5W1H method will help you ask the right questions, expand your inquiry, and obtain the right information, which in turn helps you find the best solutions. This tool is very popular amongst journalists whilst also being used and applied to different contexts. This method allows you to guide all your team members and to gather all the factual elements needed for a complete and objective understanding (Imarah & Jaelani, 2020). The 5W1H method is widely utilized to give a comprehensive and delicate analysis to a specific issue or knowledge, such as in production management, marketing, and so on (A. Awal, 2018).

2.7. Suction and Blowing System:

These systems allow the abatement of the dust in the working range and the yarn feeding area. Suction and blowing systems usually incorporate a blower in the knitting range and swiveling fans in several points where the yarn passes. [I.A.S]

2.8. Air Gun

It feeds the yarn through the yarn carrier tubes. It is used to clean the external dust from the knitting zone and also for cleaning the machine.

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Fig.21. Air Gun

2.9. Fabric Inspection System

Fabric inspection is the visual examination or review of in relation to some standards. The main objective of inspection is the detection of the defects as early as possible in the manufacturing process so that time and money are not wasted later on in either correcting the defect There are some methods to inspect knitted fabric and grading them accordingly. Methods are-

- 4-point system
- 10-point system

In Jinnat Complex, DBL Group maintain 4 Point System in fabric inspection. 4-point system is used due to its easiness and good performance or output. Most of the knitted fabrics are inspected through 4-point system and also most of the knitting factory use 4-point system. It is certified by the American Society for Quality Control (ASQC) as well as the American Apparel Manufacturers (AAMA).

2.9.1. 4 Point System

The 4-Point System assigns 1,2, 3 and 4 penalty points according to the size and significance of the defect. More than 4 penalty points do not be assigned for any single defect. Defect can be in either length or width direction, the system remains the same. Only major defects are considered. No penalty points are assigned to minor defects.

Fabric defects are assigned points based on the following-

Size of the defect	**Penalty Point**
3 inch or less	1 points
Over 3 point but not over 6	2 points
Over 6 point but not over 9	3 points
Over 9	4 points
Hole size equal or less 1 inch	2 points
Hole size over 1 inch	4 points

After inspection of the fabric, total penalty point is calculated for 100 square yard fabric and the fabric is given grading accordingly. The inspector will add up the defects points and then use the following formula to determine the rate of points per 100 yards.

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Final calculation, Grade point = Total points X 36X100/fabric width(inch) X Length(yds)

After inspection and pointing through the process, finally the fabric is given a grade. The acceptance level of grading is given below-

Point	Grade
0-20	A
21-28	B
Above 28	C

But acceptance level of grading in DBL is given below,

Point	Grade
Upto 12.5	A
12.5-24	B
Above 24	C

DBL follow this grading for better quality of products. Grade A and Grade B fabrics are delivered to the grey fabric storage. Grade C fabrics are being hold up for the quality control department to decide whether it's going to be accepted or rejected.

2.10. Waxing and Twisting

Waxing

The purpose of applying wax to yarn is to improve efficiency of knitting and weaving process by reducing frictional resistance between yarn and yarn, yarn and needle, and yarn and other objects: the wax is the best and ideal lubricant. For that purpose, without using the wax, favorable efficiency cannot be expected especially in today's high speed knitting process. Although the wax is considered to be the best lubricant, the types of the wax must be selected very carefully.

Twisting

Twist is simply the spiral arrangement of fibers around the axis of the yarn. Through twisting, the fibers are bound together and create a stronger yarn. The number of twists involved is normally referred to as turns per inch or turns per meter. The amount of twist added to yarn defines its strength, and an optimal level of strength is sought through careful calculation. Twist also affects the look of the yarn, changing its appearance to be duller or brighter.

DOI: https://doi.org/10.5281/zenodo.15200877

3. Methods and Findings

3.1. Raw material

Cotton Yarn

- Manufacturers Name: Matin spinning Mills. Ltd
- Yarn Type: 100% Cotton
- Yarn Count: 32 Ne,28 Ne,30 Ne
- Yarn Package Type: Cone Package

