A QUALITY CONTROL STUDY OF THE CUTTING PROCESS DURING METAL SHEETS DESIGNS IN GOD'S TIME ENGINEERING LTD, BENIN CITY.

BY

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BENIN CITY

OCTOBER, 2024.

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A PROJECT SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL ENGINEERING
IN
PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE AWARD OF BACHELOR OF ENGINEERING (BENG), IN
INDUSTRIAL ENGINEERING
UNIVERSITY OF BENIN, BENIN CITY

OCTOBER, 2024.

CERTIFICATION

This is to certify that the project work was prepared and submitted by EHIJATOR AGHEMIWOLO GREGORY with matriculation number ENG2103022 in partial fulfilment of the requirement for the award of B.Eng. (Industrial Engineering), University of Benin, Benin City, Edo State.

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DEDICATION

I dedicate this research work to God Almighty who has been the source of my strength and provision through men, to complete this project and the program for which it was undertaken.

I also dedicate this project to my Lovely Parents Mr and Mrs Paul Ehijator and my Siblings for their endless love, support and prayers for the journey so far.

ACKNOWLEDGEMENT

My deepest gratitude goes to God who has been the source of my strength and provision through men, to complete this project and the program for which it was undertaken.

My Project Supervisor, Dr. F. O. Uwoghiren, for his invaluable guidiance, patience support and expert advice throughout this research process. His insight and feedbacks were crucial in ensuring that the direction and substance of the project work comes out in good shape.

I would also like to extend my gratitude to the entire faculty of Engineering and staffs of the Department of Industrial Engineering at the University of Benin, for their expertise and contribution in ensuring a conducive environment for a smooth execution of the project work. I must acknowledge my parents Mr and Mrs Paul Ehijator, and also my siblings for their unwavering love and support in Prayers and finance to bring this work to a success.

My sincere appreciation goes to participants of this project, whose contributions so far were fundamental to every aspect of the research. Eng. Augustine, thank you for the willingness to share your experiences and perspectives to enrich the quality and depth of my findings. And to my teammates, course-mates and friends for the encouragement and for the stimulating discussions that has helped in refining my ideas and approaches.

ABSTRACT

In order to produce high-quality products, companies have to engage in a variety of activities, one of which is overseeing every stage of the production process which involves the use of some Statistical Process Control (SPC) techniques, with the aim of locating weaknesses and optimizing outcomes. To reduce operating expenses in production, a corporation must implement quality control through careful monitoring and exacting standards to ensure that the production activity fulfills its objectives efficiently. An effective quality control regime will help the manufacturing workflow proceed without unnecessary disruptions.

Hence, this research investigates the application of control chart (P-chart) in monitoring and managing the cutting process during metal sheets designs in God's time engineering LTD, Benin City.. The study aims to establish control limits and identify potential sources of variation in key parameters like edge quality and Surface finish. By implementing control charts (P-Chart), this research seeks to improve the consistency and reliability of God's time engineering metal sheets design and cutting process, ensuring product quality and minimizing defects. By constructing the P-Chart, this study aims to establish control limits, detect deviations from the desired process parameters, and ultimately enhance the overall quality control system for God's time engineering metal sheets design and cutting process. The findings of this research will provide valuable insights for optimizing the production process, reducing waste (offcuts), and maintaining high standards of product quality.

The case studied in this project is the design and cutting process of the Laser Department of God’s Time Engineering Limited, specifically regarding defects during Laser cutting. The SPC used is the Control chart (P-chart).

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Quality control is a critical aspect of in production and manufacturing field or process, particularly in the food and beverage industry where product consistency, safety, and customer satisfaction are paramount. One of the most effective tools for monitoring and controlling quality during production is the control chart, a statistical tool developed by Walter A. Shewhart in the 1920s. Control charts allow organizations to track variations in a production process and identify trends or abnormalities that may require corrective actions. This methodology has become an integral part of modern quality management systems.

The concept of quality control is to aim at preventing defective products from reaching consumers, thereby preserving the company's reputation and ensuring customer satisfaction. Since product quality is a key factor in consumer decision-making, maintaining high standards directly influences how customers perceive and evaluate a brand.

By implementing quality control processes, a company can enhance consumer trust and confidence in its performance, which in turn positively impacts its public image. Businesses that recognize this importance integrate quality control measures at every stage of the production process, whether they are manufacturing goods or delivering services.

In our daily lives, we rely on a wide range of products and services from the moment we wake up until we go to sleep. These include basic necessities and utilities such as water, electricity, transportation, healthcare, and education, as well as consumer goods like toothpaste, soap, detergent, clothing, food, gas stoves, cars, mobile phones, computers, televisions, and light bulbs.

At the heart of any effective quality control system is a clear specification of requirements and the commitment to produce goods that meet those standards. Inspections are conducted to ensure compliance, but it is important to understand that production is not complete until the final product reaches the consumer. Delivering a product that meets expectations ensures acceptance and satisfaction, marking the true completion of the production process.

Walter Shewhart of Bell Telephone Laboratories first proposed the use of statistical quality control in industrial settings in 1924. Organizations that produce goods and services for the public always strive to offer products that meet the expectations of consumers. Quality serves as a vital tool for competition (Ihunwo and Kingdom, 2016).

In recent years, quality control has become a critical instrument for organizations to succeed and remain in business. The quality of a product or service is determined by how well it meets the explicit or implicit needs and expectations of the customer. The American National Standards Institute defines quality control as the totality of a product or service's attributes that impact its ability to satisfy a specific demand.

To achieve the desired quality, it is essential to regulate every component that contributes to the product or service’s quality. Furthermore, quality control aims to ensure adequate standards concerning safety, reliability, and cost-effectiveness, especially during this advanced phase of industrial development, where product standards are highly valued. In various industries, measurement, inspection, and testing are regularly conducted either by personnel or specialized equipment to ensure that products meet quality standards before they are released to the market.

By utilizing statistical quality control methods, organizations can maximize the benefits of production and inspection while minimizing costs. This approach is crucial for industries and represents one of the most practical applications of sampling theory. Historically, many companies have relied on quality procedures that focus on the end of the production process to identify product flaws (Krishnamoorthi et al., 2018). This method of quality control can lead to significant consequences, such as scrap, rework or salvaging costs, retests, penalties for missed deadlines, complaint adjustments, product returns, and warranty fees (Krishnamoorthi et al., 2018).

God's Time Engineering LTD, being one of the first and Nation's leading company in metal fabrication, has a vast and intricate production system spanning numerous plants and quite a number of product fabrication variants. Among its most requested fabrication service is the laser-engraving and cutting services**,** which require stringent quality checks to ensure safety, quality of designs and cuts, fine detailing, Edge quality, packaging integrity and regulatory compliance to produce complex designs on metal sheets. The production of complex designs involves multiple stages ranging from collection and identification of customers design requirements to meticulously designing these shapes and objects using CorelDraw software, to cutting out these designs on metal sheets, labeling, and packaging**,** all of which are subject to potential sources of variation. Therefore, implementing a robust quality control mechanism is essential to maintaining uniformity and reduce defects or return markets.

In the highly competitive and regulated fabrication market, major deviations in quality can lead to significant reputational and financial losses. For God's Time Engineering LTD, quality is not just about meeting customer expectations but also about aligning with international fabrication safety standards such as ISO 45001, which provides a framework for managing occupational health and safety to prevent workplace injuries and other relevant standards including BS EN 1090, which specifies requirements for the fabrication and erection of steel and aluminum structures, and ISO 25980, which covers safety for welding curtains, and others following their purpose and vision i.e. to be one of the Nigerian market leaders which provides services in the metal processing, Infrastructural building products and transportation sector. In this regard, control charts serve as a valuable tool to distinguish between **common cause variations** (Naturally occurring within the process) and **special cause variations** (Evidence of malfunctions or inefficiencies in the process). By continuously monitoring production metrics such as dimensioning of metal sheets/designs, framing, cutting process and label placement, God's Time Engineering LTD can identify trends that may signal equipment malfunctions, human error, or material inconsistency. Hence, this study focuses on applying control charts specifically p chart to analyze the cutting process during metal sheet designs in God's Time Engineering LTD. The rationale for using these specific control chart lies in its capacity to monitor both variable data (such as **machine settings** or metal sheet specific parameters) and attribute data (such as defective metal sheets or mislabeled products). Through this statistical approach, the study aims to examine whether the production process is stable, capable, and within control limits.

Moreover, by analyzing historical production data using control charts, potential inefficiencies or patterns of deviation can be identified. These insights can support proactive decision-making and enhance the overall quality assurance strategy. Such an investigation is particularly important in developing economies where regulatory oversight may vary, and production plants often face unique challenges related to supply chains, infrastructure, and training.

