Determining the effectiveness of key performance indicators in a steel manufacturing company

Johan Andries Kritzinger

(Student number 20901798)

Mini-Dissertation submitted in partial fulfilment of the requirements for the degree Master in Business Administration at the North-West University

Study Leader: Prof. J.G. Kotze

Potchefstroom

2009

Abstract

The recent performance of Cape Gate Sharon does not measure up to expectations. This is, to a significant extent, due to the fact that there is no effective measurement and follow-up of performance. The implementation of an effective KPI- based, performance evaluation system, within a balanced scorecard structure, should lead to material performance enhancement in Cape Gate Sharon. This, however, requires significant investment in both capital, as well as management involvement. As a pilot study, it is therefore beneficial to focus initially on the before-and-after-effects of the implementation of the KPI-based performance management within Cape Gate Sharon Wire Mills division. The primary objective of this research is to determine the effectiveness of Key Performance Indicators in the product factories of Cape Gate.
The specific supportive objectives of this research are the following.

- To determine if effective KPIs are measured
- To determine if the implementation of KPIs have been done successfully
- To determine what the effect of specific KPI measurement in Cape Gate is.

The literature study identifies what performance measurement and management is, as well as an in-depth study into key performance indicators. A simple, logical and repeatable closed loop model within a framework is suggested for the implementation of a KPI system. For the purpose of this mini-dissertation, the research is carried out through a process of a document analysis and a data analysis. Available reports are used to determine the current performance measurement system, to determine if effective KPIs were chosen and to determine if the implementation was done successfully. Descriptive statistics were then used to analyse actual production data in order to determine the effect that KPIs have on production. The results of each supporting objective were used to determine the effectiveness of key performance indicators in the product factories of Cape Gate. It is concluded that an effective set of KPIs were chosen for Cape Gate product factories, with the exception of absenteeism. The closed-loop model was implemented successfully and all the required steps were taken. The effect of KPIs was apparent on production, utilisation and downtimes. There is insufficient evidence that an improvement was made on absenteeism and the scrap percentage. This can be contributed to infrequent and delayed measurement of the two KPIs, and the fact that absenteeism is not part of level 2 of the KPI framework.

Table of Contents

List of Figures

List of Tables

CHAPTER 1

OVERVIEW OF THE STUDY

1.1 Introduction

Cape Gate is a wire producer in the steel manufacturing sector. The company has a major share in this sector with a diverse product set. Cape Gate consists of various business units situated in South Africa, Botswana, the United Kingdom, the United States of America and Israel.

Cape Gate Vanderbijlpark is a medium-sized company (± 1600 employees) with four divisions and by far the biggest business unit in Cape Gate. The four divisions are as follows.

- Davsteel, which produces steel billets and rod using scrap steel and DRI (iron ore)
- Oren Marepha, a BEE partnership which produces cable/ropery
- Oren Wire Drawing, which produces wire for Oren Marepha
- Sharon Wire Mills, which produces wire from rod, galvanises it and produces a range of products using its special wire mill and netting factories.

Sharon Wire Mills consists of various sub-divisions delivering different products and services. Each division is dependent on each other, forming a supply chain within the Sharon Wire divisions. The various manufacturing divisions are the following.

- Sharon Wire Drawing
- Sharon Galvanising
- Sharon Netting
- Sharon Special Wire Mills (Chain Link and CG)
- Logistics

Wire Drawing receives rod from the division Davsteel, draws wire from it and delivers it to the Galvanising factories where galvanising takes place. Galvanised wire is then delivered to the netting and the special wire mills. The logistics department is responsible for the planning of machines, material flow, labour flow and all logistics-related operations. If one of these areas does not perform, the entire supply chain is affected, so continuous improvement is very important. To determine if improvements are made and to evaluate if the vision and strategy of the company are translated into action, it is necessary to measure performance on an ongoing basis.

The Balanced Scorecard (BSC) is a performance management tool which originated as a concept for measuring whether the smaller-scale operational activities of a company are aligned with its larger-scale objectives in terms of vision and strategy.

By focusing not only on financial outcomes but also on the operational, marketing and developmental inputs to these, the Balanced Scorecard helps provide a more comprehensive view of a business, which in turn helps organisations act in their best long-term interests.

Organisations are encouraged to measure, in addition to financial outputs, those factors influencing such financial outputs. For example, process performance, market share / penetration, long-term learning and skills development, as well as others.

As a subset of the Balanced Scorecard method, Key Performance Indicators (KPIs) can be used to measure performance in an organisation. KPIs are quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organisation.

The aim of this study is to determine if KPIs are effective in the manufacturing environment of Cape Gate's product factories. A literature study will be done to provide a background on the Balanced Score Card and KPI methodology. An automated KPI measurement tool will be implemented so that empirical data can be collected in an effort to compare actual results with those found in the literature study.

1.2 Problem statement

The recent performance of Cape Gate Sharon does not measure up to expectations. This is, to a significant extent, due to the fact that there is no effective measurement and follow-up of performance. The implementation of an effective KPI based, performance evaluation system, within a balanced scorecard structure, should lead to material performance enhancement in Cape Gate Sharon. This, however, requires significant investment in both capital, as well as management involvement. As a pilot study, it is therefore beneficial to focus initially on the before-and-after-effects of the implementation of the KPI-based performance management system within Cape Gate Sharon Wire Mills division.

1.3 Research objectives

The research objectives are divided into a primary, as well as into secondary objectives.

1.3.1 Primary objective

The primary objective of this research is to determine the effectiveness of Key Performance Indicators in the product factories of Cape Gate.

1.3.2 Secondary objectives

The specific supportive objectives of this research are to determine -

- If effective KPIs are measured,
- If the implementation of KPIs has been done successfully, and
- What the effect is of specific KPI measurement in Cape Gate.

1.4 Research method

This research, pertaining to the specific objectives, consists of two phases, namely a literature review and an empirical study.

1.4.1 Phase 1: Literature review

In phase 1, a literature review is provided dealing with the topic of the study. The sources that will be consulted, include the following.

- Existing literature dealing with KPI applications
- Relevant KPI references on the internet

KPIs are well-documented; accordingly, the literature review should not be a problem.

- It was developed in the early 1990s by Professor Robert S. Kaplan of the Harvard Business School and Dr David Norton, to overcome the problems of using only financial measures in performance management.

- Balanced Scorecard Key Performance Indicators (KPIs) originated from four essential perspectives. Financial, Customer, Internal Processes and Learning & Growth.
- It explores areas for improvements and provides feedback that will lead to continual improvement of strategic performance.

1.4.2 Phase 2: Empirical study

The empirical study consists of the research design, participants, measuring instrument, and statistical analysis.

1.4.2.1 Research design

The specific design that will be used, is a qualitative design with interviews and data analysis. To determine what the effect of specific KPI measurements in Cape Gate is, experimental quantitative design will be used to determine before (without control; pre-test) and after(with control; post test) effects of KPI introduction. Process charts will also be created for each KPI in order to determine each element of such a KPI.

1.4.2.2 Participants

All recorded data of the previous five years will be compared with data that will be captured in 2009.

Production managers of each plant and their foremen have direct influence on the KPIs; therefore, they will be approached to respond in this study.
KPIs will be grouped into the following (3) levels.

- Safety and environment
- Quality, production plan tracking and production efficiency
- Issues related to employees.

1.4.2.3 Measuring instrument

The main objective of this research is, an experimental study. Experimental studies are also known as **longitudinal** or **repeated-measures** studies, for obvious reasons. They are also referred to as **interventions**, because one does more than just observe the subjects. In the simplest experiment, a **time series**, one or more measurements are taken on all subjects before and after a treatment. A special case of the time series is the so-called **single-subject design**, in which measurements are taken repeatedly (e.g., ten times) before and after an intervention on one or a few subjects.

1.4.2.4 Statistical analysis

Descriptive statistics will be used to investigate if there is significant improvement in KPI effectiveness.

1.5 Limitations

There are a few limitations to the study. As implementation only will commence in June 2009, limited results will be available due to delay in the implementation of the KPI system. Because it is a new system, action to implement results, or to take action on results, may take a while. Due to the current economic crisis, production is lower than in the past, and will have an influence on the KPIs.

1.6 Chapter division

The chapters in this mini-dissertation are presented as follows.

Chapter 1 described the nature and extent of the study, including the problem statement and study objectives.

Chapter 2 contains the literature study in which the following aspects are investigated.

- Performance measurement
- Strategic Performance management
- The Balanced Scorecard
- Key Performance Indicators.

Chapter 3 details the research methodology followed for the empirical study presented in chapter 4.

Chapter 4 details the findings from the empirical research. Document analysis was done to investigate the implementation of KPIs. Data analysis was done by means of descriptive statistics in order to determine the effects of the KPI system.

Chapter 5 evaluates and integrates the findings from the literature and empirical studies and conclusions and recommendations are made for a successful ongoing KPI performance management system.

CHAPTER 2

LITERATURE STUDY

2.1 Introduction

This chapter is a literature study on Key Performance Indicators. The first section of the literature study describes the importance of performance measurement. This is followed by a short study of performance management and the Balanced Scorecard. The last section entails a detailed study of Key Performance indicators as a performance management tool.

2.2 Performance measurement

2.2.1 Overview

Kaplan and Norton (1996:1) explain the importance of measurement by comparing measurement in an organisation to the instruments used on an airplane. One would not consider boarding a plane that measures only certain aspects, for example fuel, and not airspeed. Airplanes therefore, have a dashboard of indicators which displays information required to keep the plane on track and in the air with the end goal of reaching its destination. Following this reasoning, managers of organisations should not be satisfied with anything less than a full battery of instrumentation which supplies them with the correct information regarding the environment they are competing in and the current condition of the company to guide them in reaching their goals.

Performance measurement is so important, because it gives an organisation the ability to mobilise and exploit its intangible assets, rather than only investing in and managing physical assets (Kaplan & Norton, 1996:3). Intangible assets enable an organisation to do the following.

- Develop customer relationships that retain the loyalty of existing customers and enable new customer segments and market areas to be served effectively and efficiently.
- Introduce innovative products desired by targeted customer segments.
- Produce customised high-quality products at low cost and with short lead-times.

- Mobilise employee skills and motivation for continuous improvements in process capabilities, quality, and response times.
- Deploy information technology, data bases, and systems.

2.2.2 History of performance measurement

The importance of information measurement becomes apparent without much explanation. Information measurement is not something new as introduced by the information age. Measurement in organisations goes far back in history. In 350 BC Sun Tzu (Niven, 2002:5) concludes.

> "The general who wins the battle does many calculations in his temple before the battle is fought. The general who loses, makes but few calculations."

Although Sun Tzu refers here to calculations made in his "temple", one can be certain that if they used measurement as an organisational and management tool, they would go into battle better armed, prepared and informed. An often quoted statement from Kelvin (Niven, 2002:5) also explains the roots of measurement:

> *'When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of the meagre and unsatisfactory kind '.*

According to Niven (2002:5), the words "meagre" and "unsatisfactory" paint a real picture of the importance of performance measurement. Although Kelvin quoted this presumably 160 years ago, he is already referring to the power and importance of measurement.

Today, the collection of information is even more applicable to organisations. Kaplan and Norton (1996:1) state that for an organisation to be successful in today's competitive environment, it has to adopt a set of new operating assumptions. Organisations cannot act like they did in the industrial age. They have to be cross-functioned organisations that do not specialise only in certain areas. Links to customers and suppliers cannot be done by arm's length transactions as in the past. Information age companies must learn to offer customised products without paying the usual cost for high variety, low-volume operations. Domestic borders are no longer barriers to competition from more efficient and responsive foreign companies. This new set of operating assumptions requires a more comprehensive information measurement infrastructure to know what is working, to manage the mentioned assumptions, to know where weaknesses exist and which processes may need to change so as to ensure the health of the organisation.

2.2.3 Performance measurement as a management tool

According to the IT Performance Management Group (ITPMG) (2007b:4), the most basic benefits derived from measurement, are the opportunities to increase one's knowledge and at the same time to reduce uncertainty; thereby, increasing the accuracy of your decision-making and thus, reducing risk. This is done by making observations by means of measurement and processing these observations into information. The four forms of observations mentioned by ITMG (2007b:4) are the following.

- **Characterisation.** Measurement in its purest form. To describe, to gain understanding and to establish baselines for future comparison.
- **Evaluation.** This is to determine the status with respect to plans. Measurements are the sensors that provide the signals when projects and processes are not meeting targets, so that they can be brought back under control. We also evaluate to assess achievement of quality goals and to assess the impact of improvement.
- **Prediction and preparation.** To predict so that you can plan and prepare. Measuring for prediction involves gaining understanding of relationships and building models of these relationships, so that the values observed for some attributes, can be used to predict others. This is done because one wants to establish achievable goals so that appropriate resources can be applied. Predictive measures are also used to extrapolate so as to reveal trends.
- **Improvement.** To identify roadblocks, root causes, inefficiencies and other opportunities for improvement. Measurements help plan and track improvement efforts. Measurements of current performance provide baselines to compare against, so that we can judge whether improvement actions are working as intended and what the side-effects might be.

The following are important considerations regarding characterisation in measurement Performance measurement must be (Anon., 2006a:4).

- Meaningful, unambiguous and widely understood.
- Owned and managed by the teams within the organisation.

- Based on a high level of data integrity.
- Such that data collection is embedded within the normal procedures.
- Able to drive improvement.
- Linked to critical goals and key drivers of the organisation.

Data collection is important, because most managers would like to work from a point of science rather than from a gut-feeling. Using the information processed from observations, data can be used to scientifically find the cause of a problem or to see if improvement is being made by changing a process. However, collecting the information is only half the job. *Evaluation* is required. Information must be used to track progress to see if plans are progressing. The right information must be available and easily accessible to the right persons. Reports can often evolve around production managers. These reports are in abundance and siloed, which makes it difficult to get a bird's eye view over the processes that these executives are responsible for. If the information is siloed, it cannot be easily viewed or acted upon. If the material is trapped in static computer applications, like spreadsheets, it may be made available to a limited number of employees only. All the reports need to be analysed one by one and the manager or analyst needs to track and drill down through complex data sets so as to find or correct a problem (Malik, 2009:1). It is easy to trace the root of the problem once it is found, but a lag-time occurs between detection and correction.

The value of data is directly proportionate to how fast businesses can react to it (Malik, 2009:1). More than ever, largely due to the current turbulent financial climate, organisations of all sizes need to be on their toes and responsive to the potentially game-changing information they have access to. With the trepidation resulting from the current economic uncertainty looming over the heads of many organisations, it is critical that personnel have the capability to identify how their performance data can be leveraged. Deep understanding of the state of the business today will help to make better decisions for tomorrow. This problem goes right up to the operational manager. The operational manager has to analyse siloed reports of each division in order to measure overall performance. Information needs therefore to be consolidated and results must be displayed so that it can be analysed at a glance. This will enable the organisation to identify issues and initiate a response at a faster rate. The manager will then be able to make accurate and timely assessments of the performance of his factory without the hassle of generating and analysing reports manually.

In the cycle of never-ending improvement, performance measurement plays an important role in (Anon., 2006a:4):

- identifying and tracking progress against organisational goals;
- identifying opportunities for improvement; and
- comparing performance against both internal and external standards.

Reviewing the performance of an organisation is also an important step when formulating the direction of the strategic activities. It is important to know where the strengths and weaknesses of the organisation lie, and as part of the *'Plan –Do – Check – Act'* cycle, measurement plays a key role in quality and productivity improvement activities. The main reasons it is needed, are to -

- ensure customer requirements ***have*** been met,
- be able to set sensible ***objectives*** and comply with them,
- provide ***standards*** for establishing comparisons,
- provide ***visibility*** and a "scoreboard" for people to ***monitor*** their own performance level,
- highlight ***quality problems*** and determine areas for ***priority attention***, and
- provide ***feedback*** for driving the improvement effort.

To use data as input for continuous improvements, performance measurement must be implemented. According to ITPMG (2006b:1), most organisations have not adopted the strategic use of measurement in their decision-making and planning processes. This has given rise to a measurement paradox which shows the majority of managers extolling the use of measurement while only a minority actually implement strategic measurement or performance management programs. Performance measurement can be seen to be concentrated simply on measuring specific activities, rather than measuring them with the aim of providing support and facilitating improved performance, as is the case with performance management (Radnor and McGuire, 2004:245). Performance management can be seen as a more holistic complex system that arose out of a combination of performance appraisals and performance measurement systems (Furnham, 2004:83). With a holistic perspective, effective measurement systems enable executives to take a comprehensive view of their entire landscape. With the integrated perspective that strategic measurement provides, executives are positioned to see how actions taken in one area of the terrain can affect performance elsewhere.

2.2.4 Conclusion

The importance of performance measurement was described in this chapter. There is much to be gained from the use of measurement as a management tool. The application of measurement within the context of a continuous improvement program, replaces "gut-feel" with fact-based information. However, a measurement paradox exists where an organisation is extolling the use of measurement techniques without strategically implanting performance management. An abundance of reports is an example of the measurement paradox. It is therefore, important to shift from measuring performance to strategic performance management. There is much to be gained from the use of measurement as a management tool. The strategic application of measurement will replace the gut-feel with fact-based information not siloed into reports. In the next section the principle of performance management is investigated.

2.3 Strategic performance management

2.3.1 Introduction

The previous section stressed the importance of performance measurement. The focus and contribution of measurement are fundamental to ensuring the success of performance management as a management process (Hough, 2007:191). This section entails an overview of performance management. The key to any organisation's sustained performance is not found in the singular contribution of any of the various processes in the organisation, but rather in their alignment and interaction within the overall system. According to Hough (2007:196), performance management is the key in providing the link between the vision and strategy and the integration of people management processes. Without a vision and strategy, there is no-end result or ideal state to work towards.

According to ITPMG (2006c:7), performance management by definition is an ongoing process focused on the priorities of the enterprise and on improving results through a management system linking strategic objectives, core enterprise strategies, critical success factors and key performance indicators. According to Brown and Armstrong

(1999:152), performance management can be considered as all the processes involved in an organisation to improve its total performance.

Brown and Armstrong state, that performance management has four primary purposes.

- It assists organisations by providing a basis for managing organisations and employee expectations by enabling individuals and organisations to clarify the nature of the psychological contract between them (Argyris, 1960:**7**).
- It provides a framework which facilitates the integration of corporate and individual objectives, beginning with the communication and integration of the organisation's core values.
- It establishes and clearly communicates expectations.
- It provides a development process for the organisation by setting guidelines that assist in establishing future needs and outcomes.

In principle, performance management is a management tool that focuses on the requirements of the key stakeholders and must be able to change and evolve (Anon, 2006c:8). In operation it is a consistent, structured approach and methodology used to evaluate the outcomes of activities, practices and processes at all levels of the organisation.

Performance management makes strategic objectives clear, focuses on core processes and critical variables and signals where performance is headed, providing an unambiguous basis for assessing and rewarding behaviour. Results provide insight into the actions taken by management that both positively and negatively affect the performance of the organisation, thereby enabling the continuous improvement process. Performance management provides the capability to identify critical areas of need, develop the actions necessary to address those needs and assess the results of those actions in the pursuit of continuous improvement and world class performance (Anon, 2006c:8).

2.3.2 Conclusion

The difference between measurement and performance management, is that performance management systems are concerned not only with what is achieved, but also with how it is achieved (Price, 2000:177). In the previous section, the measurement paradox was addressed where the majority of managers propagates the use of measurement while only a minority actually implement strategic measurement or performance management programs. Becoming a measurement-managed organisation can provide the understanding, and control necessary for the success of the continuous improvement process. Implementing performance management can be done with the help of frameworks that have been developed to assist organisations. The Balanced Scorecard is one of the most popular and widely used strategy implementation frameworks and the next section will describe it in more detail (Hassan and Tibbits, 2000:4).

2.4 The Balanced Scorecard

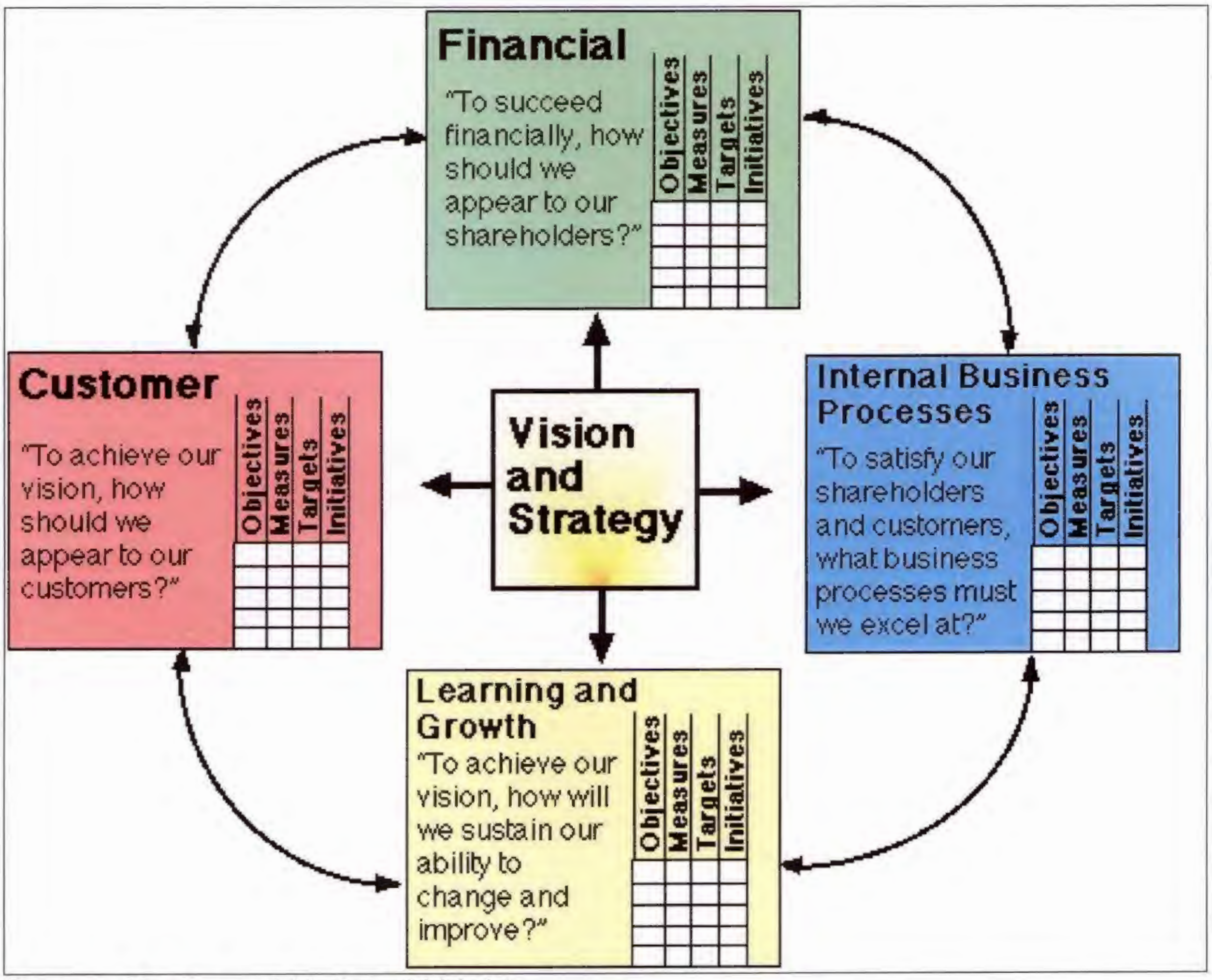
2.4.1 Introduction

Organisations face many hurdles in developing performance measurement systems that truly measure the right things. What is needed, is a system that balances the historical accuracy of financial numbers with the drivers of future performance, while also assisting the organisation in implementing their differentiating strategies. According to Niven (2002:11), the Balanced Scorecard is the tool that answers both challenges.

The Balanced Scorecard was developed by two men, Robert Kaplan, a professor at Harvard University, and David Norton, a consultant also from the Boston area. In 1990, Kaplan and Norton led a research study of a dozen companies, exploring new methods of performance measurement. The impetus for the study was a growing belief that financial measures of performance were ineffective for the modern business enterprise. The study companies, along with Kaplan and Norton, were convinced that a reliance on financial measures of performance was affecting their ability to create value. The group discussed a number of possible alternatives but settled on the idea of a Scorecard featuring performance measures capturing activities from throughout the organisation—customer issues, internal business processes, employee activities, and of course, shareholder concerns. Kaplan and Norton labelled this new tool the Balanced Scorecard and later summarised the concept in the first of three *Harvard Business Review* articles, "The Balanced Scorecard—Measures that Drive Performance." (Niven, 2002:11).

The Balanced Scorecard (BSC) is an organisational performance measurement model that links with the organisational strategy by communicating, implementing and measuring it (Du Plessis *et al.*, 2001:424). The BSC separates itself from measurement in that "...it articulates the links between linking leading inputs (human and physical), processes, and lagging outcomes and focuses on the importance of managing these components to achieve the organisation's strategic priorities" (Abernethy *et al.*, 2005:137). Such a performance measurement model is an effective tool as it lends the organisation the ability to articulate and communicate the organisation's strategy (Abernethy *et al.*, 2005:137). It aims to provide managers with a comprehensive view of the business and allows them to focus on critical areas that drive the organisation's strategy forward (Wongrassamee *et al.*, 2003:18).

Figure 2.1: A Balanced Scorecard Perspective



Source: Kaplan and Norton, 1996:14

Although the Balanced Scorecard was developed as an organisational performance management system, it can be adapted for the lower levels in the organisation to as low as the individual itself (IOMA, 2004:4). This concept is called cascading and can be described as the process whereby the performance efforts of the entire organisation are aligned and integrated. The cascading process ensures that each individual and business unit directly influences the organisation's success (Hough, 2007:193).

The performance efforts of the entire organisation should be integrated in order to achieve organisational success. The different levels of the organisation can be separated into the -

- organisational level,
- business unit level, and on the
- individual level.

According to Chang & Morgan (2000:xxiv), the Performance Scorecard management cycle can be described by the following 6 steps.

- Collection of information from the strategic goals of the organisation.
- The scorecard is then created based on a variety of Key Result areas.
- Cultivate the scorecard by ongoing monitoring based on the targets you have set.
- Cascade the procedures from the organisational level to the individual level.
- The procedures must be connected to individuals.
- Confirm and validate results.

This cycle must be used as part of continuous improvement. Once step six has been finished, the whole process starts over again.

2.4.2 Conclusion

The balanced scorecard provides executives with a comprehensive framework that can translate a company's vision and strategy into a coherent and linked set of performance measures (Kaplan & Norton (1996:3). The Balanced scorecard achieves:

- a common vision for the future of the organisation, and
- provides a general guide to commitment of long-term sustainability.

The importance of the Balanced Scorecard and performance management was explained in the previous sections. The next section entails a literature study of a performance management tool, namely Key performance indicators (KPIs).

2.5 Key Performance Indicators

For a successful performance management system, it is required that performance be linked to the strategy and vision of the company. In order to create this link, one requires a Key Performance Indicator (KPI) profile which can be used as a standard for the alignment of the organisation's strategy and performance objectives.

2.5.1 Definition of Key Performance Indicators

According to Pekeliling Kemajuan Pentadbiran Awam (Malaysia *et al.*, 2005:17), Key Performance Indicators are referred to as a basic performance measurement. Another definition comes from a business measurement expert, David Parmenter (2002:5). He defines KPIs as "...quantifiable measurements, agreed to beforehand, that reflect the Critical Success Factors of the company or (departments or projects)". Masilamani (2005:10) presented her definition of KPI as "...a relative measure of the performance of an organisation". KPI can also be used to indicate the performance of specific and focused activities in the organisation which could directly affect the value of that organisation.

Pekeliling (Malaysia *et al.*, 2005:17) looks at a KPI as something that one can measure continuously. Another aspect is that KPIs must be few in number, probably less than ten. He also believes that in order to do well in performance measurement, the company needs to understand its critical success factors so that it may increase repeat business with key customers. Furthermore, Pekeliling averred that, "...one of the main distinguishing characteristics of a true KPI is that it is monitored on a daily basis... by the senior management team..."

2.5.2 Key Performance Indicators in practice

Key Performance Indicators represent a set of measures focusing on those aspects of organisational performance that are the most critical for the current and the future success of an organisation (Parmenter, 2007:3). According to Hough (2007:196) the KPI profile describes the outputs (results) expected of the individual, i.e. what he/she must achieve to be successful in the particular role/position. It also explains how the individual will know whether he/she has successfully achieved his/her objectives.

A set of KPIs will therefore, be effective in coordinating and directing action within an organisation. The KPIs reflect a balance between cost, quality, quantity and time. Balanced measures provide insurance of one KPI working against another. These indicators must therefore, be critical factors which can immediately alert the manager if something goes wrong, so that he can react to it.

