The Application of Process Improvement Techniques at a Clothing Manufacturing Company in the Western Cape.

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Research project submitted in partial fulfillment of the requirements of a Master of Commerce Degree in the Department of Management in the University of the Western Cape.

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Declaration

I declare that *The Application of Process Improvement Techniques at a Clothing Manufacturing Company in the Western Cape* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Ebenezer Nkwain Ayeah November 2003

Signed:………………….

CONTENTS

Glossary

B/h = Button hole

CI = Continuous Improvement

CR = Cutting Room

Garm't = Garment

Inc = Incomplete

Man. = Manufactured

QC = Quality Control

Preamble

"Research Projects and Research Reports differ from mini-theses in that they are more limited in scope and rigour. Theses need to be based on a thorough review of the theoretical and empirical literature on the topic, a coherent conceptual framework and an appropriate methodology. Research Projects and Research Reports can be based on a limited review of management frameworks and appropriate use of management techniques or descriptive research". (EMS Year Book, 2003).

Abstract

This research project focuses on the application of process improvement techniques in a clothing manufacturer to address delay problems in workflow in the factory. The objective of the research is threefold; investigate delays at the beginning of production and make suggestions, show the usefulness of continuous improvement techniques in improving activities in a clothing manufacturer and demonstrate how action research can be used in doing research in production and operation management. Using tools such as flow charts, check sheets, pareto analysis, fishbone diagrams, interviews and the "ask why five times" tool, an investigation into delays led to a second investigation into sewing defects. This established that these sewing defects are caused mainly by time constraints, the malfunctioning of machines, the wrong handling of garments, and previous operations. After an investigation using the above tools it was established that these defects could be addressed by setting realistic targets, doing regular maintenance on machines, cautioning operators to be more careful during their operations, and encouraging regular checks on garments before the next operation. The action learning methodology led to the following lessons; selecting a correct measuring tool is important, that not all tools need to be used, and that it takes time to do a research project using this method.

CHAPTER ONE
BACKGROUND

1.1 Introduction

In a fast changing business world there is a need to remain competitive. Business conditions are unpredictable and competition is opening up new markets as well as imports flocking into the country. This raises issues of efficiency and effectiveness, and to attain these there is a strong need to improve continuously on the production process so as to eliminate manufacturing related problems that drive cost up and make production time consuming. Other economic factors such as labour cost, cost of capital, imports and economic policies are out of the influence of manufacturers. Therefore one of the ways to remain in business and grow is to improve continuously on existing activities to be able to gain competitive advantages of quality and cost.

This project will focus on using process improvement techniques in a clothing manufacturer to deal with problems related to delays and other problems that delays can lead to. In this research project "process improvement" would be referred to as an improvement approach, while "continuous process" improvement would be referred to as an improvement technique, and flowcharts, pareto analysis, check sheets, fishbone diagrams, interviews, brainstorming, and the why and why review etc, would be referred to as tools for improvement. This could slightly differ from the way other authors refer to them in their literature, but the concept remains the same. The project will make use of action research methodology because of its reputation to produce practical solutions to unstructured work place problems. The problem areas will be identified using process improvement tools, investigated to find the causes, and solutions will be suggested that could help reduce the impact of such problems in the manufacturing firm in question.

1.2 Origin of the Project

My supervisor approached a clothing manufacturer who agreed on using his company to conduct this research project. In order for the project to be beneficial to the company, management was asked to outline areas of interest that the project could focus on. Management identified production problems related to delays, production planning, waste control, space, bottlenecks, work-in-progress, inventory imbalances in different production lines, and response to problems in the line in order to improve on work-flow in the production line. We decided to use the continuous process improvement approach after a visit to the factory with my supervisor. The project will focus mostly on the use of continuous process improvement technique and tools, and how they could be used to improve on the flow of work in the production line with specific attention to problems related to production delays.

1.3 Rationale of the Project

Many organizations that want to undertake process improvement find themselves at crossroads because of the many improvement programs that are available out there, and each one seems promising to deliver the best results. Manufacturers may be tempted to think that they would get the same results whether they apply Continuous Process Improvement, Business Process Improvement, Business Process Re-engineering or Business Process Benchmarking.

This research project is particularly important because the management of some firms never really think about the approach of process improvement in relation to the particular problem to be addressed. Most of these approaches are considered to deliver the same results, which can at times be misleading. This will be an opportunity for the project to try to show how useful continuous process improvement technique could be in addressing some production process flow problems such as delays.

1.4 Project Objectives

This research has three major objectives, and they are as follows:

- Investigate delays at the beginning of production in the sewing department, and make suggestions on how to address them.
- Demonstrate how continuous improvement technique and tools could be appropriately used to carry out improvement in a clothing manufacturer.
- To show the suitability of action research methodology in production and operation management research.

1.5 Process Improvement

Continuous process improvement is the philosophy that aims at continuously improving on all factors that are used in the conversion of input into output. This improvement involves materials, methods, equipment and people. Continuous improvement brought about a shift from the old notion that "if it is not broken, don't fix it", to the new notion that "just because it isn't broken doesn't mean it can't be improved" (Stevenson, 1996: 118). Originating in the USA, it did not receive so much attention until it made very remarkable positive improvements to the Japanese manufacturing sector. The Japanese refer to it as *kaizen*, a Japanese name for continuous improvement. The success of this improvement technique in the Japanese economy has led to its implementation in many industrial sectors elsewhere (Stevenson, 1996).

Process improvement comes in different forms; continuous process improvement, business process re-engineering, process renovation and process redesign. In short there can be two approaches of process improvement: continuous process improvement and breakthrough process improvement (Povey, 1998). According to a study of continuous versus breakthrough improvement by Harrington (1995), there is a difference between the two. The former is a gradual improvement process in all sections of the company with an improvement that is small, but remarkable per year while breakthrough process improvement is a radical improvement process that targets certain parts of the company, and produces very good results, which may at times not be so sustainable in a long run.

The *Kaizen* tool kit is based on the Deming cycle, developed by Edward Deming, and also referred to as the Deming Wheel or the PDCA (plan, do, check and act) cycle. There are different steps or stages in process improvement proposed by different authors, as well as different set of tools for process improvement, which will be examined in detail in the next chapter. From these a process improvement set of steps or stages that best suit the manufacturing situation will be selected for use in this research project. The steps would be used as a guide to the different stages in process improvement, and the tools will be used in mapping out the process, identifying problem areas, the causes of the problems and suggestions will be made to address the identified problems.

This project will try to demonstrate how these tools could be used to resolve problems in the production line related to production delays.

1.6 The Clothing Industry in the Western Cape

The clothing sector in South Africa has undergone major changes since the start of transformation in the early 1990s. Globalization, liberalization, tariffs reduction, and an increasing free market economy with increasing influx of cheaper clothing products from foreign countries have had some negative effects on the sector. These have created intense competition and a need for efficiency in the sector (Wesgro sector report, 2002).

There are greater prospects for the sector with recent trade agreements such as the African Growth and Opportunity Act (AGOA), and the South African /EU (European Union) trade Agreement. With such opportunities there is an increasing need for greater productivity and efficiency. This creates a need for clothing manufacturers to consider process improvement techniques.

Manufacturers in the industry are increasingly searching for a competitive advantage on the cost of production, efficiency, and effectiveness, delivery time and quality in order to be able to penetrate into foreign and local markets. This has necessitated the need for an improvement technique that is sustainable, and will in the long run deliver sustainable results, rather than what momentarily seems like positive results. The reasons why continuous process improvement has become a useful utility in the industry is because of its simplicity, and the little technological investment involved in its implementation as compared to the high investment involved in other improvement techniques such as re-engineering and renovation (Prasad, 1999).

The industry is a major employer in the Western Cape. To save employment and assure future job creation, it has become an imperative to make the industry more competitive, especially in the face of globalization, deregulation of the South African economy, the increasing elimination of tariffs and other trade barriers. These are good reasons for an improvement project to be initiated to save the industry from collapse. Harrington (1995: 17) in giving reasons for improving sums it all in the following quotation: "If you are not improving you are not only holding still. Instead you are slipping backwards at a rate of about 5-10 per cent a year compared to your competition because they are improving". With this view the importance of a sustainable improvement program cannot be over-emphasized.

1.7 Company Site and Background

The company was originally started in the United Kingdom, and moved to South Africa in the 1930s. It employs about 630 people, and produces approximately 7000 garments a day. The company has warehouses and distribution facilities in Durban and Johannesburg.

The company has a production facility of 10000m^2, with computerized pattern, marker making and cutting, modern sewing machines, and automatic processes such as pocket and belt loop setting. The company has and will continue to invest in new equipment. The company has adopted a simplified "Just-In-Time" philosophy.

The company's commitment to quality enabled it to be awarded the coveted South African Bureau of Standards Mark for its quality work wear. It is also ISO 9002 accredited. The company specializes in two product lines: leisure-wear and protective-wear.

The company's leisure-wear division is primarily Jean-wear oriented. The levels of expertise and experience, in addition to plant and modern machinery have a positive effect on this category of clothing. The company is rated highly in the local market as a Jean-wear manufacturer. The company supplies medium to large chain store organizations. The garments cover various sectors of the consumer market namely; men's-wear, ladies'-wear, boys' and girls' wear, ladies' outsize garments and maternity wear.

The marketing team combines forthcoming trends in styling, fabrication and styling, fabrication and coloration together with customer requirements, to design garments. Their product profile extends from basic five pocket core jeans to fully-fashioned styles, aimed at the middle to upper price range. They can also manufacture under the customers own house label or create a new brand to suite image and requirement. Amongst others Woolworths is their major customer. The company is also currently exporting to the United Kingdom, Germany and the United States of America.

The protective-wear division produces a range of boiler suits, two-piece work suits, dustcoats, work trousers and shirts mainly with 100% cotton material and also with specialized material that are flame retardant and acid repellent. The company produces and develops garments to their customers' specifications. The major local customers in this product range are; Alusaf, Anglo-American Corporation, Columbus Stainless Steel, Eskom, Genmin, Highveld Steel, JCI (Johannesburg Consolidated Investments), Saldanha Steel, C.B.I. (Chicago Bridge and Iron Company), Cape Town City Council, Veitsch Radex, Caltex, BP (British Petroleum), Mossgas, KWV (Ko-operatiewe Wynbou Vereeniging), and Stellenbosch Farmers Winery. The company also currently exports to Germany and the Middle East.

The company is committed to help small businesses by outsourcing services such as printing, embroidery, screen-printing and maintenance.

1.8 Research Project Methodology: Action Research

Action research can be generally defined as research in action rather than research about action. It is the application of scientific methods of fact finding and experimentation in seeking action solutions to practical social or organizational problems with the collaboration of practitioners and laymen experiencing these problems (Gilmore & Smith, 1996; Coughlan & Coghlan, 2002). It involves a cyclical process of plan, act evaluate and then repeat the cyclical process again. It is a participative approach of problem solving with members of the organization under study participating actively in the cyclical process. In as much as this research method is aimed at taking action it also adds something to the existing body of scientific knowledge (Coughlan & Coghlan, 2002). This kind of research method is well suited for this research project since it is aimed at finding practical solutions to manufacturing problems in a clothing factory. In this way suggestions can be given to real working environment problems.

1.8.1 Characteristics of Action Research

According to Dick (2002) and Coughlan & Coghlan, (2002), action research has the following characteristics:

- The action researcher does not merely act as an observer during the research, but he/she is actively involved in making the action happen. The researcher in this project will actively make action happen by actively getting involved in the action in the shop floor in order to get a sense of what is actually going on the factory, and in that respect be able to observe and reflect on the action in the factory.
- Action research is conducted in real time. This means that the action will be observed reflected upon and analyzed as it unfolds. In this research project the researcher will observe the action as it unfolds, and it is from this action that useful data will be gathered and analyzed to reach conclusions and make suggestions.

- Action research has a double challenge of solving a practical organizational or social problem and contributing to the body of scientific knowledge. The action researcher engages in the action during the research and then stands back and reflects on the action in order to contribute to the body of knowledge. In this research project only the first goal will be fulfilled due to the limited scope of the research to be able to add to the body of scientific knowledge.
- It is generally cyclical with the recurrence of similar steps in a sequence. With a cyclical way of investigating problems in a manufacturing environment it gives chance for flexibility, and adaptation to changing circumstances in the environment.
- It is also participative since the clients and informants are active in the research project through the provision of necessary data. It would only be through the collaboration and participation of the shop floor workers and other employees that this project could be able to identify the problem areas, the causes of the problems identified, and with their suggestions and propositions, solutions could be suggested to the factory management for implementation.
- It is more often qualitative than quantitative. Qualitative research gives more room for investigation, and flexibility to the changing environment, and in a constantly changing environment like the manufacturing sector, problems could come up today, and disappear tomorrow. Qualitative research creates the chance for going with the changing environment, and this project falls within this line of thought.
- It is reflective, at each stage of the research the process and the outcome need to be reflected upon. Often problems in the manufacturing environment are inaccurately perceived, and defined incorrectly, so it is only through interaction and observation in the manufacturing environment that one can really reflect to come out with the real problems. This project is one of these types. One cannot only depend on

management's perception of the problem in order to know the actual problem areas, but would have to observe, reflect and analyze the situation in the manufacturing environment to formulate the real problems.

- Action research is also responsive since it needs to respond to emerging needs and situations. Most often problems change their manifestation or their nature, and it is with such a research method that these changes could be easily adapted to the research objectives. The manufacturing situation in question is a good example where the manufacturing situation and problems change frequently, creating a need for any research to be responsive to such changes.

The steps of action research identified by its proponents are; plan, act, observe and reflect, and then repeat the process again if necessary (Dick, 2000). With the research project in question there will be a need to plan for the project, initiate the process of investigation, observe what is actually happening in the production environment, reflect on it in order to establish the problem areas, and when circumstances change there is a need to do the same process again in order to proceed with the project.

