Identifying defect causes of weft greige knitted fabric: the Case of MAA-Garment & Textiles Factory

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DECLARATION

This is to certify the thesis entitled **''IDENTIFYING DEFECT CAUSES OF WEFT KNIT GREIEGE FABRIC'' (A Case Study: MAA-Garment & Textiles Factory On Knitting Section)** submitted in partial fulfillment of the requirements for the award of the degree of M.Sc. in Industrial Engineering (Production and Industrial System Engineering), Mekelle University, Mekelle, through department of Industrial Engineering, done by Kalayu Gebru under my guidance. The work contained in this thesis has not been previously submitted for a degree or diploma at any other higher education institutions to the best of my knowledge and belief.

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ABBREVIATION and ACRONYMS

ASQC----- American Society for Quality Control.

AAMA----American Apparel Manufacturers Association.

FOH--------Factory Over Head.

SOP---------Standard Operating Procedure.

ABSTRACT

A fabric defect is any abnormality in the fabric that spoils the aesthetics i.e. the clean & uniform appearance of the fabric and this hinders its acceptability by the consumer. There are three sections in the textile wing of the company of which knitting section one. This section is the beginning of fabric production that it plays significant role in the succeeding process that special care need to be given for its output from quality perspective. Likewise, this section has relatively good data record but revealing the existence of different type defect. In this section, the observed fabric defects are needle-line, hole, lycra jump, oil stain, sinker mark; and this problem has resulted in high rejection rate (7.87%) which is accounted to a loss of 150,101.5 birr per month and it also damages the image of the company.

This research aims to address the above quality problem of knitting section by identifying the 80% causes of quality defects and proposing the possible solution for the critical ones. In dealing with the quality problem, direct observation, interview, check sheet & reports were used to collect data and these data were also analyzed using Pareto technique, and focus group discussion.

After the data is analyzed, the four critical fabric defects (Needle line, Hole, Yarn variation and Lycra jump) are achieved and these fabric defects need to be corrected to minimize the rejection rate by 80%. The output of the research indicated that the existing 7.87% rejection rate can be reduced to 1.574% which resulted in the net difference of 6.296. This implies that the net monthly reduction in fabric rejection rate is about 5533.6 kilogram which really affects the total production in the section. This research has found results with a set of recommendation, remedies and standard operation procedure (SOP) that are proposed to be performed by the company.

CHAPTER ONE: INTRODUCTION

1.1 Background and Justification of the Study

Quality is essential for any manufacturing or service industry to guarantee sufficient market share and meeting customer satisfaction there by to win customer loyalty. In fact, in today's very competitive market, it can be said that quality is the main factor in determining the success or failure of an organization. As such, Ethiopian textile industries, like MAA garment, are no different. Quality tools have been used in many textile industries to boost quality particularly in the area of manufacturing processes and support functions. The core objective of the majority of the quality tools is improvement of quality by reducing variation while producing products which meet predefined or predetermined specifications. As such, Quality improvement measurements assume that product quality characteristics can be precisely specified in measurable terms, and reducing variation in the process will also reduce variation in the target values. Like many textile industries, MAA garment has a set of desirable quality standards that are measurable. However, many of products from the knitting section did not meet a predefined quality standard regardless of the high tech machinery that the section is equipped with. This being the case, the objective of this project is to identify the critical knitting faults with their root causes and suggesting possible solution.

As knitting is the process of converting yarns to fabric, during the process defects like needle-line, hole, yarn variation, lycra jump, oil stain, sinker mark and so on are appeared and because of these defects the rejection rate reaches to 7.87% and cost of loss is 150,101.5 birr per month. This rejection rate is caused due to various reasons such as yarn tension, machine dust, worn-out knitting element(sinker, needle, feeder),air condition, yarn imperfection, misalignment of yarn feeder, damaged cylinder cut, blockage of oil hose, machine jerky. Therefore the required quality standards (parameters) will not be fulfilled as per the customers' demand and to avoid this rejection rate of fabric, it is necessary to avoid defects by prioritizing them.

1.2 Company Background

MAA Garment and Textile factory is one of the modern private owned factories in Ethiopia. It is established in 2004 and equipped with state of art production facilities producing textile (yarn, griege and finished dyed fabric), woven and knitted garments (T-shirt, Polo-shirt, trouser, Bed-sheet, Pack-out, Pants, Pajamas etc). The vision of the company is to become an exemplary organization in local as well as international textiles and apparel markets. To achieve this vision, the company has set strategies on the area of developing a strong customer relationship, engaging in a continuous product development, implementing methods for reduction in cost of production without affecting quality of products, providing continuous personnel training and capacity building.

MAA has suppliers from nation and international and widely its market is targeted to USA & European countries, with customers like H & M, Kik, Takko, Hahns and the like. There are domestic (Almiko, Amibara, etc.) and overseas (Hantsman, Thies, Juki, etc.) suppliers of the raw material used in the process in the company. The daily production is 10,000 garment pieces and to produce these articles it has to pass the following processes production units: Spinning ⟶ knitting⟶ dyeing & finishing⟶ garmenting.

The company's organization structure is as below:

CEO
⇩
General Manager
⇩
Deputy Manager
⇩
Head of departments for each production units; Quality head; Maintenance head; planning head

Quality department is the responsible entity to control and monitor the quality status of each material, process and products of the company. To do its task properly, the department has deployed the following qualified personnel in the knitting section.

Table 1.1 Quality Staffs Deployed in Knitting Section

S/N	Job title	Number of employees	Qualification
1	Department head	01	Diploma in secretarial science
2	Division head	01	Diploma in management
3	Quality supervisor	01	10^{th} grade complete
4	Quality checkers	05	10^{th}grade complete

Source: [Company's organizational structure]

As the last three quality reports show, the rejection rate due to fabric defects was tabulated as below.

Table 1.2 Yearly quality rejection rate

S/N	Year	Rejection rate(&)
1	2011	6.73
2	2012	8.35
3	2013	7.87
Total		7.65

Source: [Company's Monthly QC report]

At the first time of interview, 55 employees were supposed to be interviewed and out which only 49 of them were the respondents as shown in table 1.3.

Table 1.3 the number of interviewees with their position

S/N	Job title	Number of respondents
1	Knitting section head	01
2	Production supervisors	04
3	Quality supervisor	01
4	Maintenance supervisor	01
5	Quality checkers	06
6	Mechanics	07
7	Machine operators	29
Total		49

Source: [Company's structure]

Following the interview, a tally sheet was also distributed for 26 employees (3 production supervisors; 01 quality supervisor; 06 mechanics and 16 machine operators) of the section and out of which the 22 have responded timely.

1.3 Problem Statement

There are three sections in the textile wing of the company of which knitting section is one. This section is the beginning of fabric production that it plays significant role in the succeeding process that special care need to be given for its output from quality perspective. Likewise, this section has relatively good data record but revealing the existence of different types of defect. The section has been found to have higher rejection due to different defects and this problem has resulted in high rejection rate (7.87%) as it is revealed from the existing data of the section.

Even though, this amount of rejection rate is indicated in the section's recorded data, the trail to distinguish between the most influential and least influential defects are not found yet made and their respective root causes are not clearly figured out. This in turn paves the way for the problem to remain inherent and created difficulty in solving them. Therefore, this work incorporates the process of finding the dominant defect with their respective root cause and in turn solving them accordingly.

1.4 Objective of the Study

1.4.1 General Objective

The general objective of this research is in identifying defect causes of weft greige knitted fabric in knitting section and proposing possible solution.

1.4.2 Specific Objectives

- To identify and measure the critical fabric defect types and their root causes in the section
- To estimate cost of rejection rate (cost of lost) for the section under investigation.
- To provide the possible solution for the identified critical defects.

1.5 Significance of the Study

The quality status of knit griege fabric has a great impact for the succeeding production units of the company as production of fabric are started from this section. Therefore this study is helpful in different of which the following are the significant one:

- ✓ In pointing focus areas where one can address the problem so as to reduce the rejection rate.
- ✓ To show the scientific approach to tackle the problems in the knitting section that the rejection rate is reduced.
- ✓ Other researchers can use the result of this research as base for further study.

1.6 Scope and Limitation of the Study

This research is carried out in knitting plant of MAA Garment and Textile factory, focusing on identifying defect causes of weft greige knitted fabric and this study had the limitation of time and resources not to implement the project in that section.

1.7 Research Questions

In the course of this research the following questions are to be answered.

i. What are the critical defects and their frequency of occurrence?
ii. What is the magnitude in terms of cost incurred due to the fabric defects?
iii. What solution can be proposed to alleviate the defect types identified?

1.8 Orginization of the research

The Thesis is organized in the following thesis layout. Chapters are developed to present the components of the research, and the order of the chapters corresponds to the flow of the work as follows.

The research starts with the first chapter namely introduction and this Includes background information of the subject matter and the company, problem statement, research question, objectives, scope, and significance of the study, together with the research framework. The again the second chapter incorporates Literature Review Including the review of previous research works on quality related issues. This is followed by Methodology Included in it the way to collect data, analyze them, interpret them, and represent the data and their respective results in general. Then again, data Presentation and Analysis and results is presented on Chapter 4 and includes the procedures used to arrive at the overall results is shown in detail. Finally the results of the finding are concluded on chapter five namely Conclusions and Recommendation summarizing the finding of the case, the recommended principle to be applied and future research areas in to be focused on general.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction to Textile Technology

2.1.1. The Evolution of Textiles

Although man's first articles of clothing and furnishing were probably animal skin wraps, sometimes stitched together using bone needles and animal sinews, he soon attempted to manipulate fibrous materials into textile fabrics, encouraged by experience gained from interlacing branches, leaves and grasses in the production of primitive shelters.

The word 'textile' originates from the Latin verb texere – to weave – but, as the Textile Institute's Terms and Definitions Glossary explains, it is now 'a general term applied to any manufacture from fibres, filaments or yarns characterized by flexibility, fineness and high ratio of length to thickness' at right angles or some other angle [2,3].

The common textile processes are:

Spinning ⟶ knitting/weaving ⟶ dyeing/printing ⟶ garment.

Spinning is the act or process of converting staple or short lengths of fiber, as cotton or rayon, into continuous yarn or thread.

Knitting is the process of manufacturing fabric by transforming continuous strands of yarn into a series of interlocking loops, each row of such loops hanging from the one immediately preceding.

Weaving is a major process of making fabric or cloth. In it, two distinct sets of yarns called the warp and the filling or weft are interlaced with each other to form a fabric.

Dyeing is the process of adding color to textile products like fibers, yarns and fabric

Textile printing is the process of applying color to fabric in definite patterns or designs

Textile finishing can be defined as all processes (chemical and/or mechanical), employed subsequent to textile coloration which impart additional functionality/superior aesthetics to the textile material. Mostly, textile finishing is applied to fabrics (woven, knitted, nonwovens); however textile finishes can also be applied to fibers and yarns.

The **garment** manufacturing process is the means through which articles of clothing are created for stores and other commercial outlets.

Yarns are the raw materials manipulated during knitting. A yarn is defined as ‘an assembly, of substantial length and relatively small cross-section, of fibers or filaments, with or without twist’.

Knitting is the most common method of inter-looping and is second only to weaving gas a method of manufacturing textile products. It is estimated that over 7 million tons of knitted goods are produced annually throughout the world. Although the unique capability of knitting to manufacture shaped and form-fitting articles has been utilized for centuries, modern technology has enabled knitted constructions in shaped and unshaped fabric form to expand into a wide range of apparel, domes-tic and industrial end-uses [2].

2.1.2. Knitting Technology

The period from the mid-1960s to 1973 is often regarded by knitters as a ‘golden age’ because fashionable demand for textiles composed of synthetic fibers reached a peak during that period [2].

It is a known fact that the main material for fabric construction is yarn. Knitting is the second most frequently used method, after weaving, that turns yarns or threads into fabrics. It is a versatile technique that can make fabrics having various properties such as wrinkle-resistance, stretch ability, better fit, particularly demanded due to the rising popularity of sportswear and casual wears. As of present day, knitted fabrics are used widely for making hosiery, underwear, sweaters, slacks, suits and coats apart from rugs and other home furnishings.

Knitting is broadly classified as weft and warp knitting which are both used to produce knitted fabric [9].

1) **Weft Knitting**

   Weft knits are made by feeding yarn to all needles horizontally to construct a course. Weft knits can be produced on either a circular knit machine or a flatbed machine.

   There are three basic stitches in weft knitting [9]

   - Plain-knit stitch
   - Purl stitch
   - Rib stitch

Plain-knit stitch:

Plain knit, the basic form of knitting can be produced in flat knit or in tubular (or circular) form. It is also called jersey stitch or balbriggan stitch. A row of latch or beard needles is arranged in a linear position on a needle plate or in a circular position on a cylinder. These fabrics have the tendency of curling up at the edges which is controlled to a level through certain finishes. Plain-knit fabrics stretch more in the width than in the length and as such, they are widely used for making underwear, gloves, hosiery and sweaters.