As mentioned earlier, KPIs are a performance management tool, containing basic elements of measures and targets. The application of KPIs will assist an organisation to be focused on key areas where performance is critical for achieving the vision, mission and objectives of the organisation. Performance needs to be measured and KPIs provide the link to shift between performance measurement and strategic performance measurement. The act of simply measuring performance would not provide a proactive perception of goal and strategy achievement. Likewise, KPIs do not have meaning, unless they are linked to an evaluation system (Seang, 2003:1).

KPIs are quantifiable measurements that gauge the outcome of a critical success factor, goal and objective or performance (Bauer, 2004:1). KPIs do not often change, as it is usually long-term considerations. The definition of the KPI must stay the same from year to year. Critical success factors (CSFs) focus the attention on the key dimensions of performance that the enterprise must excel at if it is going to achieve its goals and meet customers' requirements (Anon., 2007a:9). Limited in numbers, CSFs emphasize the activities and processes that will have the greatest impact on performance that will drive accomplishment in supporting areas.

David Parmenter (2002:4) believes that in order to do well in performance measurement, the company needs to understand its critical success factors so that it may increase repeat business with key customers. He adds the following KPI characteristics from extensive analysis and from discussions with over 1500 participants in KPI workshops.

- Nonfinancial measures (Not expressed in a currency).
- Measured frequently and continuously. KPIs should be monitored 24/7, daily or weekly. A key performance indicator cannot be a key factor if it is monitored well after a problem has occurred. If a key performance Indicator is going to be of any value, it must be defined and be measured frequently.

- Acted on by the CEO and senior management team.
- Understanding of the measure and the corrective action required by all the staff.
- Ties the responsibility to the individual or the team.
- Significant impact (e.g., effect most of the core critical success factors and more than one balance scorecard perspective).
- Positive impact (e.g., effects all other performance measures in a positive way).
- Key Performance Indicators must be few in number, probably fewer than ten.

Indicators identifiable as possible candidates for KPIs, can be summarised into the following sub-categories.

- **Quantitative indicators,** which can be presented as a number.
- **Practical indicators,** that interfaces with existing company processes.
- **Directional indicators,** specifying whether an organisation is getting better or not.
- **Actionable indicators** are sufficiently in an organisation's control to effect change.
- **Financial indicators,** used under performance measurement and when looking at an operating index.

2.5.3 Why Key Performance Indicators should be used

Reh (2005:1) states that KPIs will help an organisation define and measure progress towards organisational goals. Once the mission statement has been analysed, stakeholders identified, and goals defined, KPIs are set in place so as to measure progress towards goals. KPIs are a performance management tool and they should not just act as visual metaphors. The developer should understand what constitutes KPIs that could deliver a long-term value-added tool to the organisation.

KPIs reflect strategic value drivers (Eckerson, 2004:1) to achieve organisational goals. Value drivers mean activities that, when executed properly, guarantee future success. Value drivers could help an organisation to move in the right direction in order to achieve its organisational goals, for example, high customer satisfaction or excellent service quality. KPIs, in most cases, are non-financial. It can never be a monetary measure (Parmenter, 2007:89). KPIs are "leading" and not lagging performance indicators.

The value of data is directly proportionate to how fast a business can react to it. An organisation needs to be responsive to the information they have access to. It is important that the person responsible needs to have the capability to identify how they are performing so that they can react to it.

KPIs are quantifiably based on valid data and standards. Most organisations have their own set of metrics and standards for performance measurement. But it can take organisations months and maybe years to come up with the end results. Therefore, with the use of KPIs, the existing sets of indicators could always be quantified as relevant to the organisation's need. However, it is important to accurately define the KPIs and maintain the same definition in consecutive years. It is important that the KPI is understood by those who are concerned and have the authority to take specific action to accomplish their targets (Parmenter, 2007:89).

A major benefit of KPIs is that the key issues are addressed and by using a dashboard, the results are visible. They do not need to analyse rows of data on spreadsheets or reports to come up with the same result (Anon., 2009:2). When an outcome is monitored and trended with a KPI, the resulting figure tells one the process performance effectiveness. The KPI should be an accurate, honest reflection of the process efficiency in delivering the outcome. With a reliable KPI measure of performance, the effect of a change made to a process, or a new strategy implemented, is then reflected in the KPI results produced. KPIs can offer many perspectives on an event. It can permit intense focus and scrutiny, it can detect changed conditions, it can score performance, it can indicate a change from plan, it can detect potential problems and it can drive improvement. Change to a certain operation can be monitored and the reflected KPI will echo if the change improved the result. Once the effects of a change can be monitored reliably, repeatably and accurately by KPIs, it is reasonable to use the KPI as a tool to improve the ongoing process performance. Simply introduce the test change into the process and monitor its effect with the KPI. Keep those changes that work and discard those changes that do not produce suitable results (Anon., 2009:2).

A KPI can be used to closely monitor the results of actions. When it is not certain that a result is due to a specific set of plans and actions it is useful to introduce KPIs to detect and track what is happening. KPI measures that are thought to be appropriate, can be trended over a period of time, and in different situations, to see if they, in fact, do highlight the relevant factors that are truly important to the successful outcomes from the actions. KPIs lead to positive actions and provide the key to organisational success. KPIs should generate the intended action and thus, improve performance. Only those factors that are essential and critical to the organisation reaching its goals, are selected. It is important to keep everyone's attention focused on achieving the same KPIs. How to motivate people to reach the KPIs targets? The top management could use KPIs as a carrot. Post and show the progress of KPIs everywhere in the organisation such as the main entrance, pantry room, on the walls of hallways, meeting rooms, staff areas, or even on the organisation's website. The future success could be realised if the top executives give their full commitment. When KPIs cascade throughout the organisation, it will enable everyone to march together on the right path (Parmenter, 2007:85).

2.5.4 Pitfalls of KPIs

In practice, overseeing Key Performance Indicators can prove expensive or difficult for organisations. Some impacts, such as staff morale, may be impossible to quantify. Another serious issue in practice, is that once a KPI is created, it becomes difficult to adjust to changing needs as historical comparisons will be lost. Conversely, a dubious KPI is often created because history does exist. Furthermore, if a KPI is based only on in-house practices it may be difficult for an organisation to compare with similar organisations; yet often, businesses with similar backgrounds are used as a benchmark for KPIs (Anon., 2007b:11).

a) Pitfalls when developing KPIs (Anon., 2007a:11)

- Measures not linked to strategy from above. Critical to do initially, but also revisit when either the organisational strategy or structure changes.
- Measures not driven into organisation from below. Breaks the linkage with overall strategy. Should be driven into staff performance agreements at all appropriate levels.
- Too many measures. Create lack of focus on what is really critical to managing the business (includes compliance-related measures).
- Not enough critical measures. One could be missing information vital to operations.

- Focusing only on the short-term. A cross-section of past (lagging), present and future measures is critical.
- Conflicting measures. Sub-optimizes staff or organisational performance. Example: Measuring reduction of office space per staff member while also measuring staff satisfaction with facilities.

b) Pitfalls when monitoring progress (Anon., 2007a:11)

- Measuring progress too often. Could result in unnecessary effort and excessive costs, resulting in little or no added value.
- Not measuring progress often enough. May not know about potential problems until it is too late to resolve easily.
- Collecting too much data. Could result in a mountain of data that really doesn't tell us anything more than to a lesser amount of the same data.
- Collecting inconsistent, unrepresentative or unnecessary data. Critical to understand what the data will look like, when it will be collected, at what frequency, by whom and what it means, up front.

c) Pitfalls when evaluating data (Anon., 2007a:12)

- "Dumbing the data" (i.e., reducing the value of impactful data). Too much data roll-up (summary) can mask the impact of potentially significant events or trends.

d) Pitfalls when determining improvements (Anon., 2007a:12)

- Driving the wrong performance. Be careful that the measure(s) you select will result in the desired result. Remember the "law of unintended consequences".
- Encouraging competition and discouraging teamwork. Measuring vertically (stove-piping) frequently pits one internal organisation against the others. Try to measure horizontally.
- Failure to base business decisions on data. Developing performance measures or collecting data only to comply with a requirement, does nothing to improve the position of the department, organisation or enterprise.

e) There are a few things that will help to make one successful (Anon, 2007a:12):

- View value through the eyes of the customers and measure IT in terms that are meaningful to them.

- Use organisational critical success factors to focus the measurement process.
- Establish clear linkages to provide a visible chain of evidence to current agency value.
- Measure IT capability and agility to add future value.
- Communicate the results to all stakeholders.

2.5.5 KPIs in the manufacturing environment

2.5.5.1 Introduction and overview

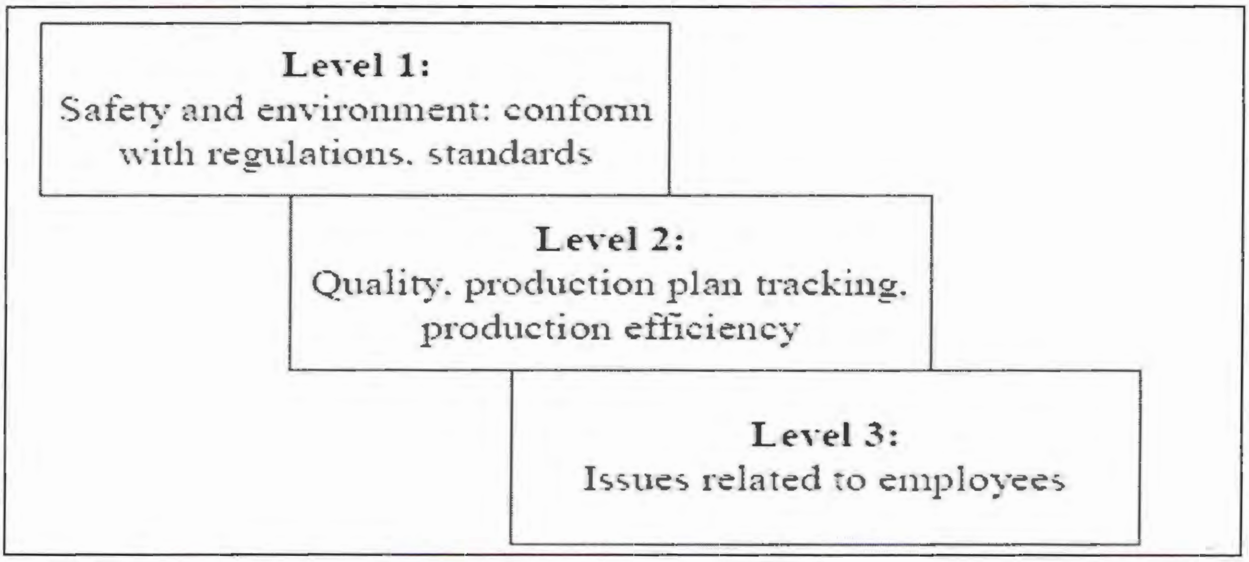
In the previous sections, the importance of measurement and the role of KPIs has been described. This section focuses on KPIs in the manufacturing environment. An essential requirement for tracking set goals, fulfillment is a suitable choice of performance indicators for assessment of production performance (Lohman, 2004:11). Some of these measurers are general and valid for all of the production processes, while others are specific and relate to a particular property of a specific production process. The choice of measures depends also on available resources and time assigned to the implementation and execution of measures (Rakar, 2004:4). The enterprise can utilise various tools and techniques for measuring the efficiency of the production process. As a production process becomes more complex, the availability and exchange of information become more critical to the efficiency of the business. The correlation of planning, production, sourcing, distribution, finance and work force information in near real-time is a proven way to empower both management and staff to reduce cost and increase production efficiency (Anon, 2006d:1).

KPIs are detailed from a top-down perspective, from the plant manager to the production supervisor, and then aligned with plant operations from the bottom up, starting with the production supervisor up to the plant manager. This alignment of KPIs is used to produce a balanced and consistent window through which the business can be viewed (Anon, 2006d:1). According to Rakar (2004:4), production has to -

- meet certain security requirements,
- effectively use given resources of energy, material and resources, and
- meet basic needs and requirements of workers to be able to run smoothly.

Not all the requirements are equally important. Performance indicators are therefore, organised in a three-level hierarchical structure. The significance of this structure is that the company starts defining and implementing key and simple indicators and processes towards more complex ones.

Figure 2.2: KPI Framework

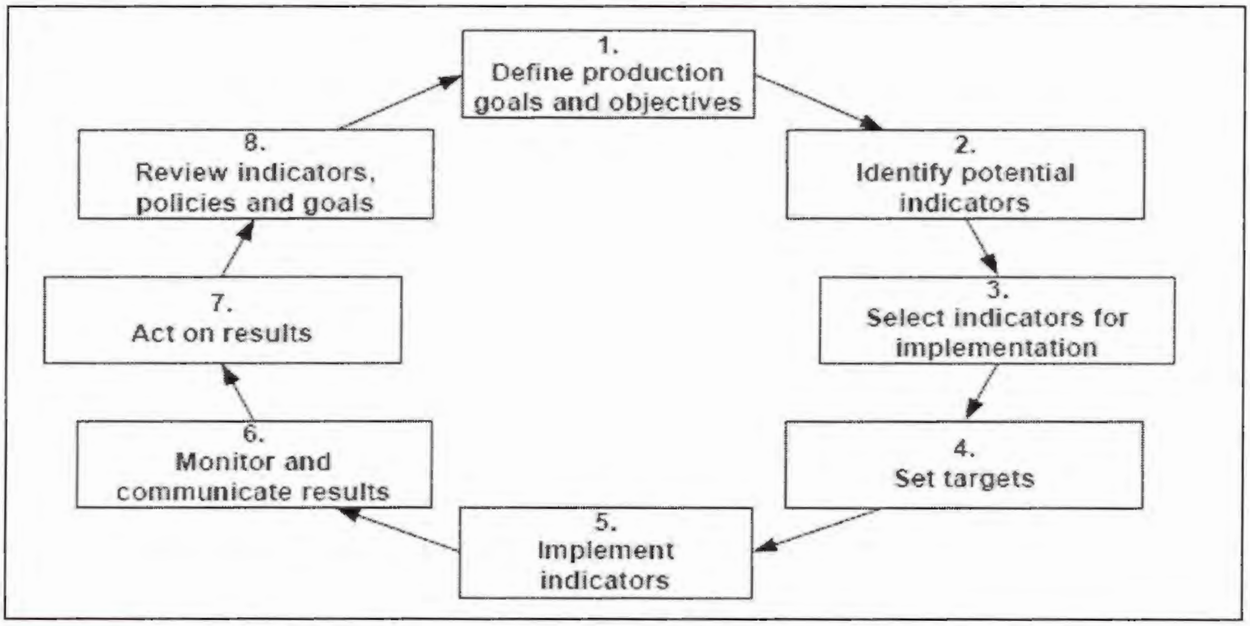


Source: Rakar, 2004:4

According to Rakar (2004:4), levels are sorted according to their importance. The First-level is characterised by safety and the environment in the sense of conformance with regulations and standards, as the production cannot run if these requirements are not met. The second level consists of indicators related to quality, efficiency and production plan-tracking. The last level deals with manpower requirements. The KPIs should be implemented starting at level one, which is the most important level, and then downwards to level two.

The following closed-loop supplied by Rakar (2004:5), can be used to introduce KPIs.

Figure 2.3: Closed-loop model for defining and measuring production KPIs



Source: Rakar, (2004:5)

2.5.5.2 Define production goals and objectives

This involves defining production goals and objectives that may reflect a company's mission. They should aim to meet and address all key aspects of an organisation's activities and encourage the employee's involvement in decision-making.

2.5.5.3 Identify potential indicators

This involves the identification of potential indicators to reflect production goals and efficiency. It is recommended that many core indicators must be used. The KPIs will be used to gauge production at a glance. KPIs must reflect the organisational goals and be quantifiable with existing data or combinations of existing data. KPIs must form the key to organisational success (Anon, 2006d:2). Kaplan and Norton (2001:103) emphasise the importance of creating KPIs from an effective performance system model. KPIs that are not linked to strategies, become a dangerous illusion of critical success factors.

In selection of KPIs, the following three areas should be considered (Seang, 2003:2):

- Productivity
- Total Quality
- Competitiveness

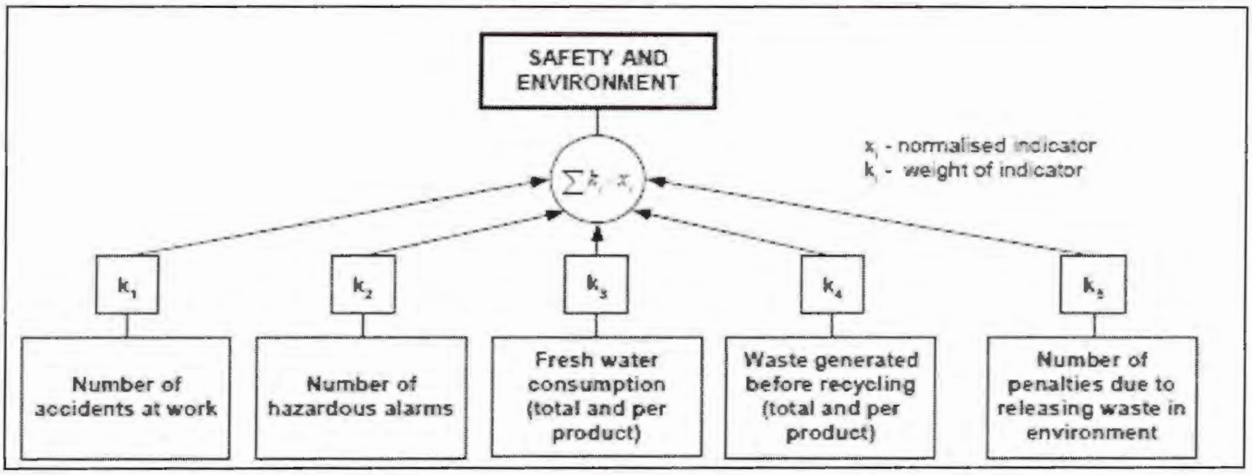
According to Rakar (2004:6), safety and the environment and issues related to employees should also be included. Using the three-level hierarchical structure mentioned earlier, potential indicators can be selected based upon the following, which includes the KPIs mentioned by Seang.

- Safety and the environment
- Quality, production plan-tracking and production efficiency
- Issues related to employees.

a) KPI: Safety and the environment

These KPIs are of strategic importance for further growth of the company, as it is regulated by various standards and regulations.

Figure 2.4: Schematic view for deriving safety and environment indicators

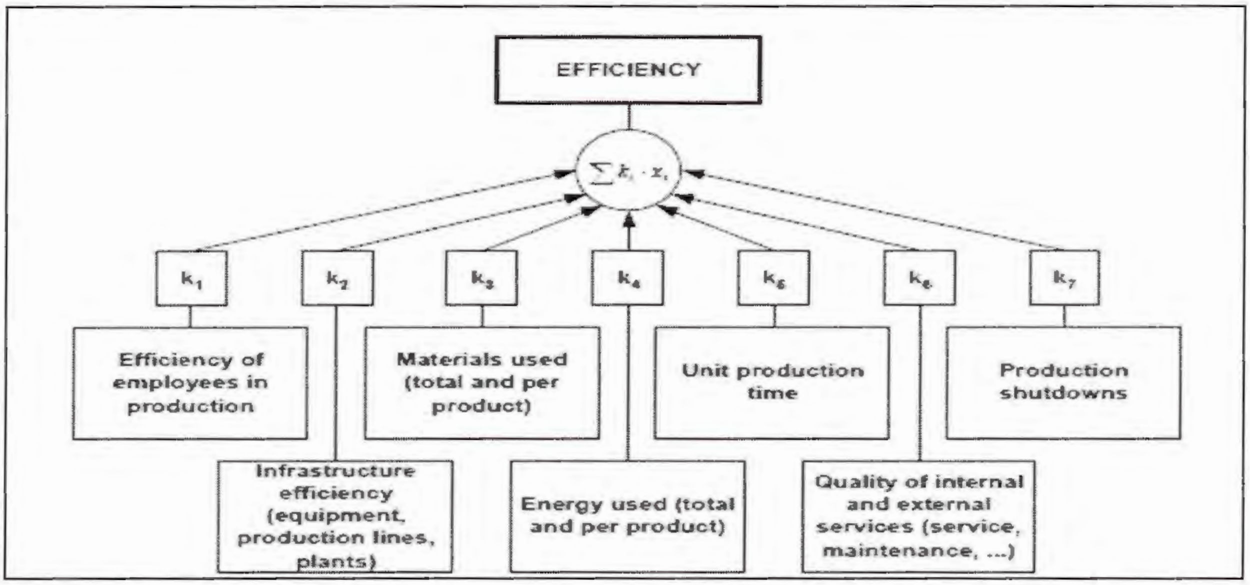


Source: Rakar, (2004:7)

b) KPI: Efficiency

Efficiency can be divided into several segments according to plant structure and other significant factors. Figure 2.5 shows possible theoretical indicators for efficiency assessment.

Figure 2.5: Schematic view for deriving efficiency indicators

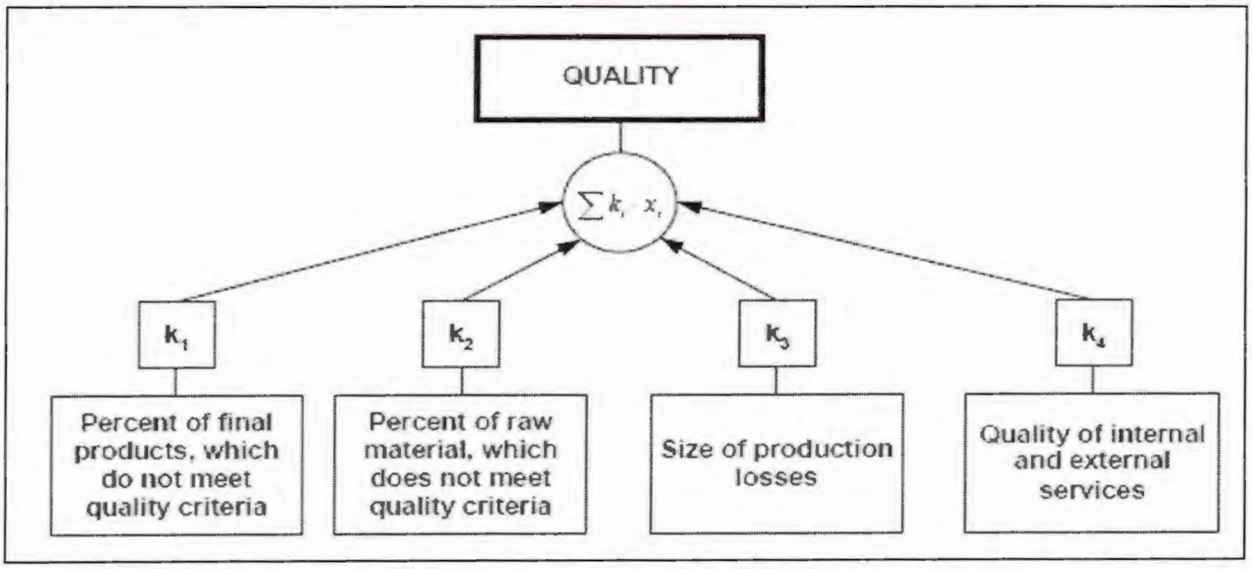


Source: Rakar, (2004:7)

c) KPI: Quality

Quality plays a significant role in the production environment. It is related to materials used, final products, production processes and services.

Figure 2.6: Schematic view for deriving quality indicators

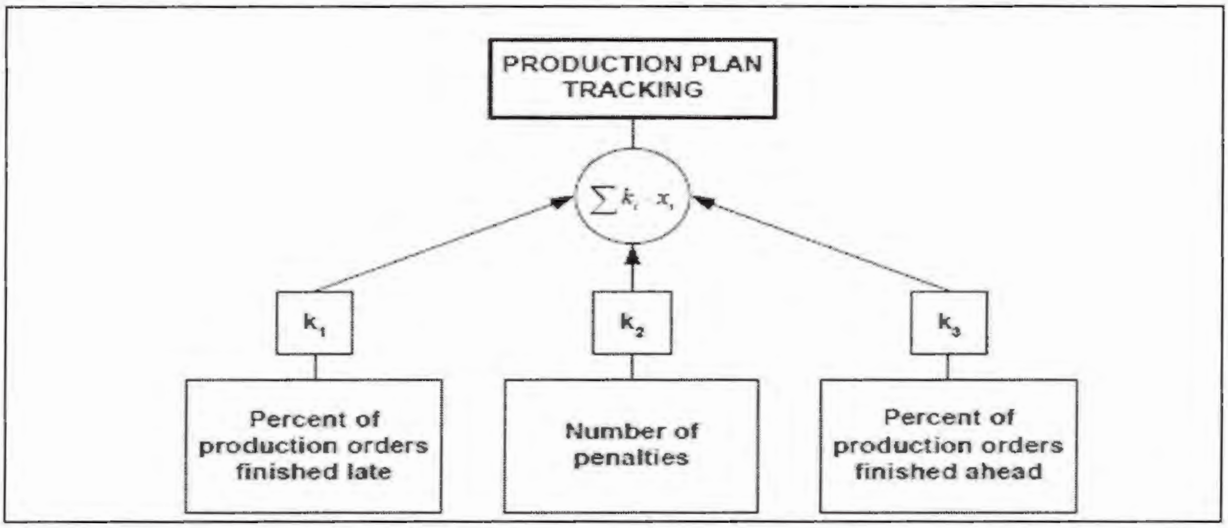


Source: Rakar, (2004:7)

d) KPI: Production plan-tracking

The following diagram is a view of deriving indicators for production plan-tracking.

Figure 2.7: Schematic view for deriving production plan-tracking indicators

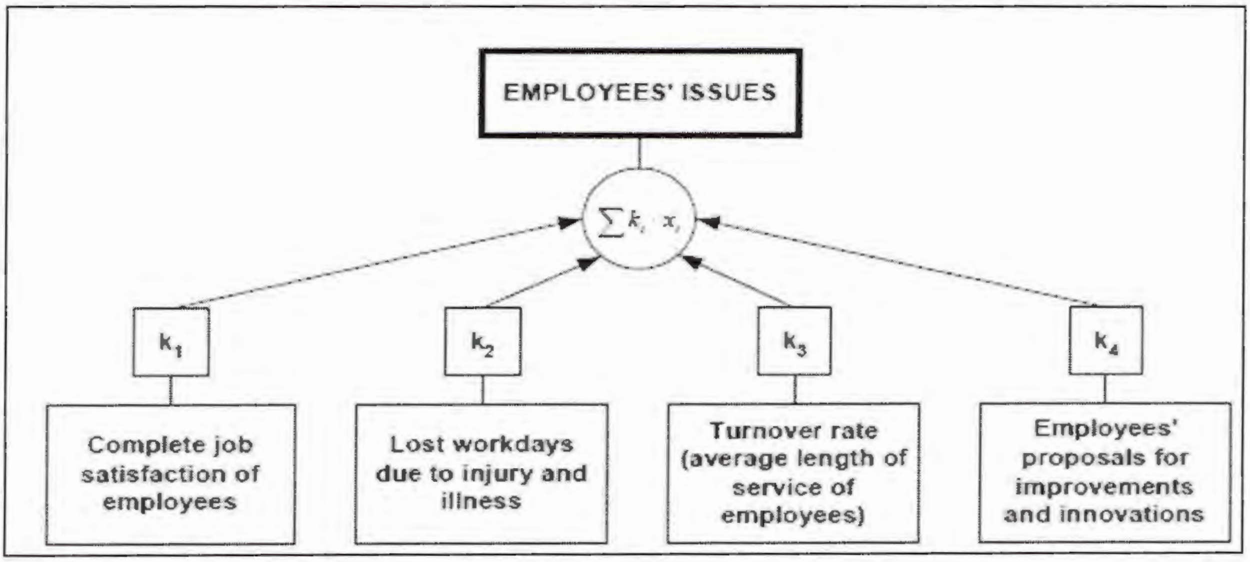


Source: Rakar, (2004:8)

e) KPI: Issues related to employees

The last level of implementing KPIs, is to consider employee's satisfaction.

Figure 2.8: Schematic view for deriving employees' issues indicators



Source: Rakar, (2004:8)

2.5.5.4 Select indicators for implementation

This involves the selection of indicators for implementation. According to Rakar (2004:3), this process should include all employees so as to ensure data availability, motivation and responsibility for implementation. In selecting KPIs for implementation, it is critical to limit them to those factors that are essential for the organisation to reach its goals. It is also important to keep the number of key performance indicators small, in order to focus everyone's attention on maximizing the same KPIs (Anon, 2006d:3). According to David Parmenter (2007:3), the number of KPIs should not be more than ten.