1.8.2 Why Action Research

According to Westbrook (1994), action research has been found particularly suitable for research in production and operations management rather than other traditional research topics and methods. It has helped to overcome deficiencies such as its relevance to practitioners, applicability to unstructured manufacturing issues and contribution to theory that production and operations management academics have failed to address using the traditional methods.

1.8.3 How Action Research is used in the Project

In this research project a simple model of action research developed from a general model of empirical research would be used. It is as follows:

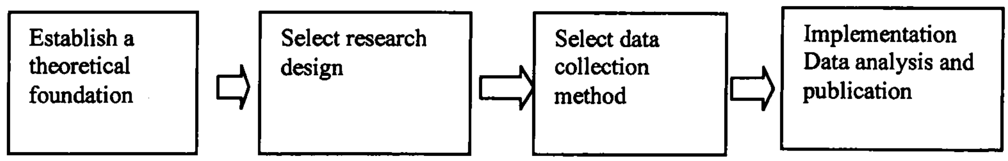


Figure 1.1 A Simple Model of Action Research (Adapted from Westbrook, 1994).

This simple model of action research would enable the researcher at the beginning to set a theoretical framework for the research. As this is a research project with a more practical orientation than the conventional academic thesis, it uses a business method rather than a full theoretical framework as its point of departure. In this project there would be a set of tools that would be used to do a continuous process improvement in the clothing factory as explained in the literature review in the next chapter. The research design in this research project therefore focuses on selecting the technique and tools that would be used, and using the technique and tools for an investigation of the real problem areas.

The continuous improvement stages or steps used changed as the original stages were found to be inadequate. This is in keeping with the action research method.

After data collection the last stage of the research would be the analysis of the data to find out the symptoms of the problem, establish the causes of the problems identified, and from the causes, solutions would be recommended to the factory management for implementation.

This simple model for action research is particularly suited for this research project because of its focus on investigating practical work place problems and proposing solutions. This research method is best suited for this research project because of its ability to provide real solutions to real workplace problems, and its flexibility in investigating unstructured management problems.

Using the characteristics of action research as mentioned earlier to seek solutions to practical operations and production problems in a manufacturing environment, a study and analysis of planning and processing of manufacturing batches was carried out. This was in an attempt to identify (as a beginning of the investigation) the problem areas, and give direction to the project investigation. Manufacturing batches were observed for their timeliness and delay as concerned their due dates (if they are actually on time or not). This was done through a regular collection of the manufacturing batch numbers in the factory daily production schedule status, and analyzing them to see whether they are meeting deadlines, and if not what are the reasons. This is in accordance with the cyclical nature of action research. This was with the participation of those in charge of seeing that planned batches are completed on time. They were also interviewed to establish the reasons for the delays. This was done in an attempt to see whether management's perception of the problem is actually correct. This was just a first step in actually establishing the root causes of the problems in the factory, and continue with an in depth investigation to determine its causes and suggest solutions. After this investigation the research was narrowed down into particular problem areas, and in particular sections where the problems were manifested.

1.9 Ethics and Confidentiality

Ethics are norms or standards of behaviour that guide the moral choices about the way researchers behave, and their relationship with those they interact with during their research (Cooper & Schindler, 2001). Ethics in research ensures that people involved in the research are not harmed or suffer as a consequence of the research. Respondents are particularly concerned here.

Researchers should ensure that respondents do not suffer physical harm, discomfort, pain, embarrassment, and loss of privacy as a result of their participation in the research activities. In line with confidentiality undertakings given to the company, information will remain confidential. Those who contributed information were consulted first, and were reminded that it was their right to refuse to participate in the research activities, and that they need to grant written consent before the revelation of their identity (Cooper & Schindler, 2001). During this research project everything will be done to ensure that those who participated in the research by contributing valuable information or assisting in its acquisition remain anonymous, and participation will only be after due consultation and consent of the person.

Neuman (2000) raises an important issue about the dilemma of the right to privacy and the right to know which is very important in the understanding of the findings and the comprehensive nature of the research. For this reason particular areas of research activities could point direction to particular persons or group of persons, but without that a lot of issues would not be appropriately addressed or understood in the research report.

CHAPTER TWO

A LITERATURE REVIEW OF PROCESS IMPROVEMENT

2.1 Definition

Process improvement is the systematic study of process flow activities with the view to improve upon them. Process improvement comes in different forms; continuous process improvement, process re-engineering (radical breakthrough), and Lee & Chuah, (2001) talk of business process benchmarking as another form of process improvement. With the increasing pressure on organizations to provide better quality at a lower price, there has been a need to continuously review different activities in the process of manufacturing or service delivery in order to reach this objective (Krajewski & Ritzman, 1996). The different improvement approaches will be briefly described.

2.1.1 Continuous Process Improvement

Continuous process improvement is a concept that seeks to carry out improvements in a continuous manner in the process of converting inputs to outputs. It is often small in nature. Continuous process improvement was pioneered in Japan, and many Japanese companies have successfully used this improvement approach. It is behind Japanese enormous industrial success though only gaining grounds in the United States of America recently despite the fact that it originated from there. This has led to the use of this approach the world over to reach efficiency and effectiveness. In Japan the term *Kaizen* is used to refer to continuous improvement (Stevenson, 1996). Continuous improvement programs have been acclaimed for their contribution to productivity and efficiency in the manufacturing sector, however, sustainable continuous improvement programs have not been quite easy to realize, and have reduced continuous improvement to a once-off improvement activity (Kerrin, 1999). Continuous improvement has become very popular in manufacturing for the last decade and half, and Toyota has successfully used it during the last twenty years to eliminate more waste out of their production system thus improving remarkably on quality and reducing cost of production (Taylor & Brunt, 2001). This incremental improvement process in the manufacturing sector is in contrast to another improvement program, process re-engineering.

2.1.2 Process Re-engineering

This is a radical redesign and re-conception of the business process to drastically improve performance so as to meet cost, quality, speed of delivery and service requirements. It can be in the form of the introduction of new technology, information technology or capital equipment that will change the production or business process entirely. According to Krajewski & Ritzman (1996), it entails a lot of investment, and can lead to big pay-offs just as it can lead to big failure.

On the other hand continuous process improvement is incremental and on-going. This enables it to realize gradual improvements over a longer period of time, and the results are more sustainable than the dramatic changes that process re-engineering can lead to, that may not often be so sustainable. According to Harrington (1995), organizations cannot entirely depend on continuous improvement nor breakthrough improvement to succeed in today's increasingly competitive business environment; they would need both methods at one point or another. This therefore means that while continuous improvement can lead to improvement, breakthrough or re-engineering cannot be completely ruled out.

2.2 Continuous Process Improvement: A Literature Review

Continuous process improvement is built on conventional (existing and established) know-how and attitude requiring collective effort, with every contribution valuable. It requires only little capital investment, but a longer period of time, involving everyone in the organization from those in the shop floor to top management. It is a gradual and company–wide process with a focus on eliminating waste, defects, errors and improving the process as a whole with quality improvement in mind. This kind of improvement is not often so noticeable, but in the long run it could lead to permanent, long-term, and unnoticeable effects in activities targeted (Prasad, 1999: 193). Continuous process improvement takes place in different stages, and this step-by-step implementation makes it more successful. The tools of this improvement technique have been the facilitating factors in the success of this technique.

2.3 Stages of Continuous Process Improvement

Different stages have been identified in continuous process improvement. A common approach is to specify different stages or steps in the sequence of activities, from the selection of the activity, to the investigation of problem and causes, to suggestions of solutions, implementation and review of the process. Stevenson (1996) proposes the following stages:

1. Process selection and the setting of improvement goals.
2. The analysis and documentation of the current process.
3. Exploring ways of improving on the existing process.
4. Design of a new process.
5. The implementation of the new process.
6. The review and evaluation of the implemented process for success or failure, in order to make necessary corrections where applicable.

He, Staples, Rose & Court (1996), identifies the following stages of continuous process improvement:

1. Assess the process to be improved.
2. Identify the problem that the current process poses.
3. Establish the major causes of the problem identified.
4. Propose solutions to the problem identified.
5. Implement the proposed solutions.
6. Review the process for documentation.

Lee & Chuah, (2001) propose a five steps method of continuous process improvement called the SUPER methodology which means:

1. Select the process to be improved.
2. Get an understanding of the process.
3. Do the measurement of the current process to identify problem areas.
4. Do the process improvement.
5. Review the improved process for results and corrective action.

Grütter, Faull, & Lomofsky (1996), propose a ten step stages for process improvement.

1. Understand the activities in the area of investigation.
2. Identify activities that add value.
3. Decide what measures to use.
4. Collect data to do measurement.
5. Classify information into value added (VA), non-value added but necessary (NVBN), and waste.
6. Identify causes for non-value added but necessary, and waste.
7. Identify the biggest losses.
8. Investigate investment suggestions.
9. Estimate improvement.
10. Implement recommendations.

These steps could be compared as indicated in the table below.

Stevenson, (1996)	**He *et al.* (1996)**	**Lee & Chuah, (2001)**	**Grütter *et al.* (1996)**
Select process		Select process	
Analyze and document	Assess process	Understand process	Understand activities
			Identify activities that add value
Explore improvement	Identify problem	Measure process to identify problem	Decide measures to use
			Collect data and measure
			Classed data into VA, NVBN & waste
	Establish causes		Identify causes for NVBN & waste
			Identify biggest losses
Design new process	Propose solutions		Investigate improvement suggestions
			Estimate improvement
Implement process	Implement solutions	Do improvement	Implement recommendations
	Review for documentation	Review for results and correction	

Table: 2.1 Comparison of the different improvement process stages

A close look at the comparison table shows that all the authors do not make use of the same stages or elaborate more on some of the stages than others. Stevenson (1996), has outlined most of the stages in the process improvement as well as other authors, but has omitted the review stage proposed by He *et al.* (1996), and Lee & Chuah (2001). He *et al.* (1996), have made use of most of the stages as the other authors, but left out the first stage by Stevenson (1996), and Lee & Chuah (2001). Lee & Chuah (2001), have omitted the stage of proposing solutions, which is a very important stage that all other authors have proposed. The stages proposed by Grütter *et al.* (1996), are quite comprehensive though they have omitted the first stage proposed by Stevenson (1996), and Lee & Chuah (2001), and the last stages proposed by He *et al.* (1996), and Lee & Chuah (2001).

These differences in approach make it difficult to make a choice of which stages of continuous process improvement to use. The choice will be guided by the most used stages by the above authors and their usefulness to this research project. It should be noted that Grütter *et al.* (1996), stages are quite comprehensive for a good continuous process improvement program, but are too elaborate for the limited nature of this research project.

All the above stages, steps or phases as the different authors cited in the table above refer to them, are similar to the Deming Cycle, also called the Deming Wheel or the PDCA (Plan-Do-Check-Act) Cycle. This is a series of interconnected activities used in the analysis of systems and the identification of opportunities for continuous improvement. It is made up of the following sequence, plan-do-check-act (Hill, 2000). 'Plan' is the point of identification of the problem or the selection of the area to be improved. The current process is then recorded using a number of tools. 'Do' is the implementation of the formulated plan. 'Check' is the monitoring of the results of the implementation to ensure correct improvement in the necessary areas and that the benefits are forthcoming. 'Act' is the documentation of the information, and here any corrective action could also be initiated. Here much effort is dedicated on maintaining the improvement made.

2.3.1 Reasons for Choosing the Continuous Improvement Stages of He *et al*

The different steps or stages outlined (table: 2.1) could be used in the research project, but the one that suits the nature of this project well would be (He *et al.* 1996), and the reasons for choosing to use them are as follows:

- Almost all authors refer to these stages, although named differently, but the activities in them remain the same.
- These stages have been a success in quality improvement in the manufacturing milieu in Japan and the western world, (He *et al.* 1996).
- These stages enable the research project to go through its different phases of investigation.
- The stages are quite simple, and easy to use in a research project like this one.

2.3.2 Explanation of the He *et al.* Continuous Improvement Stages

These stages or steps enable the research project to go through its different phases of observation, investigation, analysis and suggestions. Here follows an explanation of the different stages that would be used in this research project.

1. *Assess process*: This stage involves assessing the process targeted for improvement, with particular attention on the defects of the process, and the performance of the process. This makes the area to be improved quite easy.
2. *Identify problem*: This is when the potential problems related to activities that are problematic in the process are singled out, investigated and prioritized. After this the problem with the highest priority is given immediate attention.
3. *Establish causes*: This stage identifies the major causes of the activities that are problematic, and they are investigated and prioritized. The one with the highest priority is selected for suggested solutions.

4. *Propose solutions*: Here a number of feasible solutions for the identified problems are identified. The feasibility, side–effects and cost and benefit analysis of the prioritized solutions are established, and the best solutions are suggested.

The remaining two stages of continuous process improvement by He *et al.* (1996) would not be used because this research project ends at the level of suggesting solutions. The implementation and review of the implementation are left with the management of the factory.

Only the first four stages would be used because of time constraints that will not permit the research project to extend to the implementation stage of suggested solutions, and review of the results for corrective action. With these stages the situation in the factory will be assessed in order to attempt to identify problem areas, and after the identification the areas that could lead to remarkable change in the process will be singled out for analysis. The analysis will permit the research to identify the causes of the problems identified, and with the causes known solutions can be proposed to the factory management. Implementation is expected to follow, and after that there would be a review to assess the success of the improvement program.

2.4 Tools for Continuous Process Improvement

A variety of tools are available for continuous process improvement, and they are often presented as a "toolkit" or combination of tools. At times one is confronted with the problem of choosing which set of tools to use as they seem to promise to deliver the same results. This section will examine the different sets of tools proposed by different authors, and the best of the breed will be selected for application in this research project.