The application of control charts in God's Time Engineering LTD metal sheets designs production is also part of a broader movement towards data-driven quality assurance, where real-time monitoring, automation, and statistical process control (SPC) techniques are being adopted to replace traditional inspection methods. This shift helps in reducing material waste, improving resource utilization, and ensuring a consistent consumer experience.

However, this study serves as a vital assessment of God's Time Engineering LTD quality control mechanisms through the lens of statistical process control. It not only reinforces the importance of continuous monitoring in metal sheets design production but also provides a framework that can be replicated or adapted by similar organizations in metal sheets fabrication sector. By applying control charts to real-world production data, this research aims to contribute to the broader discourse on quality assurance and operational excellence in production.

1.2 Statement of the Problem

Despite rigorous standards and automation, God's Time Engineering LTD metal sheets designs production process may still experience quality inconsistencies due to factors such as machine wear, sensor errors, human interference, or material inconsistencies. A minor yet frequent issue is the incorrect focal distance, the laser's focal point must be set precisely on the material's surface, and even a small deviation can cause poor cut quality. This can happen due to minor calibration errors, a warped material surface, or a faulty autofocus system, which can lead to regulatory infractions, product recalls, and erosion of customer trust. These variations, if not promptly detected and corrected, can lead to product defects, customer complaints, waste of resources, and damage to the company's reputation.

This study, therefore, seeks to investigate how control charts (using p charts) can be effectively utilized to monitor and enhance the cutting process during metal sheets designs in God's time engineering LTD, Benin City. It aims to identify potential quality deviations, assess process stability, and provide recommendations for improving production consistency. The outcome of this research will support God's time engineering continuous improvement efforts and contribute to a more robust quality assurance framework.

1.3 Aim and Objectives of the study

1.3.1 Aim

To evaluate the quality control of the cutting process during metal sheets designs in God's time engineering LTD, by using a p-chart to monitor and analyze the proportion of defective products, with the goal of improving process stability and reducing product defects.

1.3.2 Objectives

In order to achieve this aim, the objectives pursued are as follows:

- To identify common types of defects that occurs during metal sheets designs and cutting in God's time engineering LTD.
- To collect and analyze sample production data on the number of defective units relative to total units produced using p-chart methodology.
- To determine whether the production process is operating within statistical control limits (UCL and LCL) based on the proportion of defects.
- To assess the effectiveness of current quality assurance procedures in detecting and preventing defective products.
- To provide recommendations for reducing the occurrence of defects and improving the overall quality of God's time engineering laser cutting process.

1.4 Significance of the study

This study is significant as it helps identify factors affecting the accuracy, efficiency, and quality of metal sheet cutting at God’s time Engineering Ltd. The findings will guide improvements in process control, reduce material waste, enhance product precision, and increase overall production efficiency and customer satisfaction.

1.5 Scope of the study

The study focuses on examining the quality control measures applied during the metal sheet cutting process at god’s Time Engineering Ltd, Benin City, covering equipment performance, cutting accuracy, and inspection methods, using a p-chart in the analysis of the sample data.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Concept of Quality

The concept of quality is multifaceted and can vary depending on the context in which it is used. Generally, quality refers to the degree to which a product or service meets customer expectations or specified requirements (ISO 9000:2015). In manufacturing and production, it encompasses attributes such as performance, reliability, durability, conformance, and aesthetics. According to Juran (1999), one of the pioneers of quality management, he described quality as “fitness for use,” emphasizing that a product must meet customer needs and be free from deficiencies. This implies that quality is not only about meeting specifications but also about ensuring that the product performs as expected under real-world conditions. Crosby (1979) offered a complementary perspective, defining quality as “conformance to requirements”, stressing that a product or service is of high quality if it meets predetermined standards with zero defects. In beverage manufacturing, this translates to consistency in taste, bottle fill level, labeling accuracy, cap sealing, and overall product presentation. Crosby also emphasized the idea that "quality is free" investing in quality control saves costs related to rework, scrap, and customer dissatisfaction.

Deming (1986), another key figure in quality management, viewed quality as "a predictable degree of uniformity and dependability, at low cost and suited to the market." His philosophy centered around continuous improvement (Kaizen), process control, and employee involvement in quality enhancement.

The International Organization for Standardization (ISO 9000:2015) defines quality as “the degree to which a set of inherent characteristics of an object fulfils requirements.” This definition provides a more formal and universally accepted understanding, emphasizing that quality is measurable and based on compliance with requirements.

In the context of fabrication products like sheet metals, quality includes elements such as . For such fast-moving consumer goods (FMCGs), maintaining high quality is essential to God's time engineering loyalty and market competitiveness.

Quality is a relative term often used in the context of a product's suitability for its intended purpose (Jayakumar & Raju, 2016). The American Society for Quality reinforces this view by defining quality as a subjective concept, with individual interpretations varying based on personal standards and expectations (Summers, 2018).

2.1.1 Function of a Production Process

The primary objective of any production process is to manage and maintain the quality of the products being manufactured, ensuring they meet established standards. Every production system typically involves two key phases: process control and product control.

Process control refers to the methods used to monitor and adjust the manufacturing process itself to maintain consistent quality. The concept of process control was introduced in 1924 by W. A. Shewhart of Bell Telephone Laboratories, who integrated principles of sampling and probability theory to develop a systematic approach.

A standard control chart, one of Shewhart's most influential contributions, typically features three horizontal lines that serve as reference points for monitoring process behavior. These are:

1. The central line (CL), representing the process mean or target value,
2. Upper Control Limit (UCL) which defines the upper boundaries of expected variation
3. Lower Control Limit (LCL) which defines the lower boundaries of expected variation

2.1.2 Statistical Process Control (SPC)

Statistical Process Control (SPC) is a methodology developed by Shewhart (1931) and later expanded by Deming (1986), which uses statistical methods to monitor and control a process. Its primary goal is to detect and reduce process variation, which can lead to defects. SPC relies on:

Descriptive statistics: Mean, range, standard deviation

Control charts: Tools to determine process stability and

Process capability analysis: To evaluate if a process meets specifications

2.1.3 Function of Quality Control

Quality control (QC) plays a vital role in ensuring that products and services meet defined quality standards and customer expectations. Its primary functions include:

1. **Establishing Quality Standards**

   Quality control helps define clear specifications and performance criteria for products or processes based on customer needs, regulatory requirements, and industry best practices.

2. **Inspection and Testing**

   QC involves inspecting raw materials, in-process designs, and finished products to ensure they meet quality requirements. Testing verifies characteristics such as durability, functionality, appearance, and safety.

3. **Process Monitoring and Control**

   Using tools like control charts (e.g., p-charts), QC monitors production processes to detect variations and ensure they remain within acceptable control limits. This helps maintain consistency and efficiency.

4. **Defect Detection and Prevention**

   QC helps identify defective products and remove them before reaching customers. It also aims to prevent defects through root cause analysis and corrective actions.

5. **Data Collection and Analysis**

   Quality control systems collect data related to defects, process performance, and product compliance. Analyzing this data supports continuous improvement efforts.

6. **Cost Reduction**

   By minimizing waste, rework, and product recalls, QC helps reduce overall production costs while improving operational efficiency.

7. **Customer Satisfaction**

   Ensuring that products meet or exceed expectations contributes directly to customer satisfaction, loyalty, and brand reputation.

8. **Compliance with Regulations**

   QC ensures that products and processes comply with relevant industry standards, legal requirements, and certifications (e.g., ISO 9001).

Statistical Process Control (SPC) is a data-driven methodology used to monitor, control, and improve manufacturing processes. It relies heavily on control charts to detect variations in processes and ensure consistency in output. Shewhart (1931) pioneered the use of control charts, which are now fundamental tools in SPC. Control charts enable companies to differentiate between common cause variation (inherent to the process) and special cause variation (due to identifiable and correctable issues) (Montgomery, 2019).

Among various types of control charts, the p-chart (proportion chart) is specifically used for monitoring attribute data, i.e., the proportion of defective units in a sample. It is ideal for situations where each item is classified as either defective or non-defective. By using p-charts, quality control teams can detect spikes or trends in the proportion of defects and take corrective action before major issues arise.

The control chart that is most often used is the control chart p, used to control proportions with designs that do not meet (rejected) in the specified specification requirements (which are categorized as damaged). The part that is rejected p, can be defined as the ratio of most designs that are not suitable in the inspection process or inspection line to the total product that is not suitable in the inspection process.

Control maps provide moving range information drawn for data about quality characteristics to see whether the process is controlled.

The control chart is a graphical display of a quality characteristic that has been measured or computed from a sample versus the sample number or time (Montgomery, 2009).

Conceição, et al, (2018) stated that, control charts are hypothesis tests where the process is in a state of statistical control, that is, a plot point within the control limits is equivalent to not rejecting the statistical control hypothesis and a plot point out of bounds is equivalent to the rejection of this hypothesis. It is a development by Dr. Shewhart, to enhance the analysis of a process by showing how that process performs over time (Summer, 2018).