2.5.5.5 Set targets

This is important to ensure management commitment and promotes accountability.

2.5.5.6 Implementation of indicators

This involves (Anon., 2006d:4):

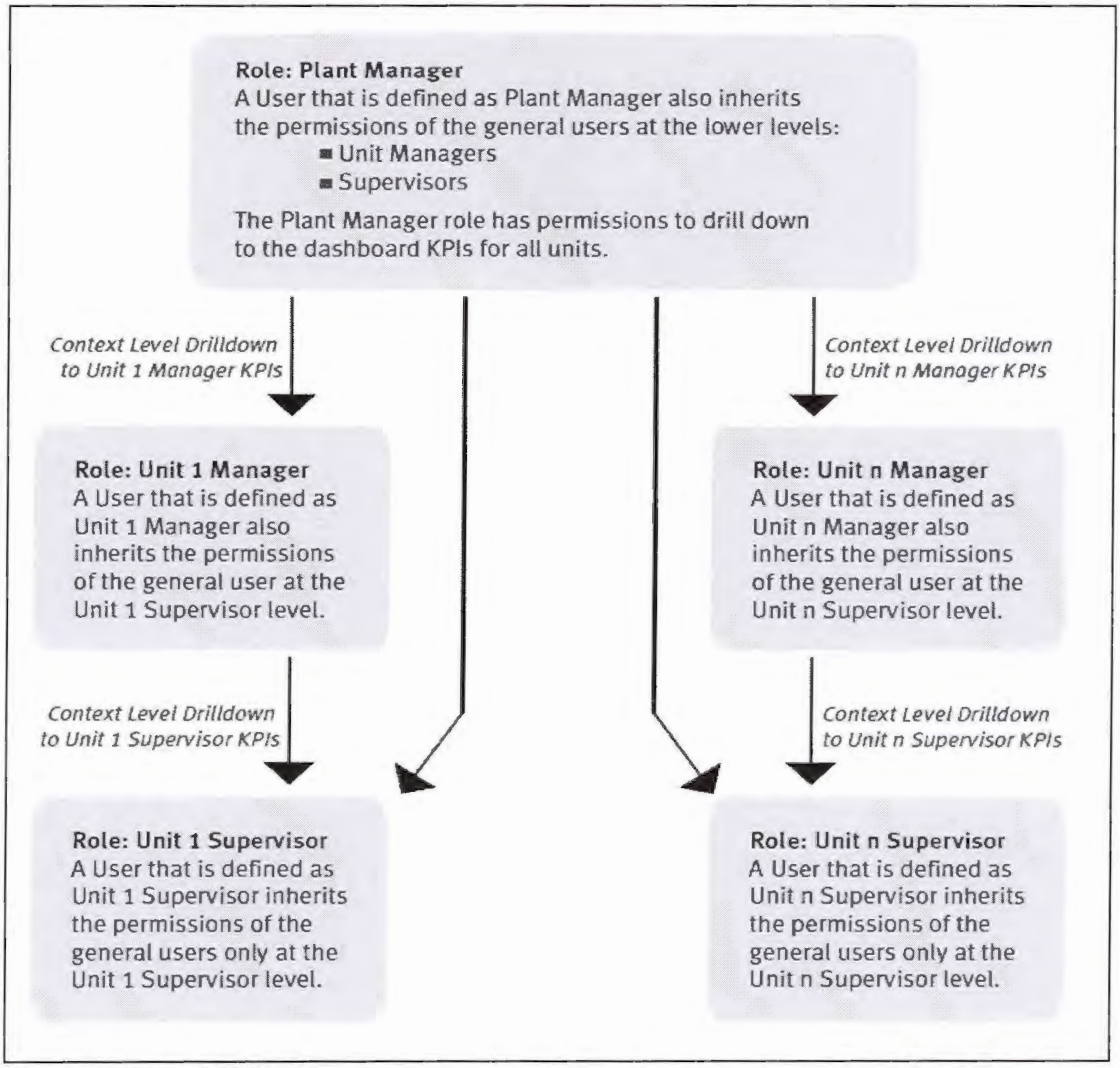
- Identify the user roles (audience) and their access to information.
- Define KPI variance notification rules.
- Identify data deficiencies.
- Identify the data composition of the KPIs.
- Identify the data sources from which the KPIs are derived.
- Define the refresh rate requirements for each KPI.
- Identify reports that are to be generated.
- Usability.

This step is the most time-consuming step and requires wide participation of an organisation's personnel. A description of each aspect is described below.

a) Identify the user roles (audience) and their access to information

The information displayed on the dashboard is specifically relevant to the type of user viewing it. The plant manager needs to see metrics that show how the entire operation is functioning; this view will incorporate information from all aspects of the business. Unit managers and operations personnel will need to see specific subsets of the information available to the plant manager that is relevant to their position (Anon, 2006d:4).

Figure 2.9: A diagram that illustrates the role relationships



Source: Anon, 2006d:4

b) Define KPI variance notification rules

Users can be notified via e-mail when KPI variances occur. The rules governing the configuration of remote notification capabilities will be defined during the study (Anon, 2006d:5).

c) Identify data deficiencies

In some cases, the data required for the formulation of a KPI may not be available from the plant floor production system. Some common examples of data deficiencies are downtime tracking and manpower performance. In order to fully realize the benefits of the dashboard / visual factory system, these functions may need to be added as part of the overall project implementation phase (Anon, 2006d:5).

d) Identify the data composition of the KPIs

It must be determined whether the individual KPIs will consist of single or composite data elements. In either case, the specification for each distinct data element will consist of descriptive attributes, including source, structure, type, scale and unit of measure. In addition, composite KPI definitions must include the operation(s) that are to be performed on the data elements in order to arrive at the desired KPI (Anon, 2006d:5).

e) Identify the data sources from which the KPIs are derived

The data to be used in the display of the KPIs can come from multiple sources. These sources can include databases, spreadsheets, text files and manually entered data. Each source and its associated location, accessibility, entry method (automated or manual), security and administration must be identified. In addition, any potential for additional overhead (network, database, processor) caused by the KPI data acquisition should be identified (Anon, 2006d:5).

f) Define the refresh rate requirements for each KPI

The data refresh rate for each KPI must be determined. Some values may need to be updated or totalized on hourly, daily, weekly, monthly or yearly boundaries. The data required to perform historical comparisons and trends on KPIs for dashboard visualization purposes, usually need to be aggregated in a dedicated dashboard database. The depth of the data and the administration of the database, must be defined in this phase (Anon, 2006d:5).

g) Define the visualization of each KPI

The data can be displayed in a pie, trend, chart, graph, gauge, tabular or video format. The desired format for each KPI display and associated titles, headings and groupings of data must be defined. The dashboard graphic page(s) will be developed from the results of this step (Anon, 2006d:6).

h) Identify reports that are to be generated

The data definition requirements for the dashboard KPIs and the reports are the same; therefore the items listed above apply to reports. Other considerations specific to production reports that must be defined are the following.

- Frequency of generation
- Formatting
- Printing requirements
- Archiving requirements

(Anon, 2006d:4)

i) Usability

The following items will need to be addressed prior to the software design phase (Anon, 2006d:4).

- Reliability and access
- User customization (adds / deletes / and modifies reports)
- Monitor locations and types (for a screen-sizing considerations)
- Number and types of users
- Menu organisation (hierarchy)
- Special user considerations (colour blindness, dark environment and bright environment).

2.5.5.7 Monitor and communicate results

For continuous improvement to occur, it is necessary to periodically communicate and evaluate results from indicator use. It is recommended to establish a system for regular evaluation, interpretation and presentation of results to employees and other interested parties (Rakar, 2004:4). This way, a company can increase competiveness, improve its public image and gain customer's trust.

2.5.5.8 Act on results

This step is critical in the process of the effective use of indicators. Corrective measures are taken for the purpose of continuous improvement of production performance (Rakar, 2004:4). At the end of the review meetings, inadequacies should be discussed. All parties involved should then decide on the best method to supply the employee with the right resources to do the job properly. Only after the organisation has fulfilled its duties in supplying the employee with the necessary resources, should the employee take full responsibility for poor performance.

2.5.5.9 Review of indicators, policies and goals

This step lays the ground for the setting of new goals, objectives and indicators. Here, indicator elimination and the selection of new ones are performed (Rakar, 2004:4). A performance management system is not the type of system that can be drafted once and then utilised into the future. It is important to get feedback from both line supervisors and employees as to the effectiveness of the system. Does it fulfil their expectations? Is it useful? Is it achieving the required results? Suggestions and improvements can be integrated into the system, so that it is being continuously upgraded to cater for the changing needs of the organisation and its staff.

2.5.6 Conclusion on KPIs

The advantages, disadvantages and the steps to implement KPIs effectively, were described in this chapter. It is unfortunate that so many difficulties and so many problems exist or arise when attempting to institute the use of KPIs as a means of improving organisational performance. It is better to be aware of these, than to blithely proceed based on the notion that everyone will readily accept the idea and assist in its implementation. Two of the most important things to recognise, are the level of senior management support, a most necessary ingredient for success, and the willingness of the organisation's culture to use measurement as a management tool.

It is critical to approach the development and implementation of your performance improvement program with a simple, logical and repeatable model as described in the chapter. The model should be as dynamic as the organisation itself. This is necessary in order to sustain its value and that means being able to reassess old measures and develop new ones. A repeatable process is necessary to get this done.

Taking a miinimalist approach to getting the KPI system started, will allow the organization to take a small bite of the elephant providing the best chance of having short-term success. This initial success will allow the developers to demonstrate measurable improvement at the selected point of attack and make the case for the next program step. To accomplish this success, carefully and objectively, review the organisation's performance from the standpoint of the stakeholders. The key is to find a manageable area of focus that is under the control of those that want to improve and will gain benefit from that improvement. Once it is known where the organization wants to improve, it will be easy to determine what measures are necessary to determine performance and success.

2.6 Summary

Much thought should be given to why a Performance Management Program is to be developed, prior to beginning its actual development. Too many organisations, encouraged by software vendors, rush out to purchase "tools" for scorecard or dashboard development, well in advance of having determined the rationale, objectives and goals of the program. The net result of this is all too often, more shelfware and a failed program. The time invested in establishing the program's goals and objectives, as well as the anticipated outcomes, will provide the foundation for the program. Taking this foundational approach and getting senior management agreement to it, will allow the communication of the program and its benefits to the rest of the organisation, which is another critical success factor. It is also much easier to build a framework on top of a sound foundation.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

The primary objective of this research is to determine the effectiveness of Key Performance Indicators in the product factories of Cape Gate.

The supporting objectives are to determine -

- If effective KPIs are measured,
- If the implementation of KPIs has been done successfully, and
- What the effect is of specific KPI measurement in Cape Gate.

Chapter two contained the literature study in which the following aspects were investigated.

- Performance measurement
- Strategic performance management
- The Balanced Scorecard
- Key Performance Indicators.

A research methodology was followed to compare the empirical results of Cape Gate's performance with the findings in the literature study. Chapter four details the findings from the empirical work. This chapter details the research methodology followed. A short description of KPIs that entail the scope of this study is addressed, followed by the data gathering and the analysis method used.

3.2 Key Performance Indicators: Cape Gate Sharon

Key Performance Indicators are seen as a part of continuous improvement, where KPIs are seen as a performance measurement system for registered projects, as well as a tool to detect problems. The Sharon business unit's strategy is to improve efficiency by increasing production and decreasing cost. The business unit focuses on production and the preliminary KPIs were determined for each production unit, as follows.

- Sharon Galvanizing Factories
- Sharon Wire Drawing Factories
- Sharon Netting Factory
- Sharon Chain Link Factories

- Sharon Barb Wire Factory
- Sharon Mine Pack Factory
- Sharon Utilities Factory
- Sharon Logistics
- Sharon Pickling Plant
- Sharon Electrical and Maintenance Engineering.

Due to privacy restrictions, the scope of this study will include only KPIs based on the product factories, which are the Sharon -

- Netting Factory
- Chain Link Factory.

The netting factory has one production manager, two foremen, and ± 99 operators. The chain link factory has one production manager, two foremen, 1 clerk and ± 71 operators. These two factories receive galvanized wire from the galvanize factory as a raw material to produce wire products in the form of looms and diamond mesh wire.

3.3 Information gathering method

The data for this dissertation were collected by using multiple sources and techniques (Soy, 1997:2). For the purpose of this case study, the research was carried out through a process of document analysis and data analysis.

Document analysis was used to determine if effective KPIs are measured and to determine how successful the implementation thereof, was. Data analysis on actual recorded data was used to determine the effectiveness of KPIs.

3.3.1 Document analysis

Document analysis was used to determine if effective KPIs are measured and to determine how successful the implementation thereof was in the two product factories, Netting and Chain Link.

Current available production reports were investigated to determine the current performance measurement in Cape Gate. Production and technical specifications of the KPI system were retrieved and investigated. These documents contained all the information regarding the *implementation* of the KPIs. These documents were therefore, used to compare the implementation of the KPI system with the closed-loop model as described by Rakar (2004:5). KPI *selection* forms part of the closed-loop model and is addressed together with the *implementation* of the KPI system.

3.3.2 Data analysis

Data analysis on actual recorded data before and after the implementation of the KPI performance measurement system was used to determine the effectiveness of KPIs. Descriptive statistics were used to determine the effect of each KPI. Descriptive research is that which seeks to identify themes within a case through a detailed description encompassing as much of the mini-dissertation detail as possible. Robson (Winegardner, date unknown: 6) defines the purpose of descriptive research as the portrayal of an accurate profile of persons, events, or situations. This in turn, requires extensive knowledge of the research subject in order to identify appropriate aspects on which to gather information.

In descriptive statistics, elaboration upon the data can be done by measuring the dispersion. In descriptive statistics, usually the range of the standard deviation and variance is used to measure the dispersion. Range is defined as the difference between the highest and the lowest values. Standard deviation is also called the root mean square deviation. Variance can simply be derived from the square of the standard deviation. For the purpose of this study, any improvement of each KPI was interpreted by determining the mean and standard deviation before and after implementation. The standard deviation measures the average scatter around the mean (Levine et al., 2008:105). The larger the scatter, the less control one has over one's operations. The standard deviation was therefore, used as a tool to interpret how the manager was in control of the specific indicator. The mean was used to determine if there was improvement in performance in each of the KPIs.

The mean and standard deviation were interpreted visually by means of graphs. A fixed mean and standard deviation were used to show the total average effect that the KPI system had on performance over a period of time. A moving average and standard deviation was used to show how the performance gradually changed over the total period of time. To determine if the standard deviation changed significantly, the F-Test for differences between two variances was used for each of the indicators. To determine if there was a significant change in the mean after the implementation of the KPI system, the Pooled-Variance t-Test for the differences between two means was used for each indicator. The results of the F-Test for differences between two variances were also used to determine if the Pooled-Variance t-Test for the differences between two means was based on equal or unequal variances.

For the production KPI, it was expected that the results would be void, because of lower demand due to the economic crises. Currently, the aim for production is to produce as close as possible to targets with the least amount of labour and machines. Targets have therefore, been reduced, but machines and labour as well. The production KPI will therefore be evaluated according to production as a percentage of the target. Because it is currently not favourable to produce more than target, the only aspect that was investigated, is the amount of scatter, or standard deviation. Improvement on the production KPI was therefore, seen as a reduction in standard deviation. To determine if a change was significant, the F-Test for differences between two variances was used. The economic crisis did not have an effect on utilisation, because machines that did produce were not scheduled and no labour was allocated to that machine.

The F-Test for the differences between two variances can be used to determine whether two populations have the same variability (Levine *et al.*, 2008:397). The results of the hypothesis test will therefore, tell one if the change in variance was significant or not. For the purpose of the case study, significant change in variance was seen as important because:

- a reduction in variance and standard deviation meant less scatter and therefore better control of your operations, and
- it is a prerequisite for determining if the Pooled-Variance t-Test for the differences between two means is based on equal or unequal variances.

For a given level of significance, α, to test the null hypothesis of variances:

$$H_0: \sigma^2{}_1 = \sigma^2{}_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2{}_1 \neq \sigma^2{}_2$$

Where H_0 is the null hypothesis test and H_1 is the alternative hypothesis test. $\sigma^2{}_1$ and $\sigma^2{}_2$ are the variances before and after the implementation of KPIs.

For the purpose of this study, if H_0 was rejected, it was concluded that there are significant evidence that there are difference in the variance and therefore, the standard deviation.

The Pooled-Variance t-Test for the differences between two means can be used to determine whether there is a significant difference between the means of the two populations (Levine et al., 2008:372). For the purpose of the case study, significant change in the mean was seen as important because the effectiveness of some KPIs was measured in the increase or decrease of the mean. For a given level of significance, α, the one-tail hypothesis tests were:

$$H_0: \mu_1 \geq \mu_2$$

$$H_1: \mu_1 < \mu_2$$

Where H_0 is the null hypothesis test and H_1 is the alternative hypothesis test. μ_1 and μ_2 are the means before and after the implementation of KPIs.

For the purpose of this study, if H_0 was rejected, it was concluded that there is significant evidence that the difference between the two means are $\mu_1 - \mu_2$.

3.4 Summary

For the purpose of this mini-dissertation, document analysis was used to determine if effective KPIs are measured and to determine how successful the implementation thereof was. Data analysis on actual recorded data was used to determine the effectiveness of KPIs. The KPI performance management system was implemented on the 1st of June 2009. The first month was a transition phase so that the managers could familiarise themselves with the system. Performance review started at the end of July 2009 for the month of July. Results before July 2009 will therefore, be seen as data before implementation and results from July 2009 onwards as data reviewed with the use of the KPI system.

CHAPTER 4
EMPIRICAL STUDY: APPLICATION WITHIN CAPE GATE

4.1 Introduction

This chapter details the findings from the empirical work using the methodology stipulated in chapter three. Document analysis was done to investigate the implementation and selection of KPIs. Data analysis was done by means of descriptive statistics to determine the effects of a KPI system.

4.2 Document analysis

4.2.1 Current performance measurements in Cape Gate

Current available production reports were investigated so as to determine the current level of performance measurement in Cape Gate. Production and technical specifications of the KPI system were retrieved and investigated in order to compare the implementation of the KPI system with the closed-loop model as described by Rakar (2004:5).

Document analysis showed that currently, for each business unit, measurements are in place to collect data on the following.

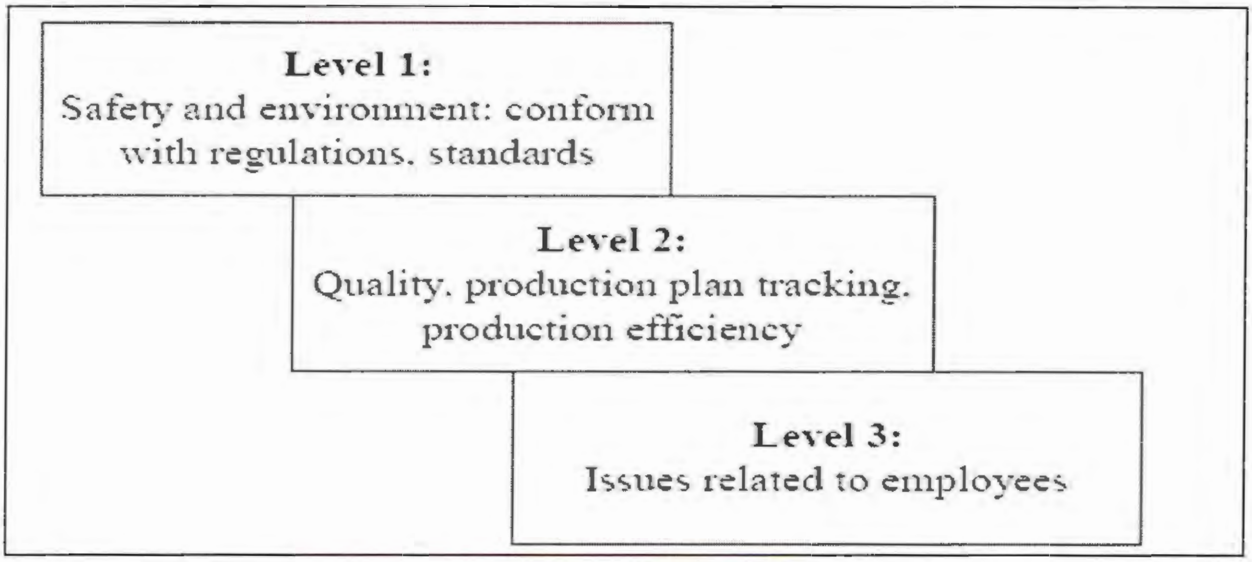
- Employees booked per factory per shift per machine
- Employees absent per factory per shift per machine
- Clock-times of employees
- Run-time of machines
- Scheduled times of machines
- Downtime reasons of machines
- Machine speeds
- Machine target speeds
- Machine production
- Machine production targets
- Product information scheduled on machine
- Products on hold, due to quality reasons
- Products scrapped per factory.

This information is used in each factory to generate literally hundreds of reports which have evolved around production managers. These reports are siloed to certain employees only. To analyse these reports, an analyst is required to know where all the data are and how the reports are connected to each other.

4.2.2 Evaluation of the introduction of KPIs in Cape Gate

Introduction of KPIs should be done using the three-level hierarchy model, together with the eight step closed-loop model for introducing performance indicators. The three-level hierarchical structure is shown again below.

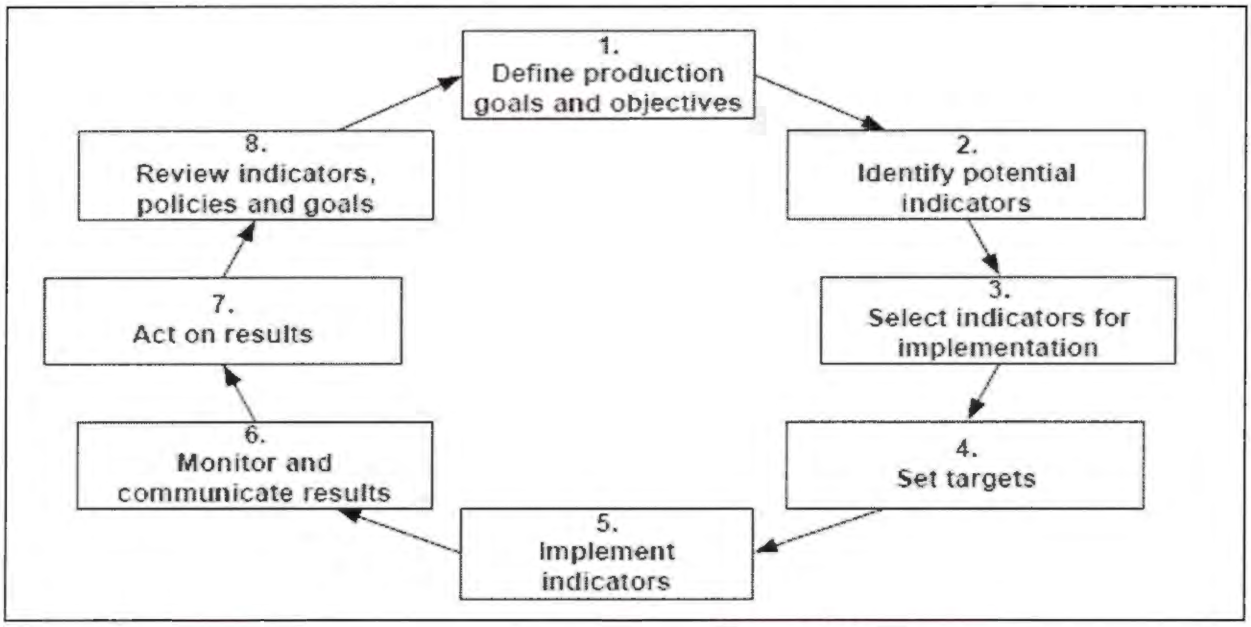
Figure 4.1: KPI Framework



Source: Rakar, (2004:4)

The three-level hierarchy model is a theoretical model for introducing KPIs by means of the cascading process. KPIs cascade from the business level downwards to the individual by means of the three levels specified in the model. Theoretically, the closed-loop model should first be implemented for level one. When the loop is completed, the next step will be to implement the closed-loop model for level two and level three.

Figure 4.2: Closed-loop model for defining and measuring production KPIs

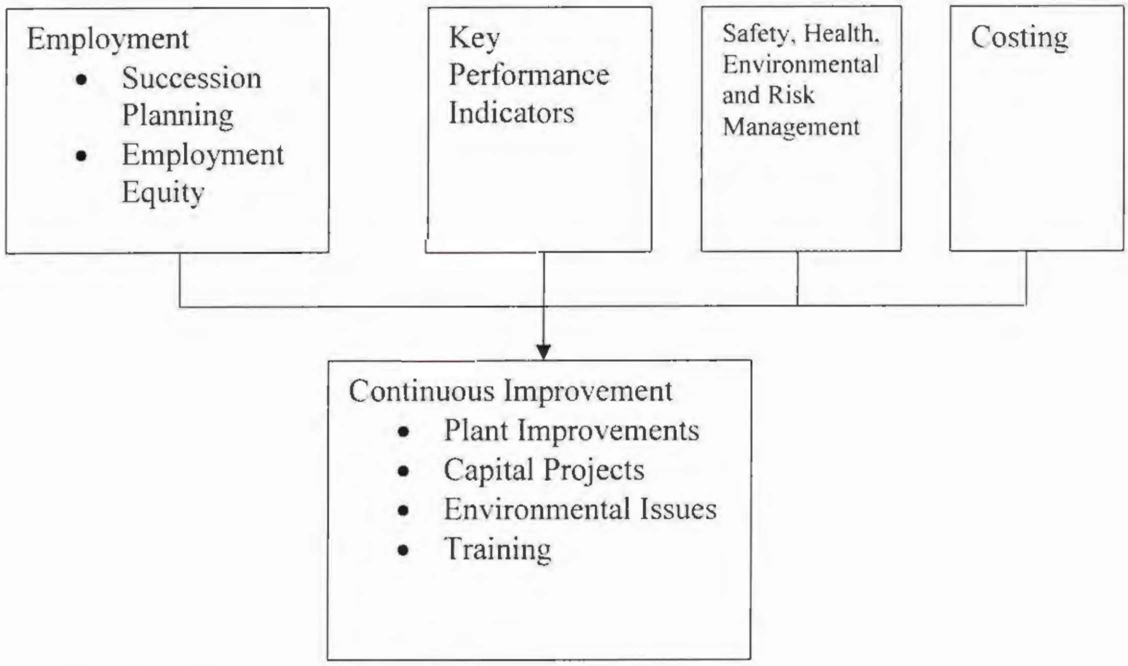


Source: Rakar, (2004:5)

Figure 4.2 illustrates the closed-loop model for introducing KPIs to each of the three levels. Level 1 has already been implemented by the safety, health, environmental and risk management (SHER) department. Although the KPIs of the SHER department are beyond the scope of the mini-dissertation, it is important to note that it was implemented and that level 1 of the hierarchy model was completed. Cape Gate is currently on level 2 of the hierarchy model. To determine if the KPIs were successfully introduced, document analysis was used to compare actual introduction of KPIs with the steps stipulated in the close-loop model. For an effective introduction of KPIs based on the cascading process, all the steps in the closed-loop model must relate to level 2 of the hierarchy model. Each step of the closed-loop model was investigated and is described in detail in the following sections.

4.2.2.1 Define production goals and objectives

Figure 4.3: A diagram that illustrates continuous improvement in Cape Gate



Source: Internal Company Document, 2008

The Sharon business unit's production goals and objectives are to improve efficiency by increasing production and decreasing cost. This is done by means of continuous improvement with the following prerequisites.

- Employment
- Key Performance indicators
- Safety, health, environmental and risk management (SHER)
- Costing.

4.2.2.2 Identify potential indicators

According to the literature study, potential indicators can be derived from the following schematic views.

Figure 4.4: A table with schematic views to derive indicators

Source: Rakar, 2004:4-8

Potentials for Cape Gate are summarised in the following table with reference to the above-mentioned theoretical KPIs. Due to organisational culture, it is preferred to name KPIs accordingly to the terminology used in Cape Gate.

Table 4.1: Preliminary Key Performance Indicators for production factories

Potential indicators selected for Cape Gate	Theoretical indicator names	Hierarchy Level
Overall equipment efficiency (Based on operating restrictions)	Infrastructure efficiency	2
Operator efficiency	Efficiency of employees in production	2
Productivity	Unit Production time	2
Production	Unit Production time	2
Utilisation	Infrastructure efficiency	2
Mean-time between failures	Production shutdowns	2
Downtimes of machines	Production shutdowns	2
On hold	Percent of final products, which do not meet quality criteria	2
Scrap	Size of production losses	2
Yield	Materials used	2
Time per product	Unit production time	2
Absenteeism	Lost workdays due to illness	3

Source: Developed by the author, 2009

Most of the potential indicators that were selected as potential indicators, are level two indicators on the hierarchy level, with only absenteeism as a level three indicator. No indicators were selected from Level one: Safety and Environmental issues. Excluding absenteeism, a successful selection of potential indicators based on the cascading process was made.