Purl stitch:

Purl stitch, also called link-and-link stitch, is made on flat bed knitting machines and circular machines by needles using hooks on both ends to alternately draw loops to the front of the fabric in one course and to the back in the next course. The fabrics look similar on both the sides resembling back of the plain knit. Heavy, jumbo stitch is also possible which gives a bulky effect to the fabrics. However, It is comparatively slower and a costly technique. The fabric doesn't curl at the edges. Purl stitch is widely used in infant wear and kids clothing due to its crosswise stretch and excellent lengthwise stretch.

Rib stitch:

Rib stitch produces alternate lengthwise rows of plain and purl stitches and as such the face and back of the fabrics are look-alike. Rib stitch can be produced on a flat rib machine as well as circular rib machine. In the flat rib machine, one set of needles is placed opposite the other set of needles in an inverted V position. In the circular rib machine, one set of needles is placed vertically in a cylinder and the other set of needles is placed horizontally on a dial. In both the machines, one set of needles pulls the loops to the front and the other set of needles pulls the loops to the back of the fabric. Each set of needles alternately draws loops in its own direction, depending on the width of the rib desired. For instance, rib stitches can be 1X1, 2X2, 2X1, 3X1, and the like. Accordion rib is the combination of 1x1 and 2X2.

The fabric doesn't curl at the edges and as the fabric possess an excellent widthwise elasticity, it is widely used for making such clothing that needs an excellent fit such as wristbands of sleeves and waistbands of garments, underwear and socks for men and children[7].

2.2. Quality in Textile Factory

2.2.1 Over view quality and quality control.

The textile industry is one of the world's oldest. The earliest known textiles include scraps of linen cloth found in Egyptian caves dating from about 5000 B.C. In the western world, textile manufacturing remained a family business until the early 1500s, when the first factories were built. In Asia, especially China, centralizing and standardizing textile production occurred as early as the Zhou Dynasty (11th to 8th centuries B.C.). Very explicit stipulations and standards existed for silk and cotton fabrics. One dynasty decree stated, "Cottons and silks of which the quality and size are not up to the standards are not allowed to be sold on the market."

In the West, an early regulation for quality assurance in the textile trade dates back to 14^{th}-century, Germany, Called tuchshau ("showing of cloth"), the regulation involved expert inspectors who, along with an equal number of city council members, observed the entire manufacturing process starting at the loom, where warps were inspected. No piece of cloth could be sold unless it was produced under this supervision [3].

In the textile production cycle, knitting is of great importance both because of its high incidence on the total transformation costs and for the influence which it exerts on the quality of the finished product especially the number of defects per piece. The central and the most costly operation take place on circular knitting [2].

Quality: The word itself is a concept and implies a degree of excellence the nature of which is dependent on the reasons for the product being appreciated. Quality is the main ingredient in a product that delights the customer either by meeting or exceeding his expectations. Quality can be defined as a combination of the characteristics or properties of a product that make the product usable [3].

The American Society for Quality Control (ASQC) defines quality as a systematic approach to the search for excellence (synonyms: productivity, cost reduction, scheduled performance, sales, customer satisfaction, team work, the bottom line). It can be summed up by the expression "suitability for use". It can also be stated as conformity to specifications from the manufacturer's view point.

Quality control is one of the terms used to cover the procedures concerned with planning and control of quality. Other terms such as statistical quality control and total quality control are also used and all of them have similar functions. Quality control by any name is basically a systematic regulatory process which

1. Establishes standards appropriate to the quality objectives of the company

2. Has techniques for measuring the degree of conformity to these standards

3. Uses statistical methods for analyzing the significance of deviations from these standards

4. Reports on the findings of the analyses and when necessary recommends and follows –up on corrective actions. In the final analysis, the ultimate responsibility for the quality of the fabric produced in a factory is that of the top management.

As in most other manufacturing industries, for many centuries quality in the textile industry was achieved through final inspection of finished goods. This final inspection was often used to create different grades of quality, products of which were then sold at various prices. Manufacturers slowly began to add inspection and control to the quality of raw materials and the production processes [3].

2.2.2. Quality Parameters and Control in Knitting Process

Yarn Knotting

Whenever yarn breaks or finished, it should be knotted instead of twisting as this is normal practice used in industry. Because, in case of twisting it is likely that it may open and may cause cut in the fabric. It is also one of the ways to reduce the cut in the fabric.

During yarn knotting, the operator should use scissor / clippers for cutting the extra knot edges. The extra knot edges should not be more than 5 mm in lengths [1].

Handling and Storage of Fabric Roll

Fabric roll should not be placed on the floor as it causes oil marks on the fabric. A clean plastic sheet may be used to place the fabric roll on the floor. Also place plastic sheet over the stored rolls to avoid accumulation of fluff on the fabric [1].

Graphical Representation of Defects

Graphical representation of fabric defects is very useful to analyze the quality.Fabric defects should be represented graphically to easily monitor the quality and take necessary corrective actions for each machine. Data recording in tabular form is not easy to analyze whereas, graphical representation makes easier to view the trend. Also, it is useful to find out the most recurrent faults.

One Feeder Tube Knitting Machine

The quality of incoming yarn can be easily monitored using one feeder tube knitting machine. Another model of this machine is available with a creel for testing more than one yarn cones automatically.

Yarn Tension

Yarn Tension plays an important role in the knitting. It should be set properly at start of each order and monitored as well. Yarn tension meter should be used to set the yarn tension. The tension calculating formula for all type of yarns is [1]:

Grams = 5315 / S (Count) × 20

This provides the starting guidelines for tension setting which can further be adjusted by experimenting. Variation in tension of yarn occurs due to improper winding. The following should be taken care of [1]:

- MPF washer spring adjustment
- Slow vibration of stopper
- Presence of yarn eye guides (feeder, pipe, creel) on all machines
- Replacement of damaged pipes
- Even yarn wrapping on MPF (Main Pully Feeder)

Yarn Eye Guides

All yarn eye guides (feeder, pipe and creel) play an important role in knitting process. Missing yarn eye guides cause variation in yarn tension and high friction hence affecting smooth flow of

yarn. This also results in yarn breakage, knitting holes and more fluff in the department. Therefore, missing eye guides must be checked at regular intervals and replaced accordingly.

Creel Pipe Position

An improper position of creel pipe affects the yarn tension and thereby affecting machine efficiency and increase fabric faults. Therefore, the creel pipe position should be properly adjusted for smooth flow of yarn and damaged pipes should be replaced with new ones. Also position of ring guides on creel should be at the centre of paper cone tip.

Yarn Passage

Yarn passage should be as smooth as possible. It should not touch any part of the machine other than guides. Similarly, the correct passage of yarn should be followed. If yarn touches any part of knitting machine other than guides, it will increase the hairiness in yarn due to rubbings. It will also affect the yarn tension and affects the machine efficiency and increase fabric faults (Knitting holes). To overcome this problem, appropriate adjustment in the position of MPF should be made.

MPF Tension Washers

MPF tension washers play an important role. As the name shows, MPF tension washers control the yarn tension. If MPF tension washer is out of order or missing, it will cause variation in yarn tension and high friction hence effecting smooth flow of yarn. This also results in yarn breakage and fabric fault especially in fine yarn count. Therefore, missing MPF tension washers must be checked at regular intervals and replaced accordingly.

Damaged Paper Cones

If paper cones on the creels are damaged, it causes yarn breakage during unwinding from these cones. It happened if the yarn suppliers is using paper cones of poor quality and/or also care is not being taken during transportation and material handling. The mill management must complaint the supplier if damaged cones are received. Also, handling of yarn should be improved while loading / unloading as well as placing on the knitting machine.

Slub Catcher Gauge

The following slub catchers are recommended to use [1]:

- 0.4 mm slub catcher for 59/s and above count
- 0.6 mm slub catcher for 24/s to 39/s

Bar (Patta) Line

Bar line is a major fault on the knitting machine. Bar line is basically appears due to yarn tension variation or due to yarn quality. These are following steps for analysis of bar line [1]:

- Take a piece of fabric from the defected portion
- Marked length of 60 centimeters on both sides of fabric for analysis
- Take out some yarns and find out the average length of yarns
- If yarn which is creating bar line have same length as compare to other yarns.

This shows that the bar line may be appearing due to mixing yarn lot or using different yarn count if the stitch length of all yarns is not same, then it will be the fault of yarn tension. To control Patta in knitted fabric due to yarn tension variations, detect the feeders where the Patta is visible and find out the respective feeders. Then keep on changing the position of the cones on the creel till no such effect is visible.

Press off Problem

Press off is another problem being faced in knitting department. Press off problem is basically a yarn breakage and it results due to the bad quality of yarn. During knitting of fabric yarn break from feeder appears in the fabric as press off because it broke after sensor.

To control the press off problem, the better quality yarn should be used and yarn tension variation should be controlled on the knitting machine. The following points will help to reduce the press off problem [1]:

- It should be ensured that passage of yarn is proper. It should pass from all yarn eye guides and also should not touch with any other part on the knitting machine

- All missing yarn eye guides should be checked at regular intervals and replaced accordingly. Otherwise, yarns tension variations will result in press off
- The tension of all yarns should be set equal
- The professional style of knotting should be adopted and operators should use scissor for cutting extra knot edges
- Fluff should be removed from machine and especially from feeders. Fluff in feeders creates tension variation in yarn and increase the possibility of yarn breakage

Methods to Control Winder Lines

Winder line is another problem of knitting. Following are the guidelines to control the winder line [1]:

- Fastening woven fabric on the both ends of nip roller.
- Ensuring minimum possible tension pressure on the fabric during winding.
- Plaiting in a box.
- Edge of the fabric from both sides should be made free by creating groove on the nip roller
- Slightly lower down the frame of fabric on knitting machine.
- Changing the design of frame with Cadaratex frame (Fukuhara).
- Slightly moving the winder line at inspection machine during inspection
- The storage time of fabric should be as minimum as possible specially incase of lycra fabric
- Also, in dyeing department the fabric should not be stored for longer period of time

Oil Stains

Oil stains is the serious problem that affect the quality of fabric. One possible reason is the use of excess oil than the actual requirement of the machine. This excess oil spreads on the machine causing high accumulation of fluff at cylinder, this fluff than goes under the needles and sinkers which creates oil stains in the fabric. To control this problem, an appropriate amount of oil should be used.

Another possible reason is the frequent machine stoppages. When machine stops frequently, the absorption of oil becomes high at the needles and sinker as compared to the running condition of machine and that causes oil stains in the fabric.

Spot Marks on Fabric Surface

Spot marks (Lycra, Polyester, Inlay yarn) on fabric surface are due to improper adjustment of sinker timing. Proper setting of sinker timing with adjusting feeder setting controls this problem. Yarn tension is also another reason and it should be checked by tension meter and adjusted one by one on all feeders and if required tuck tension should be increased.

Double Stitch Problem

The following are the precautions to avoid the double stitch problem in a particular fabric:

- Yarn passage must be smooth. Missing eye guides or improper yarn passage causes yarn to vibrate
- Control of yarn Tension. Tension meter should be used to control

Air Circulation System

The overall cleaning condition on production floor affects fabric quality. To get good quality fabric, floor cleaning and fluff suction system should be adequate. To improve fluff suction system, increase the capacity of suction system or install air conditioning system to maintain relative humidity of department as well as proper suction of fluff. At least industrial vacuum cleaner should be used for fluff control.

Separating & Covering the Knitting Machine

The striper machines should be covered with polypropylene sheets to avoid fluff accumulation from one machine to another. This will improve the fabric quality.

Similarly, the machines which are not in operation should be covered with polypropylene sheets from top to bottom for avoiding the accumulation of fluff on it.

Due to less accumulation of fluff on the machine, the maintenance of machine will be decreased and it will increase the machine life.

Method of Checking Greige Fabric GSM

It is general industry practice to check the greige GSM with GSM cutter. As in this case, sample size taken is too small, therefore, GSM measured with GSM cutter shows more variation. Large dia GSM cutter may be used to make the result more accurate and reliable. The simple and accurate method to find the actual GSM of fabric is based on three basic parameters i.e. fabric weight, length and width of the fabric. It can be checked by producing the fabric / 20 round and then dividing the weight of produced fabric by the area (length*width) of the fabric.

The actual GSM can be calculated as follows [1]:

GSM = (6) / (2) gram / m^2

GSM = g / m^2

Guidelines for Checking of GSM

The following are the further guidelines for checking the greige GSM:

- Actual GSM of greige fabric (as explained above) should be measured at the start of new article
- Greige fabric roll should be cut as per counter meter reading on the machine. In this practice, weight of each roll will be same. This is the easiest way to check the GSM of each roll

Stitch Length of Fabric Sample

Stitch Length should be checked whenever starting the new order or problem arises.

