

**PRODUCTION SYSTEM DESIGN AND OPERATIONAL  
PERFORMANCE OF STEEL MANUFACTURERS IN KENYA**

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**A Research Project Presented In Partial Fulfillment of the Requirements for the  
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2016

**DECLARATION**

This is my original work and has not been submitted for a study in any University or Institution.

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This project report has been submitted for assessment with my authorization as the University Supervisor

Name...**DR. MAGUTU P. OBARA**

Date.....

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## **ACKNOWLEDGEMENT**

This research report is a culmination of hard work, commitment and contribution of various people and institutions, some of whom only, shall be mentioned here.

I wish to extend special gratitude to all employers who accepted to participate in the study and actually took their time to fill in and return the questionnaire.

Just to mention, the researchers applaud the support and guidance accorded by my supervisor DR. Magutu P. Obara without whom this work would not have been concluded, accept the well-deserved thanks for being understanding, helpful, patient yet so professional. I am forever grateful.

To those entire not individually, we wish to reiterate that your cooperation and support is cherished and we say ‘Thank you all’.

Above all is my utmost gratitude to God almighty who has always filled my cup and assures He never forsakes His children

## **DEDICATION**

This project is dedicated to my family and friends for their continued support.

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## **ABBREVIATIONS**

PSD: Production system design

KAM: Kenya Association of Manufacturers

## **ABSTRACT**

The current competitive world market has positioned many companies under immense pressure to withstand the completion. The focus on the manufacturing or production system design performance has become more important. Alongside the growing competition in the industrial sector, it is apparent that improved levels of, effectiveness, output, quality and efficiency will only be attained by advancing new and enhanced production or manufacturing system design. The goals of this study were to find out the production system design adopted by steel manufacturers in Kenya and the impact these production system designs have on operational performance of steel manufacturers in Kenya. The population in this study comprised of all steel manufacturing firms in Kenya. Particularly, the respondents were the Maintenance Managers, Production Managers, and Plant/Operations Managers. Primary data was used to collect the data using questionnaires. The researcher has made use of descriptive and correlation and regression analysis to present the result in tables and figures. Process Oriented Production System Design, Industry Production System and Robust Production System Design were established to be the main systems adopted by the companies. The study also establishes that the product system designs have impacts on the leadership, quality, customer satisfaction and the supply chain management. The study thus concludes a positive relation between product system designs and the operational performance, which is supported by a coefficient of correlation of 0.784. The study thus recommends that the management of the companies to not only adopt any product design system, but also choose the design that works the best for that particular organization.

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of the Study

Companies are experiencing a more difficult task in competing in the current dynamic market environment. Particularly, in the past decade, the business environment has undergone drastic changes over the years, with introduction of new strategies. The managements are thus necessitated to formulate operation strategies which will ensure their survival. However, today's customers' demands go beyond just lower pricing of goods and services because customers want the best quality products, priced at least possible price and available whenever needed (Jackson, 2000). Thus, in order for businesses to retain their competitiveness, they are supposed to offer production systems that can handle the level of the requirements defined by the consumers and the market, at large. Correct adjustments in order to accommodate the changing requirements and the effective utilization of the available materials and resources in the context of the production systems are essential capabilities that these systems need to maintain higher operational performances. That is, effectiveness and efficiency of systems operations, in a rapidly changing corporate environment is a necessity (Slack, Chambers and Johnston, 2008).

Scholars, Gaither & Frazier (2001), suggest that whenever a commodity is designed the product's features or attributes are established as well as the manner as it will be produced. Therefore, whenever a new manufacturing system is developed, its design (including product and manufacturing system), its planning and controls, and the improvement activities should take place (Slack et al., 2008). Skinner (1985), on the other hand, suggests that the PSD (production system design) purposes to establish and define a clear set of production or manufacturing politics. Additionally, Askin & Goldberg (2002) cite that the production system designs involve managing resources of production so as to meet the customers' demands.

Other authors like Slack et al. (2007), Gaither & Frazier (2001) and Askin & Goldberg (2002) suggest that the production system designs ought to start earlier on, when designing the product because this is the time when the item is produced and its production system is organized or established. This makes it possible to make product designs decisions that take into account the production processes, to increase the overall performance of the respective production systems. However, in complex projects in general customer requirements change frequently, and the design is developed simultaneously to the construction stage. In such a context, the production system cannot be designed completely before production starts. In this case, production and production system design should overlap (Schönsleben, 2009).

The growth and transformations of markets, operational environment society, and the customers' desires and needs have shaped the progress production systems and production itself. One can envision that the future production would be flexible, high-tech, safe, clean, safe, society-driven and highly skilled. The aspects and paradigms that drove for evolution or change of the past manufacturing systems and production technology will sustain the change into the unknown (DG Research, 2003).

### **1.1.1 Production System Design**

One can distinguish the approach taken to the production system's design that affects the activities that are carried out by the manufacturing company. The systems design process is a unique all-inclusive and top-down, recursive, and iterative analytical course, that is applied in succession via all stages of the development, which is used to: transform the requirements and needs into a unique set of system's process and products description, produce vital information for the decision makers, and Provide input for the next level of development. Expanding on Wu (2004) and Engström, Jonsson and Medbo (2008), Säfsten (2002) identifies three main designs of production systems:

The concept-generating practice which is driven by different constraints such as, type of product, number, and volume of variants. The concept-driven practice is driven by something external such as a pre-existing design or the significance of an actor. The supplier-driven approach practice driven by an external supplier suggesting possible alternatives based on more or less detailed requirement specifications. The three designs

imply different degrees of involvement by the manufacturing company in the production system design process.

In a concept-generating practice the manufacturing company is responsible for all activities from the analysis of the situation to a complete production system in operation. On the other hand, in a supplier-driven practice, the supplier takes care of parts of the activities. In the most extreme case all work activities are outsourced to a supplier. Further, it is widely recognized that product and production system design should be integrated in order to reduce the time required for introducing new products on the market (Magrab et al., 2010). Gerwin & Barrowman (2002) define integrated product development to be the approach used in the management that is meant to improve the new products' development performances (or the development time).

As a result, several issues related to the development of the product are considered simultaneously rather than sequentially. However, in contrast to a non-overlapping and non-interacting development of products, an integrated approach also increases the need for coordination. One possibility to ensure a high degree of coordination of the different work activities is the ability to apply a product developmental process. A product development process describes the sequence of steps and activities the company has to deploy (Ulrich and Eppinger, 2007).

### **1.1.2 Operational Performance**

Operational performance is a vital component of the organization's competitive priorities in the context of its operations strategy (Narasimhan and Das, 2001). Operational performance is an important aspect of management (Panupak & Robert, 2008). Performance is achieved when an organization successfully achieves a competitive edge over its competitors by using quality, cost, speed, and flexibility (Dangayach & Deshmukh, 2001). These are best practices that lead to increased operational performance and which, if a company decides to abandon may lead to poor performance. These capabilities are applied to contribute to overall performance.

Dimensions employed normally match with the general set of competitive precedence, i.e. quality, flexibility, delivery, and the cost performance. Quality may be viewed from

up to 8 different perspectives; performance, reliability, features, conformance, serviceability, durability, aesthetics and assumed quality (Ward et al., 2006). Flexibility is also regarded to be a multifocal notion (Sethi and Sethi, 2000; Gerwin, 2003). D'Souza & Williams (2000) name the four proportions of production volume, process, variety, flexibility, and the material handling plasticity. Likewise, Das (2007) observes that the outwardly visible attributes of any extremely flexible production system include an exceptionally wide product assortment, highly flexible delivery times, and major opportunities to product customization.