Indicators based on the "production plan-tracking section" were considered, but it forms part of the logistics department and is not part of the scope of this study. The "Quality of internal and external services" indicator was considered, but it forms part of the maintenance and electrical engineering department, which is not part of the scope of this study.

The raw materials of the product factories are final products from the galvanising factories. The "Percent of raw material which does not meet quality standards" are thus, considered as KPIs for the galvanising factories.

4.2.2.3 Select indicators for implementation

The following were selected as KPIs for implementation.

Table 4.2: Key Performance Indicators for production factories

KPIs selected for Cape Gate	Theoretical indicator names	Hierarchy Level
Production	Unit production time	2
Utilisation	Infrastructure efficiency	2
Downtimes of machines	Production shutdowns	2
On Hold	Percent of final products, which do not meet quality criteria	2
Scrap	Size of production losses	2
Yield	Materials used	2
Absenteeism	Lost workdays due to illness	3

Source: Developed by the author, 2009

The following were excluded:

a) Overall equipment efficiency (based on operating restrictions) (OEE)

- Utilisation was chosen above OEE, as OEE can provide an unbiased picture of the performance of the factory. OEE includes time alowances for manual operations and uncontrollable downtimes. If the OEE reaches 100 percent, operators tend to stop the machines, whereas utilisation concentrates only on the percentage of time that a machine has run-time.

b) Productivity

- Production was chosen above productivity, as production managers must schedule a mix of products in order to reach the specified target.

c) Mean-time between failures (MTBF)

- There are hundreds of products running simultaneously with different times between failures, which vary considerably. For this reason, downtime is seen as a more manageable KPI.

d) Time per product

- The same reasoning as with MTBF is followed for not choosing time per product as a KPI.

The set of KPIs is smaller than ten, as recommended. Level 3 should be considered if step 8 of the closed-loop model is reached. The effect of KPI measurement of absenteeism will be determined in data analysis to see if it was successfully introduced.

4.2.2.4 Set targets

Document analysis revealed that production managers were involved with the setting of targets. Targets are increased when operating processes is improved by means of continuous improvement.

4.2.2.5 Implementation of indicators

Document analysis was used to determine the effectiveness of the implementation of KPIs in Cape Gate.

This section describes the implementation of Key Performance Indicators at Cape Gate, Sharon division. After investigating data requirements and deficiencies, the implementation of KPIs for level two based on the closed-loop model were separated into three phases:

- Phase 1: KPIs for factories with the required data measurement system in place.
- Phase 2: KPIs for factories with required data measurement, but no management system in place.
- Phase 3: KPIs with no data measurement

For phase 1, the measurement of data takes place and reports are generated, but it is not incorporated into a performance management system. In phase 2, the information measurement infrastructure is in place, but no reports exist or are incorporated into a performance management system. In phase 3, no measurement takes place and this phase still requires capital investment for an information infrastructure.

Phase 1 includes the following.

- Sharon Galvanizing Factories
  - Production
  - Utilisation
  - Absenteeism
  - Downtimes
  - Scrap
- Sharon Wire Drawing Factories
  - Production
  - Utilisation
  - Absenteeism
  - Downtimes
  - Scrap
- Sharon Netting Factory
  - Production
  - Utilisation
  - Absenteeism
  - Downtimes
  - Scrap
- Sharon Chain Link Factories
  - Production
  - Utilisation
  - Absenteeism
  - Downtimes
  - Scrap

Phase 2 includes the following.

- Sharon Galvanizing Factories
  - On Hold
  - Yield
- Sharon Wire Drawing Factories
  - On Hold
  - Yield

- Sharon Netting Factory
    - On Hold
    - Yield
- Sharon Chain Link Factories
    - On Hold
    - Yield
- Sharon Logistics
- Sharon Pickling Plant
- Sharon maintenance and electrical engineering

Phase 3 includes:

- Sharon Barb Wire Factory
- Sharon Mine Pack Factory
- Sharon Utilities Factory

At the time this study was done, only phase one was completed. For the scope of this project, only the following can be considered.

Sharon Chain Link factory. In the chain link factory, there are chain link machines which create diamond mesh wire as a final product. The KPIs for the chain link factory are as follows.

- Production
- Utilisation
- Downtimes
- Scrap
- Absenteeism

Sharon Netting factory. In the netting factory, loom machines provide rolls of wire (looms) to the tight winders. The tight winders create a final tight winded product ready for dispatch. KPIs for the netting factory are as follows.

- Production for loom machines and tight winders
- Utilisation for loom machines and tight winders
- Downtimes for the loom machines and the tight winders
- Scrap percentage for the netting factory
- Absenteeism for the netting factory

a) Identify the user roles

User roles have been identified per production business unit. The users that fall in the scope of this study, are the following.

- Sharon Netting Factory
  - Production Manager
  - Production Foremen
- Sharon Chain Link Factories
  - Production Manager
  - Production Foremen

b) Define KPI variance notification rules

The KPI is displayed on a dashboard. If an indicator is underperforming, it is high-lighted.

c) Identify data deficiencies

Some of the information was not available at the start of the project. The project was planned in phases so as to overcome data deficiencies. Phase 1 of the project was delayed by more than six months, due to data deficiencies.

d) Identify the data sources from which the KPI is derived

KPIs are derived from the bonus system, leave system, production system, quality system, monitoring system and leave system.

e) Define the refresh rate requirements for each KPI

The following are available in real-time.

- Production
- Utilisation
- Downtimes

This gives the users the opportunity to monitor the performance of the indicators as often as they wish. Scrap and absenteeism are only being done monthly. The effect of infrequent monitoring is investigated in the "Data Analysis" section.

f) Reporting specifications

Reporting specification was drafted before implementation with the necessary data requirements and deficiencies.

For each KPI:

- An example of the final dashboard was given
- A refresh rate was determined
- Data sources were defined
- Data requirements were defined
- Deficiencies were defined
- System owners were defined
- Time periods were defined
- Period of implementation was defined
- The usability was defined
- Users were defined

4.2.2.6 Monitor and communicate results

Performance review takes place once a month as from June 2009.

4.2.2.7 Act on results

Managers have to act on results that came from the performance review.

4.2.2.8 Review of indicators, policies and goals

This step lays the ground for the setting of new goals, objectives and indicators. Here, indicator elimination and the selection of new ones are performed. Currently, Cape Gate is at step 7 of the closed-loop model.

4.2.3 Conclusion on document analysis of KPIs

To determine if the KPIs were successfully introduced, document analysis was used to compare actual introduction of KPIs with the steps stipulated in the closed-loop model. For an effective introduction of KPIs based on the cascading process, all the steps in the closed-loop model must relate to level 2 of the hierarchy model.

Analysis of the production and technical specification document, showed that Cape Gate Sharon focused on level 2 of the KPI framework, which are indicators regarding quality, production plan-tracking and production efficiency. Excluding absenteeism, a successful selection of potential indicators based on the cascading process was made. Cape Gate is at step seven of the closed-loop model. Absenteeism falls under level 3. Issues regarding employees, and should only be implemented when all the level 2 KPIs are successfully implemented.

Document analysis showed that all of the steps in the closed-loop model were followed with the implementation of KPIs. Ideally, the next step would be to start the closed-loop model for issues related to employees. Sharon is still in the process of implementing level 2 KPIs to more factories. No evidence was found in the document analysis that indicators will be implemented from level 3 of the KPI framework. It is recommended that once all factories have level 2 KPIs, specifications should be drafted for level 3 KPIs.

4.3 Data analysis

4.3.1 Overview

Data analysis on actual recorded data before and after the implementation of the KPI performance measurement system was used to determine the effectiveness of KPIs. Descriptive statistics was used to determine the mean and standard deviation for each KPI. For the purpose of this study, improvement of each KPI was interpreted by determining the mean and standard deviation before and after implementation. Where necessary, the F-Test for differences between two variances and the Pooled-Variance t-Test for the differences between two means were used to determine if the KPI system had a significant impact.

Data analysis was performed on the following two factories.

Sharon Chain Link factories. In the chain link factory there are chain link machines which create diamond mesh wire as a final product. The KPIs for the chain link factory are as follows.

- Production
- Utilisation
- Downtimes
- Scrap
- Absenteeism.

Sharon Netting factory. In the netting factory loom machines provide rolls of wire (looms) to the tight winders. The tight winders create a final tight winded product ready for dispatch. KPIs for the netting factory are as follows.

- Production for loom machines and tight winders
- Utilisation for loom machines and tight winders
- Downtimes for the loom machines and the tight winders
- Scrap percentage for the netting factory
- Absenteeism for netting factory.

4.3.2 Production KPI

For the production KPI, it was expected that the results would be void, because of lower demand due to the economic crisis. Currently, the aim for production is to produce as close as possible to targets, with the least amount of labour and machines. Targets have therefore, been reduced, as well as machines and labour. The production KPI will therefore, be evaluated according to production as a percentage of the target. Because it is currently not favourable to produce more than target, the only aspect that was investigated is the amount of scatter, or standard deviation. Improvement on the production KPI was therefore, seen as a reduction in standard deviation. To determine if a change was significant, the F-Test for differences between two variances was used.

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in production percentage for the population of data before the implementation of KPIs

σ^2_2= Variance in production percentage for the population of data after the implementation of KPIs.

4.3.2.1 Chain Link

Production figures were analysed for the period 2008/01 up to 2009/10. For each period, the production as a percentage of the target was determined. The mean and standard deviation was also determined for each period. The following table summarises the results.

Table 4.3: Chain Link Production mean and standard deviation

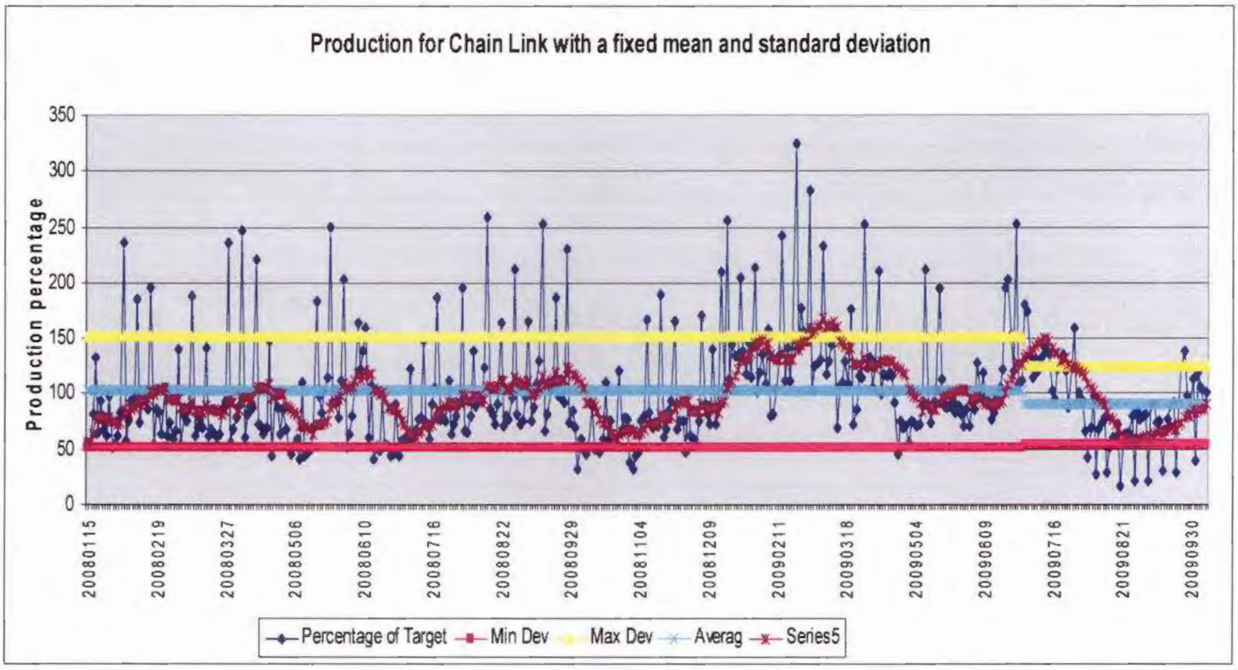
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
101.57%	50.1	89.7%	37.1

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the production for the period 2008/01 up to 2009/10 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

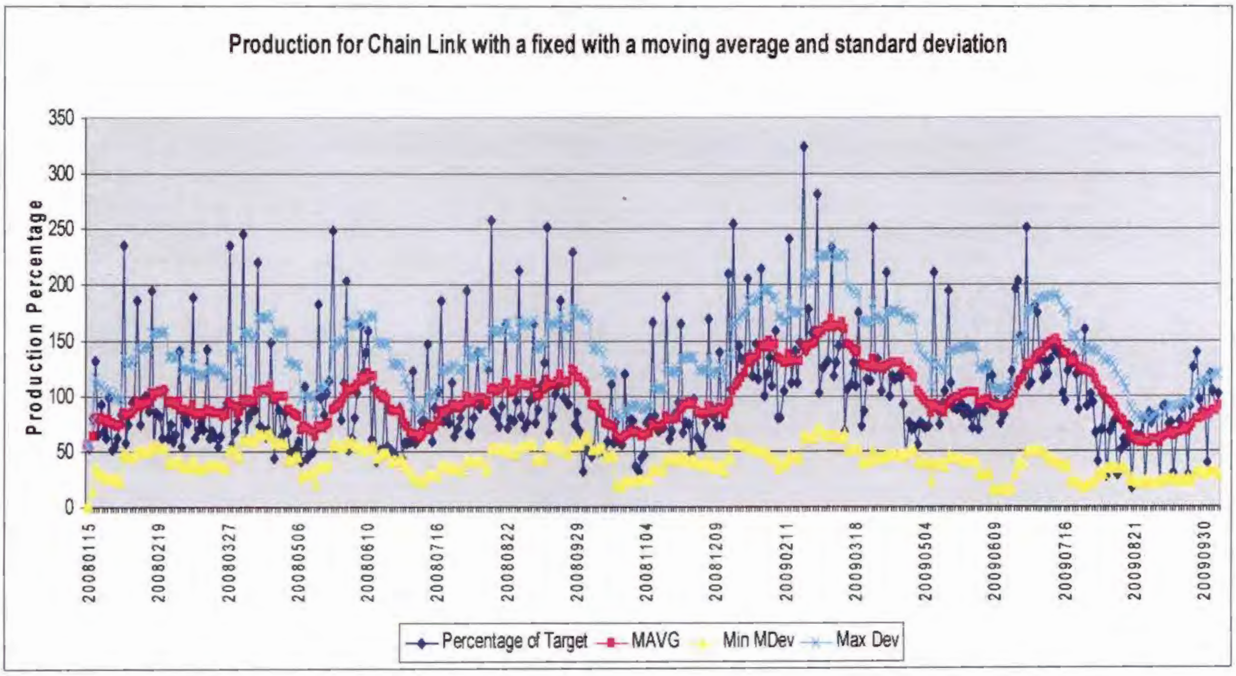
Figure 4.5: Production for Chain Link with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the production for the period 2008/01 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.6: Production for Chain Link with a moving average and standard deviation



Source: Developed by the author, 2009

From the two graphs, one can immediately see of KPI performance measurement. In a very short period, the scatter around the mean has been reduced significantly. Up until July 2009, production varied considerably from that of the target. From July 2009 onwards, the scatter or standard deviation was reduced from 50.1 to 37.1. Using the F-Test for differences between two variances, it was proven that a significant change in standard deviation took place. Using production as a KPI had immediate effects on the control of production. A smaller scatter or standard deviation shows that greater control is applied on production output.

The mean of the production as a percentage of the target dropped from 101.57 to 89.7 percent. With the implementation of KPIs, targets have been changed to reflect the amount of machines scheduled in the factory. From the moving average graph, one can see that the production percentage gradually increased from 70 to 100 percent at the end of the test period, ending with an average of 89.7 percent.

Control over production output increased significantly, and production output gradually increased to 100 percent of the target. These two findings show that the production KPI was successfully implemented in the chain link factory, with positive results.

4.3.2.2 Netting

In the netting factory, a production KPI exists for the loom machines and the tight winders.

Production KPI for loom machines

Production figures were analysed for the period 2009/04 up to 2009/10. For each period, the production as a percentage of the target was determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.4: Netting loom machines production mean and standard deviation

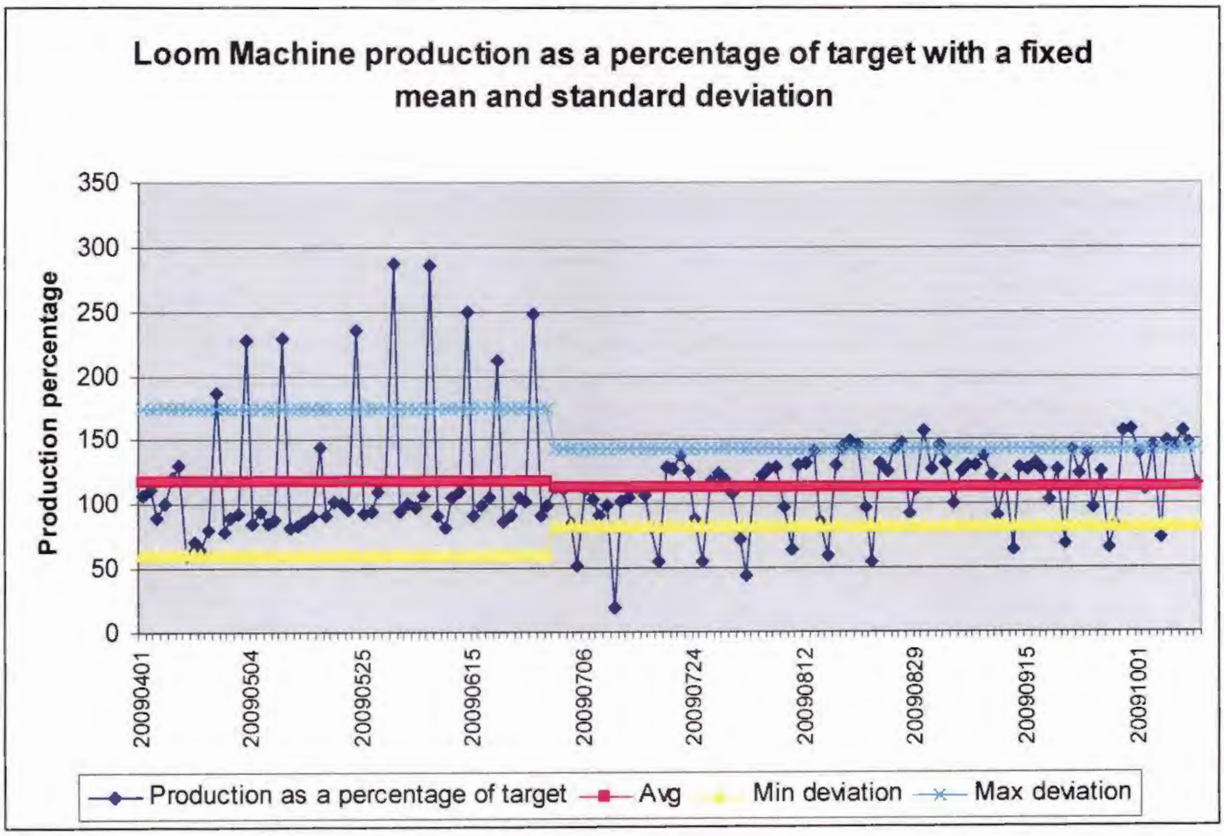
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
117.8%	56.64	113.1%	30

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the production for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

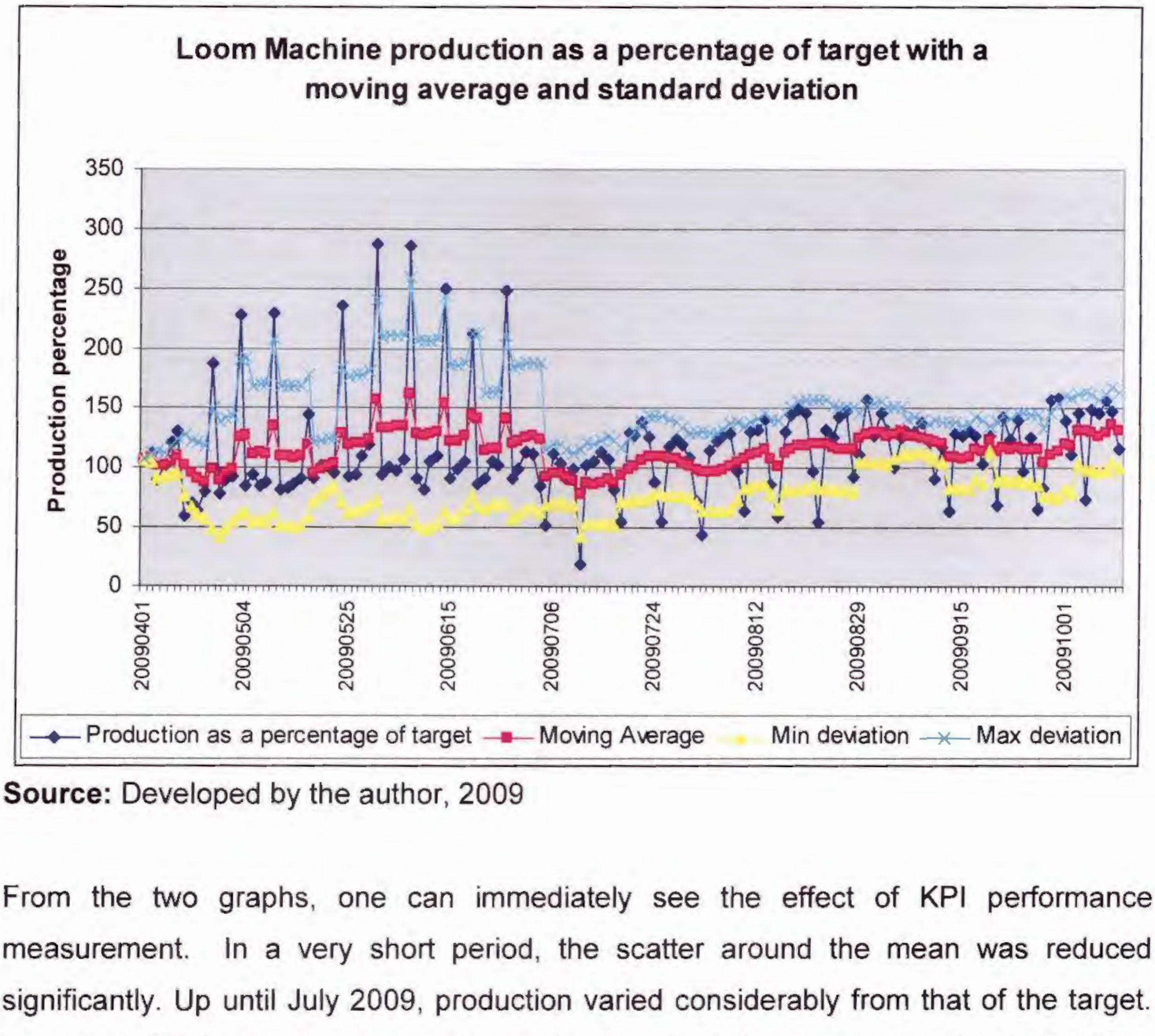
Figure 4.7: Production for Netting loom machines with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the production for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.8: Production for Netting loom machines with a moving average and standard deviation



Source: Developed by the author, 2009

From the two graphs, one can immediately see the effect of KPI performance measurement. In a very short period, the scatter around the mean was reduced significantly. Up until July 2009, production varied considerably from that of the target. From July 2009 onwards, the scatter or standard deviation was reduced from 56.64 to 30.1. Using the F-Test for differences between two variances, it was proven that a significant change in standard deviation took place. Using production as a KPI had immediate effects on the control of production. A smaller scatter or standard deviation shows that greater control is applied on production output.

The mean of the production as a percentage of the target, dropped from 117.8 to 113.1 percent. With the implementation of KPIs, targets have changed to reflect the amount of machines scheduled in the factory. From the moving average graph, one can see that the production percentage gradually increased from 95 percent to just over 100 percent.

Control over production output increased significantly, and production output gradually increased to 100 percent of the target. These two findings show that the production KPI was successfully implemented for the loom machines in the netting factory, with positive results.

Production KPI for tight winders

Production figures were analysed for the period 2009/04 up to 2009/10. For each period, the production as a percentage of the target was determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.5: Netting tight winders production mean and standard deviation

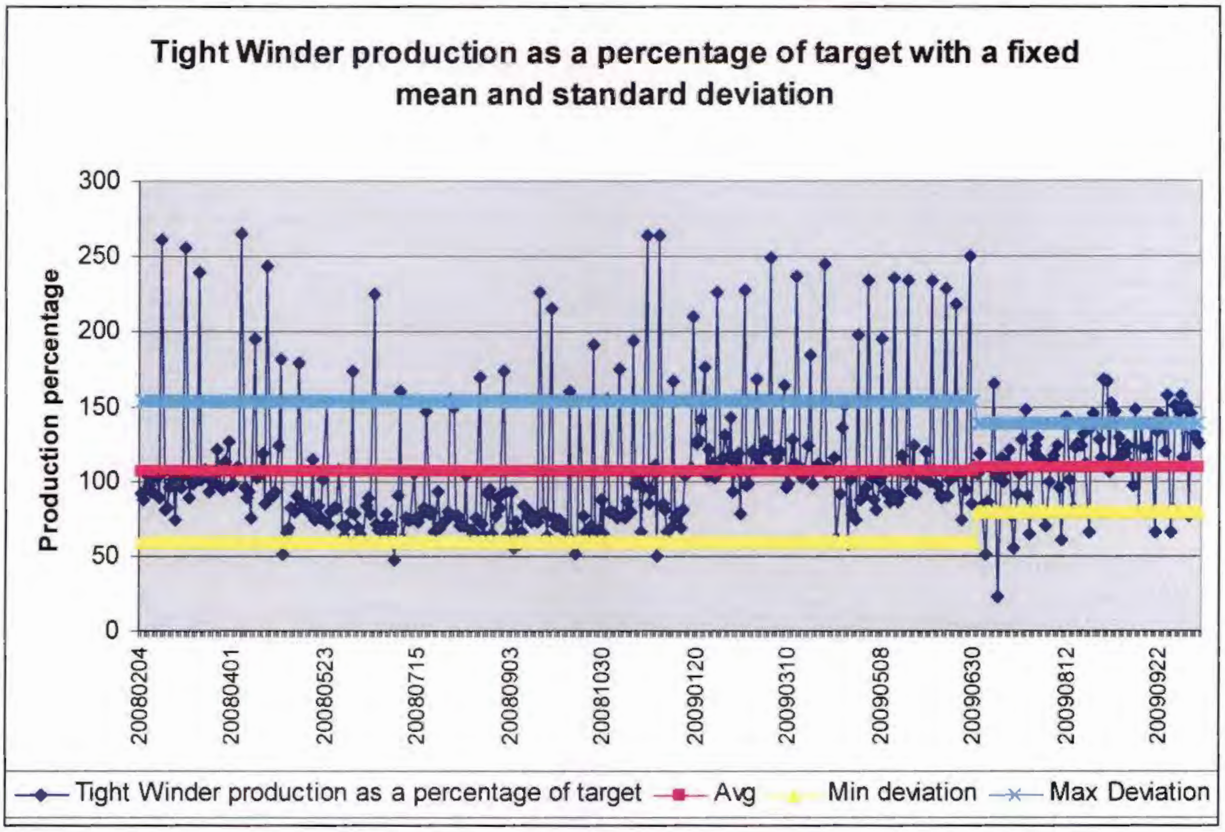
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
106.66%	46.82	108.45%	29.66

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the production for the period 2008/01 up to 2009/10 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

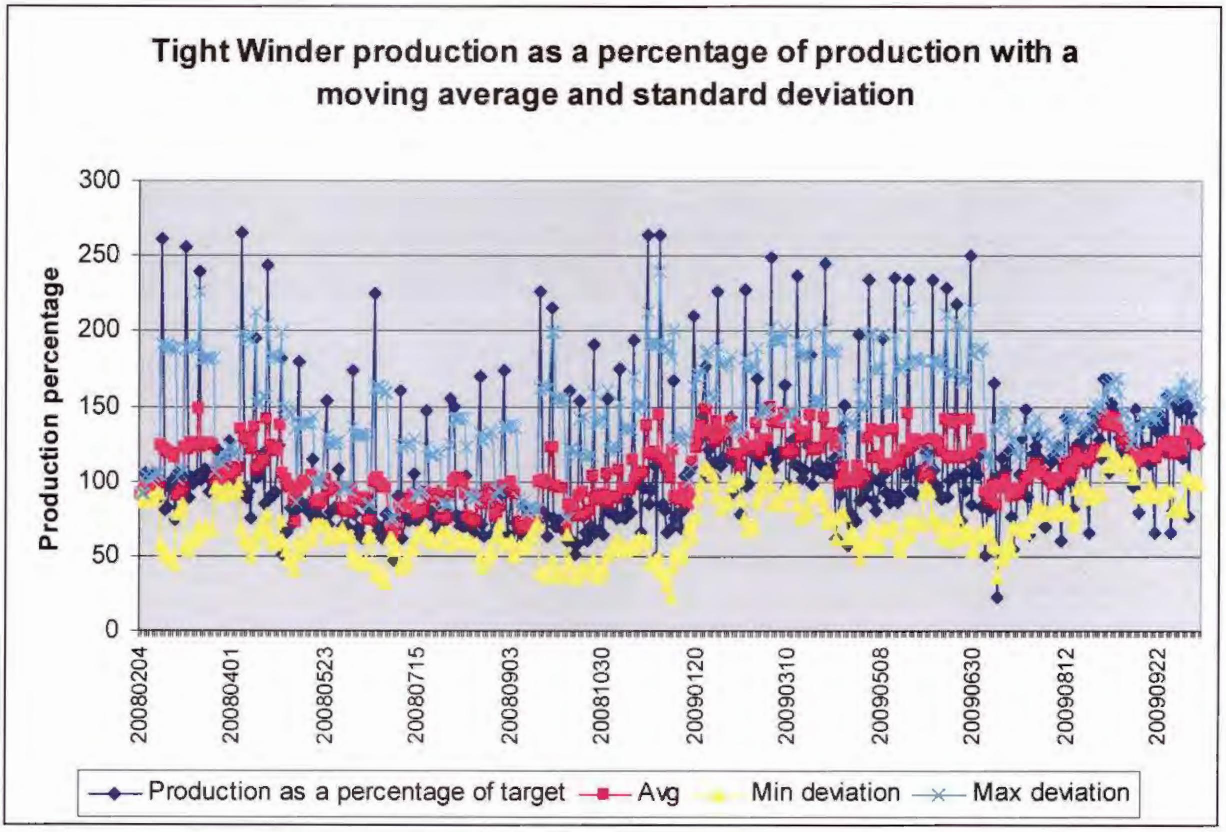
Figure 4.9: Production for Netting tight winders with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the production for the period 2008/01 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.10: Production for Netting tight winders with a moving average and standard deviation



Source: Developed by the author, 2009

From the two graphs, one can immediately see the effect of KPI performance measurement. In a very short period, the scatter around the mean was reduced significantly. Up until July 2009, production varied considerably from that of the target. From July 2009 onwards, the scatter or standard deviation was reduced from 46.82 to 29.66. Using the F-Test for differences between two variances, it was proven that a significant change in standard deviation took place. Using production as a KPI had immediate effects on the control of production. A smaller scatter or standard deviation shows that greater control is applied to production output.