The use of round meter for setting the stitch length is better. However, if it is not available then, it may be checked manually. But in any case, it must be checked when starting the new article or in case of any problem.

Calibration of Round Meter

Round meter is sometimes used for the setting of stitch length. It is advised that round meter must be checked and calibrated for the correct setting. Check the stitch length manually and compare the results with the round meter reading.

Measuring Actual Stitch Length

To find the actual stitch length, take a sample of fabric and mark 100 needles and then take out at least three yarns each and measure the stitch length. Compare this value with the round meter value. **Example**: We have a sample of fleece fabric produced on m/c having diameter of 30 inch, Gauge 18and total number of needles 1692. 100 needles were marked and then three knits, tuck and inlay yarn each were taken out. Stitch length of knit, tuck and inlay was measured. Mean value of the actual stitch length of knit, tuck and inlay was [1]:

Knit = 47 cm
Tuck = 41.3 cm
Inlay = 18.9 cm
The round meter reading on the same machine having Machine diameter of 30 inch, Gauge 18 and total number of needles 1692 was found to be:
Knit = 782
Tuck =683
Inlay =300
Converting round meter value to the /100 needle stitch length
Knit = 782/1692*100= 46.2 cm
Tuck =683/1692*100= 40.4 cm
Inlay = 300/1692*100=17.7 cm

Comparison

Comparing round meter reading with the actual readings revealed that:

- Actual Knit stitch length is 1.7 % higher
- Actual Tuck stitch length is 2.2 % higher
- Actual Inlay stitch length is 3.8 % higher

The round meter should be checked at regular intervals to avoid any problem. However, when variation in GSM arises check actual stitch length as well.

Fabric Inspection

It is worth considering a total inspection environment which can improve the overall standard of the inspection department. The main action of a fabric inspection machine is to unroll measure and re-roll the fabric, and to contribute to an environment in which it can be inspected by an examiner [13, 14].

This requires the following characteristics [1, 14]

- Suitable edge control to provide a finished roll of attractive appearance
- Winding characteristics, which do not distort the fabric structure or dimensions, which suggests tensionless wind up through, overfeed in the case of stretch fabrics
- Stopping and starting which will not disturb the roll, nor the fabric structure nor its dimensions
- Winding characteristics should be such that any form of handling by the examiner is minimized
- The machine should be simple to load and unload
- Lighting should be controllable and of variable intensity, so that the most critical faults may be detected most easily without loss of detection of less critical faults.

Analysis of Inspection Sheet Machine Wise

The analysis of defects should be done machine wise. This analysis will show the individual record of every machine and the traceability of machine with too many faults will become easier to find the root cause of problems. The collected data should be analyzed and checked regularly, especially in case of same fabric construction running on different machines for controlling the variation of faults. Immediate actions should be taken after observing data for reducing rejection % age

Yarn Inspection

Apart from checking the weight of yarn deliveries, following yarn properties may be checked to ensure the quality of raw material [1]:

Further Yarn Checks (1^{st}order priority)

- Count Tests on Staple Fiber Yarns: Check on count variability, within cones and between deliveries: to be within tolerance of specification
- Condition Checks: Check on incorrect condition
- Yarn Unevenness (U %)

Further Yarn Checks (2nd order priority)

- Yarn twist: On new deliveries and on demand for fault diagnosis. To be within specified tolerance
- Co-efficient of friction: Test and compare to specification

Fabric Stability and Finished Width

Fabrics knitted on circular machines have a set number of Wales, determined by the knitting machine used, - its diameter and gauge (needles per unit length of cylinder circumference). The fabric will be knitted from a certain yarn type and knitted loop length, partly on economic grounds and partly to avoid being too dense or too light a fabric [14].

There is a commercial incentive to finish fabric as wide and as long as possible. The loop structure of knitted fabrics makes it possible to stretch these fabrics to an appreciable extent. However, in the stretched state the forces on each loop are not balanced, and so the fabric becomes unstable, giving it a tendency to revert to a more natural, relaxed state during which an increase in fabric stitch density will take place, together with a consequent reduction on area, i.e. shrinkage will always occur. It is not possible to set a fabric at what are in effect unrealistic dimensions and at the same time achieves a stable fabric. Therefore, certain diameters of knitting machines are to be used (which is a must unless we are prepared continually to replace existing machinery). Since the fabric will be knitted within fairly narrow ranges of yarn type, count and loop length, then the fabric must be finished as near as practical to its natural width and length and not over stretched, if it is to be without excessive shrinkage in service (e.g. washing). In this state the fabric will have fairly definite width and length dependent on the machine, yarn and loop length used. Efficient lays should be planned on these dimensions, and not on some predetermined ideal.

If shrinkage is not an important consideration, then extra width and length can be considered. The fabric characteristics can be determined by calculations form the fabric geometry and by trials, and the finished dimensions to be stipulated modified accordingly. Unless these factors are fully understood, a satisfactory fabric specification will not be possible [1].

2.2.3. Inspection

Inspection in reference to quality control in the apparel industry can be defined as the visual examination or review of raw materials (such as fabric, buttons, zippers, sewing threads,. trims, etc.), partially finished components of the garments and completely finished garments in relation to some standards, specifications, or requirements, as well as measuring the garments to check if they meet the required measurements. The principle involved in inspection is the early detection of defects, feedback of this information to appropriate people, and determination of the cause, ultimately resulting in the correction of the problem. The main objective of inspection is the detection of defects and non conformances as early as possible in the manufacturing process so that time and money are not wasted later on in either correcting the defect or writing off defective garments. For inspection to be effective, the entire inspection loop as shown in Fig. 2.1 must be completed [5].

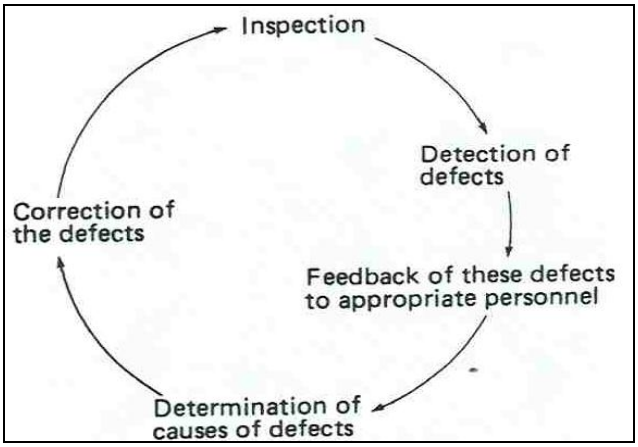


Figure 2. 1 Inspection Loop

Fabric Inspection

Fabric inspection is usually done on fabric inspection machines. These machines are designed so that rolls of fabric can be mounted behind the inspection table under adequate light and rerolled as they leave the table. Defects in a fabric can be seen readily with these machines, as the

inspector has a very good view of the fabric and the fabric does not need to be reversed to detect defects

There are various fabric inspection systems,

1. 4-Point system
2. 10-Point system
3. Graniteville "78" system

4-Point System

The 4-point system, also called the American Apparel Manufacturers Association (AAMA) point-grading system for determining fabric quality, is widely used by producers of apparel fabrics and by the Department of Defense in the United States and is endorsed by the AAMA as well as the ASQC.[13]

To use this system you have to know following things.

1. Fabric inspection method or preparation
2. Criteria of giving penalty points based on defects and defect length.
3. Calculation method of total penalty points for total defects found in a fabric roll or than
4. A Check sheet or format for recording data
5. Knowledge of different types of defects (how a defect looks and its appearance)

Penalty points are assessed to a piece of fabric according to the length of defects measured in inches. Fabric flaws or defects are assigned point values based on the following as stated in Table 2.1.

Table2.1:- point values for fabric defects (4-point system) [13]

	Points allotted
Length of defect in fabric, either length or width	
Up to 3 in.	1
Over 3 in. up to 6 in.	2
Over 6 in. up to 9in.	3
Over 9 in.	4
Holes and openings (largest dimension)	
1 in. or less	2
Over 1 in.	4

Total defect points per 100 yd^2 are calculated, and normally those fabric rolls containing more than 40points/100yd^2 are considered "seconds." However, a garment manufacturer, based on the price line and type of garments produced, may use more or less than 40 points/100yd^2 as an acceptance criteria.

For example, a fabric roll 120 yard long and 48 inch wide contains the following defects.

2 defects up to 3 inch. 2 x 1=2 points

5 defects over 3 inch. but less than 6 in. 5 x 2 = 10 points

1 defect over 6 inch. but less than 9in. 1x3= 3 points

1 defect over 9 inch. 1 x 4 =4 points

Total defect points = 19

Therefore,

Points/100yd^2 = $\frac{\text{total points scored in the roll x 3600}}{\text{Fabric width in inches x Total yards inspected}}$

$= \frac{19 \times 3600}{48 \times 120}$

= 11.9 defect points/ 100 yd^2

So if the acceptance criteria are 40 points/100yd^2, then this roll is acceptable.

The maximum number of defect points to be counted against any one linear yard is 4 points. Overall, fabric quality is assessed on the basis of the number of defect points per 100 yd^2 of fabric.

Quality Control Tools:

Production environments that utilize modern quality control methods are dependent upon statistical literacy. The tools used therein are called the seven quality control tools. These include: Production environments that utilize modern quality control methods are dependent upon statistical literacy. The tools used therein are called the seven quality control tools. These include [5]:

Check sheet; Pareto chart; Flow chart; Cause and Effect Diagram; Histogram; Scatter Diagram; and Control Chart.

The function of a **check sheet** is to present information in an efficient, graphical format. This may be accomplished with a simple listing of items. However, the utility of the check sheet may be significantly enhanced, in some instances, by incorporating a depiction of the system under analysis into the form figure 2.2. Check sheet [5].

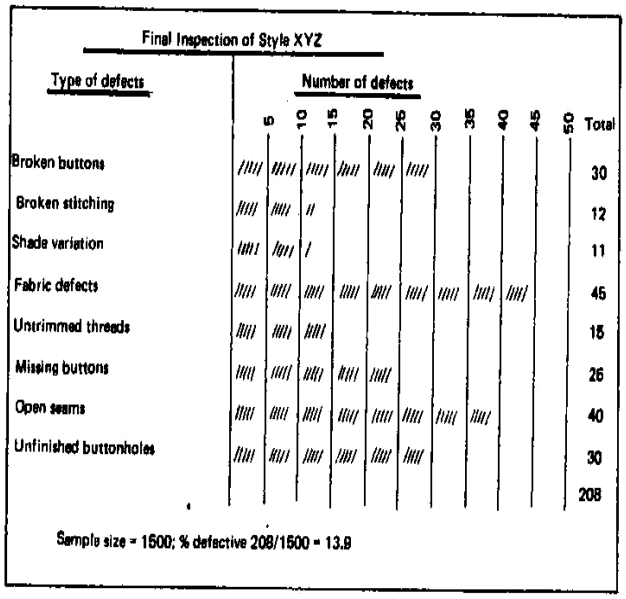


Figure2.2 Check Sheet

A Pareto diagram is a simple bar chart that ranks related measures in decreasing order of occurrence. The principle was developed by Vilfredo Pareto, an Italian economist and sociologist who conducted a study in Europe in the early 1900s on wealth and poverty. He found that wealth was concentrated in the hands of the few and poverty in the hands of the many. The principle is based on the unequal distribution of things in the universe. It is the law of the "significant few versus the trivial many." The significant few things will generally make up 80% of the whole, while the trivial many will make up about 20% [5,].

Counts Pareto: Use this type of Pareto analysis to learn which category occurs most often, you will need to do a counts Pareto diagram. To create a counts Pareto, you will need to know the categories and how often each occurred. [5, 9]

Use a Pareto diagram when you can answer "yes" to both these questions [9]:

1. Can data be arranged into categories?
2. Is the rank of each category important?

Despite its simplicity, Pareto analysis is one of the most powerful of the problem-solving tools for system improvement..

Pareto charts are extremely useful because they can be used to identify those factors that have the greatest cumulative effect on the system, and thus screen out the less significant factors in an analysis. Ideally, this allows the user to focus attention on a few important factors in a process (Figure 2.3) [5, 9].