### **1.1.3 Steel Manufacturing Industry in Kenya**

In Kenya's metal industry operations are in steel hot rolling and smelting, manufacture of wire and wire products, pipes, galvanized steel products and cold rolled metal products. The subsectors are interconnected since they depend on each other for the supplies. Since steel is a major raw material for most industries, high growth in the steel industry is expected. This makes it important to investigate the dynamics of the steel industry in the country. Furthermore, the Kenya Government Launched 'Vision 2030'. This is a road map on how the country will transform into an industrialized middle income state by the year 2030 (Kariuki, 2011) Steel industry is one of the key subsector in infrastructure development. Kenya's annual demand for steel is estimated 480,000tonnes to 600,000 tonnes, with most of the steel products are being sold on the domestic market (African business review and technology, 2012). The major Kenyan steel dealers include Athi River Steel Ltd, Brollo Kenya Ltd, Devki Steel Mills Ltd, and Accurate Steel Mills Ltd. (African business review and technology, 2012).

### **1.2 Research Problem**

The today's competitive local and global market has placed corporations under intense amount of pressure resulting in the popularization of the issue of system designs (Neumann et al., 2012). It is apparent that augmented intensity of productivity, effectiveness, efficiency, and excellence can be achieved by developing new and better production system design (Bennett, 2006; Shang and Sueyoshi, 2015). PSD (Production system design) can take different amount of time, all from a couple of weeks to several years. When an activity is repeated, such as the development new production systems, the

actors can worsen the employment of the previous knowledge and experience. Nevertheless, by the use of the structured work technique and attempting to use the experiences of 'others', the actor may be able overcome similar limitations or challenges. Any structure enhances the possibility of one concentrating on the vital parts, like the preparing and creation of the new and precise production system (Bellgran and Säfsten, 2010).

The Kenya steel Industry has continued to grow significantly despite the numerous challenges it has faced over the years. The industry is bedeviled with challenges of limited market diversification, high cost of raw material and energy, limited world class technology for doing steel business, limited value addition to the local steel firm with reliance to traditional manufacturing technologies. The above cited challenges propel the industry to take a paradigm shift if it is to remain competitive in the global steel market. Steel firms in Kenya operates within these tough market conditions with increased intensity in competition, very challenging external environment, economy's slowdown, growing complexities in running the business, and all these challenges have propelled the organization to adopt world class manufacturing philosophies to give it an upper edge in the global competition in the market.

Several studies have been done in this area both globally and locally. Locally, Mwale (2014) studied the effect of production system design on organizational performance among large manufacturing firms in Kenya and established that there is a significant relationship between the variables. Musyoka (2015), studied production system design practices in the manufacturing sector in Kenya and established that the production system designs were adopted so as to enhance productivity. Finally, Farah (2015), studied production system design practices and organizational performance in the public water sector in Kenya. He established that the production system design practices were highly dependent on the organization structure.

Based on the above studies, none of the studies concentrated on addressing production system design and operational performance of steel manufacturers in Kenya. This study therefore aimed to fill this gap by answering the following question: what are the production system designs adopted by steel manufacturers in Kenya? What is the



relationship between production system designs and operational performance of steel manufacturers in Kenya? And, what are the challenges facing steel manufacturers when implementing production system designs?.

### **1.3 Research Objectives**

The research objectives of this study were to:

- i. To determine the production system design adopted by steel manufacturers in Kenya.
- ii. To determine the impact of production system design on operational performance of steel manufacturers in Kenya.

### **1.4 Value of the Study**

The findings of this study can be important to policy makers as it may help them formulate policies that can steer the government to put in place appropriate infrastructure. Moreover, with the world becoming a global village, even the small scale entrepreneurs “Jua Kali” industry may need to be empowered to join forces to qualify being branded as world class organizations. The report can be of great value to practitioners in the industry, it will help understand the various production system designs adopted in the manufacturing industry. The report will also act as a motivation to the industry players to adopt specific production system design to strategically position themselves in the competitive business environment. The academicians and scholars may utilize the study’s findings as it adds knowledge on the production system design in the manufacturing sector. In addition, it will form basis of further research and study opportunities in areas not comprehensively covered in the report.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter explores the contributions of scholars on the production system designs and their impact on operational performance. Specific aspects covered here are Theories of production system design, and operational performance, Empirical Literature review and Conceptual framework

#### **2.2 Systems and Assembly System Theories**

Skyttner (2001) define a system as a combination of interacting elements or units that forms the collective whole that is meant to carry out particular function. The assemblage system may be perceived as a compilation of organized components like machines and people that are designed to work collectively towards the completion of the in intended goal (Wu, 2002). The assemblage scheme can be considered as an open system, that has a dynamic relation with the environment, adjusts to the competitive market and changes, and with several factors that might affect the output (Bellgran and Säfsten, 2010).

#### **2.3 Deming Theory**

The Deming's Theory was initially introduced by Deming's (1982). The theory holds that each organization must endeavour to ensure that it is constantly improving its products. This will enable them to be not only competitive but also remain customer focused. Particularly, organizations must adopt and formulate new and effective leadership to ensure that the goals and targets are attained. The organization must thus ensure proper coordination between all the parties involved in production. This could be through building quality into products through mass inspection. Organization should cease reliance on mass inspection by building quality into a product in the first place. Organization must cease awarding business based on price instead look at quality of product, minimize total cost and build relationship with a single supplier with loyalty and trust. Deming Theory will be useful for this study because it encompasses both PSD and operational performance for efficient and effective supply chain.

## **2.4 Production System Design**

This sections looks into details three production system design; Process Oriented production system design, robust production system design and industry production system design.

### **2.3.1 Industry Production System Design**

Industry Production System Design consist of either concept generating, concept-driven or the supplier driven approach depending on what influenced the design processes inside a company (Säfsten, 2002). The result of the constraint-driven approach is that a 'new' system solution is generated; a concept-generating approach to the design process is described.

Whereas the concept-generating approach was applied, the design process more or less followed the phases prescribed in the general design process. When the concept-driven approach was applied, a preferred production system concept was given from the beginning of the design process and the conceptual design phase was more or less excluded (Säfsten, 2002).

The supplier-driven approach, involves different degrees of involvement by the manufacturing companies. From the perspective of the system supplier can the design process be of either a concept-generating character or a concept-driven character. The system suppliers often use standard solutions, which are modified according to the specific situations, i.e. a concept-driven approach is often applied (Engström et al., 2008).

### **2.3. 2 Robust Production System Design**

Continuous improvements, fast and parallel development processes, and reduced set-up times in the production systems are a reality for today's enterprises. It requires production systems to be designed in such a way that internal and external changes as well as disturbances can be handled during operation without losing efficiency, flexibility and speed and as a consequence profitability (Corrêa, 1994). Production systems must be robust enough to handle internal and external changes and disturbances.

A methodology for achieving robustness is robust engineering, which optimizes for the robust function (Taguchi et al., 2000). The robustness of the production system in

meeting the dynamic environment can be the difference between success and failure to a manufacturing company. The consequences of a non-robust production system can be low utilization of resources and a disability to handle frequent disturbances (Corrêa, 2014). Opportunities to increase system robustness are improved if the whole life cycle of systems is taken into account. The single life-cycle phase of production operation only provides limited possibilities to reduce disturbances (Bellgran et al., 2012). In addition, robust design solutions are much easier to modify (and at a much lower cost) during early phases of production development.