Yarn Color: Grey Yarn, Dyed Yarn

Fig.22. 100% Cotton Yarn

3.2. Working Procedure

DOI: https://doi.org/10.5281/zenodo.15200877

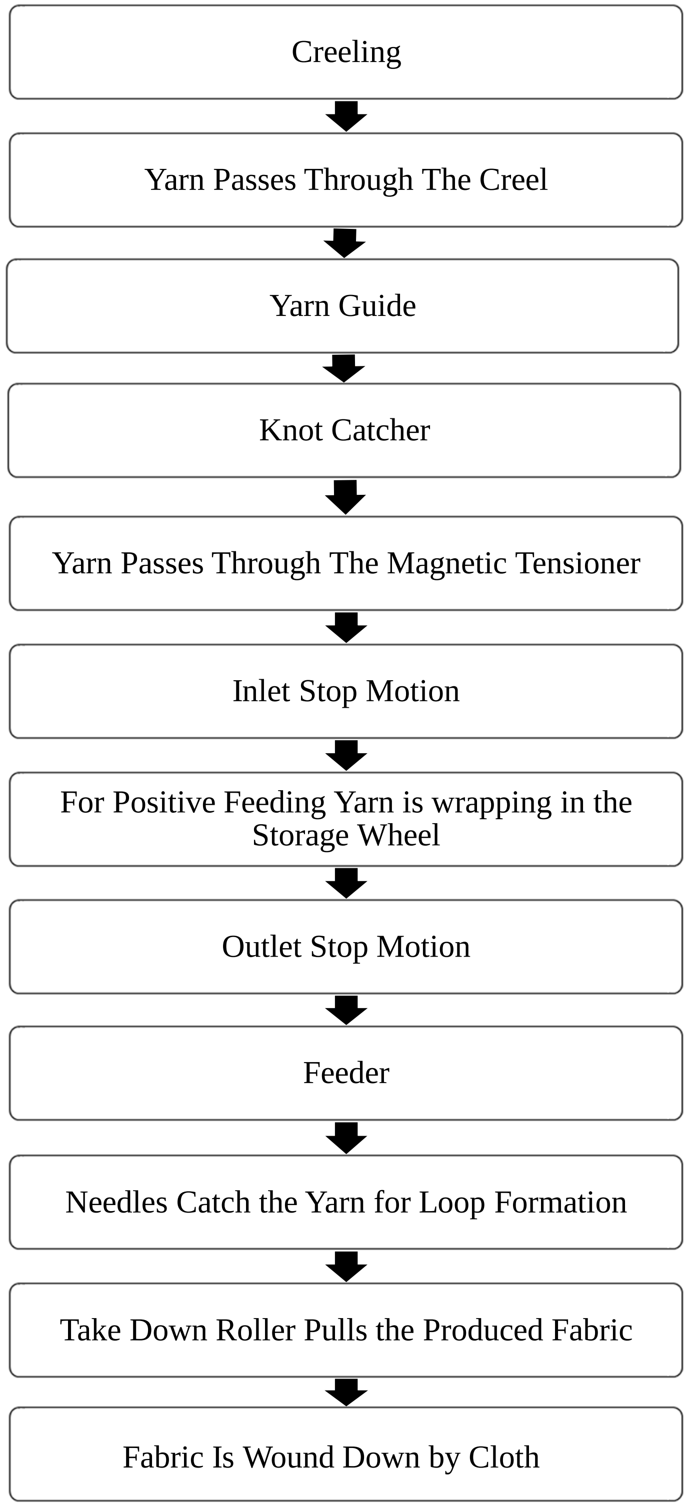

Fig.23. Flow chart produce of single jersey fabric (100 % Cotton)

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3.3. Produced Fabric

- Fabric Type: Single Jersey,Grey Fabric

3.3.1. Structure Single jersey fabric sample

Diagrammatic Notation **Needle Set Out**

kkkk

kkkk

kkkk

1			
	2		
		3	
			4

Cam Arrangement:

F1	F2	F3	F4
5	5	5	5
5	5	5	5
5	5	5	5
5	5	5	5

Sample:

As we worked with three samples,the pictures of the samples are given bellow:

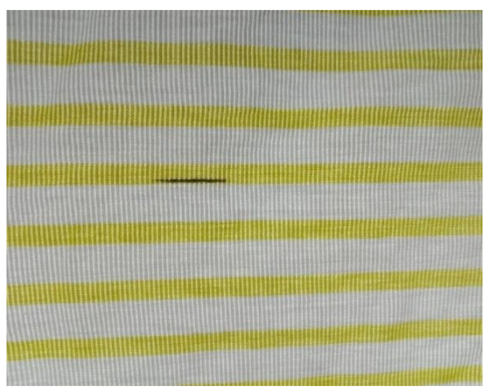

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Fig.24. Sample 1 Fig.25. Sample 2

Fig.25. Sample 3

3.4. Specification of the Machine and Equipment

3.4.1. Single Jersey Circular Knitting Machine

The machines that we work on were Single jersey Circular knitting machine.As the 3 three machines were same with different specifications,a picture is provided and their specifications are provided individually.

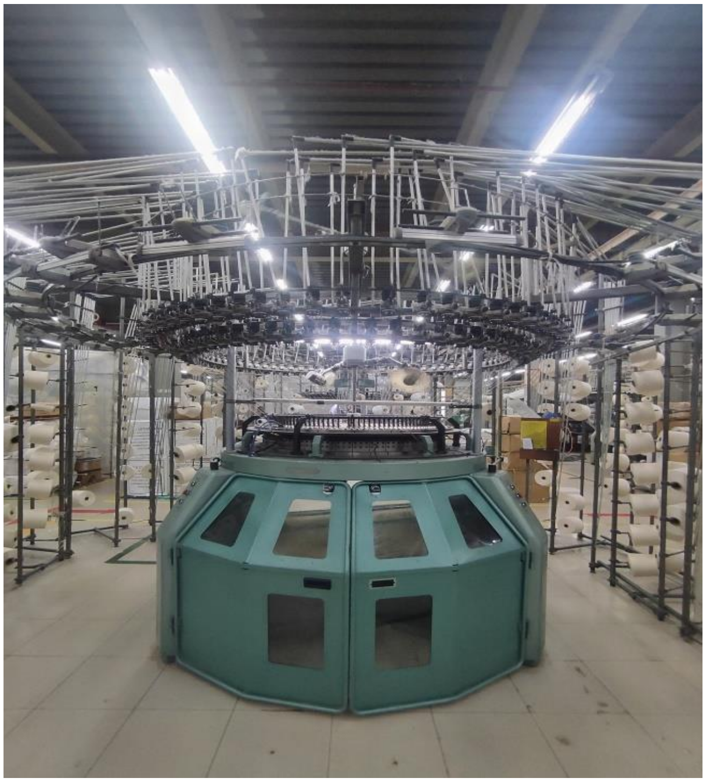

Fig.26. Single Jersey Circular Knitting Machine.