The control chart displays the quality characteristic of interest plotted against time. A control chart typically has a center-line (CL) and two control limits an upper control limit (UCL) and a lower control limit (LCL). The center-line and control limits help define the in control central tendency and natural variability of the process, respectively. The center-line is almost always set equal to the arithmetic mean or expected value of the plotted statistic, so that approximately half of the subgroup values will fall on each side.

The control limits are then usually set equal to the center-line plus and minus three theoretical standard deviations of the plotted values (Benneyan, 1998).

Control charts are plotted on a rectangular coordinate axis- vertical scale (ordinate) representing the statistical measures $\bar{X}$ and $\bar{R}$ and horizontal scale (abscissa) representing the sample number. Hours, dates or lot numbers may also be represented on the horizontal scale.

Sample points, mean or range are indicated on chart by points, which may or may not be joined (Bhasin et al, 2016). Control charts are used in two distinct phases. In the first phase, control charts are used retrospectively on a set of historical data to determine whether or not a process has been in statistical control, while in the second phase, it is used prospectively with samples taken sequentially over time to detect changes from an in-control process. (Smeti, et al, 2007, Montgomery, 2009).

2.2 Application of P-Charts in other Production sectors

Research has demonstrated the effectiveness of p-charts in sectors such as beverage and food production environments. Singh and Arora (2018) applied p-charts in a bottled water and bottled drinks plant to track packaging defects and significantly reduced the defect rate through real-time monitoring and corrective measures. Similarly, Kumar et al. (2020) used p-charts in a soft drink facility to monitor cap sealing issues and label misplacements, improving the production line's performance by reducing variability.

In the context of God's Time Engineering Ltd, p-charts are particularly useful due to the repetitive and automated nature of the production process. Monitoring attributes such as quality of designs and cuts, fine detailing, Edge quality, packaging integrity and regulatory compliance allowing for rapid feedback and immediate adjustments on the production line. Moreover, p-charts provide visual representation and clarity in quality reporting, making it easier for management to make data-driven decisions.

2.3 Purpose of Control charts

Control charts are a fundamental tool in **Statistical Process Control (SPC)**, used to monitor, control, and improve the consistency and reliability of processes over time. First introduced by **Walter A. Shewhart** in 1924, control charts help distinguish between normal process variations (common causes) and unusual variations (special causes) that may indicate a problem requiring corrective action (Shewhart, 1931).

2.3.1 Monitoring Process Stability

- **Purpose:**

  Control charts are primarily used to determine whether a process is stable and in a state of statistical control.

- **Explanation:**

  By plotting process data over time and comparing it against statistically calculated control limits, control charts reveal whether variations fall within expected bounds. If data points remain within the limits and display no unusual patterns, the process is considered stable. “Control charts provide a graphic display of process behavior over time and help determine if the process remains in control” (Montgomery, 2019).

2.3.2 Detecting Special Cause Variations

- **Purpose:**

  To identify non-random or assignable causes of variation that may require immediate investigation and corrective action.

- **Explanation:**

  Special cause variations are often due to specific faults—such as equipment malfunctions or operator errors. Control charts help flag these variations through signals like points outside control limits or trends/patterns in the data. “One of the key purposes of control charts is to signal the presence of special causes of variation so that they can be identified and eliminated” (Evans & Lindsay, 2017).

2.3.3 Reducing Defects and Improving Quality

- **Purpose:**

  To proactively identify and reduce process variability, thus minimizing defects and improving overall product quality.

- **Explanation:**

  By providing early warnings of process drift, control charts enable preventive action rather than reactive fixes, leading to improved consistency and quality output. “Using control charts in production helps in improving quality by highlighting areas where process performance can be enhanced” (Juran & Godfrey, 1999).

2.3.4 Supporting Decision-Making with Data

- **Purpose:**

  To enable data-driven decision-making in quality control and process management.

- **Explanation:**

Control charts allow managers and quality professionals to base decisions on factual evidence rather than assumptions or intuition. This supports strategic improvements and resource allocation. “Control charts facilitate objective decision-making and reduce reliance on subjective judgment in quality control” (Oakland, 2014).

2.3.5 Measuring Process Capability and Performance

- **Purpose:**

To assess whether a process can consistently produce within specification limits.

- **Explanation:**

Although control charts monitor process control, they are often used alongside capability analysis to evaluate how well a process meets customer or regulatory requirements. “Control charts, when integrated with process capability studies, provide a complete view of process performance” (Montgomery, 2019).

2.4 Quality Control Challenges in fiber laser cutting Process of God’s Time Engineering Ltd

Despite advanced technologies, quality control in the design and metal cutting process faces challenges such as mechanical malfunctions, human error, material defects, and environmental factors. Ramasamy and Ravindran (2017) observed that even minor fluctuations in temperature or machine calibration could significantly impact product quality. Additionally, defects caused by inconsistent input materials (such as Oxygen Gas, steel plates, focus and cumulative lenses) can lead to variations in product quality. Therefore, consistent use of p-charts enables early detection of such issues and supports the continuous improvement of process capabilities (Evans & Lindsay, 2017).

2.5 Quality Assessment of the fiber laser cutting Process of God’s Time Engineering Ltd

The quality assessment of the fiber laser cutting Process of God’s Time Engineering Ltd is a crucial process that ensures consistency, safety, and consumer satisfaction across its product lines. Several researchers may have conducted assessments on various God’s Time Engineering fabrication process, focusing on physiochemical parameters, microbiological safety, sensory attributes, and ingredient consistency. These assessments are necessary due to the brand's vast global reach and the high volume of products consumed daily. It is therefore paramount to know the type of material used for their plastic bottled beverage drinks.

2.5.1 Type of Material: Mild Steel

Mild steel, also called low-carbon steel, is an iron and carbon alloy usually with 0.05–0.25% carbon. While not as strong as high-carbon or alloy steels, it's very ductile, weldable, and machinable. This makes it a popular and adaptable material for both manufacturing and fabrication. Mild steel is popular because it's easy to work with; it can be cut, bent, shaped, and welded without issue due to its low carbon content. Plus, it readily accepts surface treatments like paint, galvanizing, or powder coating, which boosts its resistance to corrosion. Its affordability and widespread availability have made it the go-to metal in construction, automotive manufacturing, and machinery production.

In summary, Mild steel is widely used in fabrication because it is strong enough for most applications, easy to work with, inexpensive, and readily available, making it the preferred choice for producing structures, sheet metal parts, and general engineering components.

2.5.2 Size and Thickness of Material used.

At God’s Time Engineering Ltd, the fiber laser cutting process handles a range of mild steel plate sizes depending on customer specifications and machine capacity. The most commonly processed sheet size is 1.2 m × 2.4 m (4 ft × 8 ft) which is standard in the metal fabrication industry.

The thickness of the mild steel plates typically cut on the company’s fiber laser machine ranges from 1.2 mm to 2.8mm.

- Thin sheets (0.8–3 mm) are used for ducting, signage, enclosures, and decorative panels.
- Medium thickness (4–8 mm) plates are common for brackets, frames, and machine components.
- Thicker plates (10–12 mm) are used for structural parts and heavy-duty fabrication.

The fiber laser cutter offers high precision across this range, with minimal edge distortion and clean cuts even on thicker sheets. Plate selection depends on both design requirements and material availability, with mild steel preferred for its strength, affordability, and ease of cutting. This project work shall focus on analyzing only the 1.2 and 2.8mm plates.

2.5.3 Designs and Product Examples

God’s Time Engineering Ltd produces a wide range of designs, which depends solely on customers and market requests/demand. Some commonly available designs produced include:

- **Versace Heads** (Circular or squared).
- **Versace Lines** (used as secondary designs on Gates, hand rails etc.
- **Flower designs**
- **Gate spikes**

Each of these products share similarities in production methods and quality assurance protocols i.e. designing, framing, cutting and QC checks, but are cut using different machine parameters setting depending on the size and thickness of the material being cut.

CHAPTERTHREE

RESEARCH METHODOLOGY

3.1 Research Design

This study adopts a quantitative research design with an emphasis on descriptive and analytical methods. It focuses on monitoring and assessing the quality of the cutting process during metal sheets designs in God's time engineering LTD, Benin City through statistical process control (SPC), specifically using the p-chart to evaluate the proportion of defective units in the production process.

The approach involves collecting production data over a specified period to identify variations, detect abnormalities, and determine whether the process is statistically in control. This design enables the researcher to systematically analyze quality consistency and pinpoint areas of potential improvement in the Laser department of God's time engineering LTD, Benin City.

3.2 Statistical Tools

The major tool used in this study is the p-chart, which is suitable for monitoring the proportion of defective designs in a process where the sample size may vary. The chart will help determine if the process is stable or if corrective actions are needed. Other descriptive statistics (mean, range, standard deviation) may be used for supplementary analysis.