#### **2.4 Operational Performance Measure**

Operational performance is termed as the extent to which the organization is able to meet the targets of its stakeholders (Griffin, 2003). According to Swanson (2000), operational performance is the valued productive output of a system in the form of goods or services. To achieve operational performance through production system design, the organization must consider them as assets and they must be treated with great attention so that they become productive and efficient, (Johannessen, and Olsen, 2010). High levels of conformance quality must be attained before trying to improve any other performance dimensions. In the current research, the measures of performance include quality of the service and products, delivery time, flexibility, reliability and efficiency of service delivery.

#### **2.5 Production System Design and Operational Performance**

Within the corporation the production department mainly interacts with the company's core functions of Marketing and Sales, Finance, Personnel and purchasing, in which the Marketing and Sales remains in contact with the clients, while the Purchasing remains in touch with the Suppliers only. Other pertinent elements that also contribute to the all-important organizational rule are the divisions that deal with Research, Logistics, and Development, IT, Sales, Customer Service, (or) as well Facility Management. In supply chains arise customer demands. Effective management of production orders ensures that a product will be manufactured and delivered on time.

#### **2.6 Summary of Literature Review and Research Gaps**

Based on the literature, various gaps have been identified refer to the table 2.1.

**Table 2.1: Summary of Literature Gap and Knowledge Gap**

<b>Author and Year</b>	<b>Study focus</b>	<b>Findings</b>	<b>Gap</b>	<b>Focus of the current study</b>
Ranganathan and Premkumar (2013)	Improving production system design practices through Lean and Green – A study at the Volvo Group India and Sweden	The study established that multifarious improvements by the lean via its tools on the production system design by reducing the wastes and non-value added activities and green in terms of responsible business i.e., reducing the emissions and other environmental impacts which ultimately increases the corporate image of the companies	The study was limited to Volvo Group India and Sweden	Production system design and operational performance of steel manufacturers in Kenya
Otilo (2011)	The production system design practices in cosmetics industry in Kenya.	The study revealed that there is consistent performance measures used across the production system design in the cosmetic industry and suppliers are	This study focused on the cosmetics industry and did not touch on production system	Production system design and operational performance of steel manufacturers in Kenya

		involved in production planning	design exclusively.	
Kimani (2013)	Production system design practices in Manufacturing Firms in Kenya	The study findings indicate that the most prevalent practices adopted are preventative maintenance and reduction in the preliminary finishing time.	This study was not specific to production system design in steel firms in Kenya.	Production system design and operational performance of steel manufacturers in Kenya
Githeu (2014)	Production system design practices and performance of commercial banks in Kenya	Three variables out of the six, namely Supplier Relationships, Reverse logistics, and Outsourcing were found to have strong statistically significant relationships with performance	This study was not specific to production system design of industrial approach, robust driven approach and process driven approach.	Production system design and operational performance of steel manufacturers in Kenya
Musyoka (2015)	Lean design practices in the manufacturing sector in Kenya	The study established that the main reasons for adoption for these practices were to reduce cost, profitability and long term survival of the firm. Although	Although it focused on production system design it did not focus on the steel sector but	Production system design and operational performance of steel manufacturers in Kenya

		it focused on production system design practices it did not focus on the steel sector but rather on the manufacturing sector.	rather on the manufacturing sector.	
Ngui (2015)	The relationship between world class manufacturing practices and operational performance of steel mills in Kenya	The findings revealed that there was a strong positive relationship between world class manufacturing practices and world class operational performance.	The study was a general assessment of world class manufacturing practices in relation to operational performance only.	Production system design and operational performance of steel manufacturers in Kenya
Farah (2015)	Production system design and organizational performance in the public water sector in Kenya	He established that that demand management was concerned with balancing the requirement of internal and external customers with supply chain capabilities.	This study was not specific to production system design and organization performance on steel sector.	Production system design and operational performance of steel manufacturers in Kenya

<p>Ngui (2015)</p>	<p>Relationship between world class manufacturing practices and operational performance of steel mills in Kenya</p>	<p>The findings revealed that insufficient justifications and lack of quantifiable evidence are the main obstacles to convince executives to adopt these practices. The benefits of integrating world class manufacturing include increased competitiveness, development of new and improved technology and innovation.</p>	<p>This study did not link production systems design and operational performance</p>	<p>Production system design and operational performance of steel manufacturers in Kenya</p>
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## 2.8 Conceptual Framework

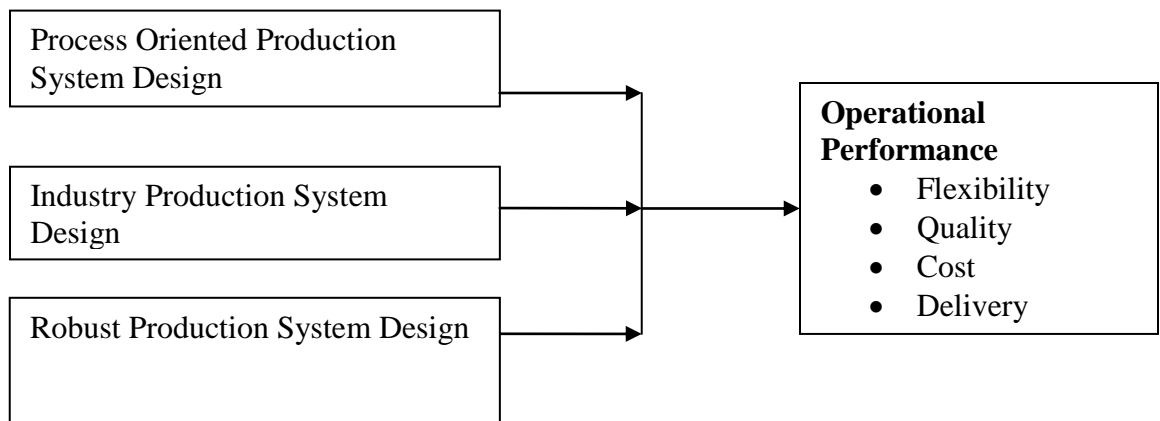
In the study, independent variables are product system design experimentation or practice while dependent variable is operational performance (measured regressively using the sum of means of its indicators) among steel manufacturers in Kenya.

**Figure 2.1: Conceptual Framework showing interrelationship between variables**

### INDEPENDENT VARIABLES

### DEPENDENT VARIABLES

#### Product System Design Practices



## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1 Introduction**

This section offers details about the methodology used in this study. The section covers the research design, research population, the data collection and analysis methodologies.

#### **3.2 Research Design**

The researcher used the descriptive cross-sectional design in this study to examine production system design in the steel mills in Kenya. A cross-sectional research involves collection that is done just once over a given period of months or weeks or days to answer the desired research question, (Cooper and Schindler, 2011). This approach allows for analysis of opinion of management in providing insight into the extent of adoption of production system design.