Specifications of the Machines:

DOI: https://doi.org/10.5281/zenodo.15200877

Machine no: 20

Machine name: Single Jersey Circular Knitting Machine

Cylinder Diameter: 42

Stitch Length: 30

Gauge: 18

Number of needles: 2376

Number of Feeder: 126

Machine no: 35

Machine name: Single Jersey Circular Knitting Machine

Cylinder Diameter: 40

Stitch Length: 32

Gauge: 18

Number of Needles: 2262

Number of Feeder: 120

Machine no: 49

Machine name: Single Jersey Circular Knitting Machine

Cylinder Diameter: 32

Stitch Length: 29

Gauge: 24

Number of Needles: 2413

Number of Feeder: 96

Fan: It keeps the knitting area free of dust, flies etc.

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Fig.27. Fan

3.4.3. Precision Electronic Balance

Functions: It is used to measure the weight of fabric samples

Specification:

- **Name of machine:** Precision Electronic Balance.
- **Manufacturer:** A&D Company Ltd.
- **Model:** EK 600i
- **Country of Origin:** Japan

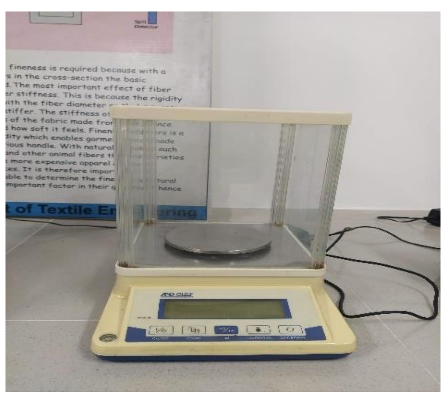

Fig.28. Precision Electronic Balance

3.4.4. GSM Cutter

Functions: It is used to cut fabric to measure the fabric GSM

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Specification:

- **Manufacturer:** James H. Heal
- **Cut Area:** 100 cm square
- **Country of Origin:** England.

Fig.29. GSM cutter

3.4.5. Scissor

Functions: It uses to cut the fabric.

Fig.30. Scissor

3.4.5. Duster

Functions: It is used to clean the body of the single jersey of circular knitting machine. It helps to reduce fly contamination.

Fig.31. Duster.

3.4.6. Polyethene sheet

It is used to cover yarn cone package and used to separate machines one from to another so that any fly or different colored yarn cannot come.

Fig.32. Polythene.

3.4.7. Tweezers

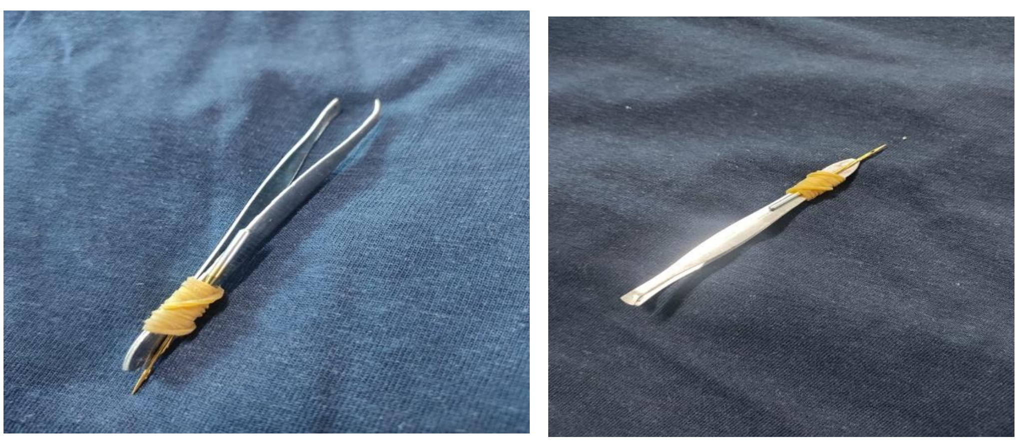

Fig.33. Tweezers.

3.4.8. fabric Inspection Machine

Fig.34. Fabric Inspection Machine.

Name of machine: Fabric Inspection Machine

Manufacturer: Foshan Bestleader Machine Equipment Co. Ltd

Model: TFJ-C3

Country of Origin: China.

4. Data Collection and Analysis

4.1. Fish bone analysis

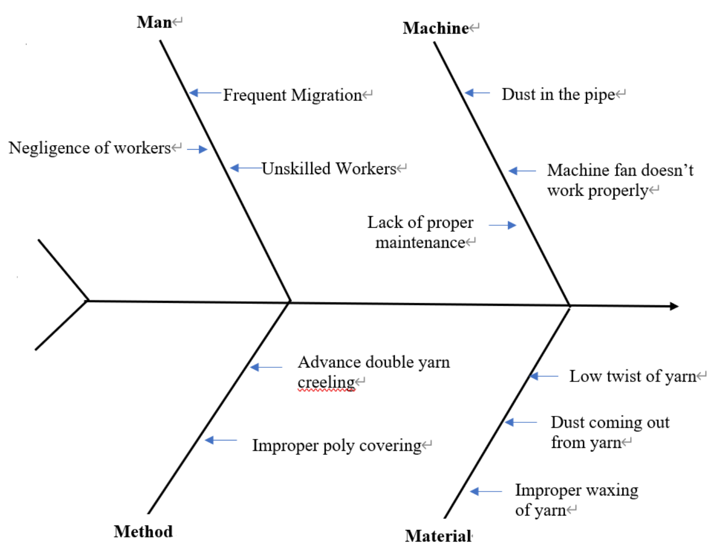

Fig.35. Fishbone Chart Analysis.