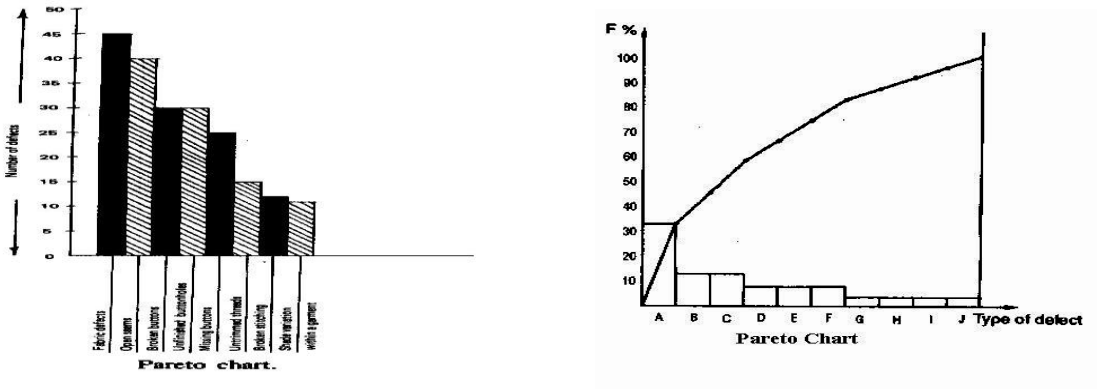


Figure 2.3 Pareto Char

2.3. Fabric faults, causes and remedies

2.3.1 Defects in the Knitted Fabrics

A defect in 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.

There are various types of defects, which occur in the knitted fabrics of all types, caused by a variety of reasons. The same type of defects may occur in the fabric, due to a variety of different causes e.g. Drop Stitches, Spirality. Prime causes of the fabric defects are, as follows [6, 14];

- Yarns
- Knitting Elements
- Knitting Machine Settings
- Dyeing
- Finishing

As regard to greige knit fabric, the first three causes are the sources for defects to occur.

Knitting Fabric Defect are those that can be created during the fabrication (fabric formation) and some of them are listed below. These defects are checked during the quality control process [6]

1. Needle line: when the needle is broken, bent, and old or damaged on the knitting machine it creates the straight line mark on the length of the fabric.
2. Sinker line: When the sinker is broken, bent, and old or damaged on the knitting machine it will create strait line mark on the length wise direction of the fabric.
3. Stripe mark/Bar defect: this defect is created when thin and thick yarns are mixed, when the tension of one yarn is varied from the others, due to count variation, when the origins of the cotton fiber from which yarns are made are different.
4. Canal mark: is the straight line mark through the length of the fabric and can be easily visible on the fabric. Can be occurred due to the needle adjustment problem.
5. Different tears and holes on the fabric: this can be occurred due to the needle breaks, yarn breaks or other.

6. Grease and oil stain: this defect arises due to the improper fabric handling of the griege fabric or if the machine is not properly cleaned. It might or might not be removed after washing.
7. Nep, thick, thin place on the fabric: this defect is due to the irregularity of yarn used for knitting. This irregularity of yarn will cause the dyeing problem usually dye absorption problem (dark and light shade) making the stripe on the fabric.[6,14]

2.3.2 Frequent faults in knitted fabrics, their definition, cause and elimination

In the terminology normally used one differentiates between the following visible from of faults in the fabric: [7, 14]

1. Cracks or holes
2. Drop stitches
3. Cloth fall – out
4. Snagging
5. Tuck or double stitches
6. Bunching up
7. Vertical stripes
8. Horizontal stripes
9. Soil stripes
10. Color fly
11. Distorted stitches

This sequence of points is absolutely random; the incorporation of defect– table faults into These 11 groups permits an initial judgment. Besides general indications and comments it is always necessary to have at least one defective fabric sample for analysis and fault ascertainment. In most of the cases an experienced technician is needed to examine the conditions on the machine and recommend the proper measures to be adopted.

Definition of faults: In daily terminology there is usually no difference made between cracks and holes. It can however be stated that holes are the result of cracks or yarn breakage. During loop formation the yarn had already broken in the region of the needle hook. Depending on the knitted structure, yarn count, machine gauge and course density, the holes have different size can therefore only be estimated if the comparable final appearance of a comparable fabric is known.
Drop stitches (runners): is the result of a defective needle. They also occur when a yarn is not properly fed during loop formation, i.e., not properly laid in the needle hooks.

Cloth fall- out: is an area consisting of drop stitches lying side by side – they can occur either when a yarn is laid out or when it breaks without any immediate connection.

Snagging: occurs almost without exception only while processing continuous filament yarns. Besides the specific sensitivity of these yarns, one main cause is mechanical strain during knitting or subsequent processes. Filaments or yarns have been pulled out of the fabric. If these are not removed or yarns have been pulled out of the fabric, if these are not removed properly the connection between courses is broken, and this results in an appearance very similar to cloth fall-out.

Tuck or double stitches: occur due to badly Knitted or non – Knitted loops. They are unintentional tuck loops or floats, also showing up as thick places or small beads in the fabric. At first instance they may also appear as a shadow when the fabric is observed against light.
Visible knots in the fabric are referred to as bunching –up .They appear as beads and turn up irregularly in the fabric.

Vertical stripes: can be observed as longitudinal gaps in the fabric, the space between adjacent Wales is irregular and the closed appearance of the fabric is broken up in an unsightly manner.
Horizontal stripes: are caused by unevenness in the courses: they traverse horizontally and repeat themselves regularly or irregularly.

Soil stripes: can appear both in the direction of Wales as well as courses.
Color fly consists: of single fibers, bunches of fibers as or yarn pieces in varying colors. It additionally sticks on the yarn or is knitted into the fabric and is Very difficult to remove.
Distorted stitches lead to a very unsettled fabric appearance. They are most disturbing in single-color yarded Goods. The fabric appearance is skittering.

Causes of Faults and their avoidance: [6, 7]
The following comments are only valid for a given interconnection between the yarn used, the type of machine employed and its setting. But there are some general principles worth mentioning at the beginning: When faults occur after using a different material. They need not be traced bank exclusively to this material.

A faults state of the knitting machine and optimum machine settings for each material and each knitted structure are, in addition to faultless yarns, unavoidable pre- requisites for preventing faults occurring during knitting.

The following statements hold good for the various faults: [7]
Cracks or holes: Larder holes could be caused by weak places in the yarn, leading the yarn to give way or break during loop formation, Small holes are after the result of a broken yarn before (or after) a Knot or splice, since the yarn end With the knot (or splice) sits tightly in this gets stuck in the needle or gives rise to a tension peak. Only one loose yarn end can slide out of the loops and the hole can be formed on one side. For a given knitting speed the ability of the yarn to slide is not sufficient (Waxing, moisture and storage). Knots in particular could have too short yarn ends. They can loosen themselves, especially when they are not tight enough. Mechanical Knotting can Weaken or damage the yarn in the knot. Knots can be too large.
These problems are not present in exactly the same manner when Splices are present in place of Knots.
Yarn take – off can be uneven or dragging. The cause could be soft or sticky cones, cones not being centered While creeling (dragging take – off) unsuitable yarn braked and yarn dude elements. The yarn tension is too high in relation to the structure and the breaking strength of the yarn. The setting of the yarn feeder is faulty in such a Way, that a needle can run into the yarn feeder with a closed latch. Through a faulty positioning of the yarn feeder the yarn is clamped between the needle breast and the yarn feeder in such a way that a free yarn movement is not possible.

The yarn feeder bore or guide or guide can have a run –in surface or have become so edgy, that the yarn is damaged. The stitch cams are so differently set that in basic or jacquard structures the stationary loops are stretched in the following knitting feeders up to break. The fabric is pulled down too strongly or in jerky movements due to defective setting or bad maintenance.
The coiler balance between dial and cylinder cams is not proper. The selected delayed timing in the dial cam before the strain the cylinder is off. With normal couliering the synchronous needle Withdrawal of dial and cylinder needles is not set precisely. In short the causes are: Yarn feeder badly set; weak place in during loop formation; knots; yarn

Solution: The yarn Tension is too high in relation to the structure and the breaking strength of the yarn. The setting of the yarn feeder is faulty is such a way, that a needle can run into the yarn feeder with the closed latch. Through a faulty positioning of yarn feeder the yarn is clamped between the needle breast and the yarn feeder in such a way that a free yarn movement is not possible running in tension is too high; yarn is too dry.

Drop stitches: The yarn is too stiff and jumps away from the needle hook while being laid – in. This is compensated by a re – adjustment of the yarn feeder or by increasing yarn tension. Yarn tension is not sufficient. Especially With jacquard structures with irregular yarn consumption and jerky processing, the yarn can shoot forward and puff itself up between yarn feeder and needle in such a way that it cannot be caught by the needle hook. The required tension compensation should take place as close as possible to the kitting zone. The yarn feeder is not properly set it presents yarn to the needle for being taken – over at an unfavorable angle. The tape, the yarn can be led through one bore for dial and cylinder needles working solely.

Fabric take – off is insufficient. Loops already formed could be hung out before the next course is produced. The structure or the pattern has not been properly conceived, thus it is not possible to maintain the same take – off tension on all loops for all the yarn types used.

Depending on the sliding ability of the yarn the structure selected drop stitches can run to different lengths in to the fabric, with is under the take – off tension. With lighter fabrics drop stitches can also be formed in connection with cracks or holes. In short the causes are: badly set yarn feeder; yarn feeder wrongly threaded-in; dial loop length not properly related to cylinder loop length, the loop jumps out of the needle hook; bad take-up; very dry material; in sufficient yarn tension and the solution could be compensated by a re-adjustment of the yarn feeder or by increasing yarn tension.

Cloth fall – out : The above mentioned points also good in connection With the occurrence of cloth fall- out .The yarn is not stitched by several needles lying adjacent to one another ,
Cloth fall – out can occur after a drop stitch especially when an empty needle with closed latch runs into the yarn feeder and removes the yarn out of the hooks of the following needles.

Snags: As already mentioned, snags mainly occur while processing Filament yarns.The tendency towards snagging can be reduced by using yarns with a coarser single filament count, lesser crimp elasticity and higher twist. During knitting all mechanical influences, caused by rough surfaces on yarn guide elements, yarn feeders, needles, fabric take- up, etc …, have to be avoided. Even after knitting some snagging can appear especially during fabric setting, if it's storing and further processing has been undertaken carefully.

Tuck and double stitches: This fault appears preferably in basic and jacquard structures.
The yarn could be the cause because of its insufficient sliding ability. Needle clearance, ifadjustable, is too small; the old loops are not brought safely behind the latch and remain on the spoon. The dial is too high; the dial needles do not support the fabric, which is thus pulled up.
The course density or couliering is not set correctly. The loops are too tight, e.g. with interlock`. These loops are not removed from the needles (mainly a problem in knitting).

Fabric take – up is insufficient, must be re- adjusted , has a one a one – sided drag on the fabric or is not continuous .In short the causes & solutions: the dial is set too high. The dial needles do not support the fabric, which is thus pulled up; the course density is not set correctly; the loops are too tight, e.g. with interlock. These loops are not removed from the needles (mainly a problem in knitting); fabric take-up is insufficient, must be re-adjusted, has a one sided drag on the fabric or is not continuous.

Bunching up: This is largely influenced by the fabric take-up and whether it functions properly. The vertical stripes and gaps in the fabric are often the result of meager setting. And its cause & solution: The yarn count selected is too fine for the machine gauge or the stitch size (course density) is not correct. Needles are bent, damaged, do not move uniformly smooth, come from different suppliers or are differently constructed.

Vertical Stripes: Vertical stripes are gaps in the fabric are often the result of a meager setting, i.e. the yarn count selected is too fine for the machine gauge or the stitch size (course density) is not correct. Needles are bent, damaged, do not move uniformly smooth, come from different suppliers or differently constructed.

Horizontal stripes: Horizontal stripes can be cased to the same extent by the yarn or by the setting of the knitting machine; they do not appear that after with worsted wool yarns.

An irregularly striped fabric or « fuzzy » fabric is solely the result of irregularities in the yarn. This can be ascertained by replacing the yarn packages. Fabric appearance alone, without doing such a test, does not indicate, whether an uneven yarn or a wrong machine setting can be held responsible. Yarn tension and its fluctuation or a hindrance in yarn delivery is frequent causes.

The setting of stitch size and uniform yarn consumption on feeders with similar settings is important pre –requisites.

Fabric take –up can also cause horizontal stripes, When a jerky a jerky impulse occurs at each machine revolution and take -up is not uniform. Couriering most also be uniform, one must also have the same yarn drawing – in ratio between dill and cylinder needles at all feeders. The machine must be mounted horizontally; needle dial and cylinder must be exactly centered towards one another. The guidance of cylinder and needle dials must not show wear and tear. These points can be normally checked and assessed only by a good technician.

Soil Stripes: Soil Stripes in the direction of the wales are solely caused by the knitting machine. In most cases they are so called needle stripes they occur when individual needles have been replaced or when the working of mechanical or automatic oiling or greasing devices is defective stripes or soiled places in the direction of the courses were already present usually in the yarn. If not caused by a standing courses, as a result of machine stoppage.

Color fly: The natural remnants in the case of other fiber like hairs with natural dark color, vegetable and from food. Fly coming from various processing stages during spinning. It can only be avoided by a careful separation of individual colors during the production.