2.4.1 The *Kaizen* Tool Kit

The name *Kaizen* is the Japanese word for continuous improvement. The notion that every activity in the organization can be improved upon on a daily basis to obtain long-term sustainable improvement is the logic behind the *Kaizen* system (Stevenson, 1996; Hill, 2000). The *Kaizen* tool kit contains a number of tools for on-going improvement. These include the following: flowcharts, check sheets, pareto analysis, brainstorming, control charts, interviews, quality circles, benchmarking, cause and effect diagrams, or *Ishikawa* diagrams, run charts and failed-safe methods (Stevenson, 1996).

2.4.2 Tools for Improving Quality

Krajewski & Ritzman (1996), identify the following tools as specially suited for improving quality; checklists, histograms and bar charts, pareto charts, scatter diagrams, cause and effect diagrams, graphs and data snoops. These tools will be able to identify, organize and present information for areas requiring quality improvement.

2.4.3 The Fourteen Japanese Quality Tools

Quality improvement is almost always followed by a reduction in cost. These tools are well established in the manufacturing sector in process improvement. These tools are divided into the Seven Basic Japanese tools for quality control, and the Seven New Japanese tools for quality control (He *et al.* 1996).

2.4.3.1 The Seven Basic Japanese Tools

These old tools include the following: check sheets, histograms, pareto analysis, *Ishikawa* charts, stratification analysis, the scatter plots and control charts.

2.4.3.2 The Seven New Japanese Quality Tools

These new quality tools include the following: the affinity diagram, the relation diagram, the tree diagram, the matrix diagram, the process decision program charts (PDPC), matrix data, and procedure diagram. This project will only deal with the seven basic Japanese tools because they are similar to others proposed by different authors and could be used in this project. The seven new Japanese tools would be left out because they are too sophisticated for this research project.

2.4.4 DTI (UK) Tools for Quality Improvement

These are tools compiled by the Department of Trade and Industry in the United Kingdom. The tools include the following; process mapping, process flowcharting, force field analysis, cause and effect diagrams, CEDAC (cause and effect diagram with the addition of cards), brainstorming, pareto analysis, statistical process control (SPC), control charts, check sheets, bar charts, scatter diagrams, matrix analysis, dot plot or tally charts, and histograms (Department of Trade and Industry United Kingdom, 2003).

2.4.5 SUPER Methodology for Process Improvement

This five-phase business process improvement framework is used for the tackling of process improvement related problems in the manufacturing sector or in organizations in general. This sets out a road map for moving from the current situation to an even much better process if not a world-class performance (Lee & Chuah, 2001). The tools of the SUPER methodology include the following; the problem area matrix, benchmarking, the cause and effect diagrams, process mapping, and pareto chart.

The above tools could be compared in the table that follows.

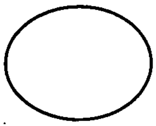
Tools	**Stevenson (1996)**	**He *et al.* (1996)**	**Grütter *et al.* (1996)**	**DTI UK (2003)**	**Lee & Chuah (2001)**
Flow charts	✔		✔	✔	✔
Time Bar			✔		
Check sheets	✔	✔	✔	✔	
Pareto analysis	✔	✔	✔	✔	✔
Histogram		✔		✔	
Cause & effect diagrams	✔	✔	✔	✔	✔
Control charts		✔		✔	
Ask Why 5 times			✔		
Brainstorming	✔		✔	✔	
Interviews	✔				
(PDCA) cycle	✔		✔		
Run charts	✔				
Scatter plot		✔		✔	
Stratification analysis		✔			
Matrix analysis				✔	

Table: 2.2 Comparison of CI Tools

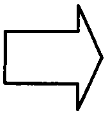
2.5 Description of Some Important Tools for Process Improvement

2.5.1 Flowcharts

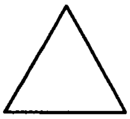
Some authors refer to it as process mapping (Lee & Chuah, 2001). This is a tool used to construct a map of the current activities that are in the present process. It is a visual outline of the key activities in the process that is targeted for improvement. This diagram maps out the different activities in the process according to the sequence of occurrence of the different activities, and it provides details of the different aspects of the tasks. This tool uses a number of symbols to represent different activities in the process flow. These are the symbols (Hill, 2000):



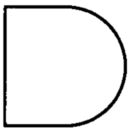
This symbol represents an operation in the process. It can be material, a product, or a piece of information acted upon to change its form or produce an output.



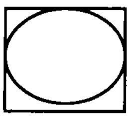
This symbol represents the movement of material, product or information to the next workstation without being transformed in any way or inspected.



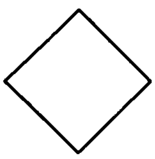
This symbol represents planned storage used for the storage of material, products or information still in the process of transformation into output.



This symbol stands for momentary storage due to work stoppage caused by an operational problem or a bottleneck that interrupts the production process.



This symbol represents two activities; the box represents the inspection of material, product or information for quality, quantity and compliance to specifications, still in the process of production, and the oval inside represents an activity carried out at the same time.



This symbol represents a decision point, such as quality control. It is at this point that a decision is made to send the product for finishing and shipment or back for repairs or rework.

The use of the process flow diagram or flow chart will assist in the assessment of the current process in the factory and the possible identification of the problem areas in the factory. From here an investigation into the problem areas can start leading to information on the frequency and the causes of the problem (Stevenson, 1996; Hill, 2000).

2.5.2 Check Sheets

This tool is also referred to as check lists. It is a data collection tool used to record the frequency of occurrence of particular characteristics related to quality problems. These are characteristics that can be measured by time or length. There are different kinds of check sheets, such as the ones dealing with defects, and the others dealing with the location of defects (these are amongst the frequently used check sheets) (Stevenson, 1996; Krajewski & Ritzman, 1996). Check sheets will help point out the most frequent problems in the area of investigation in the factory, and from here one would know which ones the subsequent investigation will focus on.

2.5.3 Histograms and Bar Charts

According to Krajewski & Ritzman (1996), these are tools used to present the data measured with the frequency of occurrence of the quality characteristics as represented in the check sheets. This will also indicate the mean of the data. Bar charts can also be used in the place of histograms. Any of these tools could be used to establish the occurrence of the characteristics of the problem, and from these analyses a focus on the recurrent ones would help in establishing causes and proposing solutions.

2.5.4 Control Charts

This tool is used for the identification of problem areas in the process, and to find out whether the process is functioning as intended. This is done in order to take corrective action. Where the process is unstable, improvement can be done without changing the level of the system, and where the process is stable only changes in the system level could lead to improvement (He *et al.* 1996; Stevenson, 1996). There are different types of control charts such as; mean control charts used for the monitoring of the central control tendency of the process, range control charts used for the monitoring of process dispersion, p-control charts used to monitor the proportions of the defects in a process and c-charts used for the monitoring of the number of defects occurring per unit (Stevenson, 1996). This is a tool that requires a data series over time, and therefore could not be used in this research project.

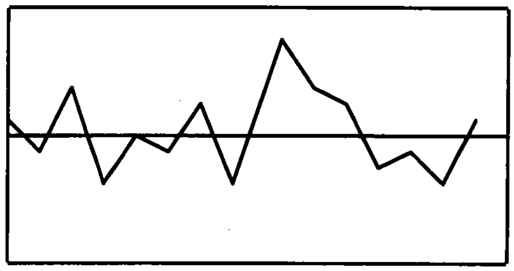


Figure: 2.1 Control chart

2.5.5 Pareto Analysis

This tool is also called pareto charts, named after Vilfrado Pareto, an Italian statistician who formulated the concept. It suggests that a few factors often cause the most effect. It is also referred to as the 80-20% rule. 80% of the effects are caused by 20% of the factors. This tool classifies problem areas according to their degree of importance starting with the most frequent or important ones (Stevenson, 1996). In this analysis it is important to prepare a bar chart that would represent the number of occurrences of the different categories or problems in their order of frequency. This helps in the identification of the biggest losses in the process being analyzed, and would definitely guide subsequent investigation. This tool will be used in this project to identify the problem areas that are worth particular attention, and with other tools such as the fishbone diagram (see below), the causes of these problems could be identified.

2.5.6 Cause and Effect Diagrams

This is referred to in Japan as the *Ishikawa* diagram, named after the Japanese professor who formulated the concept to assist workers in problem solving. It is sometimes also called the fishbone diagram because of its appearance. This diagram helps organize problems–solving efforts with the availability of different categories of layers that may be the causes of the problem. The most important identified quality problem is placed at the 'head' and the major categories of the causes of the identified problem are placed at the 'bones' and the likely specific causes are placed in the 'ribs' (Stevenson, 1996; Krajewski & Ritzman, 1996). The major categories of the causes would be investigated with the specific causes using the "ask why 5 times" approach (see below). This will help to get to the root causes of the problem. Only after such an investigation can solutions be suggested. With the fishbone diagram this research project will identify the causes of the identified problem areas in the factory in relation to their effects. Brainstorming and interviews (see below) are used in the identification of the most important causes of major quality problems that are featured in the fishbone diagram. Here follows an example of a fishbone diagram.

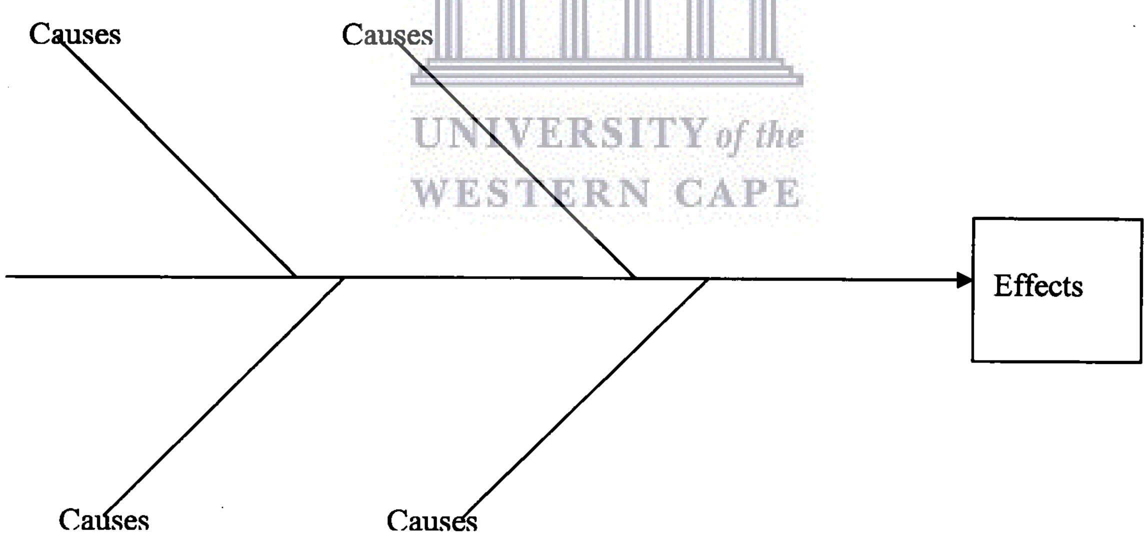


Figure: 2.2 Example of a Fishbone Diagram (Adapted from Krajewski & Ritzman, 1996 & Stevenson, 1996).

2.5.7 Brainstorming

According to Stevenson (1996) and the DTI UK (2003) publication this is a tool used to generate thoughts and ideas about quality problems identified. It can be used after the causes of a problem have been identified with the cause and effect tool. It is often a group tool during which ideas are collected and recorded without any criticism or evaluation till everyone has made an input, then there is a selection and classification of the ideas and thoughts through consensus. It can be used to identify problem areas, identify areas of improvement, design solutions to problems and develop action plans. Because of the absence of groups and teams in the factory the use of this tool would not be possible since it works best in a group environment.

2.5.8 Interviews

This is another tool used to identify problems and collect information about the problems (Stevenson, 1996). This tool could also be used to gather information about possible improvements or solutions to problems. Through interviews the causes of the problems identified could also be gathered. This will be a useful tool to engage in a one on one chat about particular problems especially the ones identified to be originating from that particular operator in the line of production. The person can then give a personal explanation of the reason why the problem occurred, and suggest ways in which the problem could be addressed. This tool is similar in objectives to the previous one, and will be solicited in this project than the previous one because of the difficulty that is posed in the factory getting operators into groups since work groups are not in existence in this factory.

2.5.9 Why–Why Review or Ask Why 5 Times Approach

This is another way of identifying causes of the problem by asking why the problem occurred, and further asking why each reason occurred, in fact why questions are asked five times about the same problem (Hill, 2000). This tool will be used in this research particularly to trace problems that have origins down the line, and the why question will be asked at each operation in which the problem occurs.

2.5.10 Matrix Analysis

This is a presentation of data in rectangular grids, displaying the data from top and down the side. At intersections are placed symbols to make possible the establishment of relationships. This gives a summary of the data and also indicates gaps in information. With an indication of gaps in knowledge it could establish the reasons for such gaps: training or failure to advise concerned persons about what exactly is to be done (DTI UK, 2002). This is a sophisticated tool and will not be used in this research project.

2.5.11 Stratification Analysis

According to He *et al.* (1996), this is a tool used to divide the focus data using the data of different circumstances and that of focus areas to get ideas to identify corrective action. Often used along side tools like check sheets. In this project check sheets would be preferred to this tool because stratification analysis is too complex for this project.

2.5.12 Scatter Plot

This is a tool used to view data set in order to dictate trends and identify operating areas, and at the same time exposing relationship between variables (He *et al.* 1996). With the knowledge of the relationship between variables it becomes easier to establish the causes of problems identified. This tool will not be used in this project because of its sophisticated nature and time constraints.