#### **3.3 Population of Study**

According to the KAM directory (2015), there are 20 steel manufacturing firms in Kenya (as listed in Appendix 2). A census is proposed given that the population is small

#### **3.4 Data Collection**

A questionnaire was the central data gathering tool for this study. The questionnaires were administered to the Maintenance Managers, Production Managers, and Plant/Operations Managers. This choice of population and respondents is based on the fact that the staffs are involved in production planning and execution at the production level. Moreover, they are the ones who interact with the systems directly as well as implementation of practices at functional. This method was preferred as it is the most feasible way of reaching all the respondents. The questionnaire is divided into five parts. Part one includes questions which are general in nature and will be used to gather some basic information about the firm. This would be useful in categorizing the firm as either large or small. The second part, seeks to address the objective of establishing the current production system design in use, applications and management practices at the steel mill

companies in Kenya. Part three addresses the third objective of examining the operational performance with production system design, while the last part determines the challenges of production system design application at the Steel mill companies in Kenya.

The “drop and pick later” method was used because the questions are simplified and unambiguous making it easy for the respondents to answer on their own. For distant companies, questionnaires were sent via postal mail with stamped envelopes provided to be mailed back. Where possible, email was used to administer the questionnaire.

### **3.5 Data Analysis**

Descriptive statistics (frequencies, cumulative frequencies, percentages and mean scores) were used to describe and establish the extent to which production system design have been adopted and benefits of production system design applications at the Steel Mills in Kenya. The analysis was carried out using statistical product and services solutions (SPSS) software. The relationship between production system design and operational performance was analyzed using regression analysis as follows.

The subsequent regression model would be used:  $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \epsilon$

Where:

Y = Operational performance

Operational performance was measured using a sum mean of its four indicators (cost, quality, flexibility and delivery)

X1 = Process Oriented Production System Design Practices

X2 = Industry Production System Design Practices

X3 = Robust Production System Design Practices

$\epsilon$  = Error term.

a = Constant which represents the level of operational performance without influence of any of production system design practices

b1, b2, b3, Coefficient of Xn which represents the estimate of effect of Xn on operational performance.

The multiple correlation coefficients R was utilized to test the relationship between the independent and dependent variables. The strength of the model in explaining the effects

of production system design practices on operational performance was then tested using R squared.

**Table 3.2: Summary of Data Collection & Data Analysis methods**

<b>Objective</b>	<b>Data Collection</b>	<b>Data Analysis</b>
General information	Section A	Descriptive statistics
To determine the production system design adopted by steel manufacturers in Kenya	Section B	Descriptive statistics
To establish the impact of production system design applications on operational performance of steel manufacturers in Kenya.	Section C	Correlation and Regression analysis
To determine the challenges in implementation of production system design of steel manufacturers in Kenya.	Section D	Descriptive statistics

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1 Introduction**

This chapter details the methodology employed in conducting this study. It covers research design, population of study, data collection and data analysis.

#### **3.2 Research Design**

A descriptive cross sectional design was used in this study to examine production system design in the steel mills in Kenya. A cross sectional study involves data being gathered just once, perhaps over a period of days or weeks or months in order to answer a research question, (Cooper and Schindler, 2011). This approach allows for analysis of opinion of management in providing insight into the extent of adoption of production system design.

#### **3.3 Population of Study**

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The “drop and pick later” method was used because the questions are simplified and unambiguous making it easy for the respondents to answer on their own. For distant companies, questionnaires were sent via postal mail with stamped envelopes provided to be mailed back. Where possible, email was used to administer the questionnaire.

### **3.5 Data Analysis**

After gathering completed questionnaires from the respondents. Descriptive statistics (frequencies, cumulative frequencies, percentages and mean scores) were used to describe and establish the extent to which production system designs have been adopted and benefits of production system design applications at the Steel Mills in Kenya. The analysis was carried out using statistical product and services solutions (SPSS) software. The relationship between production system design and operational performance was analyzed using regression analysis as follows.

The following regression model will be used:  $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \epsilon$

Where:

Y = Operational performance

Operational performance was measured using a sum mean of its four indicators (cost, quality, flexibility and delivery)

X1 = Process Oriented Production System Design

X2 = Industry Production System Design

X3 = Robust Production System Design

$\epsilon$  = Error term.

a = Constant which represents the level of operational performance without influence of any of production system design

b1, b2, b3, Coefficient of Xn which represents the estimate of effect of Xn on operational performance.

The multiple correlation coefficient R was used to test the strength of the relationship between the independent variables and dependent variable. The strength of the model in

The multiple correlation coefficients R was utilized to test the relationship between the independent and dependent variables. The strength of the model in explaining the effects of production system design practices on operational performance was then tested using R squared.

**Table 3.3: Summary of Data Collection & Data Analysis methods**

<b>Objective</b>	<b>Data Collection</b>	<b>Data Analysis</b>
General information	Section A	Descriptive statistics
To determine the production system design adopted by steel manufacturers in Kenya	Section B	Descriptive statistics
To establish the impact of production system design applications on operational performance of steel manufacturers in Kenya.	Section C	Correlation and Regression analysis
To determine the challenges in implementation of production system design of steel manufacturers in Kenya.	Section D	Descriptive statistics

## **CHAPTER THREE**

### **RESEARCH METHODOLOGY**

#### **3.1 Introduction**

This chapter details the methodology employed in conducting this study. It covers research design, population of study, data collection and data analysis.

#### **3.2 Research Design**

A descriptive cross sectional design was used in this study to examine production system design in the steel mills in Kenya. A cross sectional study involves data being gathered just once, perhaps over a period of days or weeks or months in order to answer a research question, (Cooper and Schindler, 2011). This approach allows for analysis of opinion of management in providing insight into the extent of adoption of production system design.

#### **3.3 Population of Study**

According to the KAM directory (2015), there are 20 steel manufacturing firms in Kenya (as listed in Appendix 2). A census is proposed given that the population is small

#### **3.4 Data Collection**

A questionnaire was used as the main data gathering instrument for this study. The questionnaires were administered to the Maintenance Managers, Production Managers, and Plant/Operations Managers. This choice of population and respondents is based on the fact that the staffs are involved in production planning and execution at the production level. Moreover, they are the ones who interact with the systems directly as well as implementation of designs at functional. This method was preferred as it is the most feasible way of reaching all the respondents. The questionnaire is divided into five parts. Part one includes questions which are general in nature and will be used to gather some basic information about the firm. This would be useful in categorizing the firm as either large or small. The second part, seeks to address the objective of establishing the current production system design in use, applications and management practices at the steel mill companies in Kenya. Part three addresses the third objective of examining the operational performance with production system designs, while the last part determines



the challenges of production system design application at the Steel mill companies in Kenya.

The “drop and pick later” method was used because the questions are simplified and unambiguous making it easy for the respondents to answer on their own. For distant companies, questionnaires were sent via postal mail with stamped envelopes provided to be mailed back. Where possible, email was used to administer the questionnaire.

### **3.5 Data Analysis**

After gathering completed questionnaires from the respondents. Descriptive statistics (frequencies, cumulative frequencies, percentages and mean scores) were used to describe and establish the extent to which production system designs have been adopted and benefits of production system design applications at the Steel Mills in Kenya. The analysis was carried out using statistical product and services solutions (SPSS) software. The relationship between production system design and operational performance was analyzed using regression analysis as follows.

The following regression model will be used:  $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \epsilon$

Where:

Y = Operational performance

Operational performance was measured using a sum mean of its four indicators (cost, quality, flexibility and delivery)

X1 = Process Oriented Production System Design

X2 = Industry Production System Design

X3 = Robust Production System Design

$\epsilon$  = Error term.

a = Constant which represents the level of operational performance without influence of any of production system design

b1, b2, b3, Coefficient of Xn which represents the estimate of effect of Xn on operational performance.