The fly in knitting plant with rather congested machine installation and producing color jacquards along with single colored fabrics, or while processing a large number of colors the danger of color fly is always present.

Distorted stitches: Such stitching is usually the result of bad knitting machine setting, especially unequal coulier depths between dial and cylinder needles. If one views the Wales, one can then observe that the heads of the stitches are not round (dial shape) but lopsided. They also appear to have tilted towards the one or the other side. [6, 7]

CHAPTER THREE: METHODOLOGY

3.1Data Collection

In this research different methods of data collection are employed for gathering primary and secondary data such as, literature review, direct observation, interview, and reviewing recorded data. As indicated in Figure 3.1, the research is started from defining statement of problems and specifying the objective of the study as discussed in chapter one. After reviewing literature related to the subject matter, all necessary data were collected using primary and secondary methods. The outline of the study gives clear procedures on how data is collected and analyzed to achieve objective of the study.

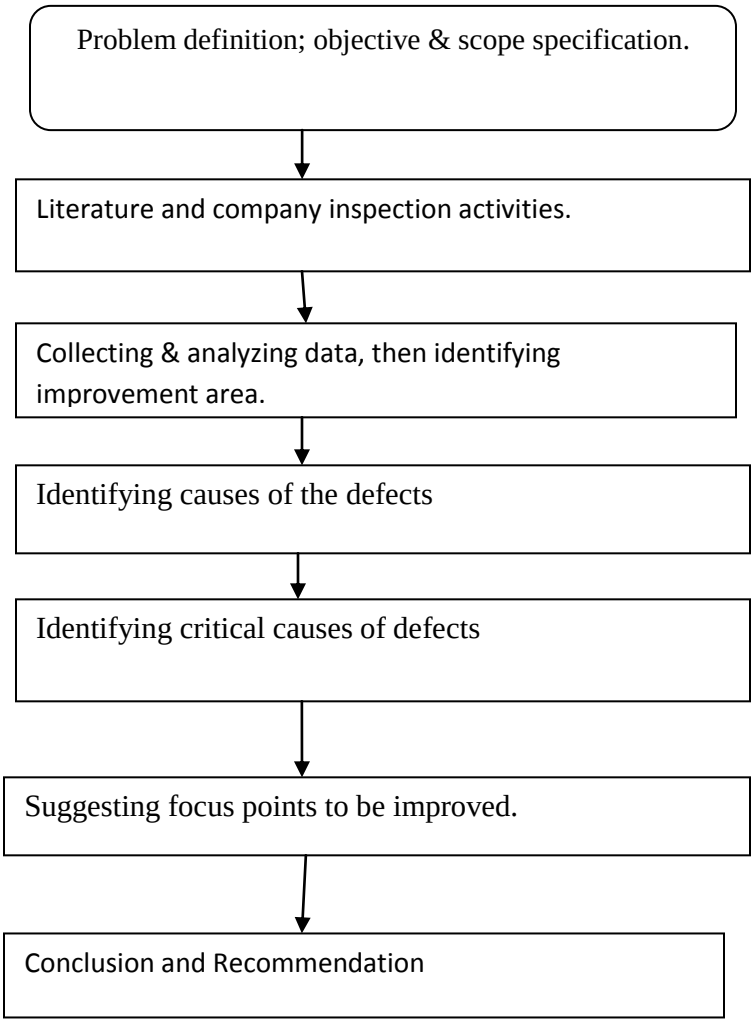


Figure 3.1 Outline of Research Methodology

3.1.1 Primary Data

Primary data was collected through direct observation, semi-structured interview (Census technique), closed ended questionnaire in the form of check sheet and this tally sheet was translated in Tigrigna so as to be understandable by the respondents as they are all not educated well. This in turn enhanced the reliability of the response they provided that he indication of the research become more representative.

The interview questionnaire was used to understand and identify possible causes for the defects. The study also used brainstorming with machine mechanics, production and quality supervisors to specify root causes of each defect types with their possible remedies.

To verify the fabric rejection rate, the researcher collected the actual fabric production and rejected fabric by direct observation. To measure the frequency of causes for the critical defects, check sheet was employed for 20 days. Finally, the method used is the focused group discussion (FGD) to mature the result obtained by using the aforementioned methods. Expert from the section with relevant knowledge emanated from he experience are included and every standard step to be FGD are also considered that he output in found to be more reliable.

3.1.2 Secondary Data

Secondary data is obtained from various sources such as, journals, articles, books, internet sources, reviewing manual and reports as references. Related literatures were reviewed to get information about Pareto's techniques, knitting technology, quality concept .Moreover, recorded data were also reviewed to rank defects as per their frequency (weight %).

3.2 Data analysis and interpretation

The collected data are analyzed using Pareto's technique. Thus, the study is concluded by suggesting a focus points for improvement and giving recommendations for future studies in the theme. The study used some scientific methods to perform analysis with the collected data to get the real meaning of the data and seeking for the critical evaluation of the information. The researcher also used direct observation & group discussion to measure the current quality rejection rate along with the Pareto analysis to determine the causes of defects. In general, Micro soft Excel, Pareto chart, and group discussion were employed for analysis of the data to identify critical defects and causes of rejection rate.

CHAPTER FOUR: RESULT AND DISCUSSION

This chapter entails the progressive analysis and the discussion of the results of the four critical defects mentioned. This is emanated from prioritizing four of them out of the eleven dominant defect using Pareto analysis. The step followed is described here below.

4.1. Monthly rejection rate and their frequency

The company recorded data are summarized and the rejection rate together with their respective frequency is figure out and tabulated here below.

Table 4.1 Monthly rejection rate with their defect frequency

MONTH	REJECTION RATE(%)	DEFECT TYPE WITH THEIR FREQUENCY %										
		NEEDLE-LINE	HOLE	LYCRA-JUMP	YARN-VARIATION	SINKER-MARK	OIL-STAIN	DROP - STITCH	LATCH-MARK	CONTAMINATION	LOT-VARIATION	SLUB
JANUARY	4.58	15	30	13	18	5	5	7	7	0	0	0
FEBRUARY	4.06	17	27	11	21	8	3	6	6	1	0	0
MARCH	6.6	34	1	14	25	5	5	5	6	1	2	2
APRIL	24	38	35	5	7	7	5	1	1	0	0	1
MAY	2	38	18	14	17	4	3	1	3	1	0	1
JUNE	6	20	18	18	23	3	15	0	3	0	0	0
TOTAL	47.24	162	129	75	111	32	36	20	26	3	2	4
AVERAGE	**7.87**	**27.00**	**21.50**	**12.50**	**18.50**	**5.33**	**6.00**	**3.33**	**4.33**	**0.50**	**0.33**	**0.67**

The six months quality rejection rate of the section, based on the data from the department, were characterized intensively and resulted in the following result and this result is depicted in table 4.2 below.

Table 4.2: Summarized Monthly Quality Rejection rate and Production Report

S.N	MONTH	REJECTION RATE (%)	PRODUCTION(KG)	REJECTED FABRIC(KG)
1	JANUARY	4.58	104,536	4787.7
2	FEBRUARY	4.06	111,709	4535
3	MARCH	6.6	71,918	4746.6
4	APRIL	24	77,393	18574
5	MAY	2	75,074	1501.5
6	JUNE	6	86,724	5203.4
	TOTAL	47.24	527,354	39348.2
	AVERAGE	**7.87**	**87,892.3**	**6,917**

According to table 4.2, the rate of rejection is revealed in percentage and in kilogram. And this clearly shows there is a loss and this loss is financially expressed here below.

Rejection rate in value:

According to the finance report, the average selling for first grade is 62 birr per kg whereas the second grade fabric has been sold for 40.3 birr per kg which is discounted by **21.7** (62-40.3=21.7) birr per each kg of fabric therefore its value has reduced by 35%.

Based on the costing system employed:

- Input material(yarn)=58 birr per kg
- Labor & FOH=4 birr per kg

After the compilation of six monthly quality and production reports, the average monthly rejection rate is 7.87% and production is 87,892.3 kg.

- Average monthly production=87,892.3 kg.
- Average monthly rejection rate=7.87%
- Rejected fabrics=87,892.3 kg.* 7.87%=6,917.12kg
- Cost incurred due to rejected fabric=loss in price *Qty of rejected fabrics=21.7*6,917.12=**150,101.50 birr.**

Therefore the company is incurring **150,101.50 birr** per month because of second grade fabric. Note that an average product type (plain single jersey 150 GSM) and the input type (yarn Ne=28/1) is used for this case.

Then again the defects in the section has been figured out and summarized on tabular format as follows on table 4.3.This result is arranged in their emphatic order in ascending manner, from more emphatic to the least emphatic relatively.

4.2 List of Fabric Defect Types

Table 4.3: Summarized defects with their frequency

S/N	Defect type	Frequency(Occurrence)	Percent of Total
1	Needle line	162	27.00
2	Hole	129	21.50
3	Yarn Variation	111	18.50
4	Lycra jump	75	12.50
5	Oil stain	36	6.00
6	Sinker mark	32	5.33
7	Latch mark	26	4.33
8	Drop stitch	20	3.33
9	Slub	4	0.67
10	Contamination	3	0.50
11	Lot variation	2	0.33
Total		**600**	**100**

Source: [Company's Monthly QC report]

The aforementioned table 4.3 described the emphatically arranged defects and the following Pareto chart shows the vital few and trivial many, 80/20. It is depicted here below on figure 4.1.

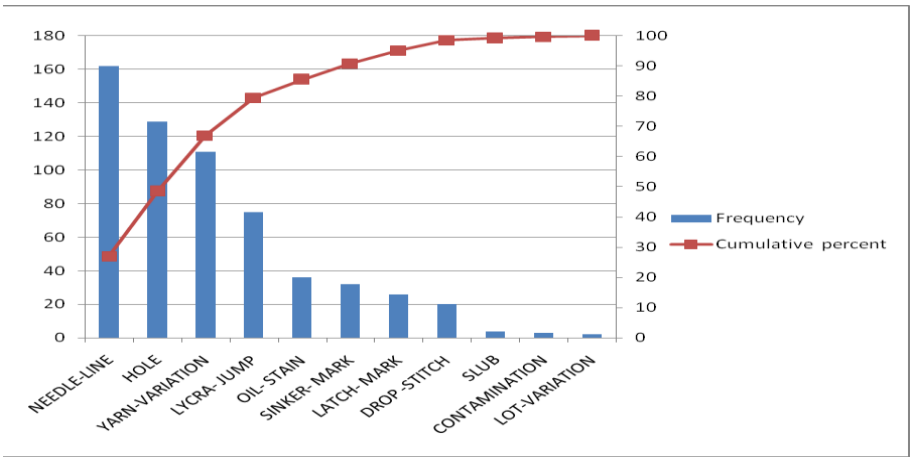


Figure 4.1: Pareto Chart for the Eleven Defects

Pareto principle states that, for many events, roughly 80% effects come from 20% of the causes. Therefore in this case this Pareto chart shows that 80% of the rejection rate comes from 20% of defect types (Needle line, Hole, Yarn variation and Lycra jump).

4.1.1 Causes for the Critical Defects

Based on the Pareto's principle 80/20 analysis above, the critical four defects are identified and shown here below as per their emphatic order and tabulated on Table 4.4 below. This emphatic order of the defects is not merely checked by the data of the company but also direct observation and registering the respective data has been made and cross checked for agreement. And, this revealed that they are of the same emphatic order as shown here below.

Table4.4. Rank of defects with their frequency

S/N	Defect type	The Observed frequency of defects	Frequency (%)
1	Needle line	266	29
2	Hole	193	26
3	Yarn Variation	69	22
4	Lycra jump	50	6
Total		**578**	**83**

The aforementioned significant defects are the point of the analysis here after and they are described as follows with respective causes. Each defect is also sorted out based on Pareto analysis and the most emphatic ones are considered.

1. **Needle line defect**: is a fault when a needle breaks down or needle hook bends then a vertical thread out mark comes along the fabrics

Table 4.5 List of causes for needle line

S.N	Causes of defect	Frequency	Frequency (%)
1	Machine dust	49	22
2	Double yarn	45	20
3	High yarn tension	41	18
4	Badly knot	31	14
5	Snarled yarn	12	6
6	Broken needle latch	11	5
7	Thick yarn	8	4
8	Poor maintenance	7	3
9	worn-out needles	7	3
10	Loose yarn tension	5	2
11	worn-out sinkers	4	2
12	Two d/t needle gauge	4	2
	Total	**226**	**100**

The result depicted on table 4.5 is analyzed using Pareto analysis as follows and the following chart is meant to describe the result of the analysis.