3.3 Method of Data Collection

The method of data collection for this research work is of secondary nature. Data is collected about the quantity of metal sheets designed and produced from proper recorded information, by the means of a secondary method of data collection.

Secondary Data Collection

Secondary data will be obtained from:

- God’s Time Engineering internal quality assurance reports
- Standard Operating Procedures (SOPs) from the quality control department
- Sales Receipts, which tells the number of plates that enters the cutting process

  These materials will provide contextual understanding and help validate the findings from the primary data.

3.4 Method of Data Analysis

This study aims to evaluate the quality control process of the cutting process during metal sheets designs in God's time engineering LTD, Benin City (Specifically in the Laser department), by applying Statistical Process Control (SPC) techniques specifically using a p-chart (proportion chart) to analyze the proportion of defective products within production batches.

3.4.1 Data Preparation

The collected data will consist of:

- Total number of plates inspected per day (n)
- Number of defective plates observed in each day (d)

  From this, the proportion of defectives in each sample will be calculated using the formula:

$$\mathrm{p} = \frac{d}{n}$$

Where:

- p = proportion of defective designs.

- *d* = number of defective designs found in the sample.
- *n* = sample size or total number of designs produced or inspected.

3.4.2 Construction of the P-Chart

Using the calculated proportions, a p-chart will be developed to graphically represent process variation over time. The chart will include:

- **Center Line (CL):**

The average proportion defective across all samples:

$$\bar{p} = \frac{\sum d_i}{\sum n_i}$$

- **Upper Control Limit (UCL):**

$$\mathrm{UCL} = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

- **Lower Control Limit (LCL):**

$$\mathrm{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

Note: If **LCL < 0**, it is set to 0, since negative proportions are not possible.

The control chart will be plotted with the sample numbers on the x-axis and the proportion of defectives (p) on the y-axis. The control limits and center line will help visualize process stability.

3.4.3 Interpretation and Analysis

The data plotted on the p-chart will be analyzed for:

- **Stability:** If all points fall within the UCL and LCL and there is no pattern, the process is considered stable and in control.
- **Special Cause Variation:** If any point lies outside the control limits or displays a non-random pattern (e.g., trends, runs, cycles), this suggests the presence of assignable causes, requiring investigation.
- **Process Capability:** The chart helps assess whether the process can consistently produce within acceptable defect levels.

P-chart helps interpret process stability, detect variations early, and maintain consistent product quality by distinguishing between normal random variation and actual process problems.

3.4.4 Software Tools

The data analysis may be carried out using:

- **Microsoft Excel** – for calculations, charting, and visualization
- **Minitab or SPSS** (Where necessary) – for advanced SPC chart generation and statistical testing

3.4.5 Statistical Testing (Optional Enhancement)

If deeper analysis is desired, additional statistical tests may be applied using:

- **Chi-square test** to assess variability between samples
- **ANOVA** (Analysis of Variance) to Determine which parameter settings yield significantly different quality outcomes.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Presentation of Data

This section shows the data that were obtained from the laser department of God’s Time Engineering Ltd. and the analysis that has been carried out.

Reasons/guidelines for defects

i. Faulty machine components such as focus/cumulative lenses, ceramic holder, nozzle etc.
ii. Impurity of oxygen gas. i.e. purity less than 97%.
iii. Jamming of work piece
iv. lack of vigilance of workers etc.

4.2. DATA PRESENTATION (Tables)

Table 4.2.1: cutting process report for June 2025

	Pan thickness - Designed and Cut (mm)									
date	**1.2**	**1.4**	**1.8**	**2**	**2.2**	**2.4**	**2.6**	**2.8**	**Total**	**defect(s)**
2-Jun-2025	34	0	0	0	0	0	0	0	34	0
3-Jun-2025	0	30	1	0	0	0	0	0	31	0
4-Jun-2025	0	20	38	4	0	0	0	0	62	1
5-Jun-2025	0	7	13	4	0	0	0	0	24	0
6-Jun-2025	36	0	0	9	0	0	0	0	45	0
7-Jun-2025	1	36	0	0	0	0	0	0	37	0
9-Jun-2025	62	16	0	24	0	0	0	0	102	1
10-Jun-2025	75	0	23	2	0	0	0	0	100	2
11-Jun-2025	0	4	0	34	2	0	0	0	40	0
12-Jun-2025	0	5	0	16	0	0	0	0	21	0

13-Jun-2025	0	14	50	0	0	0	0	0	64	0
14-Jun-2025	0	4	0	8	4	0	0	4	20	0
16-Jun-2025	50	3	38	8	11	0	0	7	117	0
17-Jun-2025	0	10	8	4	1	0	0	0	23	0
18-Jun-2025	100	0	12	31	2	50	0	0	195	0
19-Jun-2025	0	8	0	15	0	0	0	0	23	0
20-Jun-2025	56	30	0	34	0	0	0	0	120	0
21-Jun-2025	39	27	14	82	0	0	0	0	162	1
23-Jun-2025	12	12	2	7	0	4	0	0	37	0
24-Jun-2025	50	10	0	4	0	0	0	0	64	0
25-Jun-2025	0	52	1	5	0	23	0	0	81	0
26-Jun-2025	0	0	27	0	0	0	0	0	27	0
27-Jun-2025	17	64	8	5	0	30	0	0	124	2
28-Jun-2025	0	4	0	0	12	5	0	0	21	0
30-Jun-2025	6	9	15	0	0	0	0	0	30	0
Total									**1604**	**7**

Table 4.2.2: cutting process report for July 2025

	Pan thickness - Designed and Cut (mm)									
date	**1.2**	**1.4**	**1.8**	**2**	**2.2**	**2.4**	**2.6**	**2.8**	**Total**	**defect(s)**
1-Jul-2025	5	31	4	5	0	0	0	14	59	0
2-Jul-2025	10	1	0	0	0	4	0	0	15	0
3-Jul-2025	0	12	18	18	0	9	0	0	57	0
4-Jul-2025	0	43	13	4	0	0	0	6	66	1
5-Jul-2025	50	0	8	1	0	0	0	0	59	0
7-Jul-2025	0	0	1	21	0	0	0	0	22	0
8-Jul-2025	50	0	15	0	0	4	0	0	69	0
9-Jul-2025	100	45	20	7	10	9	0	0	191	1
10-Jul-2025	0	3	0	0	0	15	0	0	18	0
11-Jul-2025	10	1	2	0	1	0	0	4	18	0
12-Jul-2025	75	0	30	0	5	0	0	0	110	0
14-Jul-2025	92	16	5	2	2	0	0	0	117	1
15-Jul-2025	0	30	0	0	2	5	0	0	37	0
16-Jul-2025	30	52	29	25	0	0	4	0	140	0
17-Jul-2025	29	0	0	0	0	0	0	0	29	0
18-Jul-2025	0	0	10	25	0	0	0	0	35	0
19-Jul-2025	0	8	5	0	4	0	0	0	17	0
21-Jul-2025	0	0	15	0	0	0	0	0	15	0
22-Jul-2025	18	14	0	0	4	0	0	0	36	0
24-Jul-2025	100	51	25	1	0	0	2	0	179	1
25-Jul-2025	100	22	0	4	0	0	14	0	140	0

26-Jul-2025	0	3	0	1	1	35	0	0	40	0
28-Jul-2025	0	16	16	13	1	0	0	2	48	0
29-Jul-2025	0	1	12	4	2	0	2	0	21	0
30-Jul-2025	30	29	30	12	0	0	0	0	101	1
31-Jul-2025	50	0	10	0	5	0	0	0	65	0
Total									**1704**	**5**

Table 4.2.3: cutting process report for August 2025

	Pan thickness - Designed and Cut (mm)									
date	**1.2**	**1.4**	**1.8**	**2**	**2.2**	**2.4**	**2.6**	**2.8**	**Total**	**defect(s)**
1-Aug-2025	48	7	20	10	0	0	0	14	99	0
2-Aug-2025	0	1	16	0	0	0	0	1	18	1
4-Aug-2025	56	0	14	0	0	10	1	0	81	0
5-Aug-2025	100	0	30	0	6	0	0	0	136	0
6-Aug-2025	6	51	14	5	7	0	0	0	83	0
7-Aug-2025	0	7	5	35	4	0	0	1	52	0
8-Aug-2025	150	15	6	0	0	5	0	0	176	1
9-Aug-2025	0	13	8	0	0	0	0	0	21	0
11-Aug-2025	0	22	5	14	0	0	0	0	41	0
12-Aug-2025	67	0	20	4	0	0	0	2	93	0
13-Aug-2025	100	0	0	33	0	0	0	0	133	1
14-Aug-2025	0	15	1	6	0	0	1	0	23	0
15-Aug-2025	133	16	6	11	0	0	0	0	166	1
16-Aug-2025	90	1	0	0	0	0	0	0	91	0
18-Aug-2025	10	7	0	0	0	0	0	0	17	0
19-Aug-2025	0	0	20	0	0	0	0	6	26	0
20-Aug-2025	78	8	3	0	0	0	0	0	89	0
21-Aug-2025	22	3	14	10	0	0	3	0	52	0
22-Aug-2025	1	0	5	15	0	0	0	0	21	0
23-Aug-2025	69	0	47	0	0	0	0	0	116	1
25-Aug-2025	0	24	0	0	0	9	0	0	33	1
26-Aug-2025	0	6	5	3	0	1	0	2	17	0