The multiple correlation coefficient R was used to test the strength of the relationship between the independent variables and dependent variable. The strength of the model in

explaining the effects of production system design practices on operational performance was then be tested using R squared.

**Table 3.4: Summary of Data Collection & Data Analysis methods**

<b>Objective</b>	<b>Data Collection</b>	<b>Date Analysis</b>
General information	Section A	Descriptive statistics
To determine the production system design adopted by steel manufacturers in Kenya	Section B	Descriptive statistics
To determine the impact of production system design on operational performance of steel manufacturers in Kenya.	Section C	Correlation and Regression analysis
To determine the challenges in implementation of production system design of steel manufacturers in Kenya.	Section D	Descriptive statistics

## **CHAPTER FOUR**

### **DATA ANALYSIS, RESULTS AND INTERPRETATIONS**

#### **4.1 Introduction**

This chapter focuses on the data analysis, interpretation and presentation of the findings. The main purpose of the study was to determine the production system designs adopted by steel manufacturers in Kenya and the impact of these production system design have on operational performance of steel manufacturers in Kenya. The data was gathered exclusively from the questionnaire as the research instrument. The researcher has made use of descriptive and correlation and regression analysis to present the result in tables and figures.

#### **4.2 Response Rate**

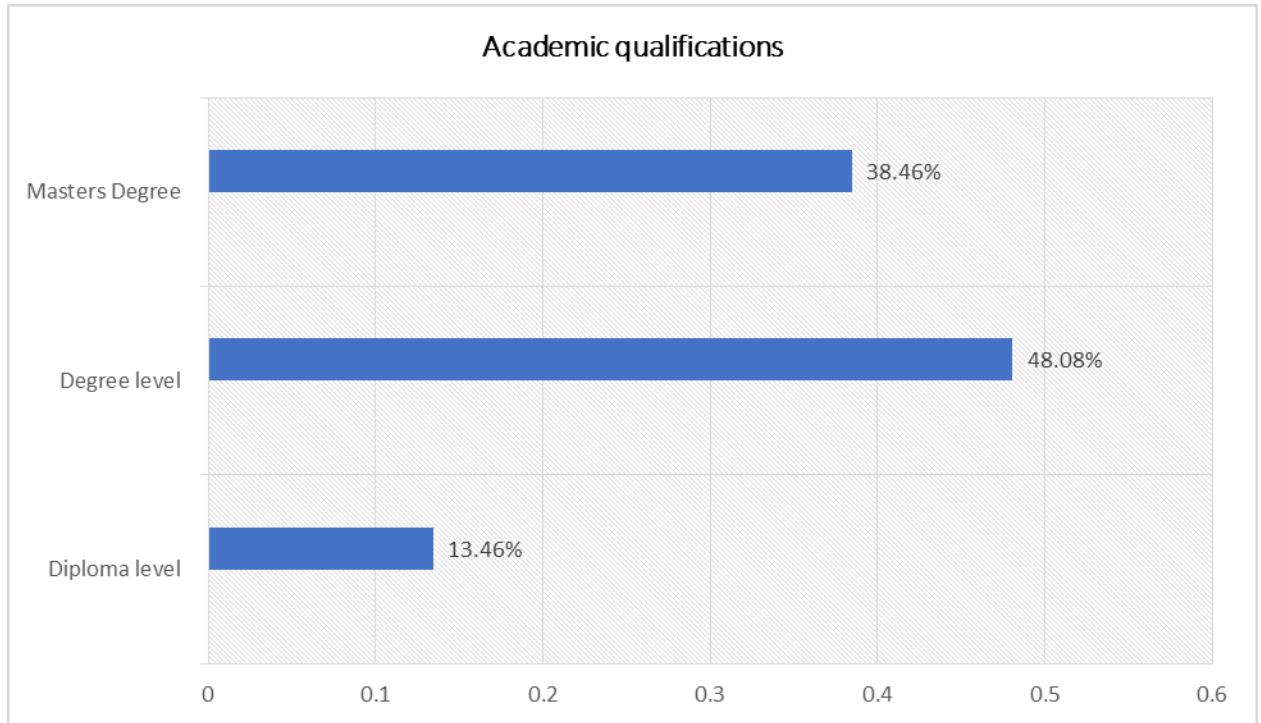
The study aimed at collecting primary data from the respondents. To achieve this, questionnaires were issued to 60 respondents who entailed the Maintenance Managers, Production Managers, and Plant/Operations Managers currently working at the steel manufacturing firms in Kenya. Out of which 52 questionnaires were dully filled and returned. This represents a response rate of 87%. The 8 who didn't respond, gave reasons as to having busy schedules. According to Mugenda and Mugenda (2008), a response rate of 50% is adequate enough, 65% is good while above 75% is very good. This implies that the response rate obtained was very good and enabled generalization of the findings.

#### **4.3 Background Information**

##### **4.3.1 Academic qualifications**

The section sought to determine the academic qualifications of the respondents. The findings as shown by Figure 4.1 indicate that 48% of the respondents were established to have Degrees, 34% had Master's degrees, while the remaining 13% had Diploma's. This implies that respondents were well qualified for their respective jobs. They were thus knowledgeable of the companies' practices and gave valid information.

**Figure 4. 1 Academic qualifications**



*Source: Research Data, 2016*

#### **4.3.2 Position the respondents**

This section sought to establish the position the respondents were in their organizations. Table 4.1 represents the findings obtained. The findings show that 46% were maintenance managers, 31% were production managers while 23% were operations managers. This thus shows that the respondents were in the managerial levels of their respective organizations thus well conversant with the study topic. This is due to them being directly involved with the production system designs .

**Table 4. 1 Position the respondents**

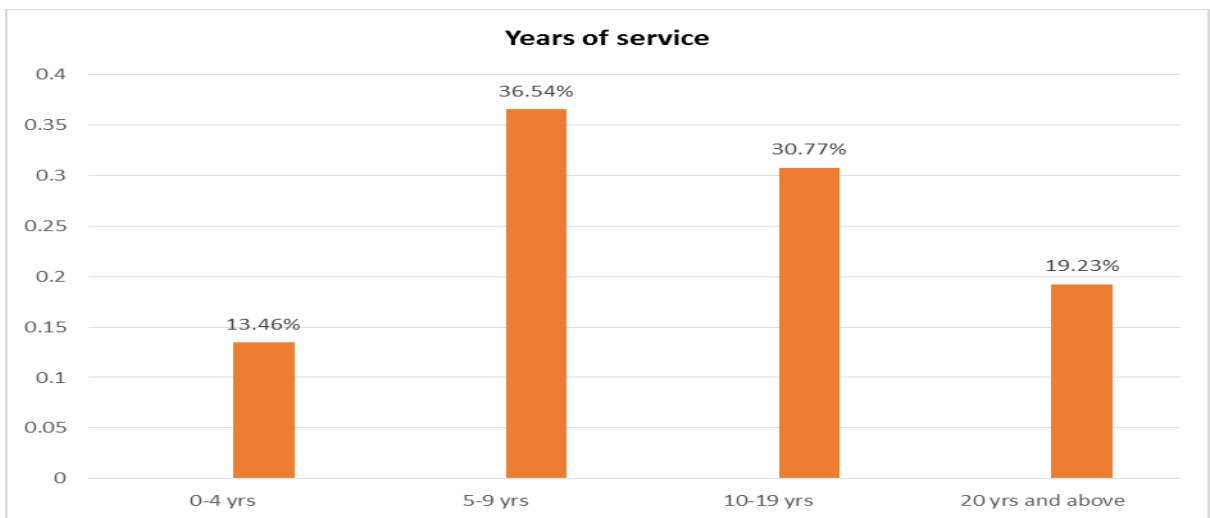
Position	Frequency	Percentage
Plant/Operations Managers	12	<b>23.08%</b>
Maintenance Managers	24	<b>46.15%</b>
Production Managers	16	<b>30.77%</b>
Total	<b>52</b>	<b>100.00%</b>