2.5.13 Matrix Diagram

According to He *et al.* (1996), this is a tabular diagram used for the facilitation of identification of relationships between sets of factors. This tool is very useful for resource planning and sequencing, and prevention of failure. This tool is too sophisticated for use in a simple project like this one.

2.6 Choice of Continuous Improvement Tools

Due to its popularity and acclamation in the manufacturing sector, the *Kaizen* tool kit has become almost indispensable when considering any sustainable improvement in the manufacturing environment, especially when the problems in question are related to work flow. This explains why this research project will make use of a combination of some of the most common and important tools from the different set of tools proposed by different authors (table 2.2) to address problems relating to delays in the manufacturing firm in question. These will be tools that have been consistently used by most of the four authors. These will include amongst others the following: flowcharts, check sheets, pareto analysis, cause and effect diagrams, why and why review and interviews. The others are not suitable for use in this project due partly to their sophisticated nature, their non-applicability within this context and the limited time available for the project. This choice is not much different from the results of the study led by Chapman and Hyland (1997) which indicates that not only did a greater majority of Australian, American, Canadian and European manufacturing firms view continuous process improvement as very important, they were also in a greater number considering and using problem identification tools such as the 'seven basic tools', which comprise most of the tools that would be used in this research project, and very few of them used the sophisticated tools and techniques proposed by other authors.

CHAPTER THREE
PROJECT FINDINGS AND ANALYSIS

3.1 An Overview of the Business Processes in the Factory

A general overview of the business processes in the factory is important to give a high-level overview of what is involved in the manufacturing of garments. A brief outline of the business processes will follow the diagram of the major business processes outlined below.

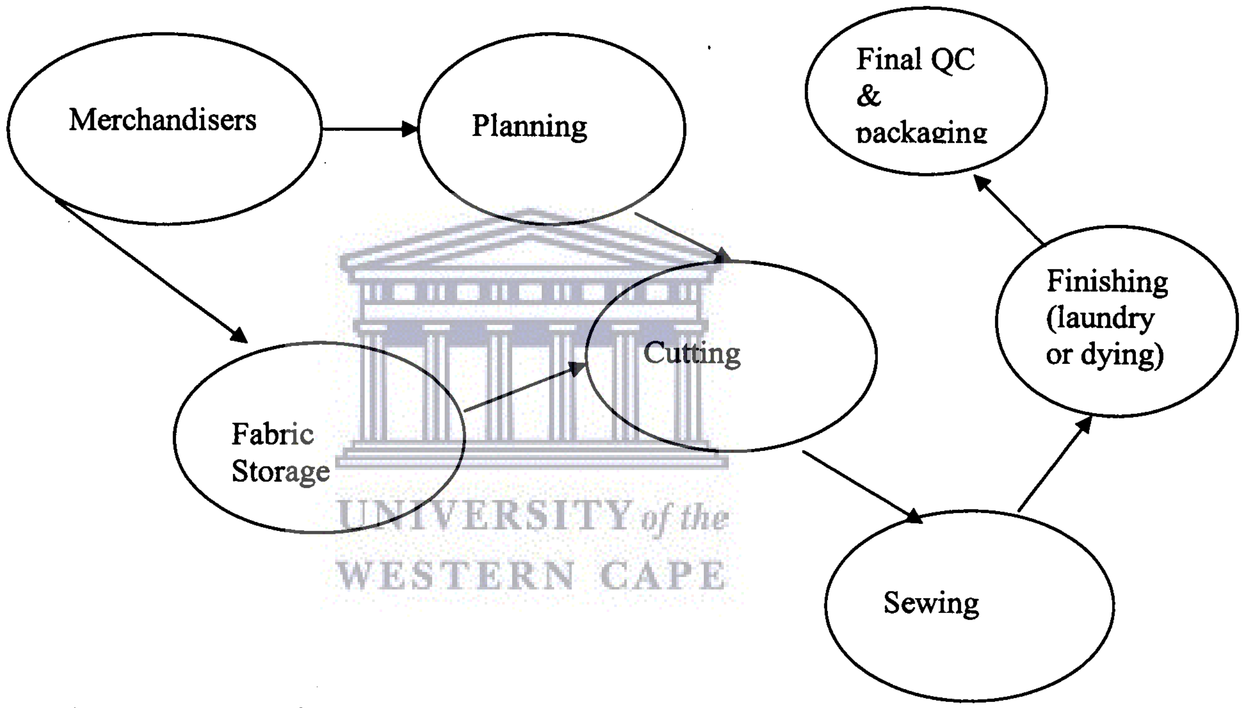


Figure: 3.1 A Diagram of the Major Business Processes

(The arrows in the diagram are an indication of where the process of manufacturing of garments starts and goes through till the garment is ready for dispatch to customers).

- The merchandiser prepares a cutting check and issues it to the planning department. He also makes sure that the storeroom carries enough inventory on the fabric that is needed for the manufacturing of the garment for which a cutting check has been issued.

- The planning department uses this cutting check to plan for production. After planning the marker makers do a lay of the garments in the computer, and then send it to a computerized marker plotter that plots the marker. When plotting of the marker is finished the marker is examined by a marker inspector for accuracies, usage of space, any omissions and for wrong positioning of the garment parts.
- The storeroom dispatches fabric according to the manufacturing batch on request from the cutting room and orders from merchandiser to enable the cutting room to do their job.
- The cutting room depends on markers from planning and fabric from storeroom for their work. When the cutting room receives markers, they are used for the laying of the fabric, and cutting of the garment panels. This is done according to the production schedule of different manufacturing batches. The laying of the garment could either be by the rolling machine or manually depending on the length, and the number of layers that are supposed to be laid. After the laying of the garment, it is cut into different panels. Cutting could either be by a computerized cutting machine or manually. When cutting is finished the garment panels are sorted out into their different parts and sizes by the sorters. During sorting the garment panels are allocated numbers to avoid any mix-up during manufacturing. The denim garment panels are checked for flaws on the fabric after they have been sorted before subsequent transfer to the sewing room.
- In the sewing room the manufacturing of the garment takes place. Here there are two different sections; protective-wear and leisure-wear.
- The manufactured garments are taken to the finishing area, and here the garments are either taken for laundry or for dyeing.

- When the garments have been dyed or washed, then they are finally checked for quality and packaged for shipment.

The business process that will be represented in some details in a process flow diagram will be the sewing process. This is because of the high value adding that sewing has in the whole process of the manufacturing of a garment, and it is likely that most manufacturing problems could come from this business process.

The observation and investigation carried out included the cutting room because the business process immediately preceding the sewing room was also relevant to the investigation.

3.2 Investigation into Production Scheduling Delays

This phase of the investigation will use the continuous process improvement stages or steps of He *et al.* (1996). The steps selected for use here, and the activities in each of these steps are illustrated in the next sections.

3.2.1 Step 1: Asses the Process

The business processes that would be targeted for eventual improvement would be the cutting and sewing processes. This is because they are high value adding activities in the business process, in fact, they are the major or the core activities in the factory, and likely to be the ones with most manufacturing problems.

3.2.1.1 Measurement Used to Asses the Process

At first the measurement was focused on garments panels leaving the cutting room to the sewing room to see whether they arrive in the cutting room on time, particularly that operators are not kept waiting in the sewing room because of the late arrival of garment panels. This method of measurement was problematic because at anytime that one manufacturing batch or another was delayed another one could be sent into the sewing room just to keep the operators busy, and little or no cases of delays could be measured at this point. For this reason it was decided that it would be better to measure delays at the end of production in the sewing room. Then the factory daily status was used, and any manufacturing batch whose due date for delivery has passed or that still had outstanding numbers for completion after the due date, was selected for analysis, and employees concerned were interviewed to establish reasons for the delay.

3.2.2 Step 2: Problem Identification

After the above measurement and interviews with those responsible with ensuring that production batches are completed before due dates, the major problems that were at the cause of manufacturing delays could be established. These problems, in order of frequency of occurrence are as follows:

1. Expediting
2. Quality
3. Planning
4. Fabric
5. Overstock
6. Communication.

The following pareto analysis gives an indication of the problems identified according to their magnitude and in order of priority.

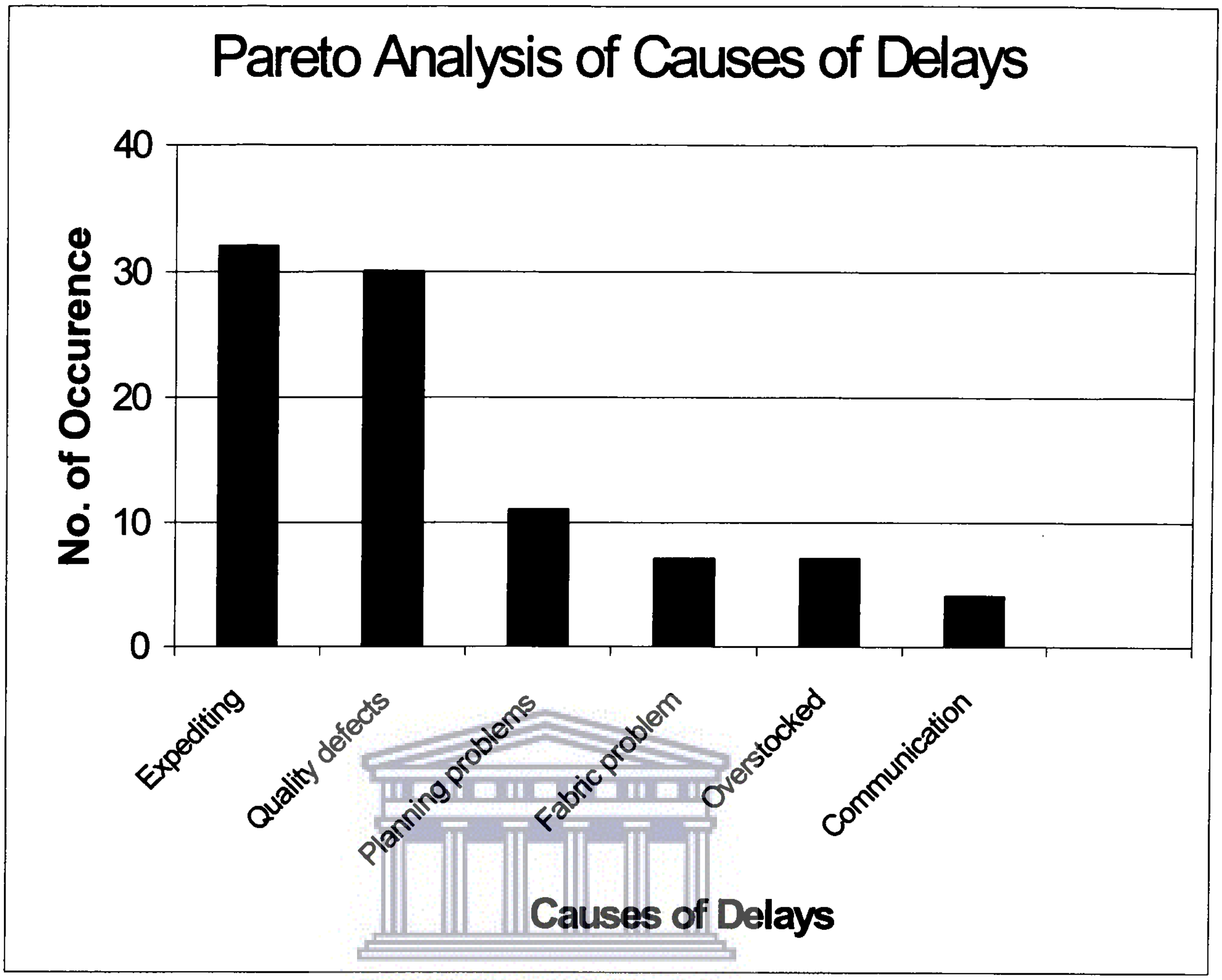


Figure: 3.2 Pareto Analysis of Causes of Delays

3.2.3 Step 3: Establish Causes of Scheduling Delays

After a careful study and analysis of different manufacturing batches for a period of about three months, the following problems have been identified as causes of delays or work scheduling shifts in the factory, (in order of frequent recurrence and the corresponding number of cases): expediting = 32, quality problem = 30, planning problems = 11, overstocking = 7, fabric problems = 7, and communication = 4. These problems are briefly described below.

3.2.3.1 Expediting

This is when in the course of the manufacturing process or part of it a manufacturing batch is interrupted, and kept aside for sometime in order to introduce more urgent work in the line.

3.2.3.2 Quality Defects

This is a situation when the manufacturing process or part of it is not completed due to one of the following defects: sewing, dyeing, laundry, and embroidery.

3.2.3.3 Planning problems

This is when work is not done within planned time, not due to the lack of the necessary capacity or resources, but merely because such capacity is underestimated, overestimated or focused on other work.

3.2.3.4 Overstocked

It is when manufacturing is interrupted because the factory carries enough inventory in that product range to meet its customer demands for an estimated period of time.

3.2.3.5 Fabric problems

This is when the wrong fabric is used or when a fabric is used with flaws, and when after manufacturing, the garment turns out different due to changes in the nature of the fabric after one of the finishing processes like laundry or dyeing.

3.2.3.6 Communication

When work is delayed because of the lack of necessary information or its misdirection.

It is necessary to point out an overlap between expediting and rescheduling since most expediting cases are rescheduled sometime in the future. In the analysis expediting is considered in the place of rescheduling because most of the forwarding of manufacturing batches is due to urgent work introduced in the lines and less prioritized work such as garments destined for the factory shop and Model Replenishing Stock (MRS) are shelved aside. These are garments produced for forecasted regular demand of clients.