27-Aug-2025	0	9	4	7	0	0	0	3	23	0
28-Aug-2025	14	5	12	0	0	0	0	0	31	0
29-Aug-2025	10	0	0	16	0	0	0	0	26	0
30-Aug-2025	33	5	6	0	0	0	0	0	44	0
Total									**1708**	**6**

Table 4.2.4: cutting process report for September 2025

	Pan thickness - Designed and Cut (mm)									
date	**1.2**	**1.4**	**1.8**	**2**	**2.2**	**2.4**	**2.6**	**2.8**	**Total**	**defect(s)**
1-Sep-2025	6	4	18	17	0	3	0	0	48	0
2-Sep-2025	6	14	0	13	0	0	0	0	33	0
3-Sep-2025	36	0	23	4	0	0	0	0	63	0
4-Sep-2025	2	2	0	0	5	10	0	0	19	0
5-Sep-2025	0	24	0	0	0	0	0	0	24	0
6-Sep-2025	15	13	3	0	0	0	0	0	31	0
8-Sep-2025	50	7	0	21	0	0	0	0	78	0
9-Sep-2025	0	19	0	0	0	0	0	0	19	0
10-Sep-2025	1	9	0	4	0	0	0	0	14	0
11-Sep-2025	1	16	50	7	0	0	0	0	74	0
12-Sep-2025	13	0	9	0	0	0	0	0	22	0
13-Sep-2025	4	0	7	0	0	0	0	0	11	0
15-Sep-2025	131	0	2	0	0	0	0	0	133	0
16-Sep-2025	0	35	13	7	0	0	0	0	55	0
17-Sep-2025	55	13	9	0	0	0	0	0	77	0
18-Sep-2025	17	1	10	34	0	0	0	0	62	0
19-Sep-2025	24	4	8	0	0	0	0	0	36	0
20-Sep-2025	54	12	0	14	0	0	0	0	80	0
22-Sep-2025	100	13	51	0	26	0	0	0	190	2
23-Sep-2025	0	10	3	5	0	0	0	0	18	0
24-Sep-2025	0	25	0	7	0	0	0	0	32	0
25-Sep-2025	54	0	20	0	0	0	0	0	74	0

26-Sep-2025	0	30	47	49	2	0	0	0	128	1
27-Sep-2025	0	45	19	0	4	0	0	0	68	0
29-Sep-2025	70	30	10	0	0	0	0	0	110	1
30-Sep-2025	10	13	0	20	0	0	0	0	43	0
Total									**1542**	**4**

4.3. DEFECTIVE RATIO / FRACTIONAL DEFECTIVES

The Tables below shows the ratio of defective designs to total number of designs produced per day.

Table 4.3.1: defects ratio to Total production per day for June 2025

date	**No of Inspected Designs (n)**	**No of defective (d)**	**Fractional Defective (p)**
2-Jun-2025	34	0	0.0000
3-Jun-2025	31	0	0.0000
4-Jun-2025	62	1	0.0161
5-Jun-2025	24	0	0.0000
6-Jun-2025	45	0	0.0000
7-Jun-2025	37	0	0.0000
9-Jun-2025	102	1	0.0098
10-Jun-2025	100	2	0.0200
11-Jun-2025	40	0	0.0000
12-Jun-2025	21	0	0.0000
13-Jun-2025	64	0	0.0000

14-Jun-2025	20	0	0.0000
16-Jun-2025	117	0	0.0000
17-Jun-2025	23	0	0.0000
18-Jun-2025	195	0	0.0000
19-Jun-2025	23	0	0.0000
20-Jun-2025	120	0	0.0000
21-Jun-2025	162	1	0.0062
23-Jun-2025	37	0	0.0000
24-Jun-2025	64	0	0.0000
25-Jun-2025	81	0	0.0000
26-Jun-2025	27	0	0.0000
27-Jun-2025	124	2	0.0161
28-Jun-2025	21	0	0.0000
30-Jun-2025	30	0	0.0000
Total	**1604**	**7**	
Average			**0.0027**

Table 4.3.2: defects ratio to Total production per day for July 2025

date	No of Inspected Designs (n)	No of defective (d)	Fractional Defective (p)
1-Jul-2025	59	0	0.0000
2-Jul-2025	15	0	0.0000
3-Jul-2025	57	0	0.0000
4-Jul-2025	66	1	0.0152
5-Jul-2025	59	0	0.0000
7-Jul-2025	22	0	0.0000
8-Jul-2025	69	0	0.0000
9-Jul-2025	191	1	0.0052
10-Jul-2025	18	0	0.0000
11-Jul-2025	18	0	0.0000
12-Jul-2025	110	0	0.0000
14-Jul-2025	117	1	0.0085
15-Jul-2025	37	0	0.0000
16-Jul-2025	140	0	0.0000
17-Jul-2025	29	0	0.0000
18-Jul-2025	35	0	0.0000
19-Jul-2025	17	0	0.0000
21-Jul-2025	15	0	0.0000
22-Jul-2025	36	0	0.0000
24-Jul-2025	179	1	0.0056
25-Jul-2025	140	0	0.0000
26-Jul-2025	40	0	0.0000

28-Jul-2025	48	0	0.0000
29-Jul-2025	21	0	0.0000
30-Jul-2025	101	1	0.0099
31-Jul-2025	65	0	0.0000
Total	**1704**	**5**	
Average			**0.0017**

Table 4.3.3: defects ratio to Total production per day for August 2025

date	**No of Inspected Designs (n)**	**No of defective (d)**	**Fractional Defective (p)**
1-Aug-2025	99	0	0.0000
2-Aug-2025	18	1	0.0556
4-Aug-2025	81	0	0.0000
5-Aug-2025	136	0	0.0000
6-Aug-2025	83	0	0.0000
7-Aug-2025	52	0	0.0000
8-Aug-2025	176	1	0.0057
9-Aug-2025	21	0	0.0000
11-Aug-2025	41	0	0.0000
12-Aug-2025	93	0	0.0000
13-Aug-2025	133	1	0.0075
14-Aug-2025	23	0	0.0000
15-Aug-2025	166	1	0.0060
16-Aug-2025	91	0	0.0000
18-Aug-2025	17	0	0.0000
19-Aug-2025	26	0	0.0000

20-Aug-2025	89	0	0.0000
21-Aug-2025	52	0	0.0000
22-Aug-2025	21	0	0.0000
23-Aug-2025	116	1	0.0086
25-Aug-2025	33	1	0.0303
26-Aug-2025	17	0	0.0000
27-Aug-2025	23	0	0.0000
28-Aug-2025	31	0	0.0000
29-Aug-2025	26	0	0.0000
30-Aug-2025	44	0	0.0000
Total	**1708**	**6**	
Average			**0.0044**

Table 4.3.4: defects ratio to Total production per day for September 2025

date	**No of Inspected Designs (n)**	**No of defective (d)**	**Fractional Defective (p)**
1-Sep-2025	48	0	0.0000
2-Sep-2025	33	0	0.0000
3-Sep-2025	63	0	0.0000
4-Sep-2025	19	0	0.0000
5-Sep-2025	24	0	0.0000
6-Sep-2025	31	0	0.0000
8-Sep-2025	78	0	0.0000
9-Sep-2025	19	0	0.0000
10-Sep-2025	14	0	0.0000

11-Sep-2025	74	0	0.0000
12-Sep-2025	22	0	0.0000
13-Sep-2025	11	0	0.0000
15-Sep-2025	133	0	0.0000
16-Sep-2025	55	0	0.0000
17-Sep-2025	77	0	0.0000
18-Sep-2025	62	0	0.0000
19-Sep-2025	36	0	0.0000
20-Sep-2025	80	0	0.0000
22-Sep-2025	190	2	0.0105
23-Sep-2025	18	0	0.0000
24-Sep-2025	32	0	0.0000
25-Sep-2025	74	0	0.0000
26-Sep-2025	128	1	0.0078
27-Sep-2025	68	0	0.0000
29-Sep-2025	110	1	0.0091
30-Sep-2025	43	0	0.0000
Total	**1542**	**4**	
Average			**0.0011**

4.4. DATA ANALYSIS

Considering our sample size n of the subgroup(day), and the fractional defectives for each subgroup, we can now plot a p-chart graph in order to be able to run an analysis on the data. To draw the p-chart, we need to calculate the Center line (CL) and the Control Limits (UCL and LCL).