The mean of the production as a percentage of the target remained constant at more or less 107 percent. With the implementation of KPIs, targets have been changed to reflect the amount of machines scheduled in the factory. From the moving average graph, one can see that the production percentage gradually increased from 95 percent to just over 100 percent, following the same trend as the loom machines.

Control over production output increased significantly, and production output gradually increased to 100 percent of the target. These two findings show that the production KPI was successfully implemented for the tight winders in the netting factory, with positive results.

4.3.3 Utilisation KPI

For the utilisation KPI, the change in mean was investigated so as to determine the effect that the KPI system had on the performance of the indicator. Improvement in the utilisation KPI will be seen as a significant increase in the mean of utilisation. As a prerequisite for determining if the Pooled-Variance t-Test for the differences between two means is based on equal or unequal variances, the F-test for the differences between two variances was used to determine if there is a significant change in variance. If a significant change was detected, a Pooled-Variance t-Test for the differences between two means based on unequal variances, was used. If not, the test was based on equal variances. The economic crisis did not have an effect on utilisation, because machines that did produce, were not scheduled because no labour was allocated to that machine.

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in utilisation for the population of data before the implementation of KPIs

σ^2_2= Variance in utilisation for the population of data after the implementation of KPIs.

Pooled-Variance t-Test for the differences between two means

For a given level of significance, α=0.05, the one-tail hypothesis tests were:

$$H_0: \mu_1 \geq \mu_2$$

$$H_1: \mu_1 < \mu_2$$

Where μ_1= Mean in utilisation for the population of data before the implementation of KPIs

μ_2= Mean in utilisation for the population of data after the implementation of KPIs

4.3.3.1 Chain Link

Utilisation data were analysed for the period 2009/05 up to 2009/10. For each period, the utilisation was determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.6: Chain Link utilisation mean and standard deviation

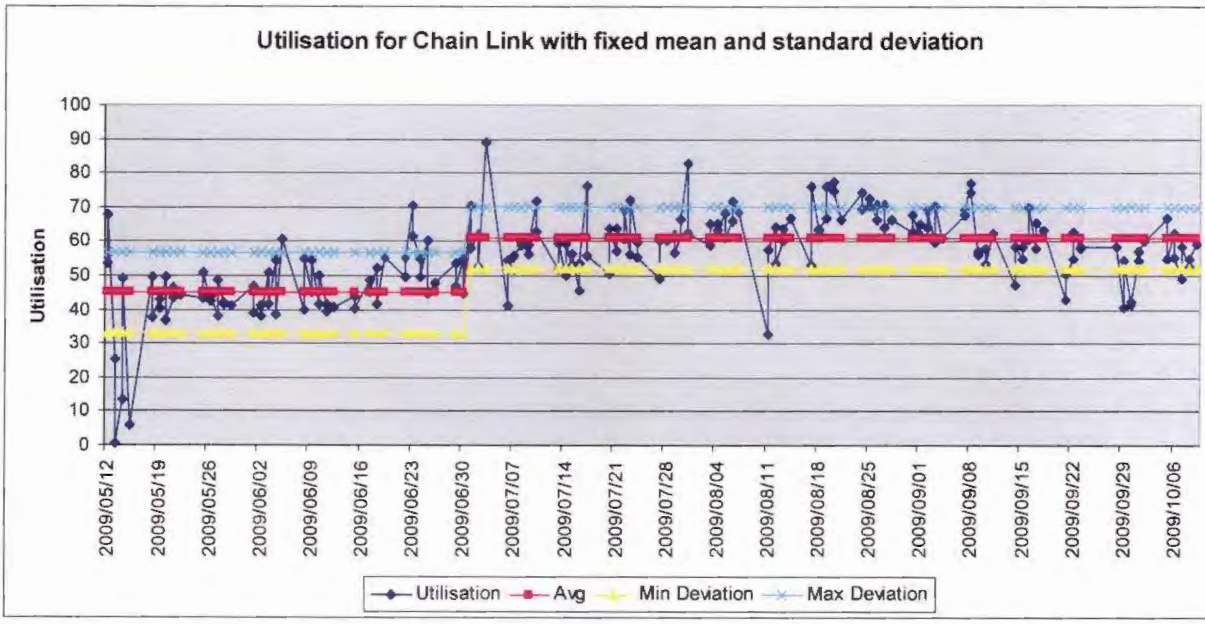
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
45%	11.69	61%	8.76

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on unequal variances. The null hypothesis was rejected for this test as well. There is significant evidence (95 percent certainty), that the mean of utilisation was 16 percent lower before implementation than after implementation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the utilisation for the period 2009/05 up to 2009/10 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

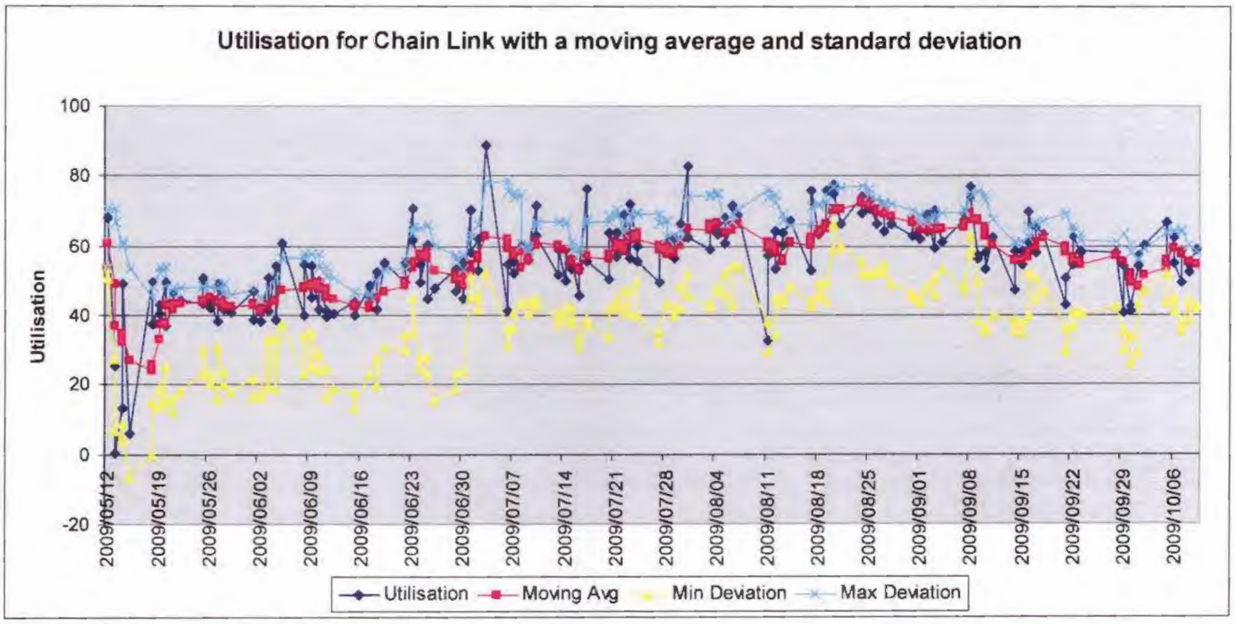
Figure 4.11: Utilisation for Chain Link with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the utilisation for the period 2009/05 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.12: Utilisation for Chain Link with a moving average and standard deviation



Source: Developed by the author, 2009

One can immediately see the effects that KPI measurement had on utilisation. Utilisation has increased from 45 to 61 percent. Using the Pooled-Variance t-Test for the differences between two means, one can say with 95 percent certainty that the mean has increased with 16 percent. Better utilisation means that the machine runs more of the time, so fewer machines can be used to reach the same production targets.

Without a doubt, it can be concluded that the utilisation KPI was successfully implemented in the chain link factory, with positive results.

4.3.3.2 Netting

In the netting factory, an utilisation KPI exists for the loom machines and the tight winders.

Utilisation KPI for loom machines

Utilisation data were analysed for the period 2009/04 up to 2009/10. For each period, the utilisation was determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.7: Netting's loom machines utilisation mean and standard deviation

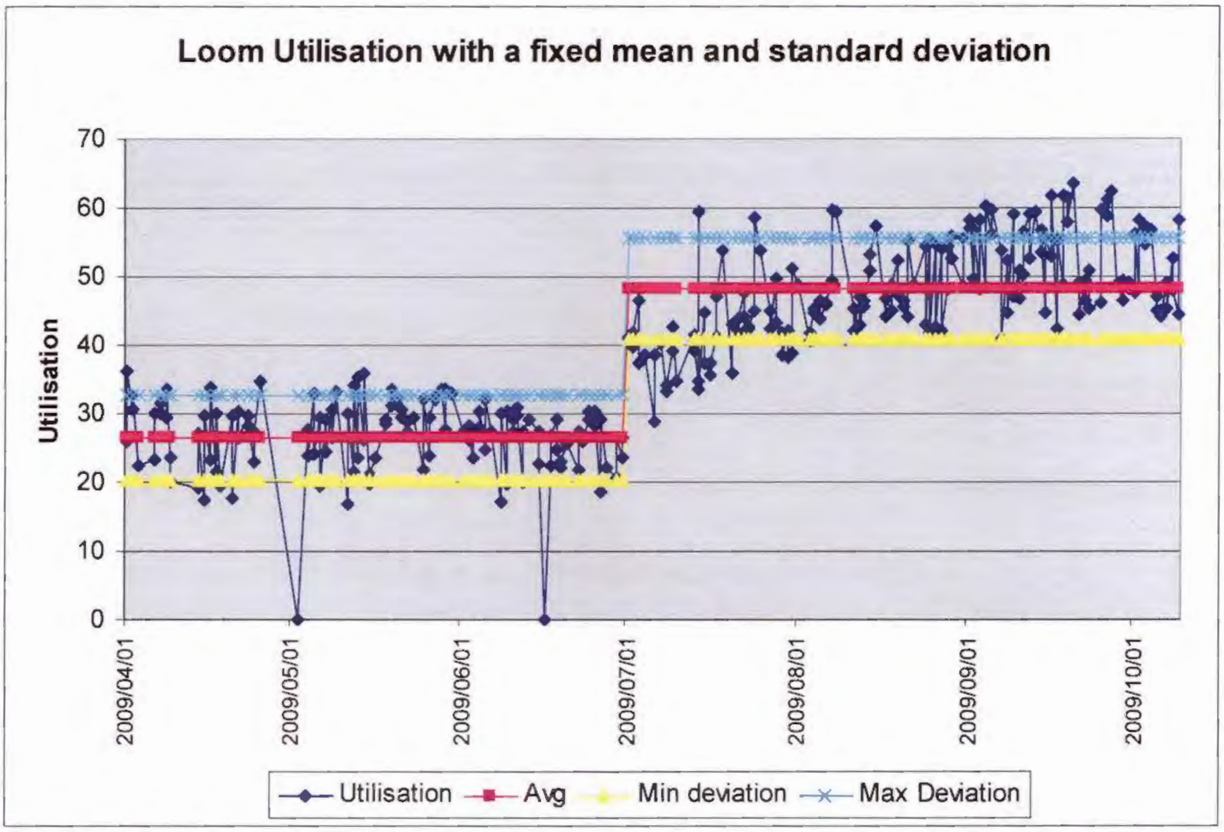
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
26.54%	6.184	48.21%	7.23

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on unequal variances. The null hypothesis was rejected for this test as well. There is significant evidence (95 percent certainty), that the mean of utilisation was 21.67 percent lower before implementation than after implementation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the utilisation for the period 2009/04 up to 2009/10, with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

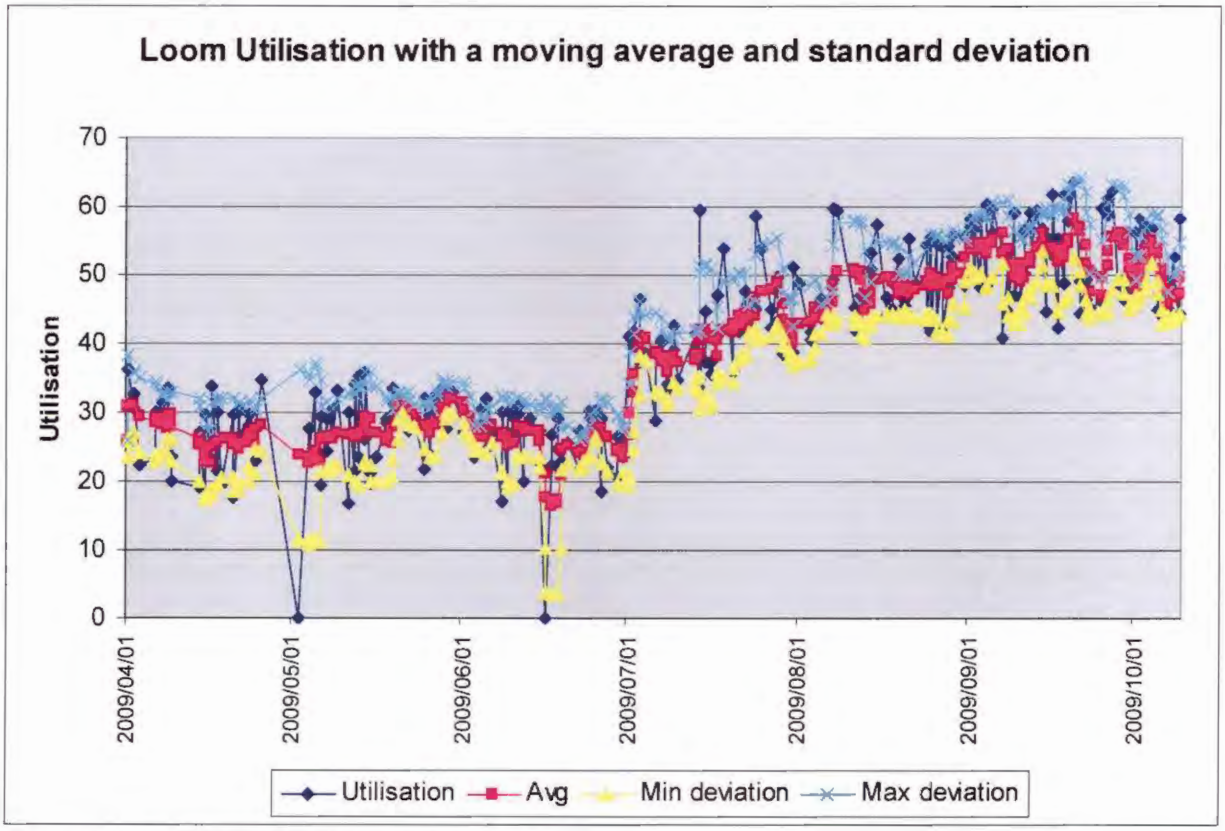
Figure 4.13: Netting's utilisation for loom machines with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the utilisation for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.14: Netting's loom machines utilisation with a moving average and standard deviation



Source: Developed by the author, 2009

One can immediately see the effects that KPI measurement had on utilisation. Utilisation increased from 26.54 to 48.21 percent. Using the Pooled-Variance t-Test for the differences between two means, one can say with 95 percent certainty that the mean has increased with 21.67 percent. Better utilisation means that the machines run more of the time, so fewer machines can be used to reach the same production targets.

Without a doubt, it can be concluded that the utilisation KPI was successfully implemented for the loom machines, with positive results.

Utilisation KPI for tight winders

Utilisation data were analysed for the period 2009/04 up to 2009/10. For each period, the utilisation was determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.8: Netting's tight winder utilisation mean and standard deviation

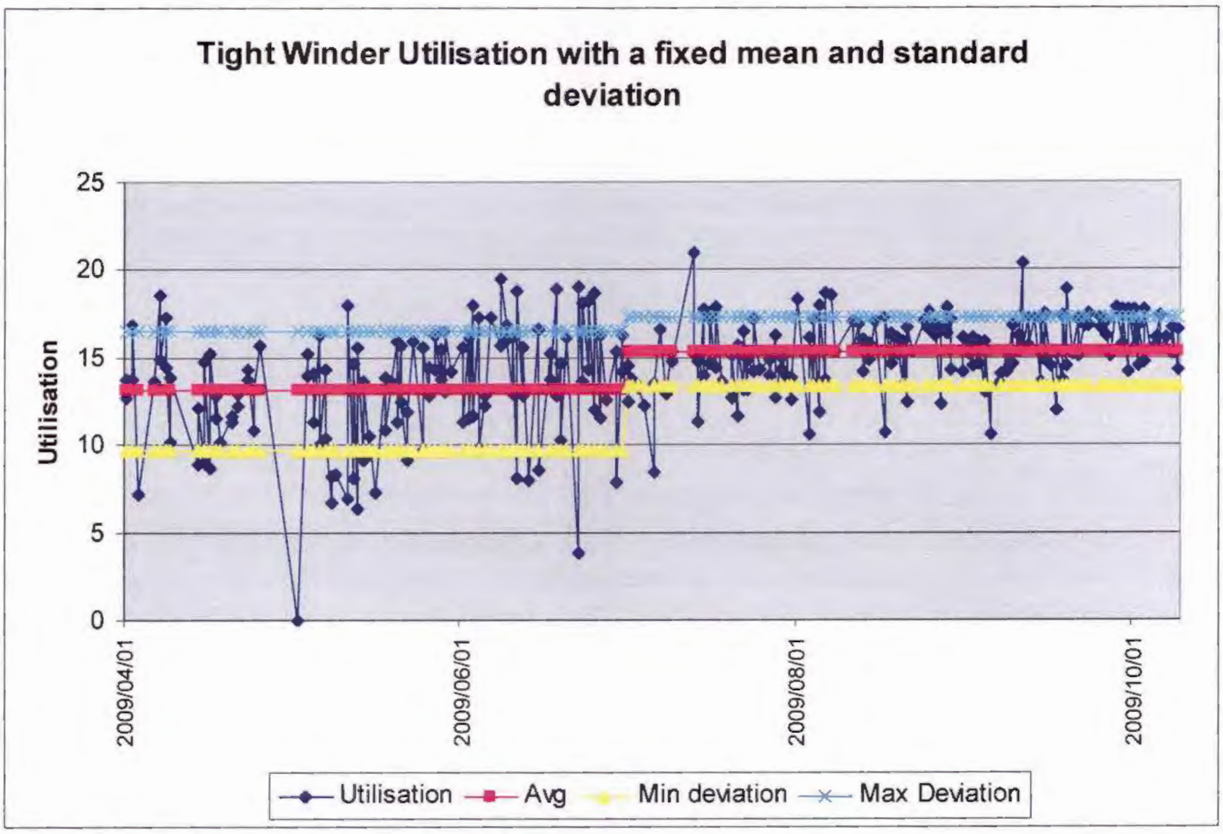
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
13.01%	3.43	15.33%	1.93

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on unequal variances. The null hypothesis was rejected for this test as well. There is significant evidence (95% certainty), that the mean of utilisation was 2.32 percent lower before implementation than after implementation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the utilisation for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

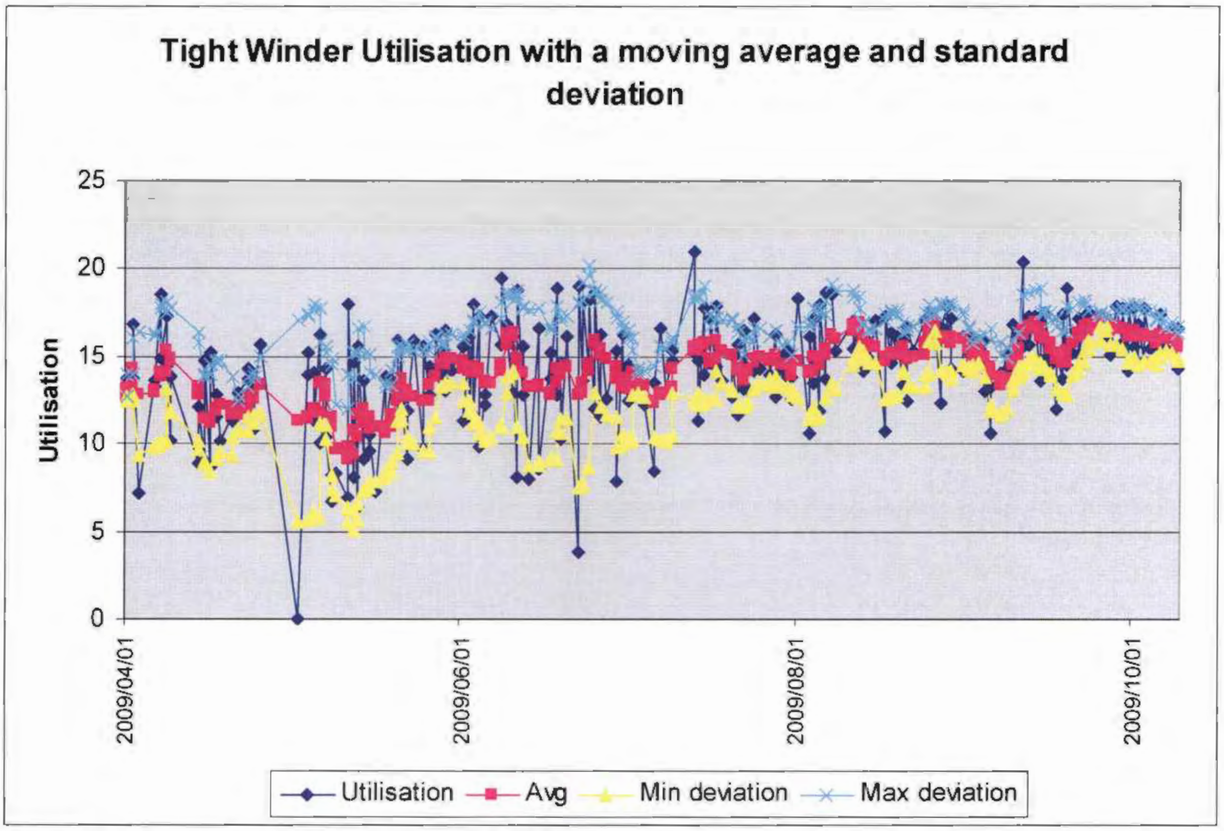
Figure 4.15: Netting's tight winder utilisation with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the utilisation for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.16: Netting's tight winder utilisation with a moving average and standard deviation



Source: Developed by the author, 2009

One can immediately see the effects that KPI measurement had on utilisation. Utilisation increased from 13.01 to 15.33 percent. Using the Pooled-Variance t-Test for the differences between two means, one can say with 95 percent certainty that the mean has increased with 2.32 percent. Better utilisation means that the machines run more of the time, so fewer machines can be used to reach the same production targets.

Without a doubt, it can be concluded that the utilisation KPI was successfully implemented for the tight winders, with positive results.

4.3.4 Downtime KPI

Downtimes are seen as a visual tool to explain why production, utilisation and absenteeism performed as they did. Downtimes are also important because they provide an analysis of downtimes, which forms a basis for continuous improvement. With continuous improvement, one can concentrate on a specific downtime with the end goal of reducing the total downtime. To do a downtime analysis, the first step is to ensure that all downtimes are booked. If a downtime is not booked, the system automatically labels it as "Unspecified". Ideally, one wants as little "Unspecified" downtime as possible so that you know why a machine is standing.

For the downtime KPI, the change in mean in the "Unspecified" and "Total" downtime was investigated in order to determine the effect that the KPI system had on the performance of the indicator. Improvement in the downtime KPI will be seen as a significant decrease in the mean of downtimes. As with the utilisation KPI, a Pooled-Variance t-Test for the differences between two means and an F-test for the differences between two variances were used for hypothesis tests.

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in downtimes for the population of data before the implementation of KPIs

σ^2_2= Variance in downtimes for the population of data after the implementation of KPIs

Pooled-Variance t-Test for the differences between two means

For a given level of significance, α=0.05, the one-tail hypothesis tests were:

$$H_0: \mu_2 \geq \mu_1$$

$$H_1: \mu_2 < \mu_1$$

Where μ_1= Mean in downtimes for the population of data before the implementation of KPIs.

μ_2= Mean in downtimes for the population of data after the implementation of KPIs.