3.2.4 Reasons for Investigating Quality rather than Expediting

Expediting has not been investigated further because the factory management looks at it as a strategy to meet up with their seasonal demand, and avoid situations where urgent orders for these products are not met. The quality problem that features second in the above pareto analysis could be further analyzed into different categories of quality defects such as sewing, laundry, dyeing, and embroidery defects. This analysis shows sewing defects as the highest compared to other quality problems. This is evident in the pareto analysis below (see figure 3.3).

It is important to establish the link between the investigation into quality problems and the objectives established at the beginning of this project. Quality problems have been found to be one of the major causes of delays at the end of the production line.

3.2.5 Further Analysis of Delays Caused by Quality Problems

A further analysis of quality defects, which is one of the most common problem, could be represented in a pareto analysis chart as indicated below.

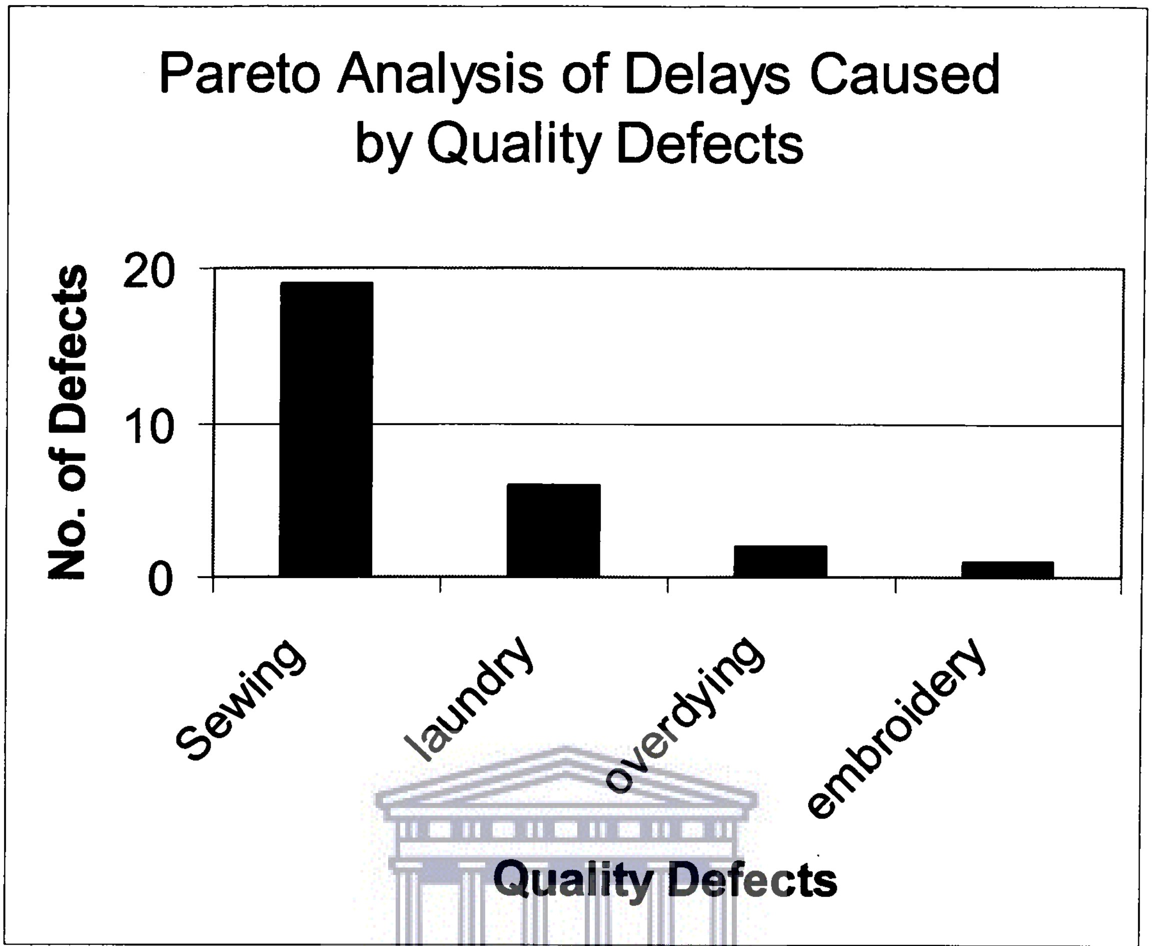


Figure: 3.3 Pareto analysis of Delays Caused by Quality Defects

The pareto analysis above further shows that the major quality problem at the factory is sewing defects which comes out with 19 cases during the period of study followed by laundry defects with 6 cases, dying defects with 2 and lastly by embroidery defects with one case. Thus the investigation would focus on sewing defects, which occur during the manufacturing of the garment, particularly the sewing of the garment. The other quality problems come from outside the factory since laundry, dyeing and embroidery are outsourced, and any investigation into these defects will run into difficulties as regards time and resources to conduct such an extensive research. The next phase of the investigation will therefore focus on sewing defects.

3.2.6 Step 4: Solutions

This step could not be accomplished because the causes of the problem identified are too broad and need a further investigation before solutions can be proposed.

3.3 Second Phase of the Investigation

This phase of the investigation will focus on the sewing defects in the factory. Sewing defects here refer to defects on garments that need repairs after manufacturing, before the garments are sent forward for finishing. Without which the garments would be sent to the factory shop if the defects cannot be repaired, or if repairs would not be able to make the garment meet customer specification.

3.3.1 Action Learning Lesson

In the above investigation there was an incorrect approach of what was measured, and when this measurement was changed it was not realized that the project objectives would not be reached. This is because measuring delays in terms of meeting manufacturing deadlines took the project way out of the objectives set at the beginning (to investigate delays at the start of production of a batch) into measuring delays at the end of production.

It was realized that this misunderstanding arose because the steps chosen for doing the improvement program did not specify that the measurement used must be clearly defined. Also the steps of He *et al.* (1996), do not prescribe the use of a process flow diagram that is very important for the understanding of the activities in the process under investigation. The steps are not as detailed as Grutter *et al.* (1996), and using them could lead to some omissions that would cloud the findings of the project. For instance they are not categorical on aspects like classify data into value adding activities, non-value adding but necessary activities and waste, leaving room for assumptions. As a result of this realization it was decided that the project would proceed with the next phase of the investigation into the major problem identified above using the ten steps of process improvement proposed by Grütter *et al.* (1996).

3.3.2 Data Collection Process

The data collection process could be divided into three phases: the first phase was a period of observation and documentation of the process of manufacturing in the factory, just to get used to activities in the factory and identify the problem area, the second phase was establishing the causes to the problems identified and the last phase was finding out the causes to the particular problem investigated and making suggestions to deal with it.

The first month of the research project was spent attempting to get to know the activities on the shop floor. This was a period of acquaintance and documentation of the operational process in the factory. This was necessary in order to understand what is going on and be able to observe and get involved in the action.

The next three months were spent collecting data to establish the causes for delay of manufacturing batches. This was done by studying the daily production schedule status for batch numbers that were overdue and incomplete or that were still planned for production when their due dates were at hand or already over. Each time such a case was identified the production manager was approached to find out the reasons for this delay. When the reasons were identified a further investigation was carried out to find out why the reasons occurred by interviewing those concerned with the causes to these delays. This was repeated each time a case of delay was identified.

After establishing all the causes for delays it was established that quality defects were amongst the highest causes, and a further investigation was necessary. The researcher had to spend some time observing the quality controller as she inspected samples of manufactured garments to identify defects. During this period the common defects and their frequency of occurrence were recorded. The next phase of data gathering was to find out why these defects occurred. To find out the causes, and make suggestions to overcome these defects, line supervisor of lines controlled and operators who created defects were interviewed each time samples were controlled from that line. At times section supervisors were also interviewed. From these interviews data was gathered about the causes of the sewing defects, and from complaints made by line supervisors and operators, suggestions were formulated for implementation. In all, five line supervisors and about twenty operators were interviewed on different occasions during this process. During the research, section supervisors, quality managers and work-study personnel were also interviewed when supervisors were not of help.

3.3.3 Investigation into Sewing Defects

This investigation would focus in the leisure-wear section of the sewing room. A number of lines would be selected for this investigation, and this includes lines 3, 4A, 7A and 7B.

3.3.3.1 Step 1: Understanding the Activities in the Area of Investigation

In this phase of the investigation it was important to first of all get a general sense of the activities that are going on in the area of the next focus. In order to get a sense of this a process flow diagram of the entire process of the sewing room was drawn up. This process flow diagram is limited to activities in the sewing room, and particularly activities in one line in the leisure-wear section of the sewing room. This is because different garments follow slightly different manufacturing processes, and a process flow diagram of activities in both sections and all the lines would be very confusing and complicated to represent. In fact the investigation could not cover all the two sections of the sewing room or all the lines in the sewing room. Doing so would have been time consuming, and monotonous since problems could be similar in different lines and sections. For the process flow diagram refer to appendix I.

3.3.3.2 Step 2: Identify the Activities that Add Value

Selecting the sewing room, and particularly the leisure wear section, as the area of focus is because of the value that sewing as a business process adds to the whole production process in the manufacturing of a garment. In fact this is the core activity of the factory. It is during sewing that the highest value in the manufacturing of garment is added. In the context of doing an investigation into quality it should be noted that any defects created during the sewing process could be considered waste as rectifying the defects requires production time during which good products could have been manufactured.

3.3.3.3 Step 3: Measurement Used

The measurement used here was observation and recording of defects after the manufacturing of garments in the quality control area that checked garments from lines 3, 4A, 7A and 7B in the leisure-wear section. This involved observing the quality controller, and recording the defects as she checked the manufactured garments for compliance with set quality specifications. This was for a period of five days in the leisure-wear section.

3.3.3.4 Step 4: Collect Information and Do Measurement

For five days in the quality control area the quality controller was observed as she checked manufactured garments for sewing defect, and during this period the different defects that were found were recorded. These defects were further analyzed into the parts of the garments that they are common in.

3.3.3.5 Step 5: Categorize Information

A total of 310 garments randomly selected from manufactured garments already examined by the quality examiner were checked for compliance to quality specifications during the period of investigation. It should be noted that the factory does not fix any percentage of garments to be checked for quality, but from the quantity selected from each batch during that period, one can deduce that an average of 4% of manufactured garments are checked for quality. Of these 310 garments checked 137 had one or more defects. This gives a defect rate of 44.2% of garments selected for quality check. As these were only a few batches from selected lines in one section of the factory this defect rate may not be representative of the overall defect rate in the factory. Most of these garments go back for repairs, but those considered not serious go through for finishing. As mentioned earlier, every defect created is waste.

3.3.3.6 Step 6: Identify Causes for "Non Value Adding but Necessary" and "Waste"

During 5 days of observation in the quality audit area the sewing defects listed below were identified as causes to delay. This is because valuable production time is spent to repair them that could have been spent in the manufacturing of different garments. Thus this activity is non-value adding though necessary to repair the garments, and is absolute waste. In this way production is delayed.

- Stitch faults
- Fraying fabric edges,
- Long threads

- Sewing tension,
- Uneven sewing,
- Labels positions,
- Missing bartacks, and
- Wrong positioning.

These are just some of the sewing defects that were found to cause delay during the period of the investigation, and do not give an exhaustive list of all sewing defects in the factory. The garments that were graded during this period were mostly men's regular fit, dockets, ladies elasticized capris, chevron skirts and over-dyed shorts. It will be helpful to define the above defects in the context used in this investigation. For these definitions refer to appendix II.

A total of 310 garments were checked for quality problems during this observation, and 278 defects were discovered in the garments. It should be noted that 278 is not the number of garments with defects, but the number of defects, and most often there were more that one defect in a single garment. At times even five defects could be found in one garment. For more details on the different sewing defects refer to the check sheets in appendix III. It should be noted that the garments with the most defects were; men's regular fit and the docket manufactured in the highly automated manufacturing section, which are lines 3 and 7A respectively. The most common defects on these two garments were uneven inseam, uneven front pockets, uneven waist-band ends, hem tension, loop position, skewed loops and waist band stitch faults. The ladies chevron skirts, lady's elasticized capris and the over dyed shorts were found to have less defects. This could be due to the difficult manufacturing process of the first two garments.

Many defects could easily be associated with particular parts of the garments, for example; uneven sewing was mostly common with the waistband and the inseam, stitch faults were common in waist band, and at times waist band-ends and inseams, sewing tension was mostly common with the hems, and loops were mostly skewed and in the wrong position.

3.3.3.7 Step 7: Identify the Biggest Losses

The next analysis will classify the sewing defects according to their frequency in occurrence in a perato analysis chart. This will be an overview of all the lines concerned namely line 3, 4A, 7A, and 7B during the period of observation of sewing defects in the leisure-wear section of the sewing room.