DOI: https://doi.org/10.5281/zenodo.15200877

No	Causes	Cost	Feasibility	Importance	Frequency	Total	Position
1	New recruitment	70	0	0	40	130	10th
2	**Negligence of workers**	**80**	**80**	**90**	**60**	**310**	**4th**
3	Dust in the pipe	50	50	60	50	210	6th
4	**Machine fan does not work properly**	**75**	**85**	**90**	**75**	**325**	**3rd**
5	Lack of proper maintenance	40	40	30	40	150	9th

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6	Dust coming out from yarn	60	60	60	50	230	5th
7	**Improper waxing of yarn**	**80**	**85**	**90**	**85**	**350**	**2nd**
8	**Improper poly covering**	**85**	**100**	**100**	**90**	**375**	**1st**
9	Unskilled workers	40	40	50	60	190	7th
10	Low twist of yarn	60	40	30	40	170	8th
11	Advance double yarn creeling	20	30	30	20	100	11th

Comment: The fishbone diagram identifies many possible causes for an effect or problem. It immediately sorts ideas into useful categories. Here some major possible causes were identified which were the reasons of Fly contamination and they were divided into four categories (Man, Machine, Method, Material).

4.2. Matrix for prioritizing the causes

5	Lack of proper maintenance	40	40	30	40	150	9th
6	Dust coming out from yarn	60	60	60	50	230	5th
7	**Improper waxing of yarn**	**80**	**85**	**90**	**85**	**350**	**2nd**
8	**Improper poly covering**	**85**	**100**	**100**	**90**	**375**	**1st**
9	Unskilled workers	40	40	50	60	190	7th
10	Low twist of yarn	60	40	30	40	170	8th

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11	Advance double yarn creeling	20	30	30	20	100	11th

Comment: A prioritization matrix is a tool that can help you prioritize tasks, goals, or anything else based on four factors-Cost, Feasibility, Importance and Frequency. Depending on these four factors we gave positions to eleven causes and took first four causes to be solved.

4.3. Pareto Chart Representation

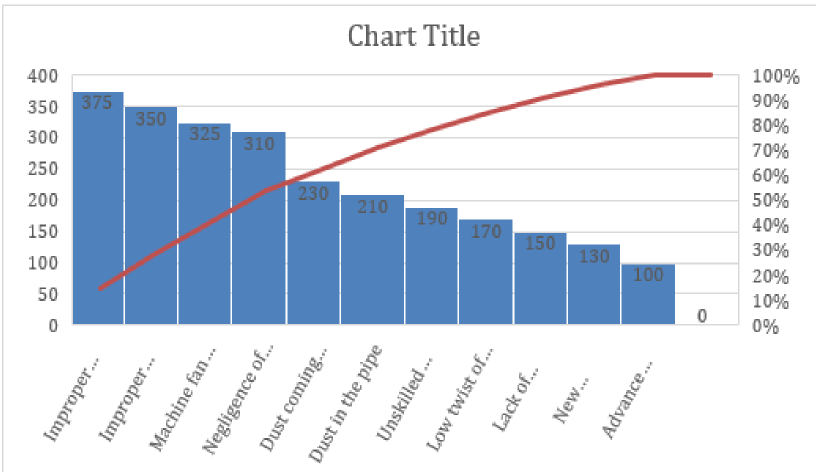

Fig.36. Pareto Chart Representation.

Comments: Pareto Analysis is a simple technique for prioritizing problem- solving work so that the first piece of work you do resolve the greatest number of problems. It's based on the Pareto Principle (also known as the 80/20 Rule) – the idea that 80 percent of problems may be caused by as few as 20 percent of causes.

Pareto charts help people decide which problems to solve first. They are useful for identifying the most frequent outcome of a categorical variable.

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4.4. 5W-1H Question

Table-3: Analysis of 5W-1H Question.

5 W-1 H Question	Reason-01 (Improper poly covering)	Reason-02 (Improper waxing of yarn)
Where the problem is?	In processing/method	Yarn / material
Why, Why and Why it is problem?	There is no poly covered in yarn cone package during knitting production	Idleness of worker, workers are not concentrated his work properly, there is no proper monitoring system.
What needs to be done? Action & measurement	It should be taken proper step in yarn cone package is to covered poly properly so that yarn fly cannot come out as ducts	Proper attention during working, proper training and monitoring
Who is responsible for that action?	Quality Control (QC) team & Officer	Operator/ floor in-charge
When to solve the problem?	Within 10 days	Within 7 days
How it will cost?	A little cost	No cost

Table-4: Analysis of 5W-1H Question

5 W-1 H Question	Reason-03 (The machine fan dost not work properly)	Reason-04 (Negligence workers)
Where the problem is?	Machine	Man
Why, Why and Why it is problem?	If dust accumulated in the machine fan that is why the capacitor, coil, bearing must be damaged and fan may be stop or be slow.	There is no proper monitoring system
What needs to be done? Action & measurement	Cleaning the fan properly and proper maintenance in a schedule way.	Counselling & follow up, Proper training
Who is responsible for that action?	Utility team	Production officer/supervisor
When to solve the problem?	Within 5 days	Within 12 days
How it will cost?	A little cost	No cost

Comment: In this method, the causes of fly contamination were asked different questions regarding the selected causes to have a detail idea so that it can be helpful for us to solve the causes.