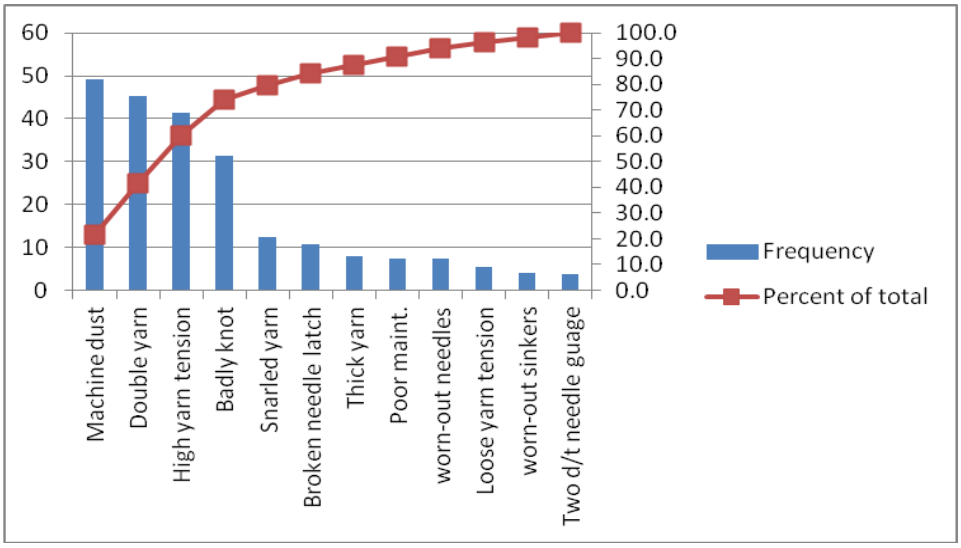


Figure 4.2 Causes of Needle-Line

Based on the above analysis the following are found to be the significant ones and here after the below mentioned four causes are to be considered for the needle line defect.

Table4.6 the Critical Causes of Needle Line

S.N	Causes of defect	Frequency	Frequency (%)
1	Machine dust	49	22
2	Double yarn	45	20
3	High yarn tension	41	18
4	Badly knot	31	14
	Total	**166**	**74**

At the first time of interview, twelve possible causes (table4.5) were identified with the help of group discussion and a check sheet format was also distributed for 20 working days to sort-out the most influential causes of the defect. In those days, 226 needle line defects were observed during that period and computed 166(74%) of the defect was caused by the four critical causes as listed in table 4.6

2. **Hole defect:** is a fault when a yarn breaks or jumps during loop formation then it gives an impression of tear or cut on the fabrics.

Table 4.7 List of Causes for Hole

S.N	Causes of defect	Frequency (%)	Frequency
1	Bad knotting	16.6	32.0
2	Machine dust	16.4	31.7
3	Double yarn	14	27.0
4	Damage of CONI+ clutch bearing	11.7	22.6
5	Loose yarn tension	10.5	20.3
6	High yarn tension	8.8	17.0
7	Rough ceramic of yarn guide	3	5.8
8	Wrong setting of yarn feeder	3	5.8
9	Contaminated yarn	2.4	4.6
10	Take-down tension(high & loose)	2.1	4.1
11	Bent needle latch	1.8	3.5
12	Thick yarn	1.5	2.9
13	Wrong setting of knob scale	1.4	2.7
14	Worn-out needles	1.2	2.3
15	Poor maintenance	1.1	2.1
16	Thin yarn	1.1	2.1
17	Worn-out sinkers	0.9	1.7
18	Mixing of two	0.7	1.4
19	Two d/t needle gauges	0.7	1.4
20	Cracked CONI pipe	0.6	1.2
21	Improper creeling of yarn	0.5	1.0
	Total	**100**	**193**

The result depicted on table 4.7 is analyzed using Pareto analysis as follows and the following chart is meant to describe the result of the analysis.

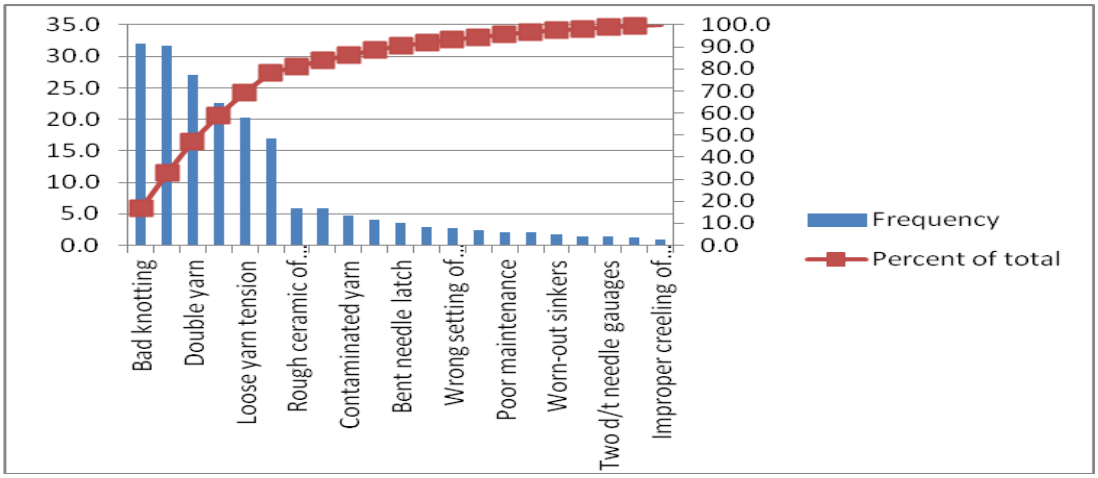


Figure 4.3 Causes of Hole

Based on the above analysis the following are found to be the significant ones and here after the below mentioned six causes are to be considered for the hole defect.

Table4.8 the Critical Causes of Hole

S.N	Causes of defect	Frequency (%)	Frequency
1	Bad knotting	16.6	32.0
2	Machine dust	16.4	31.7
3	Double yarn	14	27.0
4	Damage of CONI+ clutch bearing	11.7	22.6
5	Loose yarn tension	10.5	20.3
6	High yarn tension	8.8	17.0
	Total	**78**	**151**

A tally sheet was conducted for the twenty day, and in that time 193 hole defects were observed and out of which the 151 defects were resulted from the above six causes and they cover 78 % therefore the company need to address these causes so as to minimize the occurrence of this defect by about 80%.

3. **Lycra jump defect:** It is a fault when a lycra yarn breaks or cracks then a Stretch marks visible on fabric surface horizontally.

Table 4.9 List of Causes for Jycra Jump

S.N	Causes of defect	Frequency (%)	Frequency
1	Broken needle hook	21	10.5
2	Wrong positioning of lycra wheel	15.6	7.8
3	Dirty guiding roller	14	7.0
4	Poor quality of cotton yarn	11.2	5.6
5	Mixing of lycra & cotton yarns	9.5	4.8
6	Poor quality of spandex yarn	7.4	3.7
7	High or loose spandex yarn tension	4.4	2.2
8	Expired spandex	4.3	2.2
9	Operator's head is collided with lycra	2.8	1.4
10	Mixing of 40 & 20 deniers	2.7	1.4
11	Cotton yarn is misled	2.6	1.3
12	Malfunctioning of sensor	2.5	1.3
13	Double spandex	2	1.0
	Total	**100**	**50**

The result depicted on table 4.10 is analyzed using Pareto analysis as follows and the following chart is meant to describe the result of the analysis.

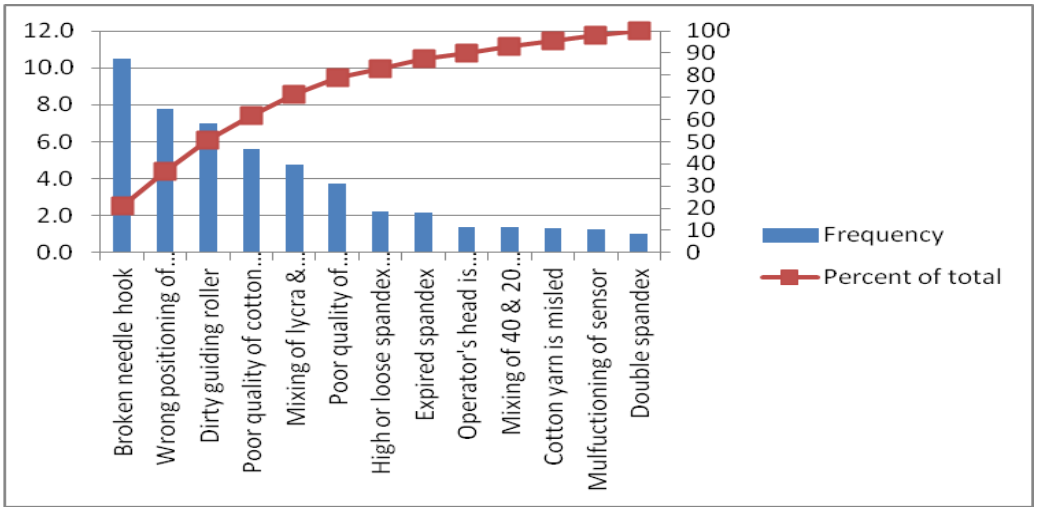


Figure 4.4 Causes of Lycra Jump

Based on the above analysis the following are found to be the significant ones and here after the below mentioned six causes are to be considered for the lycra jump defect.

Table4.10 Causes of Lycra Jump

S.N	Causes of defect	Frequency (%)	Frequency
1	Broken needle hook	21	10.5
2	Wrong positioning of lycra wheel	15.6	7.8
3	Dirty guiding roller	14	7.0
4	Poor quality of cotton yarn	11.2	5.6
5	Mixing of lycra & cotton yarns	9.5	4.8
6	Poor quality of spandex yarn	7.4	3.7
	Total	**78.7**	**39.4**

With the help of check sheet and group discussion, the six critical causes of lycra jump are identified out of the thirteen causes which are listed in table 4.9.

The factory needs to address the above critical causes of the defect, and then it can minimize the frequency of happening this defect by about 80%.

4. **Yarn variation defect**: It is caused by either mixing yarns on feed into machine or having yarn with more imperfection and the fabric will appear to have horizontal streaks.

Table 4.11 List of causes for yarn variation

S.N	Causes of defect	Frequency (%)	Frequency
1	Double yarn	35	24.2
2	Mixed Counts	34	23.5
3	Thick & thin places in one yarn cone	14	9.7
4	Two yarns are held by one needle	9.7	6.7
5	Clutch of CONI+ is disengaged	7.3	5.0
	Total	**100**	**69**

The result depicted on table 4.12 is analyzed using Pareto analysis as follows and the following chart is meant to describe the result of the analysis.

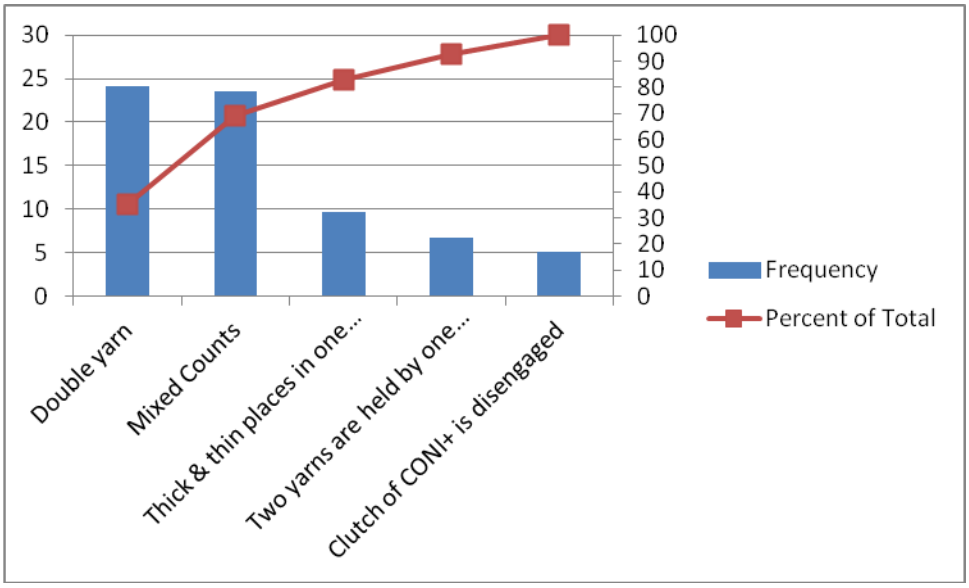


Figure 4.5 Causes of Yarn Variation

Based on the above analysis the following are found to be the significant one and here after the below mentioned three causes are to be considered for the yarn variation defect.

Table 4.12Causes of Yarn Variation

S.N	Causes of defect	Frequency (%)	Frequency
1	Double yarn	35	24.2
2	Mixed Counts	34	23.5
3	Thick & thin places in one yarn cone	14	9.7
	Total	**83**	**57**

Firstly, possible causes of yarn variation are identified then after the three critical causes are sort-out by the help of tally sheet and group discussion. As table 4.12 shows the critical causes have the weight of 83% (57 defects) to occur. It is very wise to tackle these causes so as to reduce the defect by about 80%.