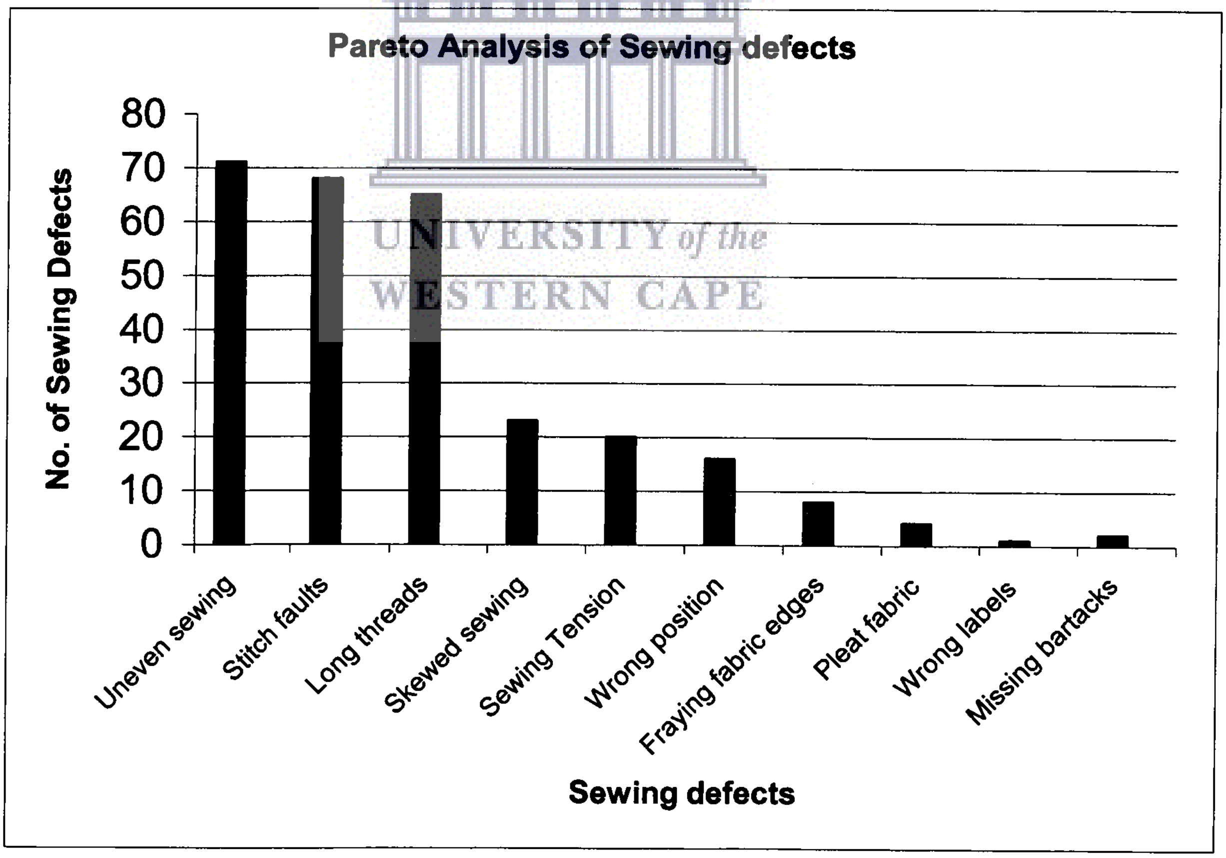


Figure: 3.4 Pareto Analysis of Sewing Defects

The above pareto analysis indicates that the biggest losses as concerns sewing defects in the lines observed in the leisure-wear section of the sewing room are stitch faults, uneven sewing, and long threads, with sewing tension, skewed sewing, wrong position and others not being so frequent, but nevertheless would not be overlooked. Sewing defects such as pleat fabric, wrong labels and missing bartacks (bartacks are repeated sewing on joined garments parts that tension could be exerted on during usage of the garment) are quite rare in occurrence. It is quite important to indicate that almost all of these defects are repaired, and those that can go through are not repaired because of the fact that they are not so serious to be noticed by customers. Uneven sewing faults are quite difficult to repair, and at times could entail unstitching a considerable part of the garment before proper repairs can take place. Stitch faults are relatively easier to repair, and threads are just too easy to eliminate because they can be cut off with a pair of scissors.

3.3.3.8 Step 8: Investigate Improvement Suggestions

This section would investigate the causes of the different sewing defects identified above, and fishbone diagrams will be used to illustrate the causes of the most recurrent defects such as uneven sewing and stitch faults. Long threads would not gain the same attention because the causes are not so elaborate to be represented in a fishbone diagram. The causes of these defects would be briefly examined below with the aid of fishbone diagrams. For details on the causes of sewing defects refer to appendix IV.

3.3.3.8.1 Causes of Sewing Defects

Uneven sewing, which is one of the most common defects, is caused principally by the following factors:

- *Material*: Uneven nips and the nature of the fabric
- *Operators*: At times operators are not attentive, and also handle the fabric badly.

- *Previous operations*: Some operations up the line such as the manufacturing of zips and the nip insertion during cutting could lead to uneven sewing.
- *Time*: High targets lead to a rush to meet targets, and thus poor execution of operations.

The following fishbone diagram represents these causes.

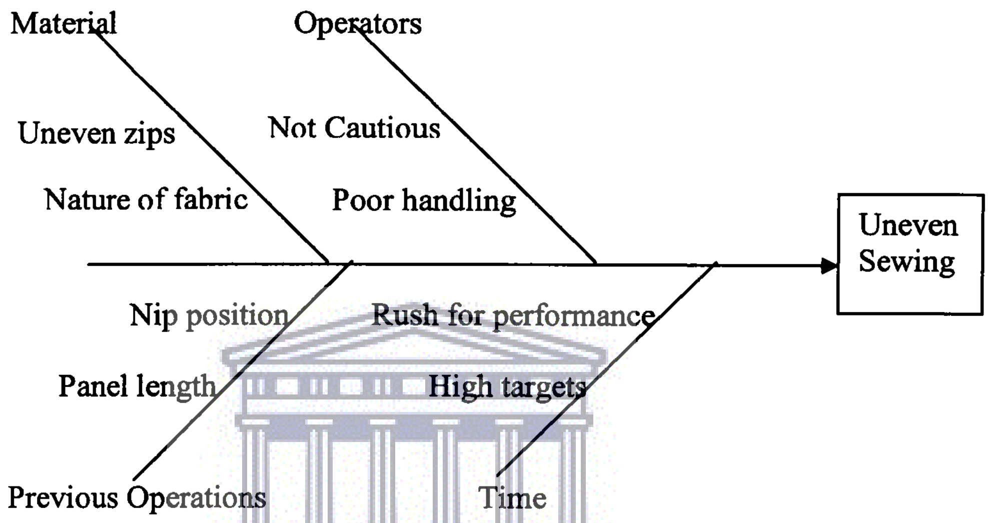


Figure: 3.5 Fishbone Diagram of Causes of Uneven Sewing

Stitch faults could be principally caused by the following factors:

- *Machine*: The malfunctioning of sewing machines has been blamed most of the time for stitch faults.
- *Fabric*: The nature of different fabric has been blamed for some of the stitch faults.
- *Operators*: Stitch faults are also said to result from the negligence of operators, and the way they handle the garment.
- *Planning*: The fact that much production is planned for relatively shorter time leads to unnecessary rush leading to stitch faults.

- *Training*: Operators are not trained sufficiently on quality check, so they often times pass on defective garments to the next operator without a quick check.
- *Usage of accessories*: Needles are available for replacement when those used are worn out, but operators do not make sufficient use of this. Guides are meant to keep operators in a straight line, but the lack of making good use of them leads to slip off stitches.

The following fishbone diagram illustrates the causes of stitch faults.

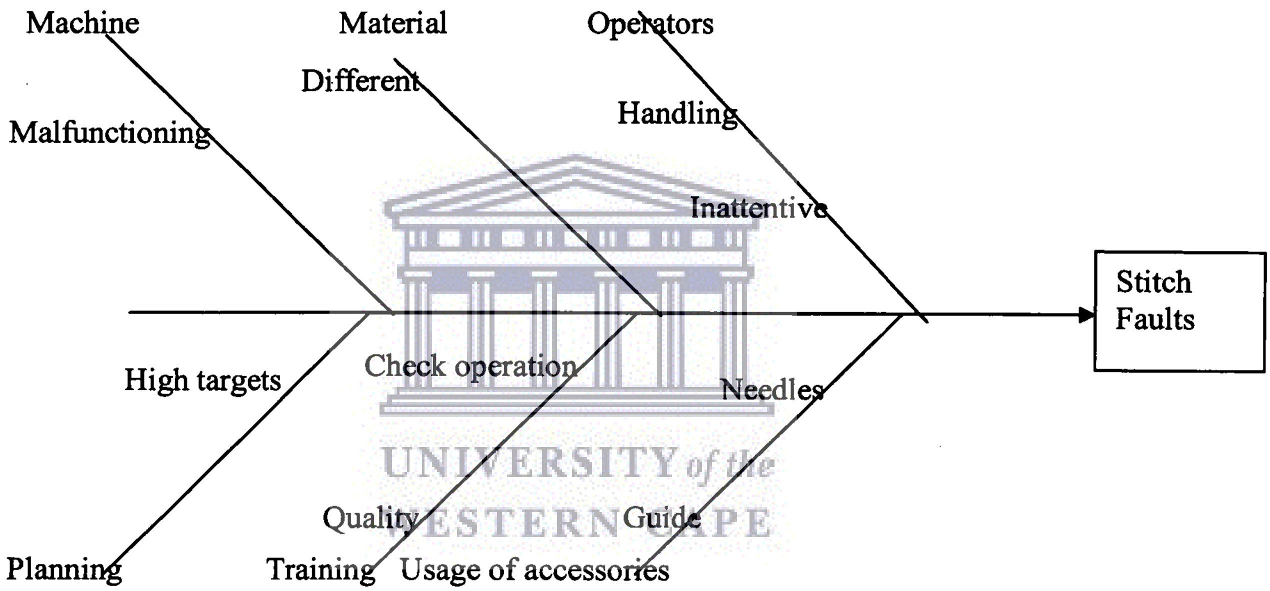


Figure: 3.6 Fishbone Diagram of Causes of Stitch Faults

As the above fishbone diagram indicates the causes of stitch faults can be classed into planning, training, usage of accessories, machine, people and material. These aspects have been briefly examined above.

The rest of the sewing defects such as long threads, fray fabric edge, skewed sewing, wrong positioning, wrong label and missing bartacks are principally caused by negligence and poor handling of garments. Sewing tension is caused by a couple of factors such as malfunctioning of machines or part of them, needles, weak cotton and defective machine parts. (For a detail analysis of causes of sewing defects turn to appendix IV.)

If one could refer to the process flow diagram (see appendix I) it should be noted that the operations that are particularly problematic are operations A, B, and C involved in the making of the front pockets found to come out at times uneven. Operation N also proves problematic because it is here that the waistband is made, and stitch faults and uneven sewing are quite common in this part of the garment. Operation O is also an operation where most problems occur, inseam and loops are made in this operation, and most faults come out in this part. Operation P is also a problematic operation because the hem is rolled here.

3.3.3.9. Suggested Solutions to Sewing Defects

From the interviews with line supervisors and operators some valuable data was gathered concerning the reasons for the occurrence of sewing defects. Operators were also questioned on what they think could be done to facilitate their work and eliminate or minimize the number of defects in manufactured garments. An analysis and interpretation of their reasons for the occurrence of defects, and what they thought can minimize such defects lead to the formulation of the following recommendation as counter measures to the identified sewing defects.

3.3.3.9.1 Stitch Faults

Operators could be trained on identifying when needles are not functioning well in order to change them. With garments that the fabric is hard the interval of changing needles can be reduced and they can be changed more times a day than usual. Machines could be checked regularly, and not wait only for breakdown in order to repair them. Operators should be cautioned to be more attentive when carrying out their operations. Realistic targets should be set taking into consideration their feasibility, and the nature of the garment to be produced. Complex garments should be allocated more time, just as less complex garments should be allocated less time. This will eliminate unnecessary speed during operations. Speed or the rush to meet targets should not in any way compromise quality.

Planning should consider the kind of garment to be manufactured before setting dead lines and setting production targets. This will reduce unnecessary speed that often gives little time for operators to check their operation or do it effectively. It should be made a point of duty for operators to check at a regular interval their activities before passing them over to the next operation to ensure that they do not pass over defects to the next operator, and to ensure that the machine is functioning properly, and that operations are without defects.

Operators should be encouraged to use facilities such as the guide on machines that enable them keep stitch to the right position, thus reducing instances of slip off stitch.

3.3.3.9.2 Uneven Sewing

Operators should be able to know the different material they work with, and to be very careful the way they pull the fabric. If fabric is pulled during an operation especially the one joining the front and back panels of the regular fit it should be made sure that the force applied to both pieces is the same so that the inseam joint comes up in the same position. Also the cutting room should make sure that both the front and the back pieces of the garment are of the same length, or operators should first try to have a look at the two pieces to be joined to ensure that one is not longer than the other before starting the operation.

Operators should be set realistic targets so that they are not obliged to rush over their activities leading to serious sewing defects such as uneven sewing. Also in a rush to meet such targets problems of handling of garments come in. In most cases garments tend to be handled with less care. Operators should be cautioned to be particularly careful at the beginning of operations such as those joining two parts of a garment like the case with the front and back panels of men's regular fit where most cases of uneven inseam were common. They should make sure that they start joining them in an even position, or that if one piece is longer than the other then they should take necessary measures to ensure that the inseam comes up in an even position.

Where previous operations are the cause of uneven sewing defects operators should immediately notify their supervisors that the parts forwarded to them could not help them do their work effectively. Operators should be able to also take responsibility of redressing less serious defects sent into their work-stations, for instance uneven zips could be easily repaired by removing a few 'teeth' from it to make it even therefore saving the waist band ends from uneven defects. Also the nip position that guides the operators to position the inseam or front pocket in an even position should be firstly checked whether it is even before the start of the operation so that in case it is not even operators should know what to do to make sure that the inseam or the other parts of the garment that the nip is meant to guide come up in the same position. If the nip position cannot be corrected by pulling one part of the garment a bit longer than the other in the operation then the operator can then reject that particular garment rather than perform a task that will be repeated later on.

The time set for any particular operation or target set for particular garments should take into consideration the nature of the garment and the ease or difficulty with which the garment can be manufactured. Past records could be of help to know the real time and quantity of a particular style that can be manufactured within a particular set time with minimum quality defects.