Where LCL assumes a negative number, it is recommended to equate it to zero (0).

Table 4.4.1: The analysis for the month of June is presented.

date	No of Inspected Designs (n)	No of defective (d)	Fractional Defective (p)	CL	UCL	LCL
2-Jun-2025	34	0	0.0000	0.0027	0.029571793	-0.024113007
3-Jun-2025	31	0	0.0000	0.0027	0.03084063	-0.025381844
4-Jun-2025	62	1	0.0161	0.0027	0.022607039	-0.017148253
5-Jun-2025	24	0	0.0000	0.0027	0.034678239	-0.029219453
6-Jun-2025	45	0	0.0000	0.0027	0.026061532	-0.020602745
7-Jun-2025	37	0	0.0000	0.0027	0.028460587	-0.023001801
9-Jun-2025	102	1	0.0098	0.0027	0.01822686	-0.012768074
10-Jun-2025	100	2	0.0200	0.0027	0.018381067	-0.012922281
11-Jun-2025	40	0	0.0000	0.0027	0.027476863	-0.022018077
12-Jun-2025	21	0	0.0000	0.0027	0.036884147	-0.03142536
13-Jun-2025	64	0	0.0000	0.0027	0.022293986	-0.0168352
14-Jun-2025	20	0	0.0000	0.0027	0.037727601	-0.032268815
16-Jun-2025	117	0	0.0000	0.0027	0.017199371	-0.011740585
17-Jun-2025	23	0	0.0000	0.0027	0.03536539	-0.029906604
18-Jun-2025	195	0	0.0000	0.0027	0.01393779	-0.008479004
19-Jun-2025	23	0	0.0000	0.0027	0.03536539	-0.029906604
20-Jun-2025	120	0	0.0000	0.0027	0.017017352	-0.011558565

21-Jun-2025	162	1	0.0062	0.0027	0.01502651	-0.009567724
23-Jun-2025	37	0	0.0000	0.0027	0.028460587	-0.023001801
24-Jun-2025	64	0	0.0000	0.0027	0.022293986	-0.0168352
25-Jun-2025	81	0	0.0000	0.0027	0.020120142	-0.014661356
26-Jun-2025	27	0	0.0000	0.0027	0.032851054	-0.027392268
27-Jun-2025	124	2	0.0161	0.0027	0.016785012	-0.011326225
28-Jun-2025	21	0	0.0000	0.0027	0.036884147	-0.03142536
30-Jun-2025	30	0	0.0000	0.0027	0.03130531	-0.025846524
Total	**1604**	**7**				
Average			**0.0027**			

The data above have been analyzed and are used to construct a P-Chart for the month of June 2025. The subgroup size varies due to varying numbers of inspected designs from the production process. The P values for each subgroup(day) have been calculated and are shown in the table for the month of June 2025.

Averages and Control Limits

The Average or Center Line has been calculated as

CL = 0.0027

UCL and LCL have been derived using the formulas :

$$\mathrm{UCL} = \bar{p} + 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$\mathrm{LCL} = \bar{p} - 3\sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

We assume LCL to be equal to zero (0) because they all assume values less than zero.

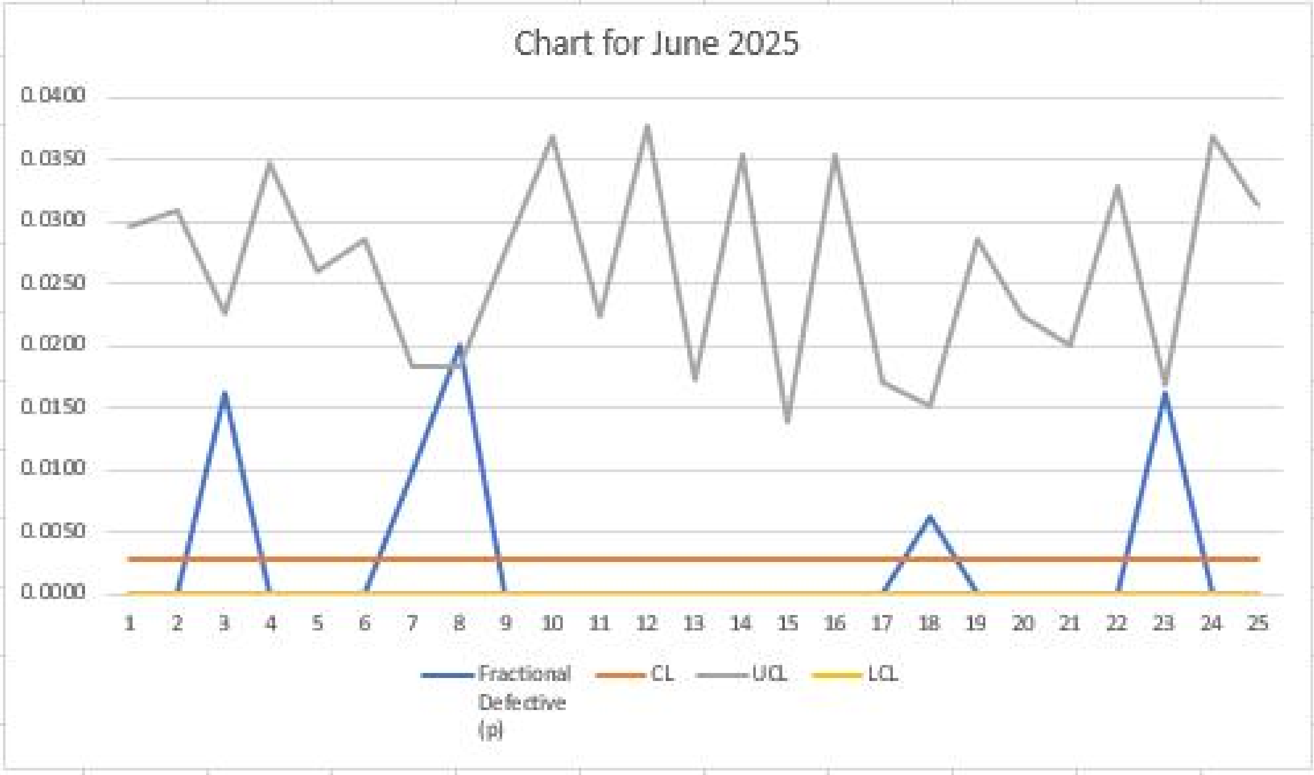

Fig 4.4.1: P-Chart for the production in June 2025

From the data analyzed using P-Chart, it is found that the average product damage occurring in June 2025 is 2.7%, of the total inspected Designs. In this month, the process is largely in statistical control**,** but there exist occasional or special causes affecting a few samples. These few points do not necessarily mean the whole process is out of control, but they signal the need for investigation into possible irregularities.

Table 4.4.2: The analysis for the month of July is presented.

date	No of Inspected Designs (n)	No of defective (d)	Fractional Defective (p)	CL	UCL	LCL
1-Jul-2025	59	0	0.0000	0.0017	0.017838546	-0.014421492
2-Jul-2025	15	0	0.0000	0.0017	0.033698602	-0.030281548
3-Jul-2025	57	0	0.0000	0.0017	0.018119089	-0.014702035
4-Jul-2025	66	1	0.0152	0.0017	0.016959197	-0.013542143
5-Jul-2025	59	0	0.0000	0.0017	0.017838546	-0.014421492
7-Jul-2025	22	0	0.0000	0.0017	0.028123462	-0.024706408
8-Jul-2025	69	0	0.0000	0.0017	0.016623977	-0.013206922
9-Jul-2025	191	1	0.0052	0.0017	0.010673402	-0.007256347
10-Jul-2025	18	0	0.0000	0.0017	0.030911337	-0.027494282
11-Jul-2025	18	0	0.0000	0.0017	0.030911337	-0.027494282
12-Jul-2025	110	0	0.0000	0.0017	0.013521645	-0.010104591
14-Jul-2025	117	1	0.0085	0.0017	0.013162812	-0.009745757
15-Jul-2025	37	0	0.0000	0.0017	0.022077073	-0.018660019
16-Jul-2025	140	0	0.0000	0.0017	0.012179737	-0.008762683
17-Jul-2025	29	0	0.0000	0.0017	0.024715628	-0.021298573
18-Jul-2025	35	0	0.0000	0.0017	0.022650947	-0.019233893
19-Jul-2025	17	0	0.0000	0.0017	0.031757970	-0.028340916
21-Jul-2025	15	0	0.0000	0.0017	0.033698602	-0.030281548

22-Jul-2025	36	0	0.0000	0.0017	0.022358032	-0.018940977
24-Jul-2025	179	1	0.0056	0.0017	0.010969026	-0.007551971
25-Jul-2025	140	0	0.0000	0.0017	0.012179737	-0.008762683
26-Jul-2025	40	0	0.0000	0.0017	0.021298367	-0.017881313
28-Jul-2025	48	0	0.0000	0.0017	0.019591523	-0.016174468
29-Jul-2025	21	0	0.0000	0.0017	0.028745075	-0.025328021
30-Jul-2025	101	1	0.0099	0.0017	0.014036742	-0.010619688
31-Jul-2025	65	0	0.0000	0.0017	0.017076062	-0.013659008
Total	**1704**	**5**				
Average			**0.0017**			

The data above have been analyzed and are used to construct a P-Control chart for the month of July 2025. The subgroup size varies due to varying numbers of inspected designs from the production process. The P values for each subgroup(day) have been calculated and are shown in the table for the month of July 2025.