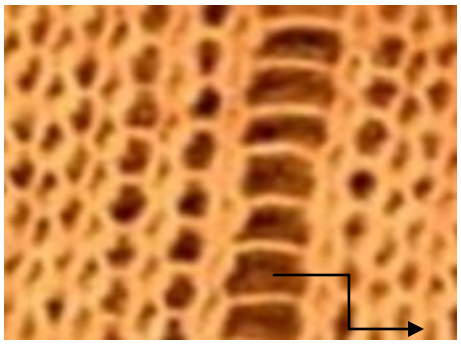
The double yarn has a frequency of 35% which is the dominant one as compared to the other causes whereas the thick & thin place of yarn has the frequency of 14% which is least relative to each other. Thus, tackling the aforementioned 35% emanated from double yarn significantly improves the occurrence of the respective defects mentioned, yarn variation.

4.3 Causes and Remedies for the critical Defects

The critical causes of each acute defect were sorted out and the respective remedies are set as it is discussed here below.

4.3.1The critical Defects (Needle-line, Hole, Yarn variation, Lycra jump)

A. Needle-line



Source: [A.S.MRAHAT KHAN, India, 2008]

Causes:

This is defect occurred when the needle hook is broken or needle latch is bent. And the main sources the defect is:

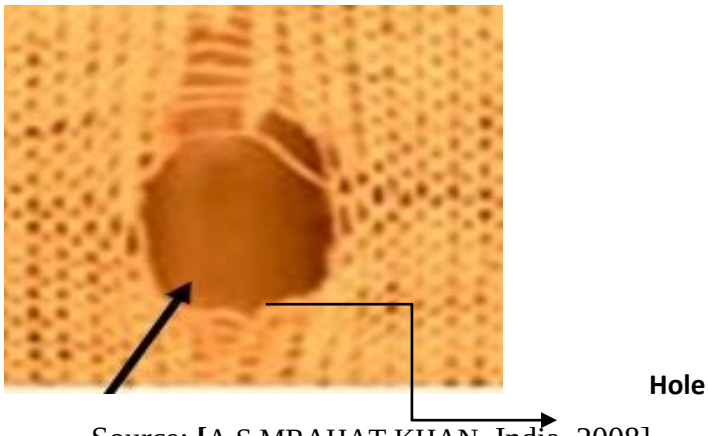
- Machine dust
- Bad knotting of yarns
- Improper take-down tension
- Very dry material
- Insufficient yarn tension
- Double yarn and snarled yarns

Remedies:

- Knitting machine has to be cleaned at least every doff (every production of 25 kg) and the floor should also swept continuously.
- The fluffs and yarn hairiness should not be permitted to accumulate over the surface of the knitting element.

- Yarn should be guided from the package up to the knitting area without unnecessary deviations in order to avoid additional increases in tension.
- The needles must also be faultless.
- Avoid pieces of yarns around creel and yarn feeders and the room humidity (65%) and temperature (22^0C) should be kept so as not to dry yarns.[7]
- The fabric take-down tension must be readjusted as per the fabric weight.

B. **Hole**



Source: [A.S.MRAHAT KHAN, India, 2008]

Causes:

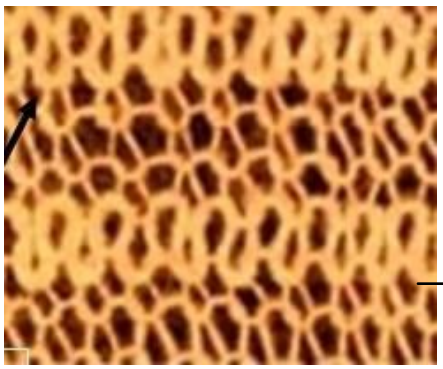
- Bad knotting of yarns
- Yarn running-in tension is high/ low
- Weak places in yarn and the yarns are doubled.
- Yarn is too dry as its moisture is less and its strength also less.
- Machine dust as the machine is not cleaned very fine dusts and fluffs will be accumulated over its knitting elements.
- Old needles and sinkers
- When the yarn guide is blocked by the accumulated yarn hairiness or fluffs.
- Damaged CONI+ clutch

Remedies:

- Yarn devices must be flawless: eyelets made of ceramic must have a smooth surface without any grooves.

- To avoid high tension, the quality pulley disc should be set correctly as per the required GSM, and fabric structure.
- The broken yarns have to be knotted like weaver's knotting (fish) system or use flat knot edge. And the extra knot edge should not be more than 5mm in length.
- The working place for knitting process should be RH=55%+/-10 and temp=20+/-2^0c so as not to dry the yarns and increase its strength.[7]
- Maintain the damaged clutch if need be replace it.
- The life time of needles and sinkers need to be regulated in formal logbook (machine history) and replace them as per the manufacturer's recommendation.[4]

C. Yarn variation



Yarn variation

Source: [A.S.MRAHAT KHAN, India, 2008]

Causes:

- When there is thin and thick place in the yarn.
- Differences in the yarn running in tension.
- When the drive loop belt of CONI+ has slippage.
- When the CONI+ clutch is disengaged.
- Double yarn and different counts are mixed together.

Remedies:

- The yarn tension should be readjusted using the quality pulley disc.
- The drive loop belt of CONI+ must be free from slippage and if need be change it by new one
- Every doff (25 kg of production) the clutch need to be checked and engaged.

- Remnant yarns have to be segregated and packed by specifying their count i.e it helps for ease identification.
- Yarns should be checked using black card and then you can take out yarns having thick & thin places.[8]

D. Lycra jump

Causes:

- Broken Needle Hook
- Wrong positioning of lycra wheel
- Dirty guiding roller
- Poor quality of lycra yarn
- Mixing of Lycra & Cotton Yarn

Remedies:

- Position of Lycra wheel needs to be checked every fabric doff.
- Guiding roller should be cleaned every fabric doff including its yarn feeders.
- Replace immediately the broken needle hook by new one.
- Lycra yarns should not be exposed either to sunlight or water as they deteriorate their quality.
- Avoid mixing lycra yarn with cotton yarn during the process.

4.3.2. Summary of remedies for critical defects

Based on this study, they were ranked with respect to their impact on rejection rate as given in table 4.13 below. Accordingly, the causes of critical defects were studied closely so as to reduce the rejection rate by 80%.

Table4.13 Summarized causes of defects with their Remedies

S/N	Defect Type	Primary Causes	Root Causes	Possible Remedies
1.		Broken Needle	Double yarns	Pieces of yarns should not be left over creel and yarn feeders ; yarn must be conditioned well while it is in knitting process and TM of yarn should be in the range of 2.8-- 3.5 not exceeding 3.5 and avoid insertion of more than two yarns to yarn feeder.[8]
			Machine dust	Machine has to cleaned every 30 minutes ;Cleaning of floor continuously; A vacuum sucker equipment should be installed on top of each machines
		Bent Needle Hook	High yarn tension	Proper machine setting based on fabric type, GSM and yarn type (cotton, lycra, polyester) example for cotton:6—10cN whereas for lycra yarn 40 denier=4cN & 20denier=2cN.[4]
			Badly knot	Proper knot should be given by the skilled operators.
2.			Double yarns	Pieces of yarns should not be left over creel and yarn feeders; TM of yarn should be in the range of 2.8-- 3.5 and avoid insertion of more than two yarn to yarn feeder.[8]
			Badly knot	Proper knot should be given by the skilled operators.
			Machine dust	Machine has to be cleaned every 30 minutes; Cleaning of floor continuously; A vacuum sucker equipment should be installed on top of each machines.
			Contaminated Yarn	Foreign materials like polypropylene, human hair, & jute fibers should be avoided during the knitting and spinning processes.
			High Yarn Tension	Proper machine setting based on fabric type, GSM and yarn type (cotton, lycra, polyester) example for cotton:6—10cN whereas for lycra yarn 40 denier=4cN & 20denier=2cN.[4]
		Jumped Yarn	clutch damage	Maintain the damaged clutch if need be replace it.
			Loose Yarn Tension	Yarn tension for cotton should not be less than 6cN and for Lycra 40 denier also not less 4cN; 20 denier not less 2cN and to maintain the required tension, tension meter is must to use in every shift (8hrs).[4]

3.			Broken Needle Hook	Replace the broken needle hook by new one.
			Poor Quality of Cotton	Yarn parameters(for 30/1s its strength is18gm/tex and total imperfection=82) should be checked before starting production in knitting.[8]
			Wrong Positioning of Lycra	Position of Lycra wheel needs to be checked every fabric doff by the operator.
			Dirty Guiding Roller	Guiding roller should be cleaned every fabric doff by the operator.
			Mixing of Lycra & Cotton Yarn	It needs Segregation of lycra from cotton yarn but needs due attention not to happen.
			Poor Quality of Lycra Yarn	Lycra yarns should not be exposed to sun light, water and expire date (6 months from the date of manufacturing) needs to be checked.
4.		Mixing of yarns	Double Yarn	Pieces of yarns should not be left over creel and yarn feeders; TM of yarn should be in the range of 2.8-- 3.5 and avoid insertion of more than two yarn to yarn feeder.[8]
			Mixed counts	Yarn counts should be segregated and labeled in an appropriate way. And avoid remnant yarns on time
		Yarn imperfection	Thick & Thin Place of Yarn	Total yarn imperfection should be maintained as per the USTER standard for instance for 30/1s is 82.[8]

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the result discussed, the study found the below mentioned critical points on which the solution is required.

- According to the analysis of the data, the fabric rejection rate was found 7.87% in the section
- Majority of the rejection rate comes from defects incorporating Needle line, Hole, Yarn variation and Lycra jump.
- The cleaning system they have already is not effective to reduce the dust in the section.
- The defect existence has influenced the company's financial performance by nearly 80%.
- The presence of defects in the section is inevitable and due this existence of fabric defects, it has been sold at lower prices, or even in some cases as rags which creates a huge loss to the company.
- This study will help for the section to identify the source of detected defects causes; therefore the responsible entity can take recommended remedial action to overcome the critical defects.

5.2 Recommendations

This research has been carried out on greige knitted fabric to improve its level of quality status.

Currently analyzed data indicates that rejection rate is very high when it is evaluated with the company's quality target [16]. To improve its quality of product the study focused in reducing rejection rate. The factory need to address the critical causes of defects to improve its quality based on the following recommendations:

- The factory need to focus on the critical identified fabric defects and their respective causes to improve its quality.
- It is recommend that Standard Operating Procedure (SOP) is used as it is the best prevention tool to minimize defect rate while operating production and it also keeps machine healthy.
- It is important to have vacuum sucker equipment over each knitting machine to have an effective cleaning system.
- The factory need to monitor machine operation, machine cleaning, yarn related fault and yarn storage to improve quality.
- The company needs to assist further research in the section periodically to reduce the rejection rate continuously.

Recommended area for future study

This thesis tried to identify critical defects using Pareto data analysis in reducing the quality rejection rate of greige knitted fabric but in the future the company as well as researchers should work on Waste of materials and quality of yarns. Other machineries in the section can be taken as case to further enhance the effectiveness.

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APPENDICES

APPENDIX A: Check Sheet Format for the Critical Defects

This check sheet format was filled by the selected knitting employees of MAA-Garment and Textiles Factory. This check sheet is prepared by post graduate student for the award of MSC. Degree in production and system industrial engineering entitled as "Identifying defect causes of weft knitted greige fabric" And I would like to thank you in advance for your usual cooperation and serious follow up in identifying the root causes of each defects. Please make tally (/) from the given possible root causes of each defect types when they are appeared during the production time for 20 working days.