3.3.3.9.3 ***Long threads***

This is not a serious problem even though it has one of the highest occurrence rates in the pareto analysis above. Threads can be simply eliminated by emphasizing that the garment examiner at the end of the line be more attentive during that operation, and make sure that the threads are all cut out of the garment. In short he/she should examine the garment thoroughly for long threads.

3.3.3.9.4 ***Sewing tension***

Since sewing tension is caused most of the time by the malfunctioning of the machine or parts of it the machines should be regularly checked for defective parts. Operators should be trained to be able to detect when a machine starts malfunctioning, and to call a mechanic immediately. The cotton, the hook, and the needles should be regularly checked to make sure that they are in good working conditions to avoid cases of sewing tension. Operators working with hems where most cases of sewing tension were reported should be a bit more cautious during this operation, and should regularly inspect the garment before handing it over to the next operator.

3.3.3.9.5 Skewed sewing

Guides placed in machines to guide operators stay within the same distance throughout the garment part should be made use of, and to use them properly operators should make sure the garment is close to the guide and stays in the same position throughout the duration of the operation. The guide will not serve its purpose if operators are not handling the garments carefully, and ensuring that they stay in the right positions. Also it will be important to regularly check parts like loops after the operation to ensure that they are straight, and before attaching parts like loops, operators should ensure that the loops are first of all straight since it was gathered that some loops come in from the "prep" line (line in which small garment parts are manufactured) skewed. When the loops are skewed they should be rejected if something cannot be done to straighten them.

3.3.3.9.6 Wrong Position

Operators should stick to positions where parts are supposed to be attached. Positions of parts commonly misplaced should be marked out more clearly to help the operator not to miss them.

3.3.3.9.7. Fraying Fabric Edge

A careful inspection of every operation will enable the operator to detect cases of fray fabric edges and deal with them immediately. So if handling is more careful fray fabric edge cases can be reduced or eliminated.

3.3.3.9.8. Fabric Pleat

This fault also has to do much with the handling of the garment. The operator should make sure that the garment is well placed on the machine, and is moved smoothly throughout the operation. This will avoid part of the garment folding over the other to cause fabric pleat.

3.3.3.9.9. Wrong Labels

In most cases where labels were a problem it was either because they were missing or wrong ones were attached. It is easy to deal with this problem. Operators need to be more careful, and make sure they attach the right labels in the right garments.

3.3.3.9.10 Missing bartacks

Operators that missed out some bartacks admitted that they merely forgot stitching some of them. In the case where an operator does many tasks, a task completion form could be established to let them tick off each task accomplished just to make sure that they accomplish all the tasks assigned to them. This could be a reminder for forgotten tasks.

3.3.3.10 Step 9. Estimate Improvement

Due to time constraints an accurate estimate of improvement was not possible. However, given the exceptionally high defect rate it should be possible to make a substantial improvement in the quality performance as most clothing factories run at a defect rate below 10 %.

3.3.3.11 Step 10: Implement Recommendations

This research project does not go as far as implementing the recommendations in the factory. This is due to time limitations of the project. Management would be responsible for this step of the research project.

Concluding this section one can say that to address these sewing defects operators need to go beyond their direct production responsibilities to pointing out sewing defects handed over to them or doing something about them if possible. If nothing can be done, then that particular garment or part of it can be immediately sent back to the person in charge of the operation where the defect occurred to correct it before sending it forward. Every operator should be a quality controller of his/her own operation, examining garments for quality after each operation for corrective action before sending them forward. In fact operators should try to get it right the first time.

CHAPTER FOUR

INTERPRETATION OF FINDINGS AND CONCLUSIONS

This chapter would focus on the interpretation and reflection on the findings of the research project as related to the three objectives identified at the beginning of the project:

- The problems found in the factory and suggestions made.
- The use of continuous improvement techniques and the tools that were selected for use; their advantages and disadvantages, and some hindrance to proper application of techniques and tools.
- Experience of doing action research, and the lessons learnt in using this research method.

4.1 Problems Found in the Factory, Suggested Solutions and Further Consequences

The investigation into delays of manufacturing led to findings that quality problems and expediting amongst others were the major causes of delays. These were secondary problems in their own right and needed further investigation to be able to establish the causes of these problems. It was decided that the next phase of the investigation would focus on quality because of the practical nature of quality problems. After an investigation into sewing defects in some lines in the leisure-wear section of the sewing room it was discovered that the following sewing defects were common; stitch faults, uneven sewing, sewing tension, long threads, wrong labels, wrong position, missing bartacks and fray fabric edges. The causes of these problems were mainly poor handling, material, time and machines. After interviewing some operators and line supervisors a number of suggestions were made to address these problems, notably setting realistic targets to operators, training them on basic quality requirements of manufactured garments, advising operators to be more cautious during operations that are problematic, and doing regular preventive checks on machines.

If these suggestions are implemented properly they could have positive effects on other related problems such as:

- *Waste*: With less defects it will be obvious that time will not be wasted in repairs, many garments will not end up as seconds or rejects.
- *Facilitate planning*: It would be much easier to plan for production if tasks are accomplished on time, than plan for production when operators take up much of the time on repairs of previous produced garments.
- *Storage space*: The work-in-progress that is held-up because operators have to attend to repairs of defects leads to the need for storage space. With less defects there will be enough space for storage.
- *Delivery time*: With less defects manufacturing could take its normal time and delivery would not have to be rescheduled.

4.2 Use of Continuous Improvement Technique and Some Hindrances

4.2.1 Use of Continuous Improvement Technique and Tools

The management technique and tools that were used in this research project are not new to manufacturers, but the problem is that they are not used with improvement goals in mind. They are only used as a way of documenting the activities in the factory, and little or no effort is made to use the tools as a way of finding where there are operational problems, and looking for ways to address them. There is activity mapping or flowcharting of activities in the production line, but this is not done with the intention to identify areas where there are manufacturing problems. The most used of these tools are flow-charts, check sheets and pareto charts to monitor production. However, the people involved in this do not go further to do a cause and effect analysis to establish the causes of some problems arising in the analyses, or interview operators to know the problems they face in their operation.

The tools that were chosen for application, that is, process flow diagrams, check sheets, pareto analysis, fishbone diagrams, ask why 5 times effects and interviews were used extensively in this project. The process flow diagram was used to get a sense of the activities in the factory, as well as identify the problem areas in the operations. With check sheets the frequency of these problems was established and the ones most recurrent were identified. The pareto analysis helped in the choosing of the problem that caused the biggest losses, and with the fishbone diagram and interviews causes to these problems were established, and suggestions were made. It should be noted that at times interviews were difficult to arrange either due to the busy schedules of those solicited or because some employees were just too shy to grant interviews (especially those on the shop floor). The 'ask why 5 times' tool was used to trace the root causes of some problems that could be traced down the line (see appendix IV). In general the tools singled out for application were of great use to the project. The other tools were too complex for the project, either because the factory activities made their usage difficult or they could not be used in that particular context.

4.2.2. Advantages of the Technique and Tools

- The technique chosen for application in this research project is a very simple technique, and does not entail any financial investment before proper application.

- The tools are not too strange to employees because they are using them in one way or another though at times without a clear understanding of the specific purpose of the tools.

4.2.3 Disadvantages

- It takes quite some time to realize the results of this technique.
- It needs repetition, because of the incremental nature of continuous improvement.
- The positive effects are not so high in a short time.

4.2.4 Some Hindrances during the Research Project

A number of difficulties could be common with using this technique during such a research project. These could include amongst others:

- Little commitment and low levels of employees participation
- Time constraints
- Changing mindsets

The continuous improvement technique has changed manufacturing in many positive ways. This depends on the commitment to acknowledge that there has been something wrong with the way things were first done, and the willingness to abandon old ways and look at things differently. This improvement approach is quite good and workable where operation activities are documented, and analyzed with the intention to have them improved upon. In the manufacturing environment there is always this difference between what is supposed to be done and what actually gets done, making it difficult for the application of a useful technique like this one.

4.2.4.1 Little Commitment and Low Participation

It becomes quite difficult to get the attention of employees in a busy working environment like a manufacturing concern. Many people look at research activities as not part of their work, and not beneficial to them at all. Worse still, it could be easily perceived as a way of questioning their work or saying that there is something that they are not doing correctly. This feeling or perception makes it difficult to have the full commitment of some employees to a research project like this, thus leading to few of them willing to participate fully in the activities of the project. Particularly when questions are asked about their area of operations there is always the feeling that their quality of work is put into question, and this makes them less willing to share valuable information concerning their operations. Some employees might become suspicious of the motives of the project even when it has been explained to them. This also affects the levels of commitment and participation.

4.2.4.3 Time Constraints

Where employees have tight schedules and targets to meet, time becomes an important factor. People may be willing to assist in the research project, but because they have delivery dates to meet or have missed out on some shipments they do not just have extra time to assist outside research projects. This becomes difficult with projects that are also working within time frames, and at times the project is interrupted because one might get to ask questions on data gathered sometime ago, and the responsible persons have forgotten about that occurrence, and cannot give relevant or useful hints on such occurrences or the information at that point will no longer be valid in analyzing such data because of changes in the situations. At times the problem is already resolved, and there would not be a need addressing a problem that is no longer in existence.

4.2.4.4 Changing Mindsets

Old habits, it is said are hard to abandon. Employees at times become tied down with the way things have been done in the past, especially when there is no major problem with that method. They think of suggestions to change as an indication that there is something wrong with their output, not as a way of searching for even better ways of doing the same thing. With these mindsets in the manufacturing environment it becomes difficult to introduce new techniques of doing things, or get employees to get out of their old ways.

4.3 Suitability of Action Research Method

The research method chosen was successfully applied in the investigation. The following points show how this research method was used:

- The action research process allowed for a great deal of reflection after observation to redefine the problem, and at times one had to change the area of observation and to go through another process of plan, act, observe and reflect in order to redirect research objective and focus. This is in line with the flexible nature of action research.
- The participation of assigned personnel was very useful in gathering information, getting to employees with useful information about the problem investigated, and this contact created a forum for interviews and probing into details of areas investigated. This is the participative nature of action research.
- The cyclical nature of the research was quite obvious during the research in that at certain levels of the investigation one had to come back to start again. Due to the fact that the measurement used at first was not correct because the cutting room has devised a way of dealing with delays of garment panels moving into the sewing room by substituting unscheduled batches with scheduled ones which

made it difficult to measure delays at the start of production, so the measurement was shifted to the end of production in the sewing room.

The simple model for action research (figure 1.1) was adhered to, using it the project framework was formulated, the research method was designed, data collection methods were established and analysis of it and recommendations were made.

4.4 Conclusion

To conclude one can say that this research project met its objectives. An investigation into production delays led to a list of causes of this production problem, such as quality, expediting, fabric, etc. Since these causes could not be all investigated it was decided that quality, which was one of the highest amongst all of them, should be investigated further. With quality referring to a wide range of defects a further analysis revealed that quality problems were classed into a number of defects: sewing, laundry, dyeing and embroidery. Sewing defects was chosen for further investigation because it was the highest and within the factory as contrast to the others that were from outsourced companies since laundry, dying and embroidery. This further investigation was necessary in order to establish the root causes of the quality problem that leads to delays, and propose suggestions to deal with them.

Using the continuous improvement technique and a number of improvement tools such as flow charts, check sheets, pareto analysis, fishbone diagrams, why and why effects and interviews an investigation of sewing defects in some lines of the leisure-wear section of the sewing room led to the fact that sewing defects could be caused by poor handling, machine malfunctioning, rush to meet set targets and wrong execution of previous operation. With the contribution of operators and line supervisors through interviews, and the observations of operators on the lines this problem could be addressed through advising operators to be more cautious during their operations, regular check on machines, basic quality training and eliminating or correcting defective parts handed down to operators.

The success of this project is due to the correct use of the action research methodology, which gave room for so much flexibility, reflection on the approach used, the participation of shop floor workers as well as senior staff in providing information on issues investigated. Using the technique and tools of continuous improvement has been a great learning experience. It must be realized that all tools could not be used for continuous improvement in all manufacturing situations. The cyclical nature of the research method made it possible to stop at certain instances and start the process all over. One thing to note about using this research method is that it needs time because of the cyclical nature of it.