Averages and Control Limits

The Average or Center Line has been calculated as

CL = 0.0017 i.e. 1.7 % average of the entire inspected designs are found defective.

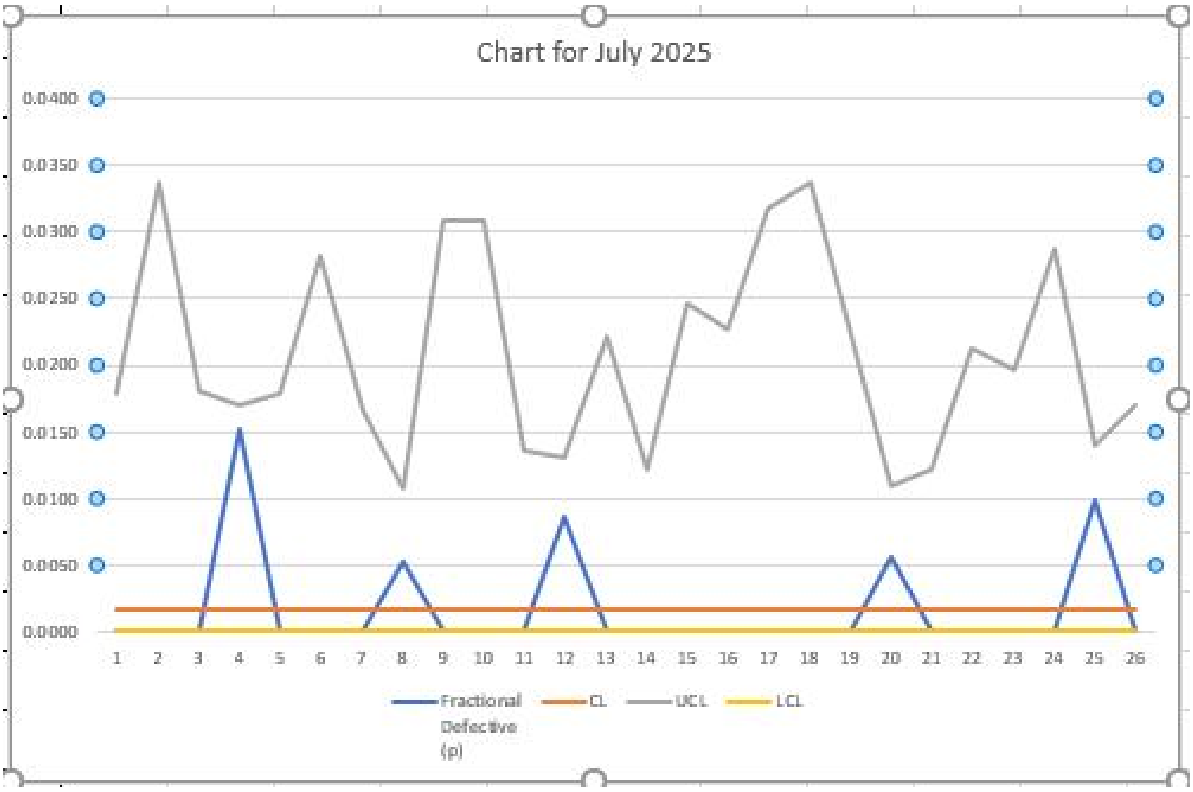

Fig 4.4.2: P-Chart for the production in July 2025

From the data analyzed using P-Chart, it is found that the average product damage occurring in June 2025 is 1.7%, of the total inspected Designs. In this month, the process is all in statistical control**.** In this month, there are no outliers as seen in the p-chart above.

Table 4.4.3: The analysis for the month of August is presented.

date	No of Inspected Designs (n)	No of defective (d)	Fractional Defective (p)	CL	UCL	LCL
1-Aug-2025	99	0	0.0000	0.0044	0.02426865	-0.01552219
2-Aug-2025	18	1	0.0556	0.0044	0.051032126	-0.042285666
4-Aug-2025	81	0	0.0000	0.0044	0.026368445	-0.017621984
5-Aug-2025	136	0	0.0000	0.0044	0.021347897	-0.012601436
6-Aug-2025	83	0	0.0000	0.0044	0.026101826	-0.017355366
7-Aug-2025	52	0	0.0000	0.0044	0.031824917	-0.023078457
8-Aug-2025	176	1	0.0057	0.0044	0.019294795	-0.010548335
9-Aug-2025	21	0	0.0000	0.0044	0.047570974	-0.038824513
11-Aug-2025	41	0	0.0000	0.0044	0.035288909	-0.026542448
12-Aug-2025	93	0	0.0000	0.0044	0.024900408	-0.016153947
13-Aug-2025	133	1	0.0075	0.0044	0.021538273	-0.012791812
14-Aug-2025	23	0	0.0000	0.0044	0.045650104	-0.036903643
15-Aug-2025	166	1	0.0060	0.0044	0.019737668	-0.010991207
16-Aug-2025	91	0	0.0000	0.0044	0.025124755	-0.016378295
18-Aug-2025	17	0	0.0000	0.0044	0.052384838	-0.043638377
19-Aug-2025	26	0	0.0000	0.0044	0.043195778	-0.034449318
20-Aug-2025	89	0	0.0000	0.0044	0.025356623	-0.016610162
21-Aug-2025	52	0	0.0000	0.0044	0.031824917	-0.023078457
22-Aug-2025	21	0	0.0000	0.0044	0.047570974	-0.038824513

23-Aug-2025	116	1	0.0086	0.0044	0.02275307	-0.014006609
25-Aug-2025	33	1	0.0303	0.0044	0.038833109	-0.030086648
26-Aug-2025	17	0	0.0000	0.0044	0.052384838	-0.043638377
27-Aug-2025	23	0	0.0000	0.0044	0.045650104	-0.036903643
28-Aug-2025	31	0	0.0000	0.0044	0.039927344	-0.031180884
29-Aug-2025	26	0	0.0000	0.0044	0.043195778	-0.034449318
30-Aug-2025	44	0	0.0000	0.0044	0.03421636	-0.0254699
Total	**1708**	**6**				
Average			**0.0044**			

The data above have been analyzed and are used to construct a P-Control chart for the month of August 2025. The subgroup size varies due to varying numbers of inspected designs from the production process. The P values for each subgroup(day) have been calculated and are shown in the table for the month of August 2025.

Averages and Control Limits

The Average or Center Line has been calculated as

CL = 0.0044 i.e. 4.4 % average of the entire inspected designs are found defective.