4.3.4.1 Chain Link

Unspecified downtimes were analysed for the period 2009/05 up to 2009/09. For each period the, downtimes were determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.9: Chain Link's unspecified downtime mean and standard deviation

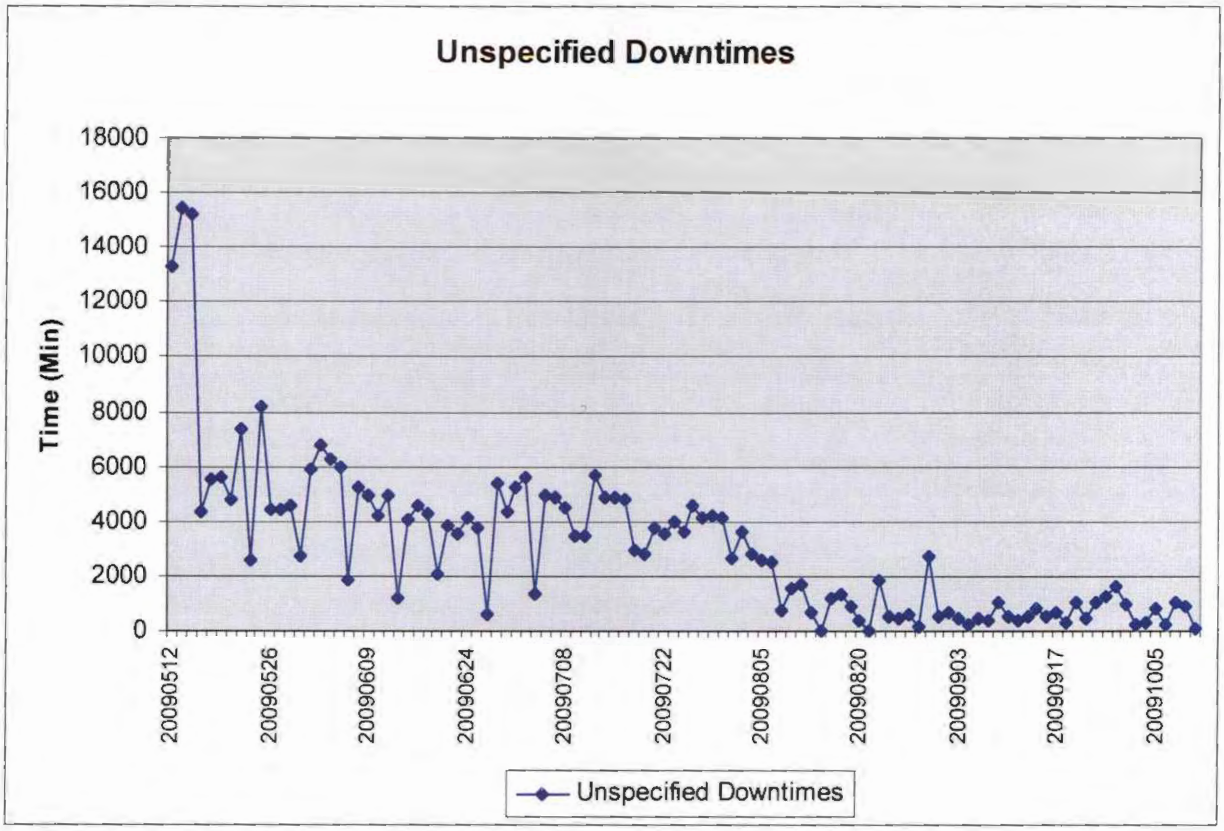
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
5324.19	3307.025	1962.02	1738.572

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on unequal variances. The null hypothesis was rejected for this test as well. There is significant evidence (95 percent certainty), that the mean of unspecified downtimes was 3362.17 minutes lower after implementation than before implementation.

The next graph shows the unspecified downtime analysis for the period 2009/05 up to 2009/10.

Figure 4.17: Unspecified downtimes for the chain link machines



Source: Developed by the author, 2009

From the graph, one can see that the unspecified downtime decreased steadily from 6000 production minutes per day in June 3009, to 58 production minutes per day in October 2009. The downtime had been effectively managed since the introduction of the KPI performance measurement system.

Total downtimes were analysed for the period 2009/05 up to 2009/09. For each period, the downtimes were determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.10: Chain Link's total downtime mean and standard deviation

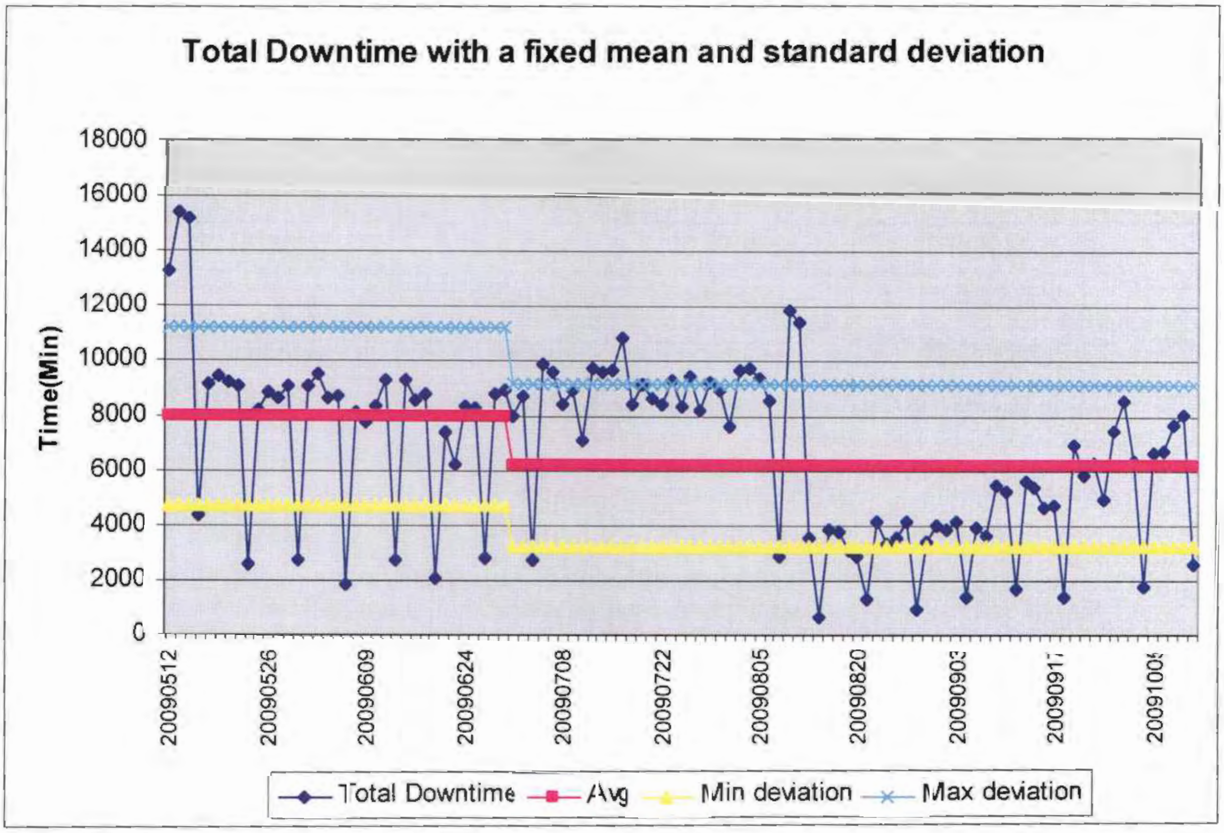
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
7960	3223.007	6224.637	2951

Source: Developed by the author, 2009

The null hypothesis was not rejected. There is not sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on equal variances. The null hypothesis was rejected for this test. There is significant evidence (95 percent certainty), that the mean of total downtimes was 1736 minutes lower after implementation than before implementation.

The next graph shows the total downtime analysis for the period 2009/05 up to 2009/10.

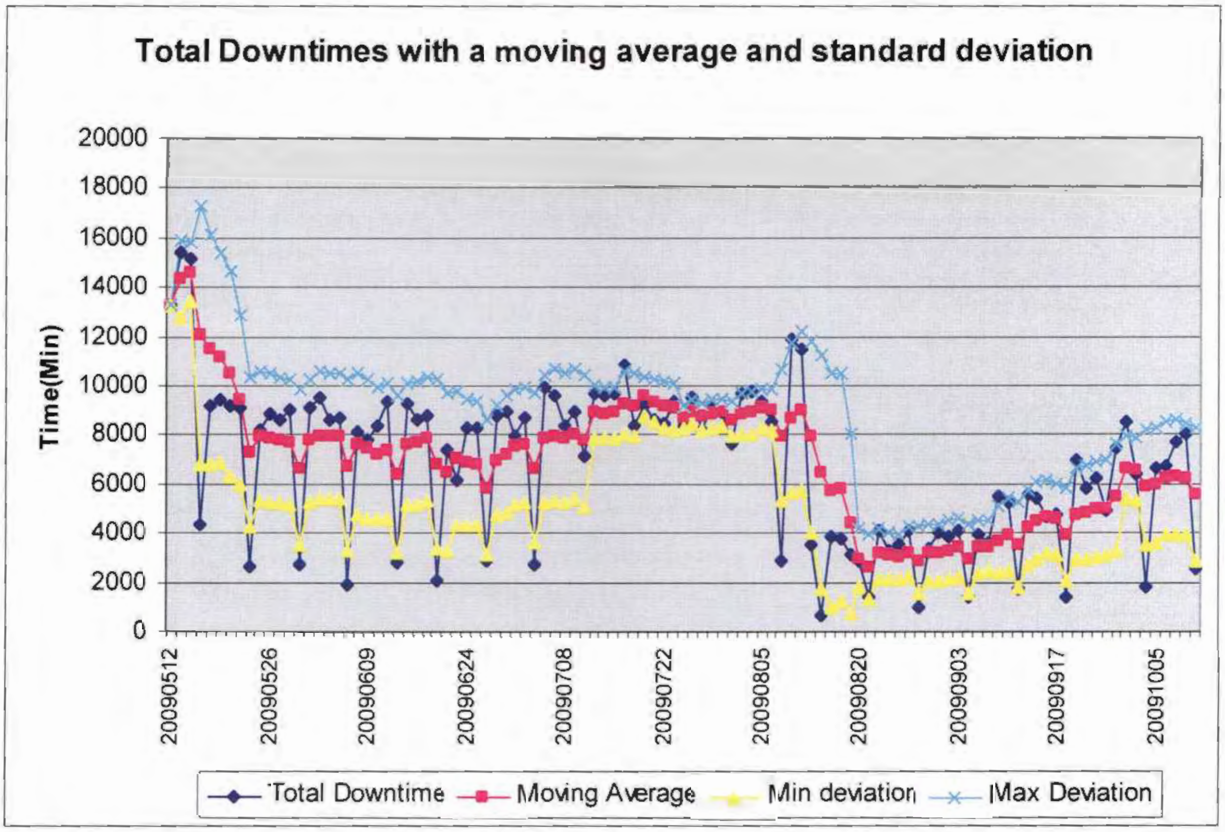
Figure 4.18: Total downtime for the chain link machines with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the total downtime for the period 2009/05 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.19: Total downtime for the chain link machines with a moving average and standard deviation



Source: Developed by the author, 2009

One aim of the downtime KPI, is to reduce the total downtime. The above graphs show a reduction of downtime in August 2009. If the above two graphs are compared with the graph in figure.11, one sees that it is the same time as when there was a reduction in unspecified downtimes. This was due to tardiness on behalf of operators who left the machines standing without reason. Most reduction in downtime took place at the end of August 2009. This will increase the reduction in the mean of total downtime after implementation even more. Less downtime means higher utilisation and production output. Using downtime as a KPI had a real effect on reducing machine idle times. Unspecified downtime was almost eliminated completely, which paves the way for continuous improvement. Downtime analysis can now be used to focus on a specific downtime to reduce it. Using the Pooled-Variance t-Test for the differences between two means, one can say with 95 percent certainty that the mean of unspecified downtime has been reduced with 3362 minutes and the mean of total downtime has been reduced by 1736 minutes.

Without a doubt it can be concluded that the downtime KPI was successfully implemented for the chain link factory, with positive results.

4.3.4.2 Netting

In the netting factory, the downtime KPI exists for the loom machines and the tight winders.

Downtime KPI for loom machines

Unspecified downtimes were analysed for the period 2009/04 up to 2009/09. For each period, the downtimes were determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.11: Loom machines' unspecified downtime mean and standard deviation

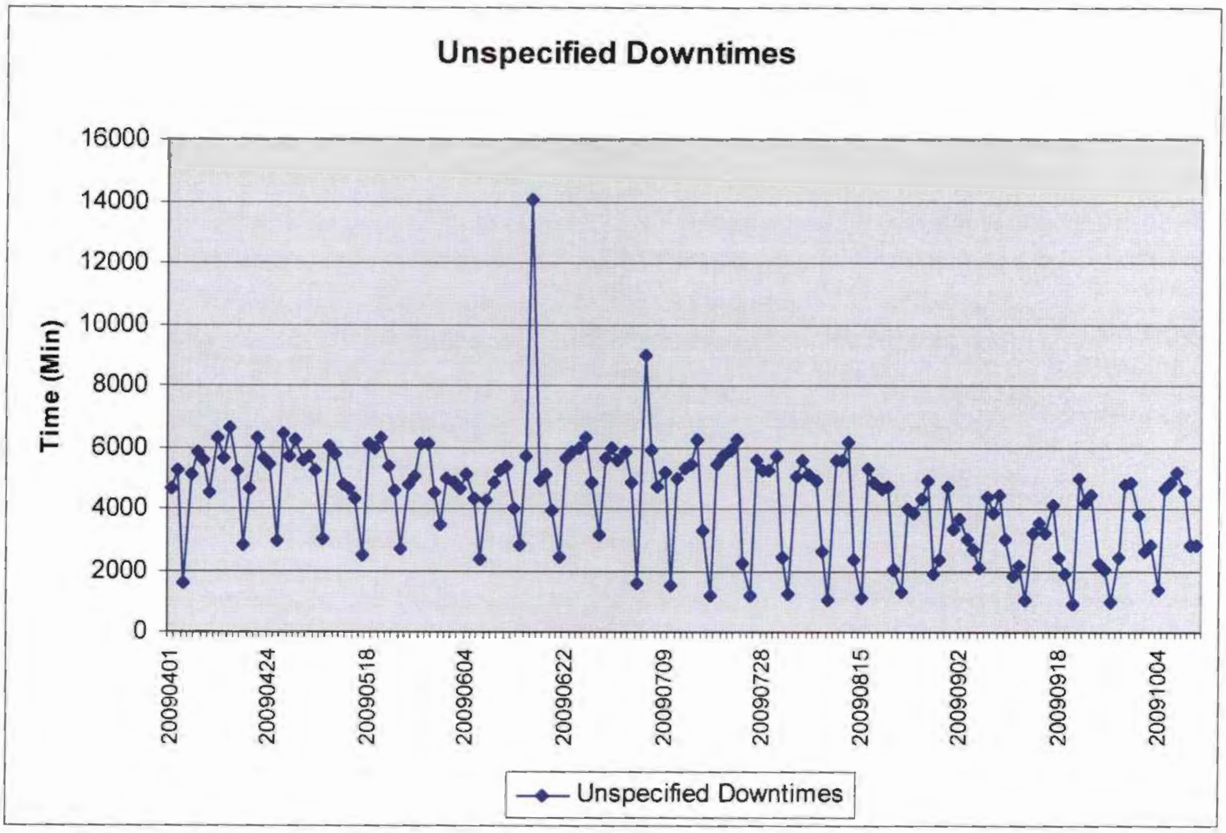
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
5053.277	1606.59	3802.173	1673.76

Source: Developed by the author, 2009

The null hypothesis was not rejected. There is not sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on equal variances. The null hypothesis was rejected for this test. There is significant evidence (95 percent certainty), that the mean of total downtime was 1251.104 minutes lower after implementation than before implementation.

The next graph shows the unspecified downtime analysis for the period 2009/04 up to 2009/10.

Figure 4.20: Unspecified downtime for the loom machines



Source: Developed by the author, 2009

Total downtimes were analysed for the period 2009/05 up to 2009/09. For each period, the downtimes were determined. The mean and standard deviation were also determined for each period. The following table summarises the results.

Table 4.12: Loom machines' total downtime mean and standard deviation

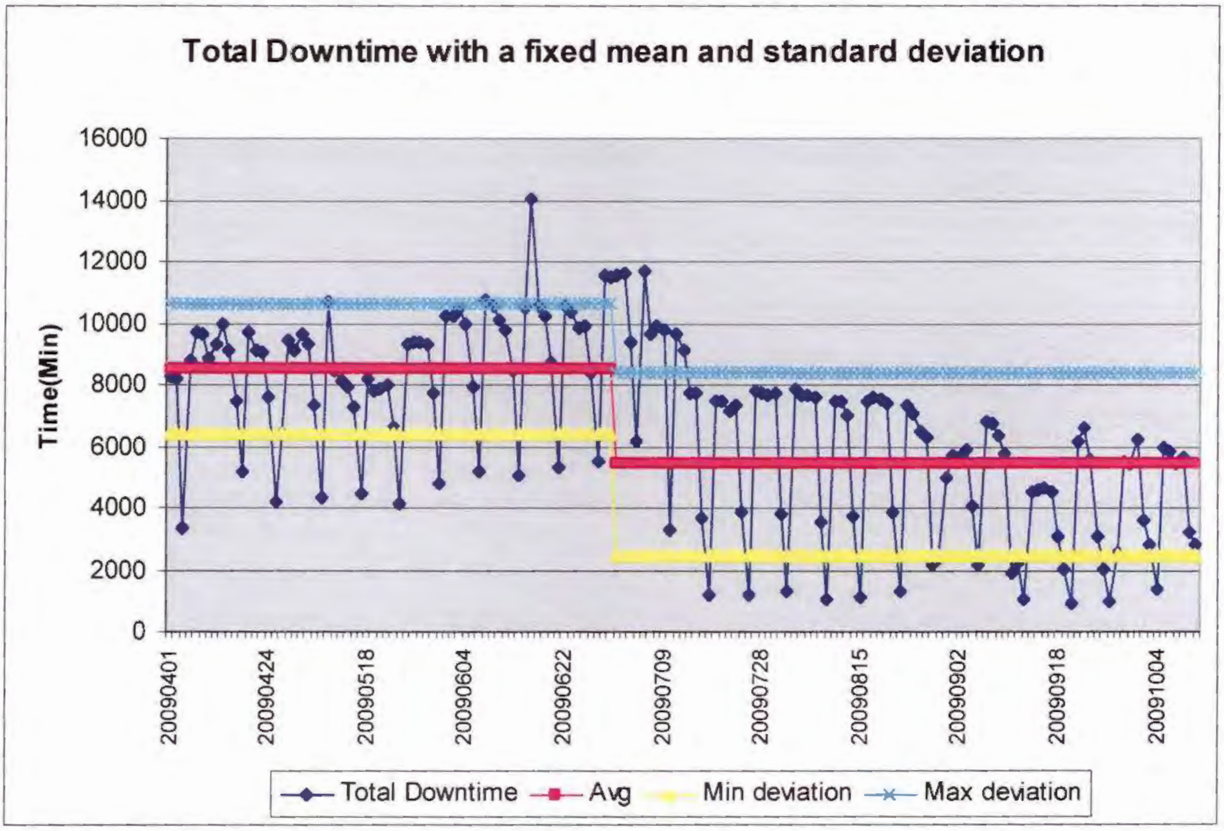
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
8503.65	1804.392	6503.649	2859.343

Source: Developed by the author, 2009

The null hypothesis was rejected. With 95 percent certainty, there is sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on unequal variances. The null hypothesis was rejected for this test as well. There is significant evidence (95 percent certainty), that the mean of unspecified downtimes was 2000 minutes lower after implementation than before implementation.

The next graph shows the total downtime analysis for the period 2009/04 up to 2009/10.

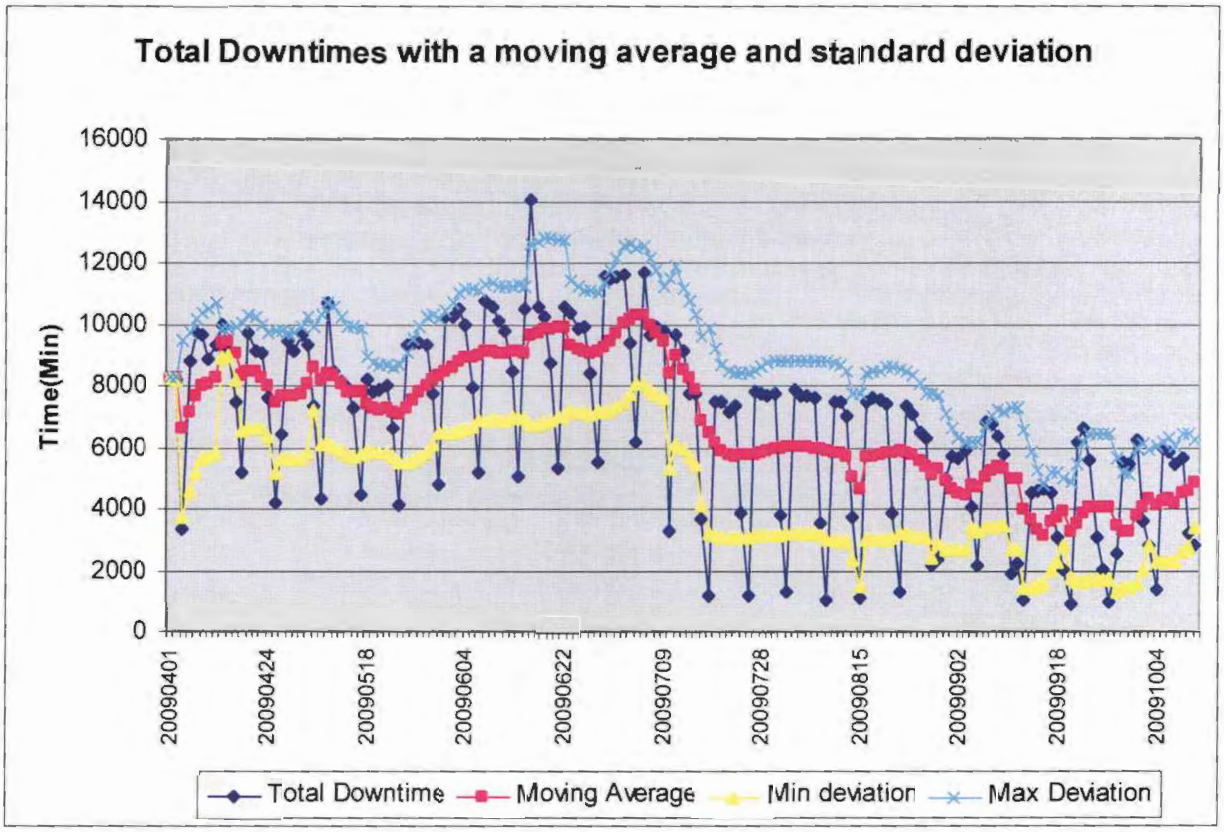
Figure 4.21: Total downtime for the loom machines with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the total downtime for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.22: Total downtime for the loom machines with a moving average and standard deviation



Source: Developed by the author, 2009

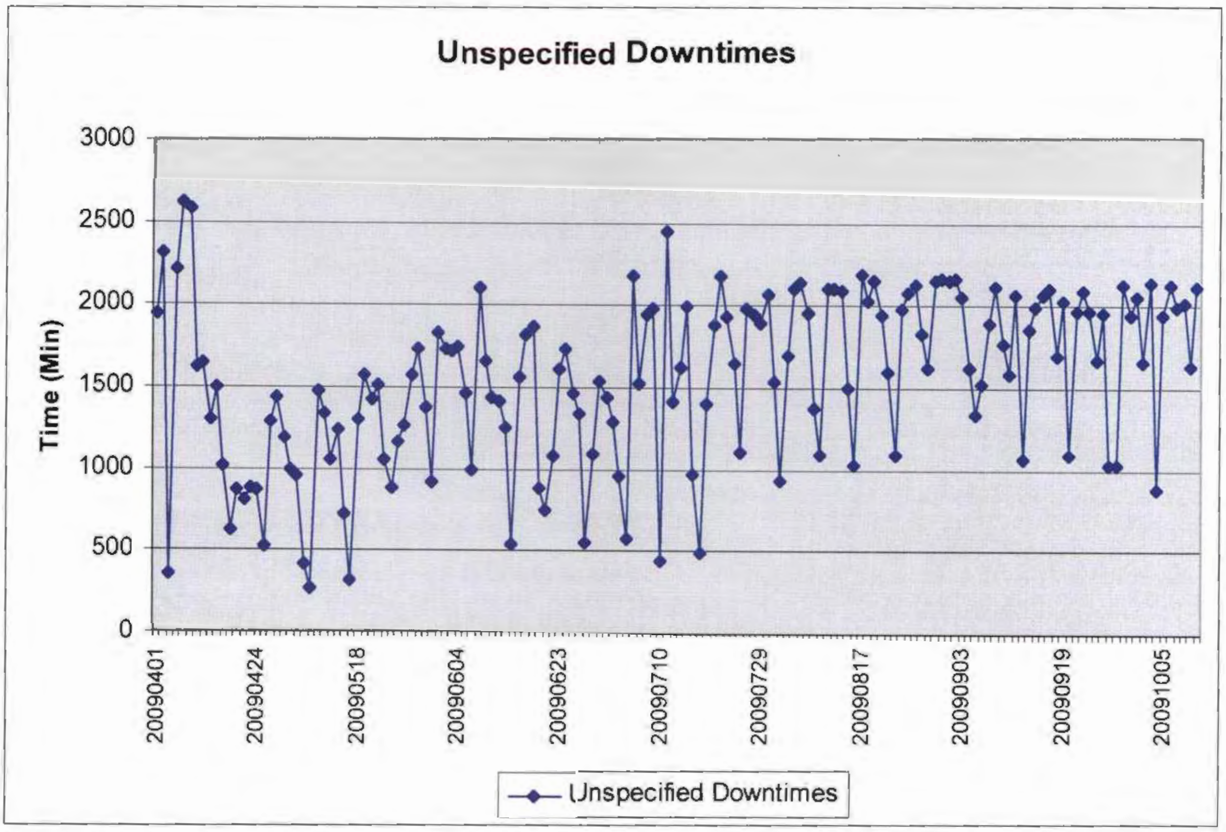
One aim of the downtime KPI is to reduce the total downtime. The above graphs show a reduction of downtimes in July 2009. Less downtime means higher utilisation and production output. Using the Pooled-Variance t-Test for the differences between two means, one can say with 95 percent certainty that the mean of unspecified downtime has been reduced with 1251 production minutes and the mean of the total downtime has been reduced with 2000 production minutes.

Without a doubt it can be concluded, that the downtime KPI was successfully implemented for the netting factory, with positive results. Although unspecified downtimes have been reduced significantly, it has not been eliminated, leaving room for improvement.

Downtime KPI for tight winders

The next graph shows the unspecified downtime analysis for the period 2009/04 up to 2009/10.

Figure 4.23: Unspecified downtime for the tight winders



Source: Developed by the author, 2009

From the graph, one can see that the KPI system had no effect on the unspecified downtimes of the tight winders.

Total downtimes were analysed for the period 2009/05 up to 2009/09. For each period the downtimes were determined. The mean and standard deviation was also determined for each period. The following table summarises the results.

Table 4.13: Tight winders' total downtime mean and standard deviation

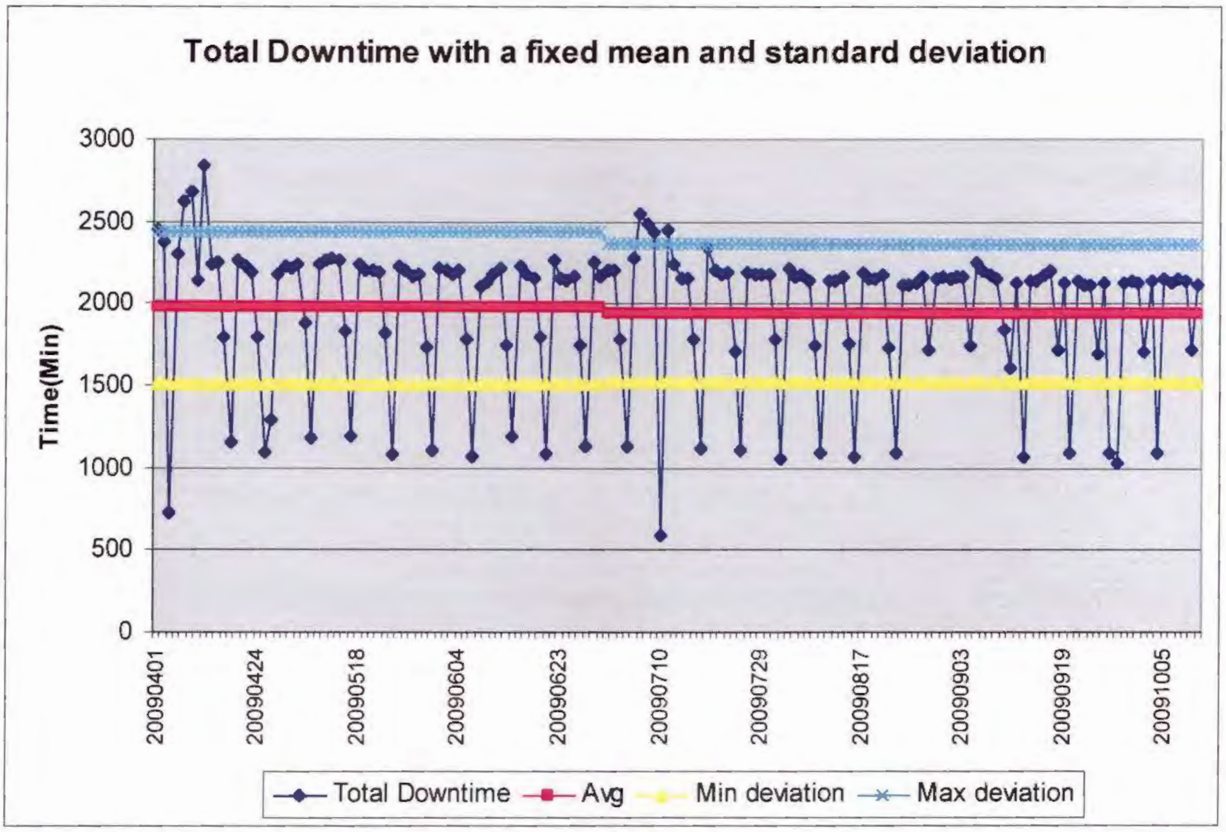
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
1975.2	457	1942.6	417.67

Source: Developed by the author, 2009

The null hypothesis was not rejected. There is not sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on equal variances. The null hypothesis was not rejected for this test. There is not sufficient evidence that there is a significant difference in the mean of total downtimes.