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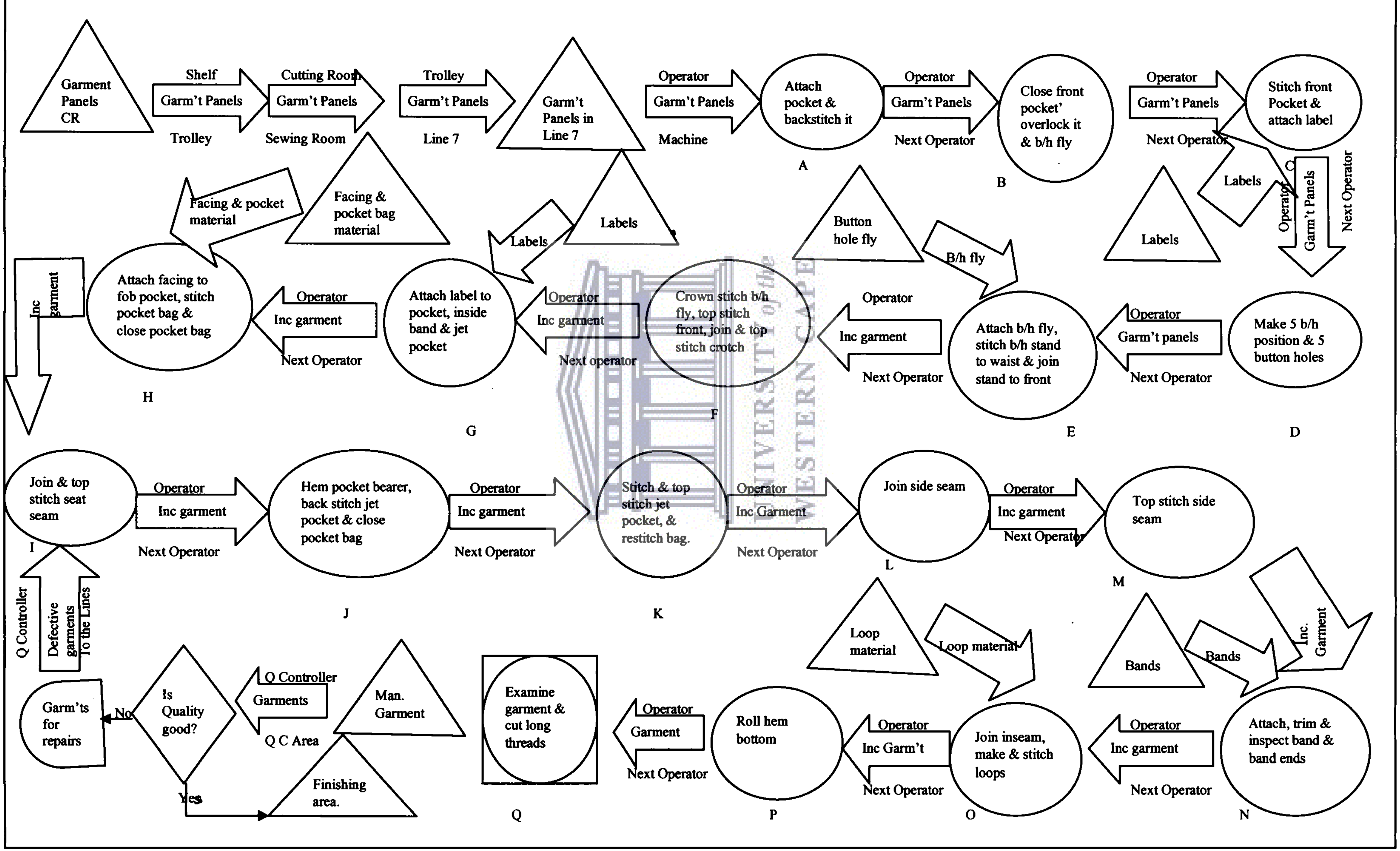
Appendix I: A Process Flow Diagram of Activities in line 7A of the Sewing Room.



Appendix II: Definition of Sewing Defects

Uneven Sewing

This is any case where there are differences in length or position of one part of the garment running onto another where there is a joint. Most areas of uneven sewing are inseams, waist band-ends, front pockets, and sometimes loops.

Stitch Faults

This is when a stitch is wrongly done, and this includes; slip stitches, untidy stitches, and slip off stitches.

Long Threads

These are loose pieces of threads that hang out indiscriminately in the manufactured garment. This is particularly problematic when they are about and above five centimeters long.

Fraying Fabric Edge

This is when a cut piece of garment is exposed without any coverage of any form in the garment.

Sewing Tension

This is when the thread does not hold on to the garment very well, and appears loose or seems to slightly pull that particular part of the garment together.

Skewed Sewing

This is any situation where sewing is not in a straight line or when different parts of the garment are not in a straight line. Most parts of the garment that were skewed were loops, and hem - stitches.

Wrong Position

This is when a piece of the garment is not placed in the right position. Most of the garment parts with such problems were loops and labels

Wrong Labels

This is a situation when different size labels are attached to different garments or when they are completely omitted.

Missing Bartacks

This is when the re-enforcement by repeated stitches in parts of the garment considered fragile such as pocket ends, splits, and other garment joints are omitted.

Fabric Pleats

This is when a garment portion slightly folds over another portion of a garment during stitching.

Appendix III: The Occurrence of Sewing Defects

Check sheets would be established to represent the defects and the days in which they occurred during the observation in the leisure-wear section. These check sheets will be according to the different days of observation and the different lines observed. The check sheets show data of sewing defects observed in the leisure-wear section for a period of five days. The garments observed include dockets, men's regular fit, ladies' elasticized Capri and ladies' chevron skirts manufactured in lines 3, 4A, 7A and 7B.

Line 3A.

Sewing Defects	**Day1**	**Day 2**	**Day3**	**Day 4**	**Day 5**	**Totals**
Stitch Faults	1	2	0	22	14	39
Fraying fabric edge	0	1	0	1	0	2
Sewing tension	0	0	0	0	4	4
Uneven Sewing	9	9	2	4	6	30
Skewed sewing	9	1	1	0	2	13
Wrong Position	4	0	0	1	0	5
Long threads	5	0	8	4	0	17
Wrong labels	1	0	0	0	0	1
Fabric pleats	0	0	1	0	0	1
Totals						**111**

Line 4A.

Sewing Defects	**Day 1**	**Day 2**	**Day3**	**Day 4**	**Day 5**	**Totals**
Stitch Faults	2	0	0	0	2	4
Fraying fabric edge	2	1	0	0	0	3
Sewing tension	1	0	1	0	0	2
Uneven Sewing	8	0	0	2	0	10
Skewed sewing	2	1	0	0	0	3
Wrong Position	0	0	0	0	0	0
Long threads	4	5	0	4	0	13

Wrong labels	0	0	0	0	0	0
Fabric pleats	0	0	0	0	0	0
Missing Bartacks	2					2
Totals						**37**

Line 7A.

Sewing Defects	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Totals**
Stitch Faults	7	6	0	1	1	15
Fraying fabric edge	0	2	0	1	0	3
Sewing tension	1	2	0	0	0	3
Uneven Sewing	8	16	0	4	0	28
Skewed sewing	5	0	0	0	1	6
Wrong Position	9	0	0	0	0	9
Long threads	4	14	0	4	3	25
Wrong labels	0	0	0	0	0	0
Fabric pleats	1	0	0	0	0	2
Totals						**90**

Line 7B.

Sewing Defects	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Totals**
Stitch Faults	3		2	0	5	10
Fraying fabric edge	0		0	0	0	0
Sewing tension	2		3	2	4	11
Uneven Sewing	4		0	0	1	5
Skewed sewing	0		1	0	0	1
Wrong Position	2		0	0	0	2
Long threads	5		0	2	3	10
Wrong labels	0		0	0	0	0
Fabric pleats	0		0	0	1	1
Totals						**40**

Appendix IV: Causes of the Sewing Defects

Causes of Uneven Sewing

This is the highest defect in occurrence during the period of observation. Uneven sewing is when the joining of one garment part does not run straight into the other one, when two attached parts on a garment are not in the same parallel position, or when the allowance allowed between one part of a garment and the other does not remain the same right through. It could become shorter or wider. This is one of the defects that operators spend quite some time to repair because at times it entails unstitching a considerable part of the garment before it could be repaired. Amongst other uneven sewing cases difficult to repair are inseam, front pockets and waist-band ends. Cases of uneven sewing that are not serious are allowed to go through for finishing without repairs. Here follows the different categories of causes of uneven sewing.

1. Material

As far as material is concerned, the operators interviewed and observations on some operations that results in cases of uneven sewing revealed that at times material sent in that work station is not even, meaning that one part is longer than the other, and when the two parts are correctly joined on one end it upsets the position of some joints in the garment. This is very peculiar with uneven inseam in men's regular fit garment. Also some fabric stretches a bit, and when operators pull them during that particular operation it leads to the non-alignment of some joint parts of the garment, this is also common with uneven inseam cases. Uneven zips that are manufactured in the 'prep' line could also lead to uneven sewing defects, in this case uneven waist-band-ends. Operators interviewed believed that at times they receive zips that are uneven, and this could lead to uneven sewing because there is a particular number of centimeters that is supposed to be inserted into the waist-band.

With most front pockets uneven sewing defects there are a number of possible causes, which cannot be directly linked to a particular operation because front pockets result from a series of operations involving a number of operators. The following factors could lead to uneven front pockets; uneven pocket nips, over insertion of garments that holds the front pocket into the waist-band or a failure to measure accurately the length of the pocket by the operator could make one shorter or longer than the other one, and if the size of the waist-band is not accurate it could also lead to uneven front pockets.

2. Previous Operations

Operators and supervisors of lines concerned with such sewing defects said that sometimes the cutting is not correct and it leads to cases of uneven inseam, pockets, waist–bands, etc. During cutting a nip (insertion into a garment to guide the operator to sew the two parts evenly) is not placed in the same position, and since the operator depends on it for guidance it instead misleads the operator, and leads to cases of uneven inseam or uneven front pockets. Also the lines that are drawn on the garment to guide the operator to get joints even are at times not in even positions, and could leads to uneven joints in garments. Operators say that at times some of the parts come in shorter than are supposed to be, and since guides for distances are already set on the machines it leads to some allowances in garments wider than others.

3. Operators

Supervisors as well as some operators on lines where these defects were frequent admitted that at times uneven inseam, pockets, waist–band, etc cases are due to wrong handling of garments. At times the operators do not just get even the first part of the garment sent into the machine and the consequence is that they displace the joint that is in that part of the garment. Some operators and supervisors linked this to the time factor. When operators struggle to keep up performance, sewing defects are the consequences. An operator spoken to after passing over a number of garments with uneven waist band-ends said she could not stop to resize the zips that were the cause of the uneven waist band because she does not want her performance to drop.

4. Time

Supervisors believe that at times the issue of time is a contributing factor to uneven sewing. They believe that most of the time a rush to meet targets leads to operators not just being so cautious during some operations, and as a result such defects occur.

Causes of Stitch Faults

This defect features one of the highest during the period of this observation. Most stitch faults go back for repairs, and it usually entails cutting out the stitches and doing them over again. The following factors could cause stitch faults:

1. Planning

Most of the line supervisor that were interviewed had the impression that some of the stitch faults are because operators are faced with targets that require them to speed up their operations, and in so doing defects are bound to occur. This is because planning sets far too high targets

2. Training

Operators are supposed to quickly check their operations for accuracy and compliance to specification before they pass over the garment to the next operator. In most cases they do not do it, so they cannot know they have passed over a defect to the next operator. This indicates a lack of training to emphasis the importance of the examination or control of an operation carried out.

3. Usage of Sewing Accessories

There exist enough tools to avoid stitch faults such as needles that are available for replacement three times a day. Since most operators interviewed think that needles are at the cause of some stitch faults, this indicates that operators are not making use of this accessory. Also guides are there to keep the stitch to the right position, and if there are cases of slip off stitches it indicates that operators do not make proper use of the guides.

4. Machine

Most operators and supervisors interviewed believed that sometimes machines are the cause of stitch faults. They believed that some stitch faults such as untidy stitches are due to the malfunctioning of machines.

5. People

Stitch faults such as stitch slip offs were generally thought to be the result of poor handling of garment. Each machine has a guide to keep the operator on a straight line, and when the stitch goes out of line it means the operator did not keep it close to the guide. This can be due to no other reason than negligence.

6. Material

Some operators and supervisors interviewed expressed the view that some fabric are hard, and at times needles do not do so well in this fabric. Also the changing of the needles three times a day may at times not be enough to avoid some stitch faults.

Causes of Long Threads

These are threads hanging around the garment that were supposed to be cut off after the manufacturing of the garment. This is just due to the fact that the garment examiner at the end of the entire operation failed to properly check the garments to cut off the threads before the garments go through to the quality control area. Usually this is not a difficult defect to repair because it merely entails cutting out the hanging threads.

Causes of Sewing Tension

This is one of the defects that is not quite frequent, but needs to be paid attention to since it requires repairs. According to the operators who create such defects, and the technician repairing the machines, tension can be caused by a good number of factors amongst which are the following: weak cotton, worn-out machine parts such as the hook, defective needles, cotton out of the tension disk and even the nature of the fabric. Tension was found to be recurrent on the hem of the garment.

Causes of Skewed Sewing

It is not a very serious defect as the first three, but nevertheless needs attention because some skewed sewing need repairs. Skewed sewing is caused by poor handling most of the time, as admitted by a good number of operators. With the case of loops the operators doing the operation claim that some of the loops are sent in skewed from the 'prep' line (line that manufactures most of the small parts attached on garments). A further investigation proved it likely, and the excuse was that loops are most of the time cut out at the edges of the fabric, (because they require thin fabric) and at times the grain of the fabric makes the fabric to be a bit skewed, and this leads to skewed loops. Continuing to ask why down the line the cutting room operators said that loop material would pose problems if positioned somewhere in the middle of the garment because they are too small, and will make cutting difficult.

This is a simple illustration of the "ask why 5 times" tool:

- Why were loops skewed: because they were made skewed in preparation.
  - Why did prep make them skewed: because they were cut skewed.
    - Why was cutting skewed: because material was placed at the edge.
      - Why was the loop material placed at the edge: because loops material is too thin, and placing it inside would affect cutting

Causes of Wrong Position

This defect is caused by wrong handling of garment most of the time. According to the line supervisors interviewed, operators are not just attentive when sewing certain parts of the garment, and that is why they place them in the wrong positions. Parts of the garment mostly affected by this are loops and labels. This defect needs repairs most of the time.

Causes of Fraying Fabric Edge

This sewing defect results from not tucking the edges of cut fabric into closed areas during operations so that it does not appear visible.

Causes of Fabric Pleats

This is not a very serious problem because it seldom occurs, but nevertheless it needs repairs. Most operators admit that this sewing defect is as a result of wrong handling of the garment. If the operators stretch the garment well enough pleats will not occur.

Causes of Wrong Labels

This refers to placing wrong labels in garments. It is not a serious sewing defect because it is not frequent, but it needs repairs. This is caused by negligence on the part of the operators responsible for attaching the labels.

Causes of Missing Bartacks

This problem seldom occurs, and it is merely caused by negligence. Operators interviewed about this defect said at times they merely forget to make the bartacks.