4.5. Steps Taken to Reduce Fly contamination

Counseling with New Helpers

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Fig.37. Counseling Period.

Comment: The helpers who were newly recruited had a little idea about Fly contamination like how it happened, what the bad effects, what need to be followed. So they were made to understand about all of it by counseling. Here proper counseling was given not to be idle and show any neglency during the work.

Training period of New Helpers

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Comment: The techniques that were learnt after discussing with the Supervisor, Assistant production officer and taking ideas from internet, they were taught to the helpers as training so that they can apply them while they are operating.

Making and using dusters

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Fig.39. Training Period.

Fig.40. Use of Duster.

DOI: https://doi.org/10.5281/zenodo.15200877

Comment: Duster was made using fleece fabric, was given to the helpers and they were taught how to use the duster to remove dusts from the knitting machine time to time.

Comment: Polythene is used as a separator where it separates one machine to another. But the used polyethene were not good before, that’s why these were not that much effective. Before we worked there, many polyethenes were torn and teared. Though it was a major issue,so full polyethene were changed and new polyethene were used in a proper way.

DOI: https://doi.org/10.5281/zenodo.15200877

Before

Machine N0-20				
Date	Fabric roll no	Fly Contra	Buyer Name	Average per roll
15-Nov	2	19	Puma	
16-Nov	2	23	Puma	
17-Nov	2	12	Puma	
18-Nov	2	8	Puma	
19-Nov	2	12	Puma	5.9
20-Nov	2	9	Puma	
21-Nov	2	10	Puma	
22-Nov	2	8	Puma	
23-Nov	2	10	Puma	
24-Nov	2	7	Puma	

After

Machine N0-20				
Date	Fabric roll no	Fly Contra	Buyer Name	Average per roll
25-Nov	2	8	Puma	
26-Nov	2	9	Puma	
27-Nov	2	6	Puma	
28-Nov	2	6	Puna	
29-Nov	2	8	Puma	3.5
30-Nov	2	7	Puma	
1-Dec	2	6	Puma	
2-Dec	2	8	Puma	
3-Dec	2	5	Puma	
4-Dec	2	7	puma	

Supervised By,

4.1.23

Swakshar Kumar Saha

Assistant Manager,Production

Knitting Division,DBL Group

Fig.41. Comparison of fly contamination before and after.

4.6. Data Collection of Fly Contamination from Machines

Graphical representation of Fly contamination in Machine No -20

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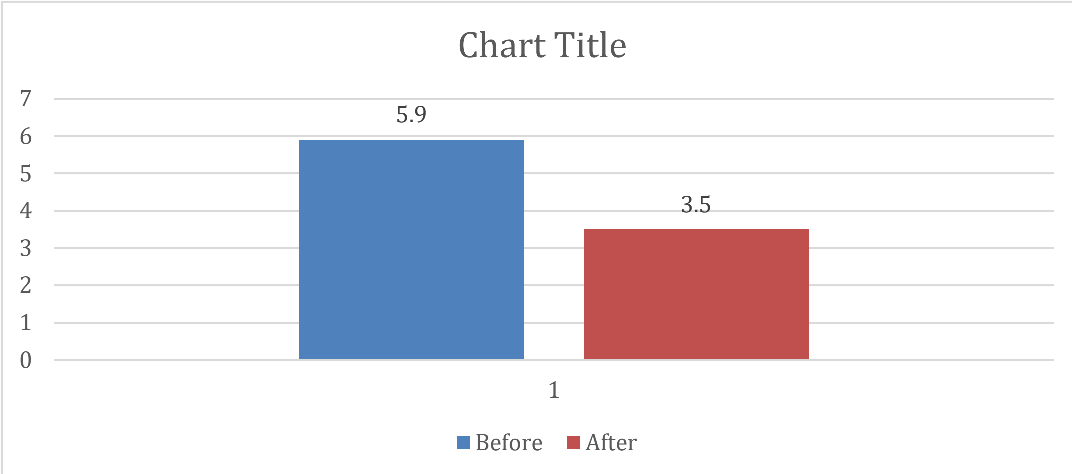

Before

Machine N0-35				
Date	Fabric roll no	Fly Contra	Buyer Name	Average per roll
15-Nov	2	10	Puma	
16-Nov	2	8	Puma	
17-Nov	2	11	Puma	
18-Nov	2	8	Puma	4.45
19-Nov	2	8	Puma	
20-Nov	2	9	Puma	
21-Nov	2	8	Puma	
22-Nov	2	9	Puma	
23-Nov	2	7	Puma	
24-Nov	2	11	Puma	

After

Machine N0-35				
Date	Fabric roll no	Fly Contra	Buyer Name	Average per roll
25-Nov	2	8	Puma	
26-Nov	2	6	Puma	
27-Nov	2	7	Puma	
28-Nov	2	7	Puna	3.5
29-Nov	2	8	Puma	
30-Nov	2	6	Puma	
1-Dec	2	6	Puma	
2-Dec	2	8	Puma	
3-Dec	2	7	Puma	
4-Dec	2	7	puma	