The next graph shows the total downtime analysis for the period 2009/04 up to 2009/10.

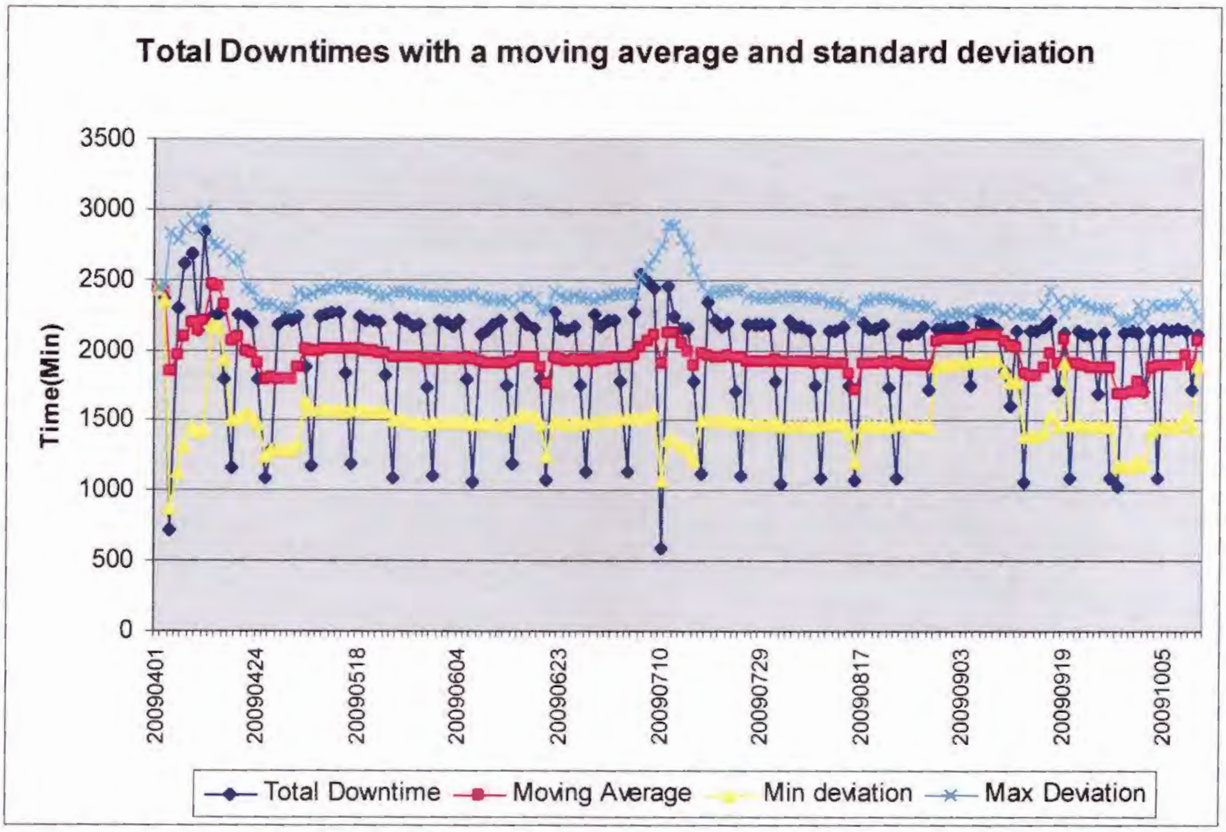
Figure 4.24: Total downtime for the tight winders with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the total downtime for the period 2009/04 up to 2009/10 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.25: Total downtime for the tight winders with a moving average and standard deviation



Source: Developed by the author, 2009

The downtime KPI had no effect on the performance of the downtime.

4.3.5 Scrap percentage KPI

As scrap figures are confidential, scrap will be analysed as a percentage of the target. For the scrap KPI, the change in the mean of the scrap percentage was investigated to determine the effect that the KPI system had on the performance of the indicator. Improvement in the scrap percentage KPI will be seen as a significant decrease in the mean of the scrap percentage. A Pooled-Variance t-Test for the differences between two means and an F-test for the differences between two variances was used for hypothesis tests.

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in scrap percentage for the population of data before the implementation of KPIs.

σ^2_2= Variance in scrap percentage for the population of data after the implementation of KPIs.

Pooled-Variance t-Test for the differences between two means

For a given level of significance, $\alpha=0.05$, the one-tail hypothesis tests were

$$H_0: \mu_2 \geq \mu_1$$

$$H_1: \mu_2 < \mu_1$$

Where μ_1= Mean in scrap percentage for the population of data before the implementation of KPIs

μ_2= Mean in scrap percentage for the population of data after the implementation of KPIs

4.3.5.1 Chain Link

Scrap percentages were analysed for the period 2006/01 up to 2009/09. For each period, the scrap as a percentage of the target was determined. The mean and standard deviation were also determined for each period. The following table summarizes the results.

Table 4.14: Chain Link's scrap percentage as a percentage of the target mean and standard deviation

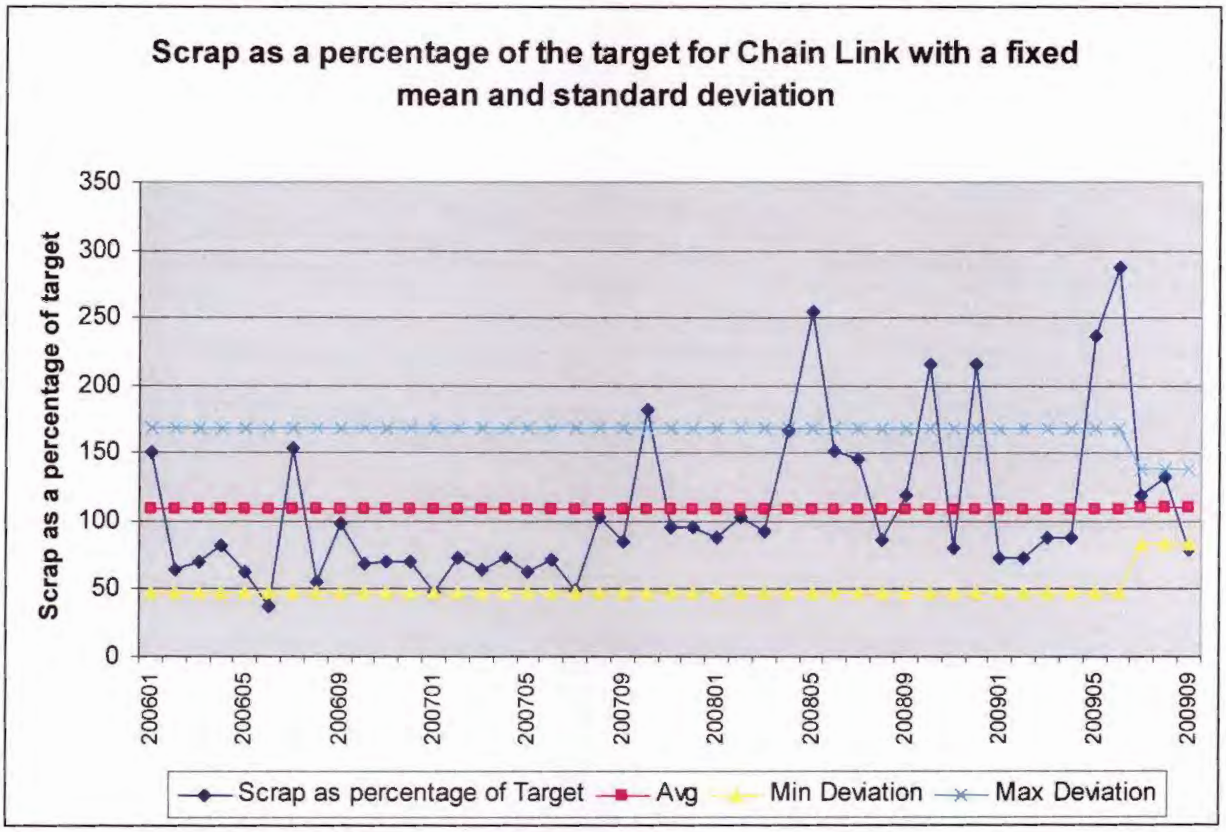
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
108%	60	110%	27

Source: Developed by the author, 2009

The null hypothesis was not rejected. There is not sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on equal variances. The null hypothesis was not rejected for this test. There is not significant evidence that there is any difference between the means of scrap percentages before and after implementation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the scrap as a percentage of the target for the period 2006/01 up to 2009/09 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

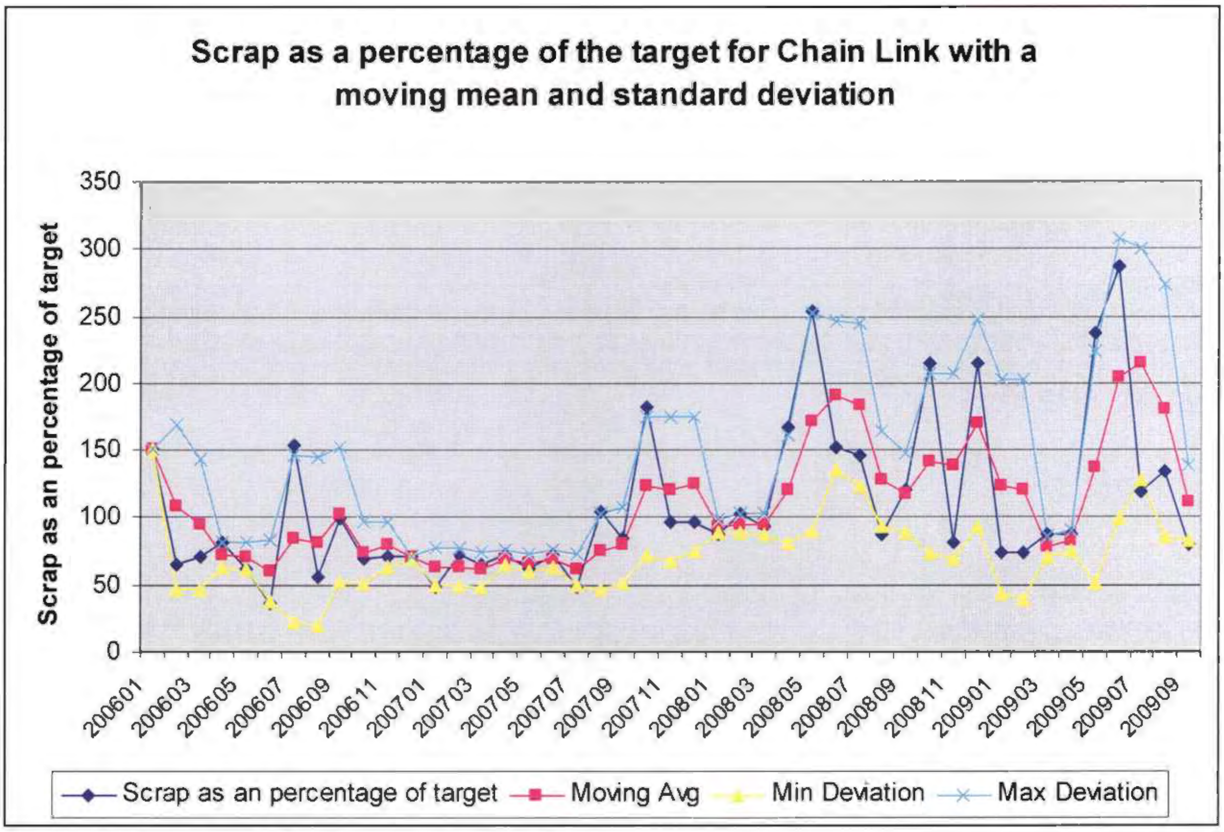
Figure 4.26: Scrap as a percentage of the target for Chain Link with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the utilisation for the period 2006/01 up to 2009/09 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.27: Scrap as a percentage of the target for Chain Link with a moving average and standard deviation



Source: Developed by the author, 2009

The scrap percentage increased in 2008. This can be attributed to the economic crisis, because machines stopped and started due to an infrequent amount of small orders. Each order from a customer required a job change, which resulted in an increase of scrap. Although the standard deviation has been reduced from 60 to 27, there is not enough data to make an accurate evaluation on the specific KPI. As mentioned in the document analysis section, the reasons for a lack of data are that scrap is measured only once a month, which makes it difficult to act on.

4.3.5.2 Netting

Scrap percentages were analysed for the period 2006/01 up to 2009/09. For each period, the scrap as a percentage of the target was determined. The mean and standard deviation were also determined for each period. The following table summarizes the results.

Table 4.15: Netting's scrap percentage as a percentage of the target mean and standard deviation

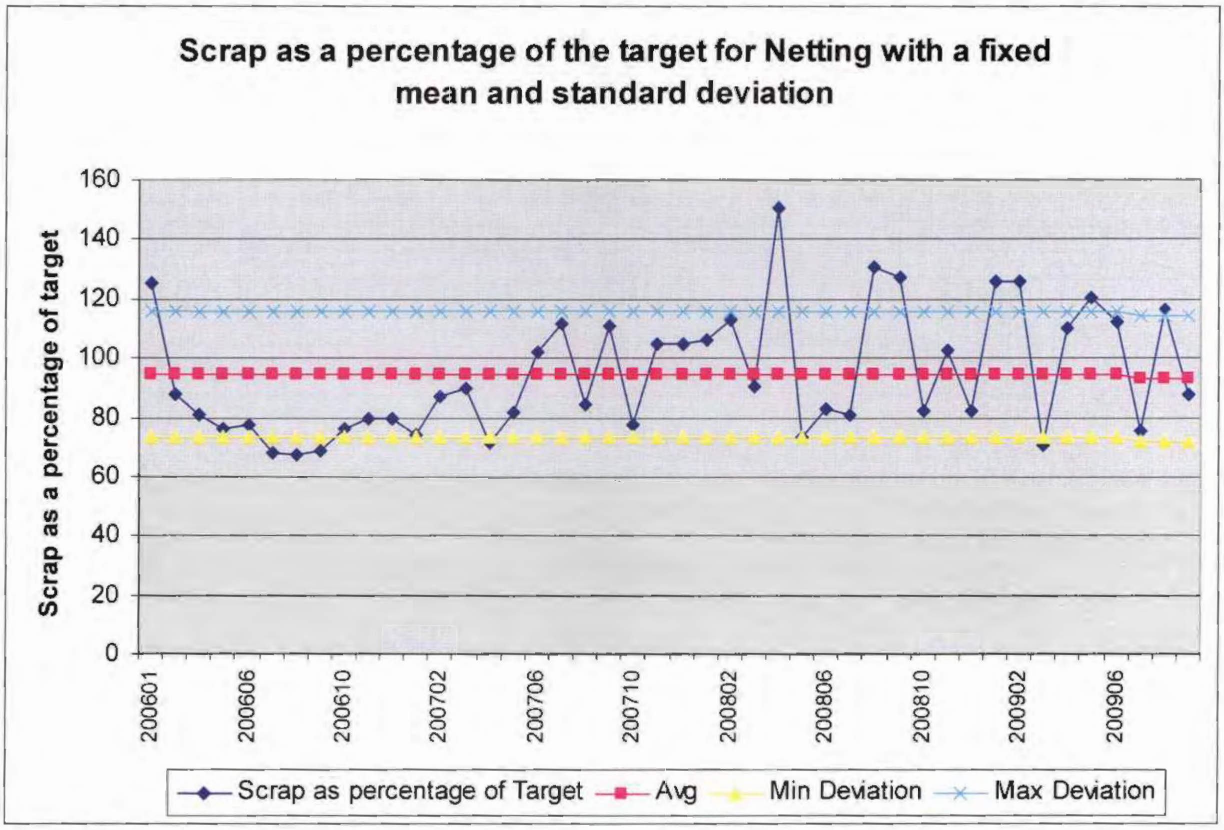
a) Before KPI implementation		b) After KPI implementation	
Mean (μ_1)	Standard deviation (σ_1)	Mean (μ_2)	Standard deviation (σ_2)
94.58%	21.16	93.44%	21.035

Source: Developed by the author, 2009

The null hypothesis was not rejected. There is not sufficient evidence that there is a significant difference in the variance and therefore, the standard deviation. It was therefore, required to do a pooled variance t-Test based on equal variances. The null hypothesis was rejected for this test. There is significant evidence (95 percent certainty), that the mean of scrap percentage as a percentage of the target, was 1.14 percent lower after implementation than before implementation.

The following two graphs show the effect that KPI performance measurement had. The first graph shows the scrap as a percentage of the target for the period 2006/01 up to 2009/09 with the minimum and maximum standard deviation. The mean and standard deviation were fixed for each period.

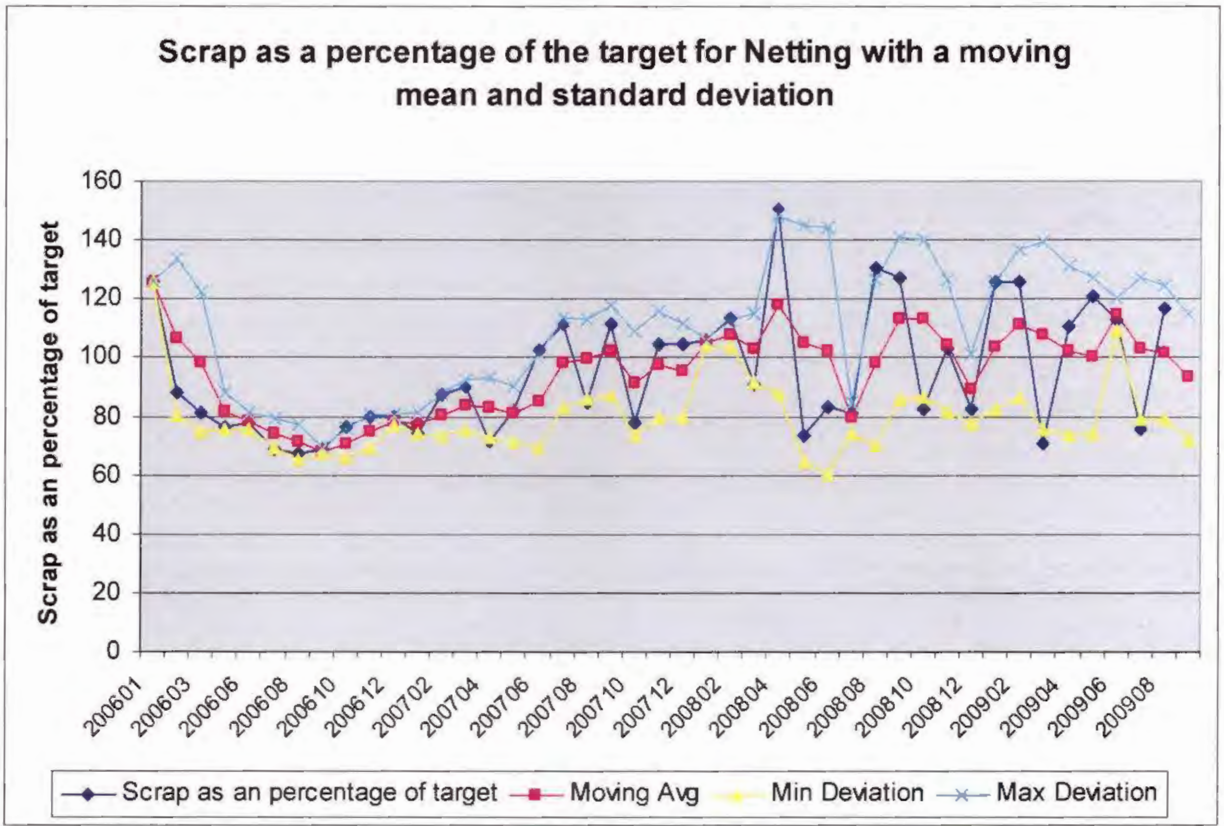
Figure 4.28: Scrap as a percentage of the target for Netting with a fixed mean and standard deviation



Source: Developed by the author, 2009

The second graph shows the utilisation for the period 2006/01 up to 2009/09 with the minimum and maximum standard deviation. A moving average and standard deviation were used.

Figure 4.29: Scrap as a percentage of the target for Netting with a moving average and standard deviation



Source: Developed by the author, 2009

Although it is difficult to see from the graphs, a pooled variance t-Test based on equal variances showed there is significant evidence (95 percent certainty), that the mean of scrap percentage as a percentage of the target was 1.14 percent lower after implementation than before implementation.

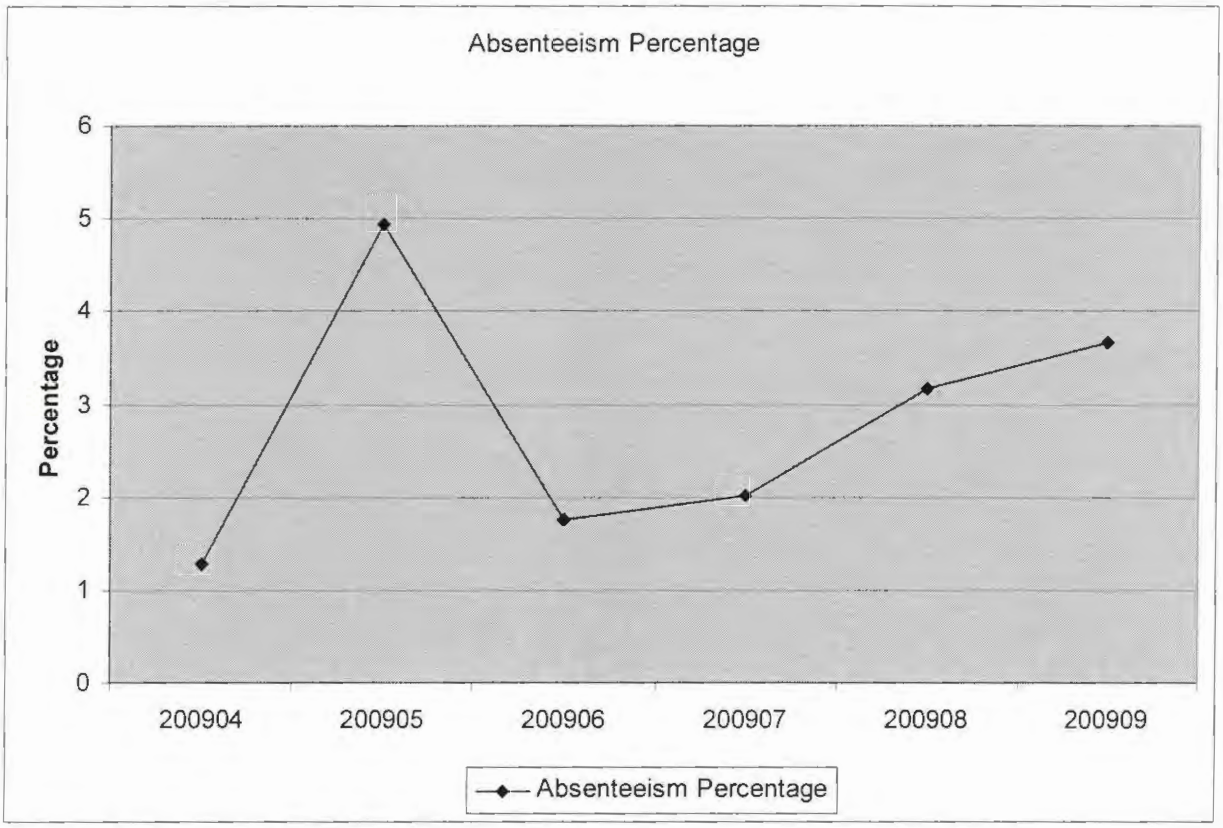
4.3.6 Absenteeism KPI

Absenteeism is the only KPI that forms part of level 3 of the KPI framework. It is a KPI that relates with issues regarding employees. Not enough data are available to make a conclusion on the absenteeism KPI.

4.3.6.1 Chain Link

The following graph shows the results of absenteeism for the period 2009/04 up to 2009/05.

Figure 4.30: Absenteeism for Chain Link



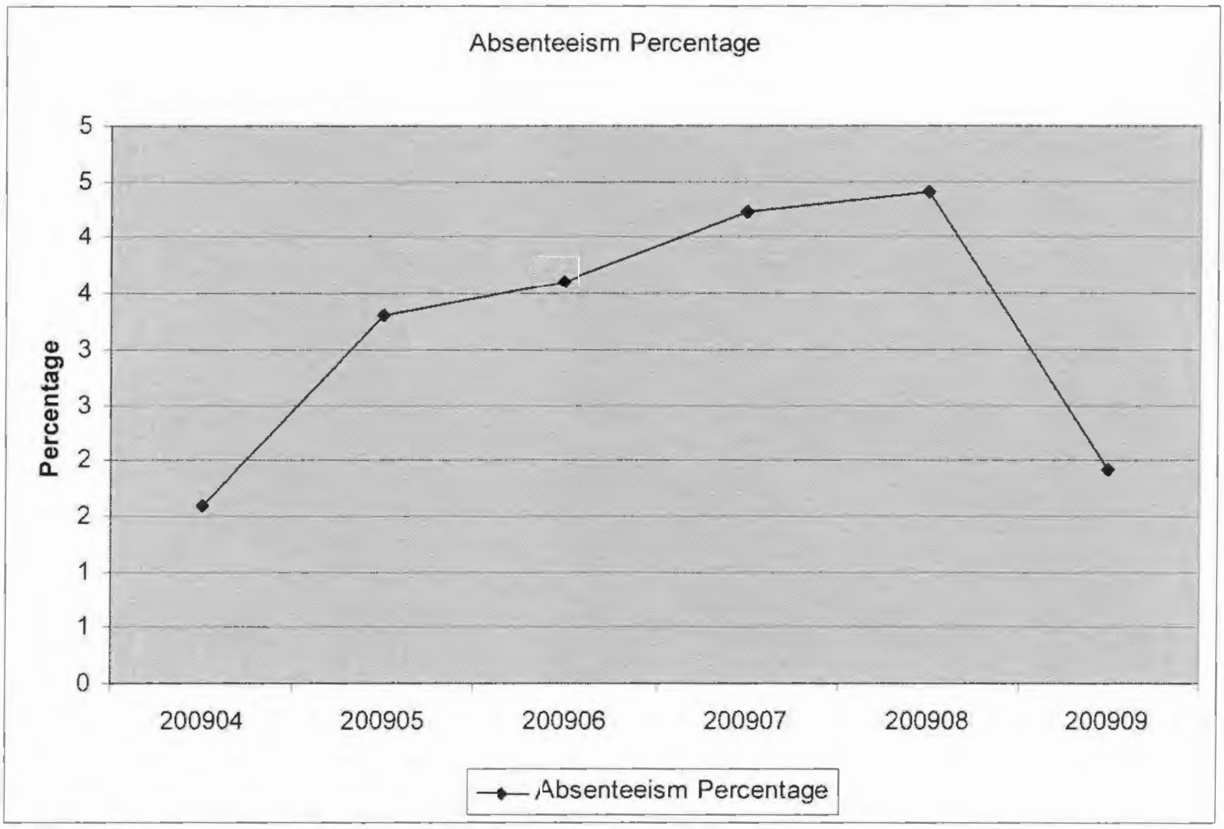
Source: Developed by the author, 2009

As with the scrap percentage KPI, absenteeism is refreshed only once a month. Not enough data are available to make an informed decision on the absenteeism KPI.

4.3.6.2 Netting

The following graph shows the results of absenteeism for the period 2009/04 up to 2009/05.

Figure 4.31: Absenteeism for Netting



Source: Developed by the author, 2009

As with the scrap percentage KPI, absenteeism is refreshed only once a month. Not enough data is available to make an informed decision on the absenteeism KPI.

4.4 Summary

For the purpose of the mini-dissertation, the research was carried out through a process of document analysis and data analysis. The KPI system was implemented on the 1st of June 2009. The first month was a transition phase so that managers could familiarise themselves with the system. All results from July 2009 onwards were seen as data reviewed with the use of the KPI system. Available reports are used to determine the current performance measurement system, to determine if effective KPIs were chosen and to determine if the implementation was done successfully. Descriptive statistics are used to analyse actual production data to determine the effect that KPIS have on production. In the next chapter conclusions from the literature study are compared with the results from the empirical study.