*Source: Research Data, 2016*

### **4.3.3 Years of service**

This section sought to establish the years the respondents had worked at steel manufacturing companies, as a measure of their experience. The results as indicated by Figure 4.2, show that 37% had worked for a duration of 5-9 years, 31% for a duration of 10-19 years, 19% for a duration of over 20 years while 13% for a duration of 0-4 years. This shows that the respondents had worked in their respective organizations for a considerable length of time and were thus well informed of the company's operations.

**Figure 4. 2 Years of service**



*Source: Research Data, 2016*

#### 4.4 Production system design

This section sought to establish the extent of adoption of the production system designs. The results obtained showed that all the company had adopted various production system designs. Thus obtaining 100% percentage frequency. The respondents were thus able to provide valid and accurate information.

##### 4.4.1 The Production System Design

Product system design is one of the main strategies used in enhancing operations in the steel manufacturing industry. The section sought to establish the various production system designs adopted by the companies. The findings obtained are as shown by Table 4.2.

**Table 4. 2 Production System Design**

<b>The Production System Design</b>	<b>N</b>	<b>Mean</b>	<b>Std Dev</b>
The planning of capacities provided by both customer and service provider as well as the scheduling of service production processes have to be taken into account.	52	4.3	1.4531
The firms production processes makes high demands on the customer, e.g. in view of providing necessary information.	52	4.1	0.5676
The firm has systems in place to support the continuous improvement process in service production.	52	4.0	1.0097
The firm's products/materials and services comply with all national and international regulations, requirements, directives and government provisions with respect of the environment.	52	4.0	1.0964
The firm has a system in place for the analysis of customers' time structures as well as their subjective and objective time perception.	52	3.9	0.6653

The firm employees are given education and training in how to identify and act on quality improvement opportunities and become a significant role for the service quality and productivity perceived by the customer.	52	3.6	1.0007
The firm allows for the planning, organizing, steering and controlling of service production processes where customer integration has to be considered.	52	3.5	0.5542
The firm enhances the management of customer relationships in realization of long term cooperation between customer and service provider.	52	3.4	1.9999

*Source: Research Data, 2016*

The respondents stated that production system design adopted to a very great extent (mean  $\geq 4.0$  and standard deviation  $\geq 1.0$ ) included; the firm has systems in place to support the continuous improvement process in service production mean of 4.0 The firm's products/materials and services comply with all national and international regulations, requirements, directives and government provisions with respect of the environment mean of 4.0 The planning of capacities provided by both customer and service provider as well as the scheduling of service production processes have to be taken into account mean of 4.3. Whereas other practices were established to a great extent ( $4 < \text{mean} < 4.3$  and standard deviation  $> 0.5$ ) such as; the firms production processes makes high demands on the customer, e.g. in view of providing necessary information mean of 4.1. While to a moderate extent ( $3 < \text{mean} \leq 3.9$ ) the firm has a system in place for the analysis of customers' time structures as well as their subjective and objective time perception mean of 3.9. The firm employees are given education and training in how to identify and act on quality improvement opportunities and become a significant role for the service quality and productivity perceived by the customer mean of 3.6. The firm allows for the planning, organizing, steering and controlling of service production processes where customer integration has to be considered mean of 3.5. On the firm enhances the management of customer relationships in realization of long term cooperation between customer and service provider mean of 3.4.

The findings thus show that the most adopted production system design practice is the planning of capacities provided by both the customer and service provider as well as the scheduling of service production processes have to be taken into account. This is vital in that it enables proper coordination not only inside the company but also outside the company. While the least adopted production system design practice is the firm enhancing the management of customer relationships in realization of long term cooperation between customer and service provider.

The findings thus established that product system design has been adopted by the steel manufacturers in ensuring that the operations go on smoothly. This is in line with who established that Bennett, (2006) effective production system design are vital in the attainment of a company's set goals and targets.

#### 4.4.2 Industry Production System Design

Industry product system design is one of the main product system designs used in the steel manufacturing industry. As such, the section sought to establish the industry production system design practices.

**Table 4. 3 Industry Production System Design**

<b>Industry Production system Design</b>	<b>N</b>	<b>Mean</b>	<b>std. dev</b>
The firm uses the layout and paper models to test the production system	52	4.5	0.5333
The firms does not consider the design process as being very structured	52	4.3	0.6233
The firm does not have a formal methods to support the design processes that are available or used by the system designers	52	4.2	1.9217
The system layout is often the foundation for the discussions and for the creation of different solutions	52	4.2	0.6678
The firm has systems to measure the extent to which the design process driven by something external	52	4.1	1.9805



The firm's system allows for internal logic, starting with an analysis of the requirements and the specific situation and working towards the solution	52	3.8	0.9812
The firm has systems in place to allow systems selection based on requirements of high product quality, flexibility, short set-up times and low cost	52	3.7	1.0051
The firm systems does not allow for a holistic and systematic evaluation of the assembly system alternatives to be made	52	3.4	0.5319
The systems allows for 'new' system solution to be generated	52	3.2	0.4231
The most common design procedure is to develop a few alternatives and then rather quickly choose one alternative which is developed further.	52	2.9	0.9921

*Source: Research Data, 2016*

The respondents stated that industry production system design was adopted to a very great extent (mean  $\geq 4.0$  and standard deviation  $\geq 1.0$ ) included; The firm does not have a formal methods to support the design processes that are available or used by the system designers mean of 4.2. The firm has systems to measure the extent to which the design process driven by something external mean of 4.1. While some other practices were established to be adopted to a great extent ( $4 < \text{mean} < 4.3$  and standard deviation  $> 0.5$ ) such as; the firm uses the layout and paper models to test the production system mean of 4.5. The firms does not consider the design process as being very structured mean of 4.3. The system layout is often the foundation for the discussions and for the creation of different solutions mean of 4.2. While to a moderate extent ( $3 < \text{mean} \leq 3.9$ ) included; The firm's system allows for internal logic, starting with an analysis of the requirements and the specific situation and working towards the solution mean of 3.8. The firm has systems in place to allow systems selection based on requirements of high product quality, flexibility, short set-up times and low cost mean of 3.7. The firm systems does not allow for a holistic and systematic evaluation of the assembly system alternatives to be made mean of 3.4 While to the systems allows for 'new' system solution to be generated mean

of 3.2 while the small extent ( $2 < \text{mean} \leq 2.9$ ) included; the most common design procedure is to develop a few alternatives and then rather quickly choose one alternative which is developed further mean of 2.9.

The findings established that the firm using the layout and paper models to test the production system was the most adopted industry production system design practices. This is due to enhancing the speed of operations. While the most common design procedure is to develop a few alternatives and then rather quickly choose one alternative which is developed further was the least used practice. This implies that though most industry production system design have been adopted up to a considerable level, there still exists some which require more improvement. This contradicts the findings of Shang, and Sueyoshi, (2015) who found out that all the practices had been adopted fully.