Defect Type: Needle Line(ኒዳልላይን)										
Causes of defect	**number of occurrence**									
	5	10	15	20	25	30	35	40	50	Total
Broken needle hook (ስባርሚፊእ)										
Machine dust (ረሳሕሞሽን)										
Double yarn (ድራበከሪ)										
Bad knotting (ሕሞቅኣተአሳስራ)										
Poor maintenance (ሕሞቅፅገና)										
Snarled yarn (ዝፋሓሰ/ዝዕፀፍከሪ)										
Worn-out needles (ዝኣረጉሚፊእ)										
Worn-out sinkers(ዝኣረጉሲንከራት)										
Thick yarn (ረጉደከሪ)										
stiff and corrod needle (ዓፂቅንሚትንሚፊእ)										
Broken needle latch (ስባርሚልሓስሚፊእ)										
Mixing of two different needle gauages(ምሕዋስክልተዝተፈላለዩዓይነ ትሚፊእ)										
Needles are collided with air gun (ግጭትሚፊእምኽኤርጋን)										
High yarn tension (ዝለዓለወጥረትከሪ)										
Loose yarn tension (ዝተሓተወጥረትከሪ)										
sample is taken for twenty consecutive days										

Defect Type:Hole (ቅዳድነ ካል)											
Causes of defect	**number of occurrence**										
	5	10	15	20	25	30	35	40	50	Total	
Broken yarn (ብጣኽሪ)											
Machine dust (ረሳሕሞሽን)											
Double yarn (ድራብኽሪ)											
Bad knotting (ሕሞቅኣተአሳስራ)											
Poor maintenance (ሕሞቅፅገና)											
Jumped yarn(ዝላልክሪ)											
Worn-out needles (ዝኣረጉመሪፊኣ)											
Worn-out sinkers(ዝኣረጉሲንክራት)											
Thick yarn (ረጉድክሪ)											
stiff and corrod needle (ዓፂቅንሚሕትንሞርፊኣ)											
Needle latch is bent											
Mixing of two different needle gauages(ምሕዋስክልተዝተፈላለዩዓይነ ትሞራፊኣ)											
Needles are collided with air gun (ግፂቅሞሪፊኣምስኤርጋን)											
High yarn tension (ዝለዓለወጥረትክሪ)											
Loose yarn tension (ዝተሓተወጥረትክሪ)											
Rough ceramic of yarn guide ሓርፋፍሰራሚክ											
Mulfunctioning of yarn sensor(ዘይሰርሕሴንሰር)											
Damage of CONI+ clutch bearing(ሞርግቢጋብኮኒ)											

Amount of yarns in CONI storage (በዝሒርታትኣብኮኒ)											
Wrong setting of yarn feeder (መጋቢክሪ)											
Slubbed yarn(ስላብድክሪ)											
Contaminated yarn (ዝተበከለክሪ)											
Damaged cylinder channels (ዝተጎደአስሊንደር)											
Creeling of yarn											
Cracked CONI pipe (ዝነ ቀፀኮኒ)											
Wrong setting of knob scale (ዝተጋገየኖብዕረራ)											
Take-down tension(high & loose) ወጥረትቴክዳወን											
Thick and thin yarn (ረጉዲንቀጠንክሪ)											
sample is taken for twenty consecutive days											

Defect Type: Yarn-variation(ያርንቫሪሽን)										
Causes of defect	**number of occurrence**									
	5	10	15	20	25	30	35	40	50	Total
Mixing of two different yarn counts(ምሕዋስክልተዝተፈላለዩዓይነ ታትክሪ)										
Thick & thin places in one yarn cone(ረጉድንቀጠኗንዘለዎክሪ)										
Double yarn (ድራበክሪ)										
Count variation in one yarn cone (ዝተፈላለዩካወንትዘለዎክሪ)										
Clutch of CONI+ is disengaged (ዘይገጠሞክለች)										
Two yarns are held by one needle (ክልተክርታትቡሉደሞርፊእ)										
sample is taken for twenty consecutive days										

Defect Type: Lycra Jump (ላይክራጃምፐ)											
Causes of defect	**number of occurrence**										
	5	10	15	20	25	30	35	40	50	Total	
Broken lycra yarn											
Mixing of lycra& cotton yarns											
Wrong positioning of lycra wheel											
Cotton yarn is misled											
poor quality of cotton yarn											
poor quality of spandex yarn											
double spandex											
dirty guiding roller											
high or loose spandex yarn tension											
Operator's head is collided with lycra											
Broken needle hook											
After hole is being created											
Expired spandex											
Mixing of 40 & 20 deniers											
Mulfuctioning of sensor											
Spandex is puched by air pressure											
sample is taken for twenty consecutive days											

APPENDIX B: Summarized Monthly Defects with their Percent of Frequency.

MONTH	REJECTION RATE(%)	DEFECT TYPE WITH THEIR FREQUENCY %										
		NEEDLE-LINE	HOLE	LYCRA-JUMP	YARN-VARIATION	SINKER-MARK	OIL-STAIN	DROP-STITCH	LATCH-MARK	CONTAMINATION	LOT-VARIATION	SLUB
JANUARY	4.58	15	30	13	18	5	5	7	7	0	0	0
FEBRUARY	4.06	17	27	11	21	8	3	6	6	1	0	0
MARCH	6.6	34	1	14	25	5	5	5	6	1	2	2
APRIL	24	38	35	5	7	7	5	1	1	0	0	1
MAY	2	38	18	14	17	4	3	1	3	1	0	1
JUNE	6	20	18	18	23	3	15	0	3	0	0	0
TOTAL	47.24	162	129	75	111	32	36	20	26	3	2	4
AVERAGE	**7.87**	**27.00**	**21.50**	**12.50**	**18.50**	**5.33**	**6.00**	**3.33**	**4.33**	**0.50**	**0.33**	**0.67**

APPENDIX C: Questionnaire format.

This questionnaire interview format was answered by the whole knitting employees of MAA-Garment and Textiles Factory. This questionnaire is prepared by post graduate student for the award of MSc. degree in production and system industrial engineering entitled as "Identifying defect causes of weft knitted greige knitted fabric" And I would like to thank you in advance for your time and usual cooperation in identifying fabric defects with their possible root.

S/N	Employee name	Job title	List down all fabric defects that you are encountered in your daily production	And also mention the possible root causes for each defects
1				
2				
3				
4				
5				
6				
7				

APPENDIX D: Focus Group Discussion

This group discussion was made among production, maintenance and quality supervisors of MAA-Garment and Textiles Factory so as to set the possible solutions for the critical defects. This questionnaire is prepared by post graduate student for the award of MSc. degree in production and system industrial engineering entitled as "Identifying defect causes of weft knitted greige knitted fabric" And I would like to thank you in advance for your precious time and usual cooperation in setting all the possible solutions for the existing problem of knitting section.

S/N	The critical fabric defects	The possible solution for each critical defects
1	**Needle line**	
2	**Hole**	
3	**Yarn –Variation**	
4	**Lycra-Jump**	

Participants of the focus group discussion

S/N	Job title	Name
1	**Production head**	**Ashenafi G/kidan**
2	**Maintenance head**	**Araya Girmay**
3	**Quality head**	**Merkeb Tadele**

APPENDIX E: Standard Operation Procedure (SOP)

Standard operation procedure (sop) for knitting production

1. **Purpose and scope**

Its purpose is to follow the sop while greige fabric is being produced

2. **Responsibilities**

Production supervisor and mechanic of knitting department are responsible to direct activities related to this sop. Where other functions have, these have been indicated.

TOOLS USED:

Tools	UM	Qty
Tweezers	Pc	01
Scissor	Pc	01
Needle hook	Pc	01
Needle insertion cam	set	01
Feeder insertion cam	pc	01

Man-powers engaged per shift

Man power	Number
Production supervisor	01
Mechanic	01
Skilled Operator	01 for two machines

PROCEDURE

1. ሓደስራሕተኞናይስራሕክዳኑተከዲኑቅድሚ 10 ደቒቓኣብስራሕቦትኤክርከብኣለዎ።

2. ኩነ ታትእታሞሽንብደንቢክርኢአለዎቅድሚፒካቡ።

- ✓ ፅሬትእታሞሽንምርግጋፅ
- ✓ ምትሕወሳስክሪክይህሉምኣንታን
- ✓ እቲክሪብትክክልናብቲሞሽንምእታወምርግጋጽ
- ✓ ስባርሞርፍእምንባሩምርግጋፅ
- ✓ ዝሾነ ዓይነ ትፀገ ም (Defects) ዘይምጭላወምርግጋፅ
- ✓ ፍጥነ ት (speed 70%) እታሞሽንምሻኑምርግጋፅ

3.ዝሾነ ዓይነ ትንብረት (Material) ንኣብነ ትመቑስ, ቅዳድጨርቂ, ወዳእኮን, ትዊዘርኣብትሕቲሞሽንዘይምህላወምርግጋፅ።

3. ኣብሕድሕድኮኒ (Con) ዘለዎጣዕንክሪካብ 15-20 ክኸውንኣለዎ።
4. እቲክላችኮኒኢንገጅድ (Engaged) ምሻኑምርግጋፅ።
5. ማጣንዘይቲሞሉእምሻኑንዘምሻኑንምርግጋፅ።
6. ሓደአፕሬተርእታሞሽንምስተልዓለት (switch on) ማንዋልስለሽ (Manual Flush) 5 ግዜክገብርኣለዎ።
7. እቲአፕሬተርሓደኢፃኣብፊደር (Feeder) ብምግባርበታካልአይቲኢፁንሓደዙርዝኣክልክዝወራኣለዎ። እዚድሞእታሞሽንካብዝሾነ ድምፅንብቀለሉትሽክርከርምሻናምርግጋፅ።
8. ንታፃዳበተን (White Push Button) መጀመርታንርብዒዙርዝኣክልይፅቀን። ንካልኣይግዜንፍርቂንሳልሳይግዜድማሓደምኤእዝርያዝኣክልምስኣዝወራንራብዓይግዜእታቆፃልበተን (Green Button) ተጠቒመምህርቲይጅምር።
9. ጥቕሜእታቀያሕበተን (Red push Button) ድማ:-
    1. ማሽንቅድሚምጥፋኣእታቀያሕበተንተጠቒም
    2. መበራህቲኣብዘጠፍአሉግዜከሊግዜቀያሕበተንተጠቒምካማሽንምጥፋእ
    3. ቅድሚዒፆምሻትካከሉግዜቀይሕበተንተጠቒም።
    4. ቅድሚዝሾነ ዓይነ ትምስራሕ

<u>ንኣብነ ት</u>:- * ዝዓፀወመልሓስሞርፍእምሻትካ * ኣብግዜምፅራግማሽን

*ዝተበጠሰከሪኣብምእሳርከሪቀይሕበተንከትጥቀም (ክትፀቅጥ) ኣለካ

11. ሓደኣፕሬተር

- ሽፍቱክቅይር

- ሪሴት (Reset) ክገብሮኣለዎ። ካብኡወፃ ኢግንምንምጣይነ ትዳታክነ ክእየብሉን

12. - ቐፀሮክሪክዓበየብሉን።

- ክልተበተን (ፃዕዳቆፃልን) ብሓባርክፅቀጥየብሉን።

- ኤርጋን (air gun) ኣብቦትኡክቅመጦኣለዎ።

- ዝኾነ ዓይነ ትዝተወሃብክምዎን ብረትብኡግባበምጥቃምንምቅማጥንኣለኩም።

- ዝኾነ ዓይነ ትድፈክትብግዚኡክትከታተሉኣለኩም።

-ኣብእዋንስራሕምመራይ,ብዘይምቑንያትካብቦታናብቦታምንቅስቓስ, ብዘይምኻንያትማሽንደወፃጣል,ኮፍምጣል, ካብማሽንወፃኢኮምፕሬሰርኤርምጥቃምንፈፂመዝተከልከለእዩ።

13. ክሪቅድሚመዳኡንሱፐርቫይዘርምንጋር

14.እታማሽንክፃእንታይዓይነ ትክርንክንደይዝኣክልGSM ተምርትክፃዝላምፍላጥግይታኾፃእዩ።

15. ትእዛዝሓላፊኾፃካተኹቡኡላለኩም።

16. ዝተወሃበክምታርጌትክተምርቱ (Produce) ኣለኩም።

17. ዝተወሃበክምፕሮዳክሽንሪፖርት (ምህርቲቅጥዒ) ብኡግባበክትፅሕፉኣለኩም።

ንኣብነት:- * ማዘሐሰባርሞርፍእ

* ደወዝበለትሰዓት

* መጠን (KG) ምህርቲ

18. ቅድሚኩሉንድሕሪኹሉንግንፅሬትእታማሽንክሕሉኣለዎ።!!

1. ኩሉግዜንፀህኢደክህልዎኣለዎ።
2. ዝተፈላለዩካወንትዘለዎምጄትሊታትክሕወስየብሉን።

3. ዘይቲኣ ብልዕሊኣቲ ጨቂኽፈስስየ ብሉን።

4. ኣግባብዘይብሉሞሽን ከፀርግን ሕልፊ ጨቂኽጥቀምን የ ብሉን።

5. እቲ ጨቂኣ ብረሳሕምድሪ ክቅመጥየ ብሉን።

6. ብኽንያትብልሽትሞፍእኣ ብቲ ጨቂዘመፅእጉድኣትብግዚኡክከታተልኣለዎ።

4. **Precautions and safety**

4.1 use safety eye goggles, dust musk, earmuff working cloth and shoes (for mechanic)

4.2 Use trans-pallet trolley of the fabric roll is heavy.

1.3 Use trolley to transport yarn cones.

1.4 All general safety rules should be strict followed during work

5 Related documents

5.1If necessary, you can use manuals of the owner.

6 Distribution

a. Production head

b. Maintenance supervisor

c. quality supervisor

Prepared By:

Name _____Sign:-_____Date: - _____