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4.1.23

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Assistant Manager,Production
Knitting Division,DBL Group

Graphical representation of Fly contamination in Machine No-35

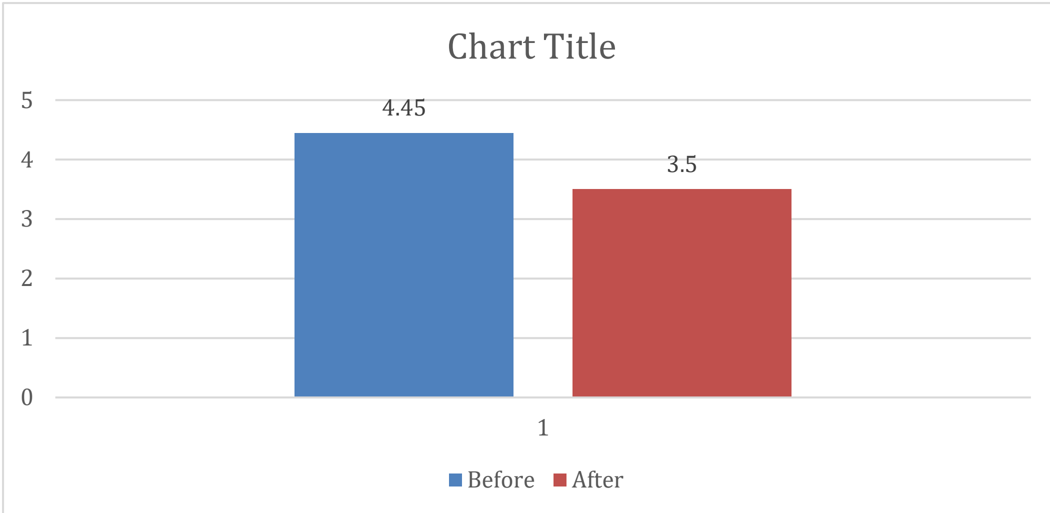

Fig.42. Comparison of fly contamination before and after

Before

Machine NO-49				
Date	Fabric roll no	Fly Contra	Buyer Name	Average per roll
15-Nov	2	12	Puma	
16-Nov	2	9	Puma	
17-Nov	2	9	Puma	
18-Nov	2	8	Puma	4.9
19-Nov	2	11	Puma	
20-Nov	2	10	Puma	
21-Nov	2	9	Puma	
22-Nov	2	10	Puma	
23-Nov	2	8	Puma	
24-Nov	2	12	Puma	

After

Machine NO-49				
Date	Fabric roll no	Fly Contra	Buyer Name	Average per roll
25-Nov	2	6	Puma	
26-Nov	2	6	Puma	
27-Nov	2	7	Puma	
28-Nov	2	8	Puna	3.45
29-Nov	2	7	Puma	
30-Nov	2	6	Puma	
1-Dec	2	7	Puma	
2-Dec	2	8	Puma	
3-Dec	2	8	Puma	
4-Dec	2	6	puma	

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Graphical representation of Fly contamination in Machine No-49

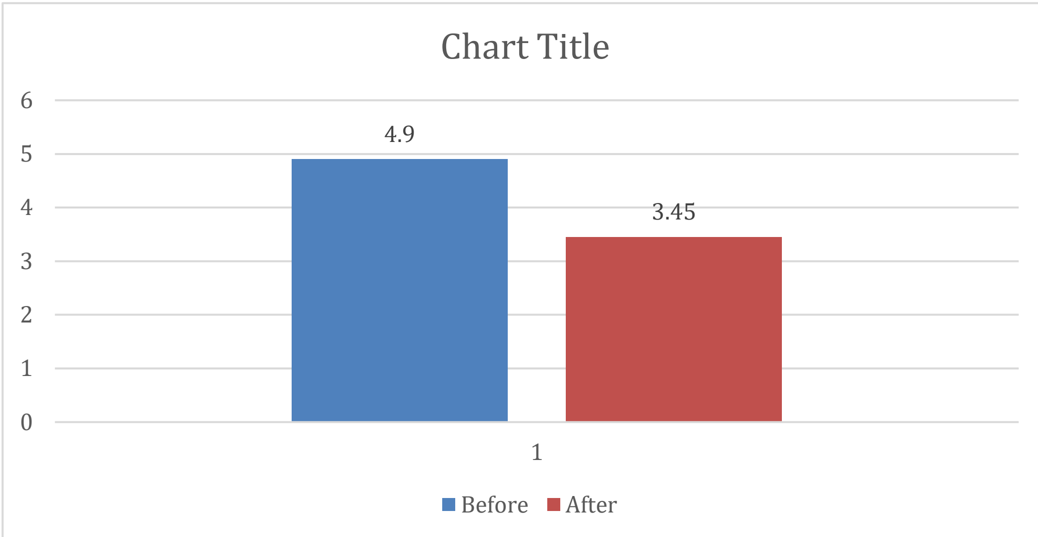

Fig.43. Comparison of fly contamination before and after

Machine No.20

15-24 November production was: 1701 kg

After some implementation, (poly covered + Repair fan+ making duster) Total cost (1990+780+20) =2790

25 November- 4 December production = 2005 kg

Production increased = (2005 -1701)