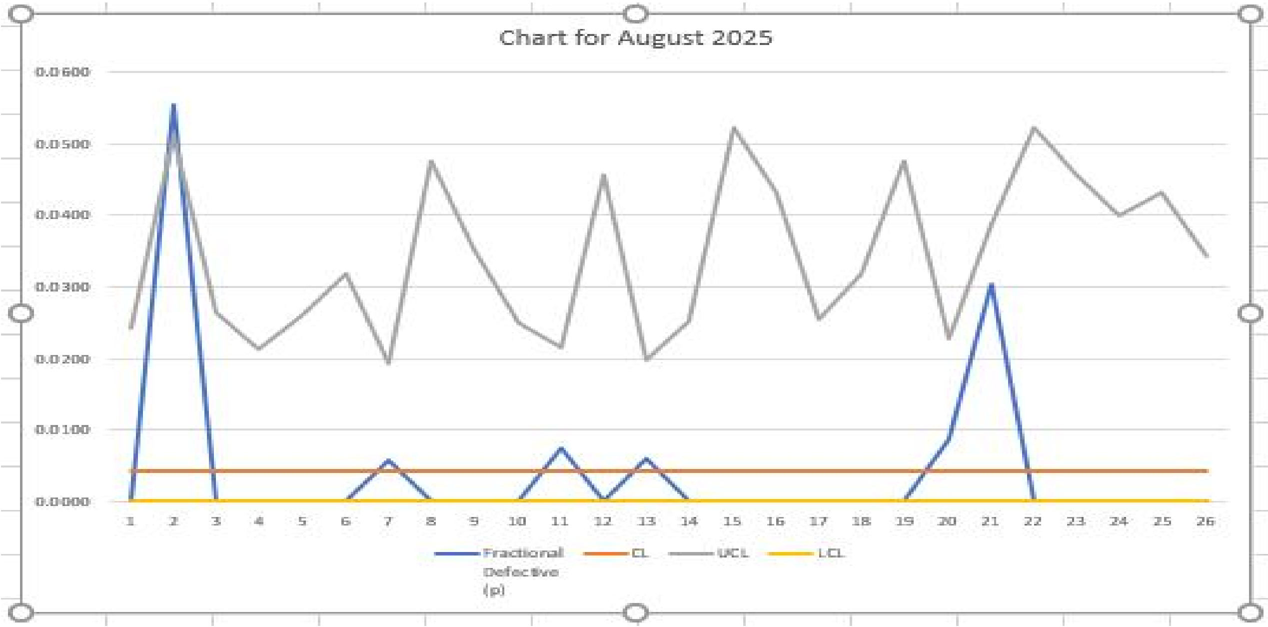

Fig 4.4.3: P-Chart for the production in August 2025

From the data analyzed using P-Chart, it is found that the average product damage occurring in the month of August 2025 is 4.4%, of the total inspected Designs. In this month, the analysis shows that the cutting process is generally within statistical control. Although one or two points slightly exceeded the upper control limit, these deviations appear to be random rather than systematic, indicating that the process remains stable but should be periodically monitored for possible special causes.

Table 4.4.3: The analysis for the month of August is presented.

date	No of Inspected Designs (n)	No of defective (d)	Fractional Defective (p)	CL	UCL	LCL
1-Sep-2025	48	0	0.0000	0.0011	0.015112081	-0.013002102
2-Sep-2025	33	0	0.0000	0.0011	0.01800848	-0.015898501
3-Sep-2025	63	0	0.0000	0.0011	0.013325025	-0.011215046
4-Sep-2025	19	0	0.0000	0.0011	0.023397877	-0.021287898
5-Sep-2025	24	0	0.0000	0.0011	0.020934719	-0.01882474
6-Sep-2025	31	0	0.0000	0.0011	0.01854682	-0.016436841
8-Sep-2025	78	0	0.0000	0.0011	0.012082279	-0.009972301
9-Sep-2025	19	0	0.0000	0.0011	0.023397877	-0.021287898
10-Sep-2025	14	0	0.0000	0.0011	0.027083666	-0.024973687
11-Sep-2025	74	0	0.0000	0.0011	0.012376392	-0.010266413
12-Sep-2025	22	0	0.0000	0.0011	0.02181869	-0.019708711
13-Sep-2025	11	0	0.0000	0.0011	0.030419296	-0.028309318
15-Sep-2025	133	0	0.0000	0.0011	0.009499807	-0.007389828
16-Sep-2025	55	0	0.0000	0.0011	0.014187107	-0.012077128
17-Sep-2025	77	0	0.0000	0.0011	0.012153654	-0.010043675
18-Sep-2025	62	0	0.0000	0.0011	0.013423581	-0.011313602
19-Sep-2025	36	0	0.0000	0.0011	0.017286721	-0.015176742
20-Sep-2025	80	0	0.0000	0.0011	0.011943566	-0.009833587
22-Sep-2025	190	2	0.0105	0.0011	0.008120431	-0.006010452

23-Sep-2025	18	0	0.0000	0.0011	0.024010124	-0.021900145
24-Sep-2025	32	0	0.0000	0.0011	0.01827134	-0.016161362
25-Sep-2025	74	0	0.0000	0.0011	0.012376392	-0.010266413
26-Sep-2025	128	1	0.0078	0.0011	0.009663165	-0.007553186
27-Sep-2025	68	0	0.0000	0.0011	0.012865309	-0.01075533
29-Sep-2025	110	1	0.0091	0.0011	0.010340799	-0.00823082
30-Sep-2025	43	0	0.0000	0.0011	0.015906884	-0.013796906
Total	**1542**	**4**				
Average			**0.0011**			

The data above have been analyzed and are used to construct a P-Control chart for the month of September 2025. The subgroup size varies due to varying numbers of inspected designs from the production process. The P values for each subgroup(day) have been calculated and are shown in the table for the month of September 2025.

Averages and Control Limits

The Average or Center Line has been calculated as

CL = 0.0011 i.e. 1.1 % average of the entire inspected designs are found defective.

For the LCL which appears to be less than zero, we assume value of zero for all. Hence:

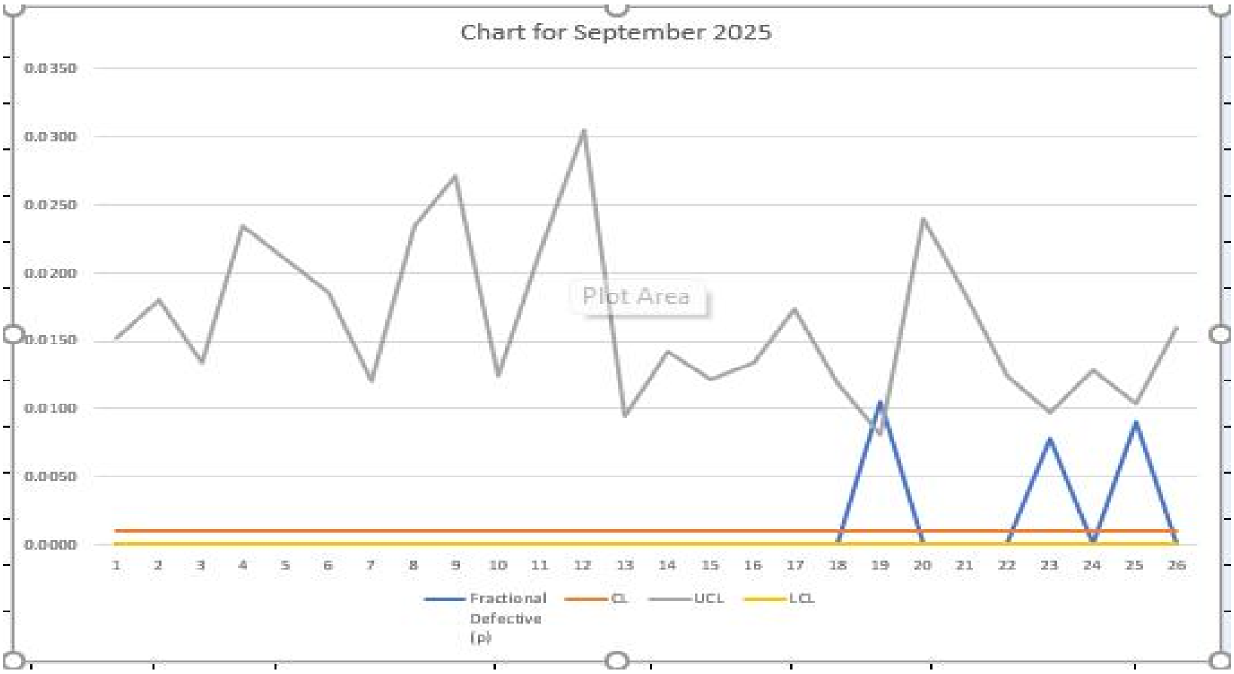

Fig 4.4.4: P-Chart for the production in September 2025

The process is generally in statistical control. Although one of its sample points slightly exceeded the upper control limit, these appear to be random variations rather than signs of a persistent problem. The cutting process remains stable but should be monitored regularly to maintain quality consistency.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this study, we have applied the statistical quality control chart using the p-chart approach to the date collected from God's Time Engineering Laser cutting process. Based on the analysis of the quality control, we've observed a slight variation in the production process for the months of June, August and September, but for the month of July, it is statistically stable and operates within acceptable control limits due to the absence of outliers for the month of July. Although one or two sample points slightly exceeded the upper control limit in the months of June, August and September, these appear to be random variations rather than signs of a persistent problem. The cutting process generally remains stable but should be monitored regularly to maintain quality consistency.

5.2 Recommendation

The findings affirm that the current operational procedures, equipment calibration, and operator practices at God's Time Engineering are effective in maintaining process stability. However, continuous monitoring and minor process optimizations are recommended to sustain and improve long-term performance. The following steps can be taken to improve efficiency and minimize losses;

1. Maintain Statistical Process Control (SPC) by continuing to use control charts to monitor the production process, this will help detect any early signs of drift or instability before defects occur.
2. Periodically calibrate the laser cutter and related equipment to maintain precision
3. Use customer quality feedback and part return data to refine quality control checkpoints and align internal standards with client expectations

4. Enforce standard operating procedures and provide periodic operator training.

5. For further research, it is recommended to use the other tools of statistical Quality control (SQC) such as X bar R chart to examine process stability since this research only covers the use of P-Chart tool of statistical Quality control (SQC).

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