CHAPTER 5
SUMMARY AND CONCLUSION

5.1 Introduction

The primary objective of this research was to determine the effectiveness of Key Performance Indicators in the product factories of Cape Gate.

The specific supportive objectives of this research were to determine -

- If effective KPIs are measured,
- If the implementation of KPIs had been done successfully, and
- What the effect is of specific KPI measurement in Cape Gate.

The literature study identified the nature and functioning of performance measurement and management, as well as an in-depth study into key performance indicators. Advantages and disadvantage of KPIs were described. A simple, logical and repeatable closed-loop model within a framework was suggested for the implementation of a KPI system.

For the purpose of the mini-dissertation, the research was carried out through a process of document analysis and data analysis. The KPI system was implemented on the 1st of June 2009. The first month was a transition phase so that managers could familiarise themselves with the system. All results from July 2009 were seen as after implementation. Available reports were used to determine the current performance measurement system, to determine if effective KPIs were chosen and to determine if the implementation was done successfully. Descriptive statistics were used to analyse actual production data in order to determine the effect that KPIS had on production.

In this conclusion, the findings and principles of the literature study are compared with the results from the empirical findings. Conclusions will be formulated on each supporting objective and the main objective of the case study.

5.2 Objective: To determine if effective KPIs are measured

According to Rakar (2004:4), KPIs should be introduced by using the three-level hierarchy model, together with the eight-step closed-loop model for defining and measuring KPIs. The hierarchy model consists of three levels, starting with safety and environment, followed by quality, production plan-tracking and production efficiency, and ending with issues related to employees. After the closed-loop model is successfully completed on a level, step one of the closed-loop model is started for the next level on the hierarchy of introducing KPIs. Current available production reports, production and technical specifications of the KPI system were retrieved and investigated in order to compare selection and implementation of the KPI system in Cape Gate with that of the recommended closed-loop model in a three level hierarchy.

Cape Gate Sharon division is currently on level two; quality, production plan-tracking and production efficiency of the three-level hierarchy model. Safety and environment KPIs are monitored by the SHER department. Cape Gate is currently in step seven of the eight steps, where results are acted upon. Currently, lateral movement in level two takes place, where KPI level two measurements are implemented for all factories. According to Rakar (2004:5), KPIS for level 2 should involve efficiency, quality and production plan-tracking. Out of a list of potential KPIs, the following were chosen.

- Production
- Utilisation
- Downtimes
- Scrap percentage
- Absenteeism.

For the first four indicators, sufficient evidence was found through document analysis as to why these indicators were selected. Valid and logical reasoning was followed for rejecting possible indicators, for example, productivity and mean time between failures. Choosing absenteeism as a KPI, is against the findings of the literature review, because it forms part of level 3 on the hierarchy level, which deals with the issues related to employees. According to David Parmenter (2007:3), KPIs should not be more than ten. Cape Gate chose only five which are too few, but more indicators will be introduced once level three of the hierarchy level has been reached. Results of each KPI are addressed in the effectiveness of KPI section of this chapter.

In conclusion, an effective set of KPIs were chosen for Cape Gate product factories, with the exception of absenteeism. The five KPIs leave room for more KPIs to be added in the third level of the hierarchy model.

5.3 Objective: To determine if the implementation of KPIs has been done successfully

In the previous section, it was stated that the selection and implementation of KPIs were done by comparing documents of implementation with the theoretical closed-loop model of implementation. Comparing each step of the closed-loop, identified only three issues.

- Absenteeism KPI selection as mentioned in the previous section.
- A delay of six months due to data inadequacies.
- The refresh rate of the scrap percentage and absenteeism KPIs is once a month

In conclusion, implementation of KPIs in Cape Gate was done successfully. Currently, Cape Gate is still on step seven, "act on result", of the closed-loop model. It is recommended that Cape Gate should remain on this level for an indefinite time until the positive effects of the results become noticeable to all involved. Implementation of level two KPIs to all departments should also be finished before ending the closed-loop model for level 2: "Review Indicators, policies and goals".

5.4 Objective: To determine what the effect is of specific KPI measurement in Cape Gate

To determine what effect KPIs had on performance, descriptive statistics by means of dispersion were used to determine the before-and-after effects. For the purpose of this study, improvement of each KPI was interpreted by determining the mean and standard deviation before and after implementation. Where necessary, the F-Test for differences between two variances and the Pooled-Variance t-Test for the differences between two means, were used to determine if the KPI performance measurement system had a significant impact. The effect of the production, utilisation, downtimes, scrap percentage and absenteeism KPIs were analysed for the chain link factory and the netting factory, which include the loom machines and the tight winders.

5.4.1 Production

Using the F-Test for differences between two variances, it was proven that a significant reduction in standard deviation took place for the chain link machines, the loom machines and the tight winders. A smaller standard deviation or scatter of data shows that greater control is applied to production output. Using production as a KPI had immediate effects on the control of production. It is therefore, concluded that control over production output has increased significantly. Although more control is applied, actual production is lower due to the economic crisis in the steel manufacturing environment.

5.4.2 Utilisation

The KPI performance measurement system had the most positive and noticeable effect on utilisation. Using the Pooled-Variance t-Test for the differences between two means on each of the chain links, loom machines and tight winder KPIs, one can say with 95 percent certainty that the mean has increased considerably. Better utilisation means that the machines run more of the time, so fewer machines can be used to reach the same production targets. Without a doubt, it can be concluded that the utilisation KPI was successfully implemented in the product factories.

5.4.3 Downtimes

The aim of the downtime KPI is to reduce the total downtime. With 95 percent certainty, there was a significant reduction of total downtimes in both production factories. Less downtime means higher utilisation and production output. Reducing unspecified downtime is also important, because one cannot act on downtimes with no specified reason. For the chain link machines, unspecified downtime was almost eliminated completely, which paves the way for continuous improvement. The loom machines had a significant reduction in unspecified downtimes. Unfortunately, there was insignificant evidence that unspecified downtimes were reduced for the tight winders. Without a doubt it can be concluded, that the downtime KPI was successfully implemented for the *chain link* factory, with positive results. KPIs had a greater impact on the chain link factory than that of the netting factory.

5.4.4 Scrap percentage

Netting is the only factory that showed a significant reduction in the scrap percentage after the implementation of KPIs. A possible reason for this, is that it is measured only once a month. A lower refresh rate has a delayed reaction on the time it takes to act on results.

5.4.5 Absenteeism

There was insignificant evidence that absenteeism was reduced. A possible reason for this, is that it is only measured once a month. A lower refresh rate has a delayed reaction on the time it takes to act on results. Another reason may be the fact that it was not the right time to introduce this indicator, as it is a level 3 indicator on the hierarchy level mentioned by Rakar(2004:4)

5.4.6 Conclusion

KPIs were very significantly effective for the production, utilisation and downtime KPIs. Only one of the production factories showed improvement for the scrap percentage KPI. No improvement was made on the absenteeism KPI. It is believed that the refresh rate of measuring KPIs has a significant impact on the time one has to act on the result, explaining why no evidence of improvement could be found for scrap and absenteeism. Steps should be taken to improve the refresh rate. It is believed that absenteeism did not perform, due the fact that it is the only indicator on level three on the hierarchy of introducing KPIs.

5.5 Pitfalls with KPIs in Cape Gate

A list of pitfalls is now listed.

- There are currently not enough critical measures. Vital operations may be missed.
- The KPIs are focused only on the short-term. A cross-section of past (lagging), present and future measures is critical.
- Scrap percentage and absenteeism are measured once a month, which falls in the acceptable range of refresh rate criteria, but one may not know about potential problems until it is too late to resolve easily.

5.6 Main Objective: Effectiveness of Key Performance Indicators in the product factories of Cape Gate

Each of the sections in this chapter were supporting objectives for the main objective, which is covered in this section.

For an effective introduction of KPIs based on the cascading process, all the steps in the closed-loop model must related to level 2 of the hierarchy model. Analysis of the production and technical specification document showed that Cape Gate Sharon focused on level 2 of the KPI framework, which are indicators regarding quality, production plan-tracking and production efficiency. Excluding absenteeism, a successful selection of potential indicators based on the cascading process was made. Although few in number, the five KPIs leave room for more KPIs to be added in the third level of the hierarchy model of introducing KPIs. Document analysis showed that all of the steps in the closed-loop model were followed with the implementation of KPIs. Sharon is still in the process of implementing level 2 KPIs to more factories. No evidence was found in the document analysis that indicators will be implemented from level 3 of the KPI framework. It is recommended that once all factories have level 2 KPIs, specifications should be drafted for level 3 KPIs.

The effect of KPIs was apparent only on production, utilisation and downtimes. There is sufficient evidence that the significant increase in performance for the above-mentioned can be contributed to the KPI performance measurement system. There is insufficient evidence that an improvement was made on absenteeism and the scrap percentage. This can be contributed to infrequent and delayed measurement of the two KPIs, and the fact that absenteeism is not part of level 2 of the KPI framework.

Bibliography

Abernethy, M.A., Horne, M.H., Lillis, A.M., Malina, M.A. and Selto, F.H. (2005) A multiple-method approach to building causal performance maps from expert knowledge. Management Accounting Research, 16 (2005), 135-155

Anon. 2006a. Department of Trade and Industry UK (DTI). Performance Measurement: From Quality to Measurement. [Web]: http://www.businessballs.com/dtiresources/performance_measurement_management.pdf Accessed: 16 June 2009

Anon. 2006b. IT Performance Management Group (ITPMG). How IT Benefits From Adopting Measurement-Management Techniques. Bethel, Connecticut. [Web]: http://www.itpmg.com/files/Download/The%20Measurement-Managed%20Organization.pdf Accessed: 15 May 2009

Anon. 2006c. IT Performance Management Group (ITPMG). IT Performance Management: The Basics. Bethel, Connecticut. [Web]: www.4it-executives.ch/images/content/pdf/Abstract_BdIII.pdf Accessed: 15 May 2009

Anon. 2006d. Maverick Technologies (Mavtech). Key Performance Indicators (KPI): Visualizing Tools for Lean Manufacturing Systems. Colombia. [Online] Available from: http://www.mavtechglobal.com Accessed: 10 July 2009

Anon. 2007a. IT Performance Management Group (ITPMG). Developing an IT Performance Management Program. Bethel, Connecticut. [Web]: http://www.itpmg.com/files/Download/Developing%20an%20IT%20Performance%20Management%20Program.pdf Accessed: 15 May 2009

Anon. 2007b. IT Performance Management Group (ITPMG). Initiating an IT Performance Management Program. Bethel, Connecticut. [Web]: http://www.itpmg.com/files/Download/Initiating%20an%20IT%20Performance%20Management%20Program.pdf Accessed: 15 May 2009

Anon. 2009. Permalink. Why use Key Performance Indicators (KPI)? [Web]:

www.bin95.com/kpi-sample.pdf Accessed: 16 Jun 2009

Argyris, C. 1960. Understanding Organizational Behaviour. London: Tavistock Publications. 7 p.

BROWN, D. and ARMSTRONG, M. 1999. Paying for Contribution. Real Performance-related pay strategies. London: Kogan Page. 152 p.

Bauer, K. 2004. The Power of Metrics: KPI's – The Metrics that Drive Performance Management. [Web]: http://www.dmreview.com/articles_sub.cfm?articleid=1009207 Accessed: 14 March 2009

Chang, R.Y. and Morgan, M.W. 2000. Performance Scorecards. Measuring the Right Things in the Real World. San Francisco: Jossey-Bass Inc. xxiv p.

Du Plessis, F., Bothma, N., Jordaan, Y. & Strydom, J. 2001. Applied Strategic Marketing. Sandown: Heinemann. 424 p.

Eckerson, Wayne W. 2004. The 10 Ways of KPI. [Web]: http://www.adtmag.com Accessed: 16 June 2009

FURNHAM, A. 2004. Performance Management Systems. European Business Journal. 83 – 94.

Hasan, H. & Tibbits, H. 2000. Strategic management of electronic commerce: an adaptation of the Blanced Scorecard. Internet research: Electronic Networking Applications and Policy, 10(5):439-450. [Web]: Emerald: http://www.emeraldinsight.com Accessed: 11 June 2009

Hough, J. 2007. Crafting and Executing Strategy. McGraw Hill Higher Education. 191 p.

Institute of management and administration (IOMA). 2004. Tactics for reducing employee confusion about performance management & pay. IOMA's Pay for Performance Report. 4(9):2-4.

Kaplan, R.S. and Nortan, D.P. 1996. Translating strategy into action: The Balanced Scorecard. Boston, Massachusetts: Harvard Business School. 3 p.

Kaplan, R.S. and Nortan, D.P. 2001. The Strategy Focused Organisation: How Balanced Scorecards companies thrive in the new business environment. Boston, Massachusetts: Harvard Business School. 103 p.

Levine, D.M and Stephan, D. F and Berenson,. M.L. 2008. Statistics for managers. Upper Saddle River: New Jersey. 105 p.

Lohman, C. and L. Fortuin, M. Wouters. 2003. Designing a performance measurement system: A Case Study. European Journal of Operational Research.

Malaysia, Jabatan Perdana Menteri. 2005. Pekeliling Kemajuan Pentadbiran Awam (PKPA) Bilangan 2 Tahun 2005: Garis Panduan bagi Mewujudkan Petunjuk-Petunjuk Prestasi Utama atau Key Performance Indicators (KPI) dan Melaksanakan Pengukuran Prestasi di Agensi Kerajaan. Putrajaya: Jabatan Perdana Menteri Malaysia.

Malik, S. 2009. Dashboards: Data Visualization for all Elements of the Business. [Web]: http://www.informationmanagement.com/specialreports/2009_136/dashboard_data_visualization-10015173-1.html Accessed: 20 July 2009

Masilamani. 2005. KPI. [Powerpoint]. Paper presented at National Conference on Key Performance Indicators (KPIs), 19-22 September 2005, Crown Princess Hotel, Kuala Lumpur.

Niven, P.R. 2002. Balanced Scorecard Step by Step: Maximizing Performance and Maintaining Results. New York. 5 p.

Parmenter, David. 2002. Developing Winning KPIs for Your Organization. White papers. [Web]: http://www.waymark.co.nz Accessed: 12 July 2009

Parmenter, D. 2007. Key Performance Indicators: Developing, Implementing and Using Winning KPIs. Hoboken: New Jersey. 3 p.

Price, A. 2000. Principles of Human Resource Management. An active learning Approach. Oxford: Blackwell Publishers Limited. 177 p.

Radnor, A. and McGUIRE, M. 2004. Performance management in the public Sector: fact or fiction? International Journal of Productivity and Performance Management. 53(3):245-260.

Rakar, A. and Zorzat, S. and Jovan, V. 2004. Assessment of Production Performance by Means of KPI. Department of Systems and Control. Ljubljane, Slovenia. 4 p.

Reh, j. 2005. Your Guide to Management: Key Performance Indicators. [Web]: http://www.management.about.com/cs/generalmanagment/a/keperfindic.htm Accessed: 16 Jun 2009

Seang. 2003. Best Practices in KPI. Paper presented at the National Conference of Key Performance Indicators, Pan Pacific Hotel, Kuala Lumpar, 21-23 October: 1-11 [Web]: http://dominoapp.npc.org.my/publications.nsf/0/4cec8e267211881B48256DC7002C719F/$file/BPKPI's221003.pdf Accessed: 15 May 2009

SOY, 1997. The Case Study as a Research Method. [Web]: http://www.gslis.utexas.edu/-ssoy/usesusers/1391d1b.htm Accessed: 21 May 2009

Winegardner, K.E. (Date not available). The Case Study Method of Scholarly Research. [Web]: https://cpub.brown.edu:8543/cpubsh/Raymond Hyatt-SO0105SO2/materialadd2.pdf Accessed: 21 June 2009

Wongrassamee, S., Gardiner P.D & Simmons, J.E.L 2003. Performance measurement tools: the Balanced Scorecard and the EFQM excellence Model. Measuring Business Excellence, 7 (1): 14-29. [Web]: http://www.emeraldinsight.com 15 July 2009

Appendices

Appendix A: Production Hypothesis Tests

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in production percentage for the population of data before the implementation of KPIs

σ^2_2 = Variance in production percentage for the population of data after the implementation of KPIs

Chain Link

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	340
Sample Standard Deviation	339
Population 2 Sample	
Sample Size	67
Sample Standard Deviation	66
Intermediate Calculations	
F-Test Statistics	1.824171
Population 1 Sample degree of freedom	339
Population 2 Sample degree of freedom	66
Two Tail Test	
Lower Critical Value	0.703613
Upper Critical Value	1.491017
p-value	0.003708
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.744138
p-value	0.998146
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.396677
p-value	0.001854
Reject the null hypothesis	

Loom Machines

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	56
Sample Standard Deviation	55
Population 2 Sample	
Sample Size	88
Sample Standard Deviation	87
Intermediate Calculations	
F-Test Statistics	3.550794
Population 1 Sample degree of freedom	55
Population 2 Sample degree of freedom	87
Two Tail Test	
Lower Critical Value	0.609621
Upper Critical Value	1.597588
p-value	1.3E-07
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.660801
p-value	1
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.481508
p-value	6.48E-08
Reject the null hypothesis	

Tight Winders

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	316
Sample Standard Deviation	315
Population 2 Sample	
Sample Size	85
Sample Standard Deviation	84
Intermediate Calculations	
F-Test Statistics	2.49184
Population 1 Sample degree of freedom	315
Population 2 Sample degree of freedom	84
Two Tail Test	
Lower Critical Value	0.72247
Upper Critical Value	1.43236
p-value	2E-06
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.76096
p-value	1
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.35085
p-value	1E-06
Reject the null hypothesis	

Appendix B: Utilisation Hypothesis Tests

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Whereσ^2_1 = Variance in utilisation for the population of data before the implementation of KPIs

σ^2_2= Variance in utilisation for the population of data after the implementation of KPIs

Pooled-Variance t-Test for the differences between two means

For a given level of significance, α=0.05, the one tail hypothesis tests were:

$$H_0: \mu_1 \geq \mu_2$$

$$H_1: \mu_1 < \mu_2$$

Where μ_1= Mean in utilisation for the population of data before the implementation of KPIs

μ_2= Mean in utilisation for the population of data after the implementation of KPIs

Chain Link

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	63
Sample Standard Deviation	62
Population 2 Sample	
Sample Size	129
Sample Standard Deviation	128
Intermediate Calculations	
F-Test Statistics	1.780623
Population 1 Sample degree of freedom	62
Population 2 Sample degree of freedom	128
Two Tail Test	
Lower Critical Value	0.638607
Upper Critical Value	1.515431
p-value	0.00638
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.68704
p-value	0.99681
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.417666
p-value	0.00319
Reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Unequal Variances

	BKPI	A KPI
Mean	45.02671	60.99015
Variance	136.7621	76.80578
Observations	63	129
Hypothesized Mean Difference	0	
df	97	
t Stat	-9.59806	
P(T<=t) one-tail	4.95E-16	
t Critical one-tail	1.660715	
P(T<=t) two-tail	9.9E-16	
t Critical two-tail	1.984722	

Loom Machines

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	124
Sample Standard Deviation	123
Population 2 Sample	
Sample Size	164
Sample Standard Deviation	163
Intermediate Calculations	
F-Test Statistics	0.714587
Population 1 Sample degree of freedom	123
Population 2 Sample degree of freedom	163
Two Tail Test	
Lower Critical Value	0.714383
Upper Critical Value	1.3889
p-value	0.050193
Do not reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.754321
p-value	0.025096
Reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.317375
p-value	0.974904
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Unequal Variances

	B-KPI	*A-KPI*
Mean	26.54275	48.16388
Variance	37.80027	52.8981
Observations	124	164
Hypothesized Mean Difference	0	
df	282	
t Stat	-27.2967	
P(T<=t) one-tail	1.96E-81	
t Critical one-tail	1.650274	
P(T<=t) two-tail	3.92E-81	
t Critical two-tail	1.96841	

Tight Winders

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	122
Sample Standard Deviation	121
Population 2 Sample	
Sample Size	160
Sample Standard Deviation	159
Intermediate Calculations	
F-Test Statistics	3.156641
Population 1 Sample degree of freedom	121
Population 2 Sample degree of freedom	159
Two Tail Test	
Lower Critical Value	0.712005
Upper Critical Value	1.393648
p-value	1.74E-11
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.752216
p-value	1
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.321144
p-value	8.69E-12
Reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Unequal Variances

	B-KPI	*A-KPI*
Mean	13.09623	15.33256
Variance	11.79263	3.735817
Observations	122	160
Hypothesized Mean Difference	0	
df	179	
t Stat	-6.45549	
P(T<=t) one-tail	4.91E-10	
t Critical one-tail	1.653411	
P(T<=t) two-tail	9.81E-10	
t Critical two-tail	1.973303	

Appendix C: Downtimes Hypothesis Tests

Downtimes

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in downtimes for the population of data before the implementation of KPIs

σ^2_2= Variance in downtimes for the population of data after the implementation of KPIs

Pooled-Variance t-Test for the differences between two means

For a given level of significance, $\alpha=0.05$, the one tail hypothesis tests were:

$$H_0: \mu_2 \geq \mu_1$$

$$H_1: \mu_2 < \mu_1$$

Where μ_1= Mean in downtimes for the population of data before the implementation of KPIs

μ_2= Mean in downtimes for the population of data after the implementation of KPIs

Chain Link

Unspecified downtime:

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	35
Sample Standard Deviation	34
Population 2 Sample	
Sample Size	70
Sample Standard Deviation	69
Intermediate Calculations	
F-Test Statistics	3.618175
Population 1 Sample degree of freedom	34
Population 2 Sample degree of freedom	69
Two Tail Test	
Lower Critical Value	0.538797
Upper Critical Value	1.74904
p-value	5.88E-06
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.596395
p-value	0.999997
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.598691
p-value	2.94E-06
Reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Unequal Variances

	UDT-A-KPI	*UDT-B-KPI*
Mean	1962.021	5324.194
Variance	3022632	10936412
Observations	70	35
Hypothesized Mean Difference	0	
df	44	
t Stat	-5.63779	
P(T<=t) one-tail	5.73E-07	
t Critical one-tail	1.68023	
P(T<=t) two-tail	1.15E-06	
t Critical two-tail	2.015367	

Total downtime:

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	35
Sample Standard Deviation	34
Population 2 Sample	
Sample Size	70
Sample Standard Deviation	69
Intermediate Calculations	
F-Test Statistics	1.192768
Population 1 Sample degree of freedom	34
Population 2 Sample degree of freedom	69
Two Tail Test	
Lower Critical Value	0.538797
Upper Critical Value	1.74904
p-value	0.527973
Do not reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.596395
p-value	0.736014
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.598691
p-value	0.263986
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Equal Variances

	TDT-A-KPI	*TDT-B-KPI*
Mean	6224.637	7960.256
Variance	8708963	10387775
Observations	70	35
Pooled Variance	9263134	
Hypothesized Mean Difference	0	
df	103	
t Stat	-2.75463	
P(T<=t) one-tail	0.003474	
t Critical one-tail	1.659782	
P(T<=t) two-tail	0.006948	
t Critical two-tail	1.983262	

Loom Machines

Unspecified downtime:

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	68
Sample Standard Deviation	67
Population 2 Sample	
Sample Size	89
Sample Standard Deviation	88
Intermediate Calculations	
F-Test Statistics	0.92134
Population 1 Sample degree of freedom	67
Population 2 Sample degree of freedom	88
Two Tail Test	
Lower Critical Value	0.631363
Upper Critical Value	1.561776
p-value	0.730057
Do not reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.680305
p-value	0.365029
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.453417
p-value	0.634971
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Equal Variances

	A-KPI	B-KPI
Mean	3802.173	5053.277
Variance	2801485	2581120
Observations	89	68
Pooled Variance	2706230	
Hypothesized Mean Difference	0	
df	155	
t Stat	-4.72183	
P(T<=t) one-tail	2.6E-06	
t Critical one-tail	1.654744	
P(T<=t) two-tail	5.19E-06	
t Critical two-tail	1.975386	

Total downtime:

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	68
Sample Standard Deviation	67
Population 2 Sample	
Sample Size	89
Sample Standard Deviation	88
Intermediate Calculations	
F-Test Statistics	0.594644
Population 1 Sample degree of freedom	67
Population 2 Sample degree of freedom	88
Two Tail Test	
Lower Critical Value	0.631363
Upper Critical Value	1.561776
p-value	0.02702
Reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.680305
p-value	0.01351
Reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.453417
p-value	0.98649
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Unequal Variances

	A-KPI	*B-KPI*
Mean	5464.881	8503.649
Variance	7467427	4440459
Observations	89	68
Hypothesized Mean Difference	0	
df	155	
t Stat	-7.86695	
P(T<=t) one-tail	2.9E-13	
t Critical one-tail	1.654744	
P(T<=t) two-tail	5.81E-13	
t Critical two-tail	1.975386	

Tight Winders

Total downtime:

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	67
Sample Standard Deviation	66
Population 2 Sample	
Sample Size	89
Sample Standard Deviation	88
Intermediate Calculations	
F-Test Statistics	1.199031
Population 1 Sample degree of freedom	66
Population 2 Sample degree of freedom	88
Two Tail Test	
Lower Critical Value	0.629834
Upper Critical Value	1.564171
p-value	0.424
Do not reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.678937
p-value	0.788
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	1.4553
p-value	0.212
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Equal Variances

	A-KPI	*B-KPI*
Mean	1942.665	1975.195
Variance	174197.7	208868.4
Observations	89	67
Pooled Variance	189056.6	
Hypothesized Mean Difference	0	
df	154	
t Stat	-0.46254	
P(T<=t) one-tail	0.322173	
t Critical one-tail	1.654807	
P(T<=t) two-tail	0.644347	
t Critical two-tail	1.975486	

Appendix D: Scrap Figure Hypothesis Tests

F-Test for differences between two variances

For a level of significance, $\alpha = 0.05$, to test the null hypothesis of variances:

$$H_0: \sigma^2_1 = \sigma^2_2$$

against the alternative hypothesis that the two population variances are not equal:

$$H_1: \sigma^2_1 \neq \sigma^2_2$$

Where σ^2_1 = Variance in scrap percentage for the population of data before the implementation of KPIs

σ^2_2 = Variance in scrap percentage for the population of data after the implementation of KPIs

Pooled-Variance t-Test for the differences between two means

For a given level of significance, $\alpha=0.05$, the one tail hypothesis tests were:

$$H_0: \mu_2 \geq \mu_1$$

$$H_1: \mu_2 < \mu_1$$

Where μ_1 = Mean in scrap percentage for the population of data before the implementation of KPIs

μ_2 = Mean in scrap percentage for the population of data after the implementation of KPIs

Chain Link

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	42
Sample Standard Deviation	41
Population 2 Sample	
Sample Size	3
Sample Standard Deviation	2
Intermediate Calculations	
F-Test Statistics	4.758284
Population 1 Sample degree of freedom	41
Population 2 Sample degree of freedom	2
Two Tail Test	
Lower Critical Value	0.247425
Upper Critical Value	39.47389
p-value	0.377355
Do not reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.310012
p-value	0.811322
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	19.47137
p-value	0.188678
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Equal Variances

	AI	*BI*
Mean	110.4444	108.254
Variance	761.8148	3624.931
Observations	3	42
Pooled Variance	3491.763	
Hypothesized Mean Difference	0	
df	43	
t Stat	0.062029	
P(T<=t) one-tail	0.475414	
t Critical one-tail	1.681071	
P(T<=t) two-tail	0.950827	
t Critical two-tail	2.016692	

Netting

F-Test for differences between two variances

Data	
Level of Significance	0.05
Population 1 Sample	
Sample Size	41
Sample Standard Deviation	40
Population 2 Sample	
Sample Size	3
Sample Standard Deviation	2
Intermediate Calculations	
F-Test Statistics	1.011731
Population 1 Sample degree of freedom	40
Population 2 Sample degree of freedom	2
Two Tail Test	
Lower Critical Value	0.246853
Upper Critical Value	39.47298
p-value	1.237849
Do not reject the null hypothesis	
Lower-Tail Test	
Lower Critical Value	0.309432
p-value	0.381076
Do not reject the null hypothesis	
Upper -Tail Test	
Upper Critical Value	19.47069
p-value	0.618924
Do not reject the null hypothesis	

Pooled-Variance t-Test for the differences between two means

t-Test: Two-Sample Assuming Equal Variances

	Scrap	*Scrap*
Mean	93.44444	94.57724
Variance	442.4815	447.6724
Observations	3	41
Pooled Variance	447.4252	
Hypothesized Mean Difference	0	
df	42	
t Stat	-0.08954	
P(T<=t) one-tail	0.464539	
t Critical one-tail	1.681952	
P(T<=t) two-tail	0.929079	
t Critical two-tail	2.018082	