= 304 kg

1 kg fabric price =30 TK

Increased earnings from production = (304 X 30) Taka

=9120 Taka

Cost benefit= (9120-2790) Taka

=6330 Taka

Monthly save money (6330 X 3) =18990 Taka

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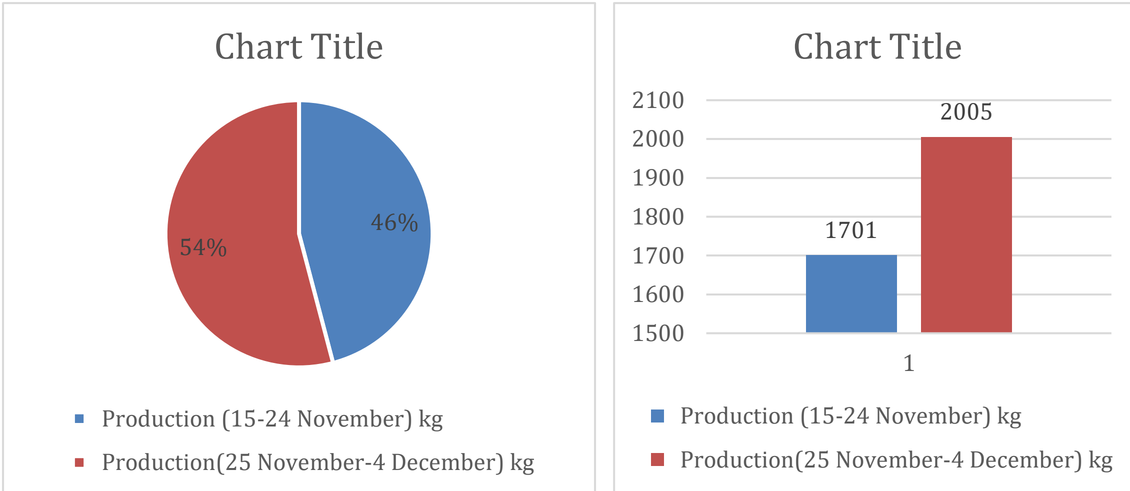
Fig.44. Comparison of Production before and after



Graphical representation of Production in Machine No -20

Machine No.35

15-24 November production was: 2485 kg

After some implementation, (poly covered + making duster) Total cost (1990+20) =2010

25 November- 4 December production = 2704 kg

Production increased = (2704- 2485) Kg

= 219 Kg

1 kg fabric price =30 TK

Increased earnings from production = (219 X 30)

=6570 TK

Cost benefit= (6570-2010)

=4560 TK

Monthly save money (4560 X 3) =13680 Taka

1 year save money (13680 X12) = 164160 Taka

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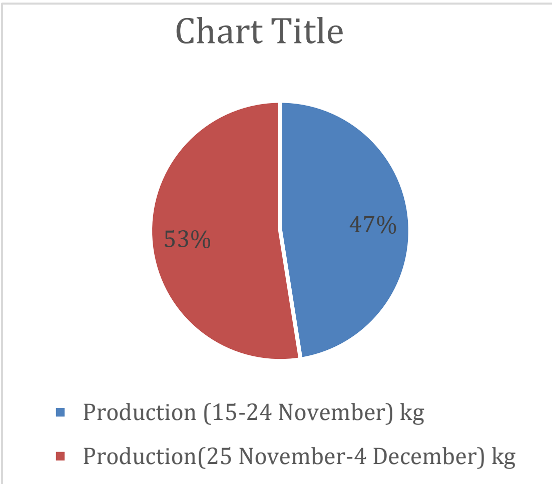
Graphical representation of Production in Machine No -35



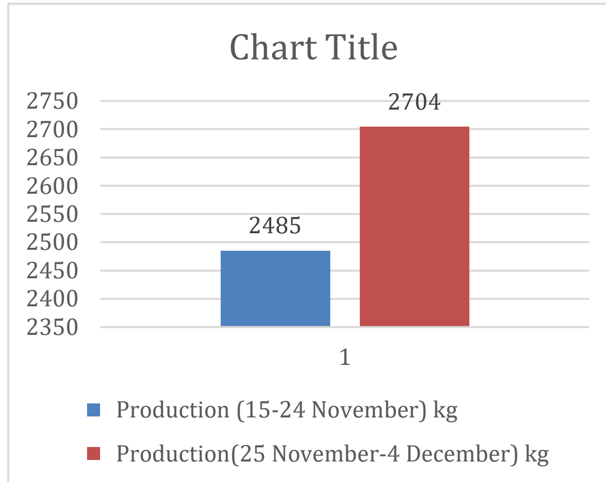


Fig.45. Comparison of Production before and after

Machine No.49

15-24 November production was: 3663 kg

After some implementation, (poly covered + making duster) Total cost (1990+20) =2010

25 November- 4 December production = 4049 kg

Production increased = (4049- 3663) Kg

= 386 kg

1 kg fabric price =30 TK

Increased earnings from production = (386X 30)

=11580 TK

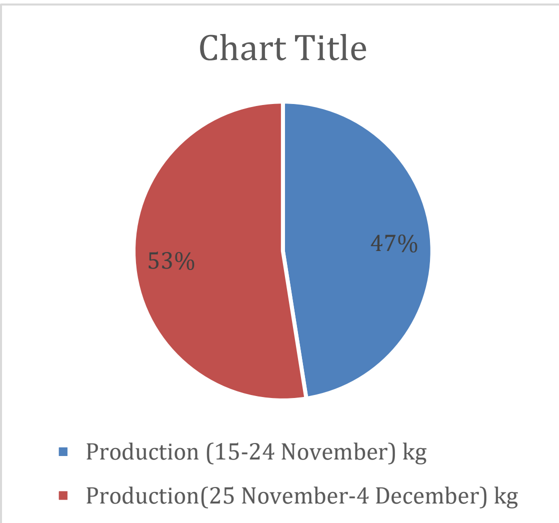
Cost benefit= (11580-2010)