#### 4.4.3 Robust Production System Design

Robust product system design is one of the main product system design used in the steel manufacturing industry. As such, this section sought to establish the robust production system design practices.

**Table 4. 4 Robust Production System Design**

<b>Robust Production System Design</b>	<b>N</b>	<b>Mean</b>	<b>std. dev</b>
The firms need for developing and transferring ordering competence is a factor of importance for the creation of robust production systems	52	4.2	1.3209
Methods, models and other types of supportive tools are means to create and maintain knowledge between and within people being involved in the process of designing robust production systems	52	4.1	0.9093
The firm's system designers identify the relevant design variables and decide about the best level of these variables based on a systems approach	52	4.1	1.342
The firms adequate pre-conditions in production disturbance handling during start-up and volume production is key	52	3.9	1.4542

The firm considers strong base for the detailed design phase determines much of the future production disturbances	52	3.7	1.5609
The firms robust system designs built new systems based on knowledge and experience from earlier projects	52	3.6	1.0989
The firm robust production systems are a way to handle the ever changing environment for manufacturing companies	52	3.4	0.4321

*Source: Research Data, 2016*

The respondents stated that robust production system design was adopted to a very great extent (mean  $\geq 4.0$  and standard deviation  $\geq 1.0$  ) included; the firms need for developing and transferring ordering competence is a factor of importance for the creation of robust production systems with a mean of 4.2. The firm's system designers identify the relevant design variables and decide about the best level of these variables based on a systems approach with a mean of 4.1.

Whereas the practices stated to have a great extent of adoption ( $4 < \text{mean} < 4.3$  and standard deviation  $> 0.5$  ) included; Methods, models and other types of supportive tools are means to create and maintain knowledge between and within people being involved in the process of designing robust production systems with a mean of 4.1. While moderately ( $3 < \text{mean} \leq 3.9$ ) was; the firm's adequate pre-conditions in production disturbance handling during start-up and volume production is key with a mean of 3.9. The firm considers strong base for the detailed design phase determines much of the future production disturbances with a mean of 3.7. The firm's robust system designs built new systems based on knowledge and experience from earlier projects with a mean of 3.6. The firm robust production systems are a way to handle the ever changing environment for manufacturing companies with a mean of 3.4.

This thus shows that the most adopted robust production system design practices established by the study was the firms need for developing and transferring ordering competence is a factor of importance for the creation of robust production systems. While the least adopted was the firm's robust system designs being built new systems based on knowledge and experience from earlier projects. Based on the means established, all the

robust production system design practices were termed to be adopted to above the moderate extent. This concurs with, Säfssten, (2002) who conducted a study on the evaluation of assembly systems: An exploratory study of evaluation situations.

#### **4.5 Impact of Production System Design on Operational Performance of Steel Manufacturers in Kenya**

Production System Design is one of the main practices used to enhance the Operational Performance of Steel Manufacturers in Kenya. The findings are as shown by Table 4.5 below showing the mean and standard deviations.

**Table 4. 5 Impact of Production System Design on Operational Performance of Steel Manufacturers in Kenya**

<b>Statement</b>	<b>N</b>	<b>Mean</b>	<b>Std Dev</b>
<b>Quality</b>			
Improved Product quality	52	4.1	1.0321
Enhanced variability in products	52	3.8	1.0812
Attainment of the customers' specifications	52	2.9	1.1203
<b>Cost</b>			
Enhanced productivity	52	4.4	1.2892
Reduced inventory	52	4.2	1.0074
Reduced production costs	52	3.9	1.0907
<b>Flexibility</b>			
Ability to adjust capacity rapidly within a short period	52	4.1	1.2304
Production in new products	52	3.9	0.9692

Ability to make adjustments in the various production methods	52	3.8	1.056
Ability to redesign the products	52	3.7	1.9907
<b>Delivery</b>			
Reduced delivery time is enhanced	52	4.1	1.2074
Reliability in delivery	52	3.6	1.2232
Delivery is on time even under pressure	52	3.4	0.9959
Delivery on due date (ship on time)	52	3.1	1.0298
<b>Overall</b>	<b>52</b>	<b>3.7857</b>	<b>1.1659</b>

*Source: Research Data, 2016*

The respondents stated that the product system design practices enhance the operations of the company to a very great extent (mean  $\geq 4.0$  and standard deviation  $\geq 1.0$ ) in the following areas; on the influence of product design on enhanced productivity mean of 4.4, reduced inventory mean of 4.2, reduced delivery time is enhanced mean of 4.1 and improved product quality with a mean of 4.1.

While the impact was established to be great on; Further, the respondent that the product system designs influenced to a moderate extent the ( $3 < \text{mean} \leq 3.9$ ); production in new products with a mean of 3.9, ability to make adjustments in the various production methods mean of 3.8, ability to redesign the products mean of 3.7, reliability in delivery mean of 3.6 and enhanced variability in products mean of 3.8. Delivery is on time even under pressure mean of 3.4, Delivery on due date (ship on time) mean of 3.1, while the least impact was on attainment of the customers' specifications with a mean of 2.9.

This means that production system design practices impacts on the operational performance of Steel Manufacturers in Kenya to a great extent with an overall mean of 3.7857. The findings concur with those of Kariuki, J. (2011) who conducted a study on

steel mill processing and recycling Industry in Kenya whereby the product system designs were established to impact greatly how the organization performed.

#### 4.6 Regression analysis

In this study, multiple regression analysis was used to determine the relationship between production system design practices and operational performance. Process Oriented Production System Design Practices, Industry Production System Design Practices and Robust Production System Design Practices were used as control variables. As shown in table 4.9 below, there is a strong positive relationship between independent and dependent variable with a coefficient of correlation of 0.784. The coefficient of determination of 0.767 indicates that the independent variables can explain 76.7 % of changes in operational performance. Thus 23.3% of the changes in the operational performance will be accounted for by other factors other than the ones mentioned above.

**Table 4. 6 Model Summary**

R	R Square	Adjusted R Square	Std. Error of the Estimate
.784a	0.767	0.741	0.002

a. Predictors: (Constant), Process Oriented Production System Design Practices, Industry and Production System Design Practices Robust Production System Design Practices

*Source: Research Data, 2016*

The analysis of variance results are shown in table 4.7 below. As shown in the table, the model developed is significant at 95% and 99% confidence level since the p-value of 0.004 is less than 0.5 and 0.1. This means that the effect of independent variables on the model has significant effect on the dependent variables.

**Table 4. 7 Model Analysis of Variance**

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	3.043	4	1.507	2.575	.0004a
Residual	4.980	15	0.2344		
Total	8.023	19			

a. Predictors: (Constant), Process Oriented Production System Design Practices, Industry and Production System Design Practices Robust Production System Design Practices

b. Dependent Variable: Operational Performance

*Source: Research Data, 2016*

The model coefficients obtained by the study are shown in table 4.11 below. As shown in the model, Process Oriented Production System Design Practices had 0.8639, Industry Production System Design Practices had 0.5654, and Robust Production System Design Practices had 0.9642. This implies that all the models have positive relation with operational performance. Thus an increase in these variables will result in improved operational performance. Additionally, the variables had significant effect at the 95% confidence level. These finding compares with that of Kariuki, (2011) who did a study in steel mill processing and recycling Industry in Kenya. The predictive model thus developed by the study is  $Y = 12.096 + 0.8639X_1 + 0.5654X_2 + 0.9642X_3$  Where; Y = Operational performance,  $X_1$  = Process Oriented Production System Design Practices,  $X_2$  = Industry Production System Design Practices and  $X_3$  = Robust Production System Design Practices.

**Table 4. 8 Model Coefficients**

	Unstandardized		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	12.096	4.0084		4.017	0.0010
Process Oriented Production System Design Practices	0.8639	0.201	-0.331	-1.098	0.004
Industry Production System Design Practices	0.5654	0.401	-0.303	-0.193	0.035
Robust Production System Design Practices	0.9642	0.056	-0.466	-1.410	0.047

a. Dependent Variable: Operational Performance

*Source: Research Data, 2016*



## **CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS**

### **5.1 Introduction**

This chapter presents a summary discussion on the production system designs adopted by steel manufacturers in Kenya and the impact these production system design practices have on the operational performance of steel manufacturers in Kenya. A conclusion discussing the general findings of the research is highlighted followed by recommendation based on the findings of the study. The limitations of the study and suggestions on areas of further research are discussed at the end of the chapter.

### **5.2 Summary of Findings**

The study sought to establish the production system designs adopted by steel manufacturers in Kenya and the impact these production system designs have on operational performance of steel manufacturers in Kenya. The study population comprised of all steel manufacturing firms in Kenya. Particularly, the respondents were the Maintenance Managers, Production Managers, and Plant/Operations Managers. Questionnaires were used as the research instrument of which a response rate of 87% was obtained. The study establishes that all the steel manufacturers in Kenya have adopted various product system design practices. This could be mainly due to the benefits accrued from their incorporation in the operations.

The findings show that the most adopted production system design practice is the planning of capacities provided by customer and service provider as well as the scheduling of service production processes have to be taken into account. Using the layout and paper models to test the production system was established to be the most adopted industry production system designs. The most adopted Robust Production System Design established by the study was the firms need for developing and transferring ordering competence is a factor of importance for the creation of robust production systems. However the product system designs were yet to attain full adoption in the companies.

The study also sought to establish the impact of Production System Design on Operational Performance of Steel Manufacturers in Kenya. The results established that that production system design impacts on the operational performance of Steel Manufacturers in Kenya to a great extent with an overall mean of 3.7857. Particularly, the influence of product design on enhanced productivity had the highest mean of 4.4 while least impact was on Attainment of the customers' specifications mean of 2.9. This means that the designs determine greatly how the operations were conducted.

Additionally, there is a strong positive relationship between independent and dependent variable with a coefficient of correlation of 0.784. The coefficient of determination of 0.767 indicates that the independent variables can explain 76.7 % of changes in operational performance. This thus affirms a positive and significant relationship between product system designs and the operational performance. Of which all the models had a positive relation with the operational performance, implying an increase in the product system design practices will cause improved performance .The predictive model thus developed by the study is  $Y = 12.096 + 0.8639X_1 + 0.5654X_2 + 0.9642X_3$  Where; Y = Operational performance,  $X_1$  = Process Oriented Production System Design Practices,  $X_2$ = Industry Production System Design Practices and  $X_3$ = Robust Production System Design Practices.

### **5.3 Conclusion**

The study sought to establish production system design adopted by steel manufacturers in Kenya. Process Oriented Production System Design, Industry Production System Design and Robust Production System Design were established to be the main systems adopted by the companies. The study concludes that the planning of capacities provided by both customer and service provider as well as the scheduling of service production processes have to be taken into account is the used product designs. The study also concludes that the layout and paper models to test the production system the firms, and need for developing and transferring ordering competence is a factor of importance for the creation of robust production systems to be the most adopted Industry Production System Design and Robust Production System Design respectively. Generally, the study concludes a fairly good extent of adoption of the practices.

The study sought to establish the relationship that existed between the research variables, which included the product system designs and the operational performance. The study establishes that the product system designs have impacts on the leadership, quality, customer satisfaction and the supply chain management. The study thus concludes a positive relation between product system designs and the operational performance, which is supported by a coefficient of correlation of 0.784. This is attributed to the fact that the product system designs will enable operations to be undertaken in a consistent and efficient way. Thus proper incorporation of the product system designs into the operations of the steel companies is most likely to result in improved operational performance.

#### **5.4 Recommendations**

The study finds out that the companies adopt various product design systems. The study thus recommends that the management of the companies to not only adopt any product design system, but also choose the design that works the best for that particular organization. This is attributed to the fact that internal variations exist among companies, thus a product design that works in one organization, will not necessarily work in another. Additionally, the companies may also differ in terms of the resources available. The study also established a positive relation between the product system designs and the operational performance. The study thus recommends that managers aiming to improve the operational performance of their companies, they should make a keen evaluation onto the product design employed. They should also allocate the required resources to enable the proper implementation of the product designs. This will enable the maximum gain from the product design systems. The government could also formulate policies that favour how the companies adopt and implement the design systems.

#### **5.5 Limitations of the study**

The study was faced with a number of limitations as it was being conducted. To begin with, the study was largely constrained by the short time available. The informants also had tight schedules and could only manage limited time to provide the required data. Therefore, they could not offer detailed descriptions of the phenomena that existed. The study was also limited that it only focused in the steel manufacturers in Kenya. This may

not be an equal representation of steel manufacturers in the region and also other manufacturers in other sectors.

In addition, some of the respondents were reluctant in providing such information concerning the product system designs as it were considered very vital. However, the researcher informed them that all the collected data will be used for academic purposes. Hence, despite these limitations, the accuracy and creditability of the study's findings was not compromised.

### **5.6 Suggestions for further studies**

Though the research questions been fully answered, there are few areas that still require further study. To begin with, the manufacturing industry plays a significant role in the economy of Kenya. However, the industry faces a lot of challenges that threaten its survival in the globalized market. Adoption of production system design is a key survival technique for the in Kenya. Hence it is important that more research is done on the implementation process of these production system designs as this study only established the relation that exists.

In addition, the study only focused to the steel manufacturers in Kenya. This may not be an actual representation of other manufacturers. Further study could be conducted on the giving consideration other manufacturers in various other sectors. This will enable complete generalization of the relationship that existed. A study could also be conducted in a different time span to establish whether the current practices will still be in use or whether other product system designs would have emerged.

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## **Appendix II: List of Steel Mill Firms in Kenya**

1. Apex Steel Ltd.
2. Athiriver Steel Plant Ltd
3. Blue Nile Steel Rolling Mills Ltd
4. Brollo Kenya Limited.
5. Corrugated Sheets Ltd
6. Devki Steel Mills Ltd
7. Doshi Enterprises
8. East African Foundry Works Ltd
9. Insteel Limited
10. Kaluworks Ltd
11. Kenya United Steel Company (2006) Ltd.
12. Mabati Rolling Mills Ltd.
13. Narcol Aluminum Rolling Mills Ltd.
14. Rolmil Kenya Limited.
15. Safal Mitek Ltd
16. Steel makers Ltd.
17. Standard Rolling Mills Ltd.
18. Techno Steel Industries Ltd
19. Tononoka Rolling Mills Ltd
20. Bhachu Industries Accurate Steel Mills Ltd

**Source, 11<sup>th</sup> Edition Kenya Manufacturers & Exporters Directory 2015.**