=9570 TK

Monthly save money (9570 X 3) = 28710 Taka

1 Year save money (28710 X 12) = 344520 Taka

Graphical representation of Production in Machine No -49



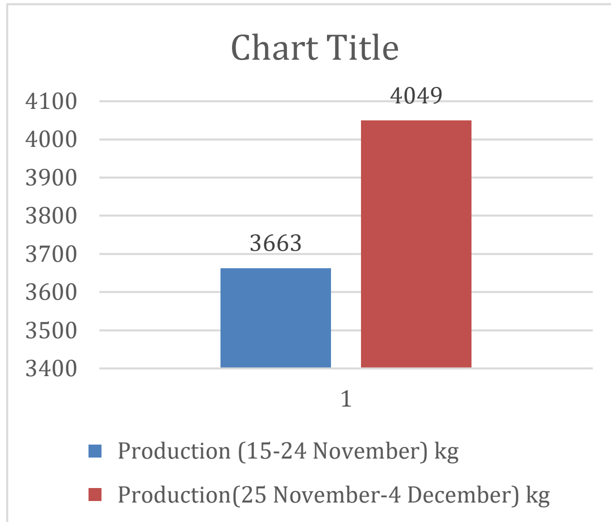


Fig.46. Comparison of Production before and after.

Average 1 year save money = (227880+164160+344520)/3

= 245520 Taka

Though we worked on 3 machines but if it is done on 50 machines then the

Save money would be = (2445520 X 50)
= 12,276,000 Taka
= 119,288.699 USD/Year

4.7. Intangible benefit & Feasibility Check

Intangible benefits

- Enhanced work experience
- Production efficiency increased
- Confidence is increased
- Inter personal relationship improved
- Friendly working environment created

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- Self-development is increased

Feasibility Analysis

- Team work increased
- Two different color yarn poly-covered is feasible
- Making duster for worker is feasible
- Counseling with workers to motivate & encourage them is feasible
- Repairing the fan is feasible

5. Conclusion

Fly contamination is a major issue in knit production, as it directly affects fabric quality and buyer satisfaction. During this study, it became evident that a lack of awareness among workers contributes significantly to fly contamination. By implementing proper awareness programs and maintenance techniques, the issue can be minimized. If fly contamination is not controlled from the beginning, it requires additional effort to remove it from the fabric, leading to increased production time and reduced efficiency. However, with the right preventive measures in place, such as regular monitoring of helpers and ensuring they follow proper cleaning techniques, the contamination can be significantly reduced. Throughout the implementation process, workers were closely supervised to ensure adherence to best practices, highlighting the importance of awareness in maintaining fabric quality. If these measures are consistently applied, fly contamination will be less frequent, production efficiency will improve, and the overall quality of the fabric will be preserved.

References

[1] Yuksekkaya, Mehmet E. "Fly Generation During Manufacturing." *Textile Research Journal*, vol. 79, no. 2, 2009, pp. 169-76.

[2] Koo, Yeong Seok. "Waxing Effect on Fly Contamination During the Knitting Process." *Textile Research Journal*, vol. 78, no. 1, 2008, pp. 75-81.

[3] Taher, Muhammad Abu, et al. "Knit Fabric Faults and Their Causes." *International Journal of Textile Science*, vol. 5, no. 6, 2016, pp. 119-31.

[4] Au, K. F. "Quality control in the knitting process and common knitting faults." Advances in knitting technology. Woodhead Publishing, 2011. 213-232. Textile Coloration and Finishing." *Research Paper*, vol. 22, no. 1, 2010.

[5] Rassel, M., and M. Hoque. "Re-evaluation on causes of circular knitting machine production efficiency and their impact on fabric quality." *Eur. Sci. J. ESJ* 15 (2019).

[6] Ahmed, Suza, and Mohammad Mohsin Ul Hoque. "Process control in knitting." *Advanced Knitting Technology*. Woodhead Publishing, 2022. 219-253.

[7] Uddin, Ahmed Jalal, and Purudeb Roy. "Transforming melange fabric waste into mélange yarn employing compact, Siro, and compact-Siro spinning: a cleaner and sustainable strategy." *Cleaner Waste Systems* 8 (2024): 100142.

[8] Shamsuzzaman, Md, et al. "Management and maintenance of textile machinery." *Advanced Technology in Textiles: Fibre to Apparel*. Singapore: Springer Nature Singapore, 2023. 31-63.

[9] Smirfitt, John Arthur. "The production and properties of weft-knitted fabrics." *Textile Progress* 5.2 (1973): 1-101.

[10] Fiorilli, Elisa. "Sustainable textile processing: an in-depth analysis of environmental and workers well-being in the fashion industry." (2023).

[11] Surjit, R. "Blending of wool with other fibers: mixing of wool with other natural/synthetic fibers for different applications." *The Wool Handbook*. Woodhead Publishing, 2024. 533-558.

DOI: https://doi.org/10.5281/zenodo.15200877