Original Article

DMAIC SIX SIGMA APPROACH IN GOLD SCRAP/WASTE MANAGEMENT PROCEDURE FOR SMES JEWELLERY INDUSTRY

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Abstract

This study uses mixed methods to collect data from a jewellery manufacturer to address the issue of gold losses during manufacturing. The research used the DMAIC technique (Define, Measure, Evaluate, Improve, and Control) to analyse and uncover root causes of gold losses, improve gold scrap collection operations, and reduce the amount of gold that has gone missing. The data was gathered through a survey and observations, all based on the theoretical framework. As a result, there are five root causes of gold losses, classified into six categories and a graphic of the impacts. The study was narrowed down to only five categories, which are as follows: methods, people, measurements, materials, and equipment are all important considerations. The researcher provided five options to address the underlying cause problem and a few control strategies for measuring and maintaining progress. This research has benefited the company in several ways. The Standard Operation Procedures (SOPs) of gold scrap management techniques have been produced to reference for scrap reduction in the jewellery making sector to control and sustain the process.

Keywords: DMAIC Six Sigma, Gold Losses, Gold Scrap.

Introduction

DMAIC Six Sigma procedures in the manufacturing process are critical to ensuring the long-term viability of SMEs, particularly the jewellery fabricator and manufacturing industry in Kelantan. As an effort in the jewellery sector, Six Sigma (SS) adoption can be viewed as a critical action plan for streamlining work processes and increasing productivity. Eliminate waste, reduce access costs, minimise variation, and improve customer experience through quality products using a new approach. The method is repeatable and reproducible to ensure uniformity and improved process monitoring to generate high-quality output. According to the ASCM Dictionary, quality can be described as a dynamic state connected with products, services, people, processes, and environments that meets or exceeds expectations and helps to create greater value. Implementing Six Sigma (SS) as a tool for continuous improvement (CI) would educate employees and management about the benefits of the appropriate methods and processes for handling raw materials, equipment, and machinery.

As part of process improvement, manufacturers are encouraged to compile big data following industry 4.0 norms and assist them in identifying the number of precious metals that enter the workshop and how much is transformed into final jewellery. The amount of gold waste generated by benchwork, or samples submitted for refinement will provide critical data for determining how much is wasted in the system. An appropriate strategy, course of action,

standard operating procedures (SOPs), or a system based on Six Sigma (SS) are required to serve as a new guideline for manufacturers when it comes to waste management. Using a sustainable management structure ensures their business's long-term viability and ability to produce a product and service of superior quality.

Literature Review

Six Sigma (SS) is a quality and process improvement methodology created by Motorola in the 1980s. Expertise in producing and providing near-perfect products and services (Vivekananthamoorthy N and Sankar S,2011) and a technique for increasing process output quality by minimising variability in manufacturing and commercial processes (K. Chandrasekaran, 2011). In addition, it is a static concept that aims to define process variation that causes an error (The Council of Six Sigma, 2018). Six Sigma is a set of problem-solving strategies and a business philosophy based on continuous improvement (CI) and method for studying data structures (B. Radha Krishnan & K. Arun Prasath., 2013). A Six Sigma specialist employs both qualitative and quantitative methods for processing improvement. The application and integration of tools as part of a system are distinctive rather than the tools themselves. Here are a few examples of statistical and graphical tools frequently employed in improvement projects under Six Sigma: DMAIC, The 5s, The 5 Why, Cause and Effect Diagram, Control Chart, Value Stream Mapping (VSM), Pareto Chart, Poka Yoke, FMEA and Kanban.

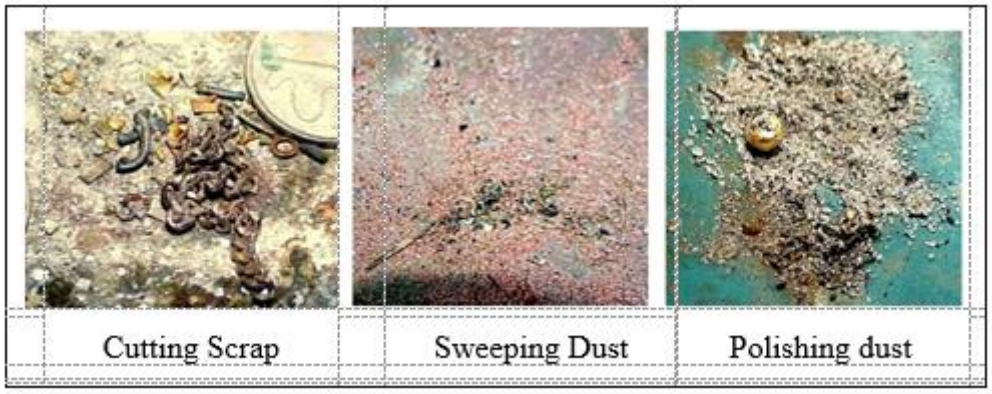
DMAIC cycles can manage both quality and long-term performance systematically and systematically. A systematic approach based on the DMAIC model can systematise the Sustainable Flowchart and Mapping Process toward sustainable manufacturing, which includes metrics to evaluate a manufacturing line's economic, environmental, and social sustainability performance. A new generation of research projects is advocating Six Sigma as a powerful methodology tool for enhancing the sustainability performance of today's manufacturing systems following this criterion. The relevance of standard operating procedures (SOPs) as a guideline for regulating and monitoring quality through proper and systematic methods in the manufacturing process is emphasised in theory on the elements that contribute to gold losses in small-scale companies. The DMAIC Six Sigma approach is one of the alternatives and techniques recommended to continue improving the gold scrap collection process in the direction of the Sustainable Development Goals Agenda and Industry 4.0, respectively.

Research Background

The different techniques were employed in jewellery manufacture, whether the pieces were produced by machine or by hand (S. Kaspin, 2013), (Kaspin, S., & Mohamad, N. (2015). According to what we all know, each stage of the jewellery-making process generates a different form of gold scrap (Kaspin, S. 2013). High-grade and low-grade gold scrap, according to Corti, Christopher W. (2002 and 1996) and Dr W.S. Rapson (1994), can be distinguished based on their composition, cleanliness from contamination, and other characteristics. High-grade scrap contains more than 20% gold by weight and includes bench scrap, casting debris, ancient jewellery, coins, and other objects of value to the gold industry (Kaspin, S. 2008). This material can be easily refined by melting it with a simple flux process (Ibid.). Low-grade scrap contains anywhere from 0.1 per cent to 8 – 9 per cent gold and includes items such as floor sweeping, polishing dust, remaining plating solution, rags and tissues plated with base be found in nature. Additionally, sludge from the wet sink trap, jewellery tumbler recirculation systems, carpets, wood flooring, watch bands and spectacle frames, and other materials could be present in the low scrap. He argued (in 1996) that these materials should be refined or purified to pure gold to achieve maximum benefit.

A sophisticated system for identifying, tracking, and controlling the amount of gold scrap generated throughout jewellery manufacturing is essential to prevent potential losses (Kaspin, et al, 2009). It is vital to follow gold losses from the beginning to the end of each stage of jewellery making using regular weighing, according to Dr Christopher W. Corti (1996) and Peter Raw (2000), to determine the source of gold losses and take action to reduce them. In response, Peter Raw (2000) developed a technique for assessing gold losses that involves comparing the actual worth of the gold to the theoretical value of the gold.

Plate 1.0 Example of the gold scrap/waste in jewellery making process.



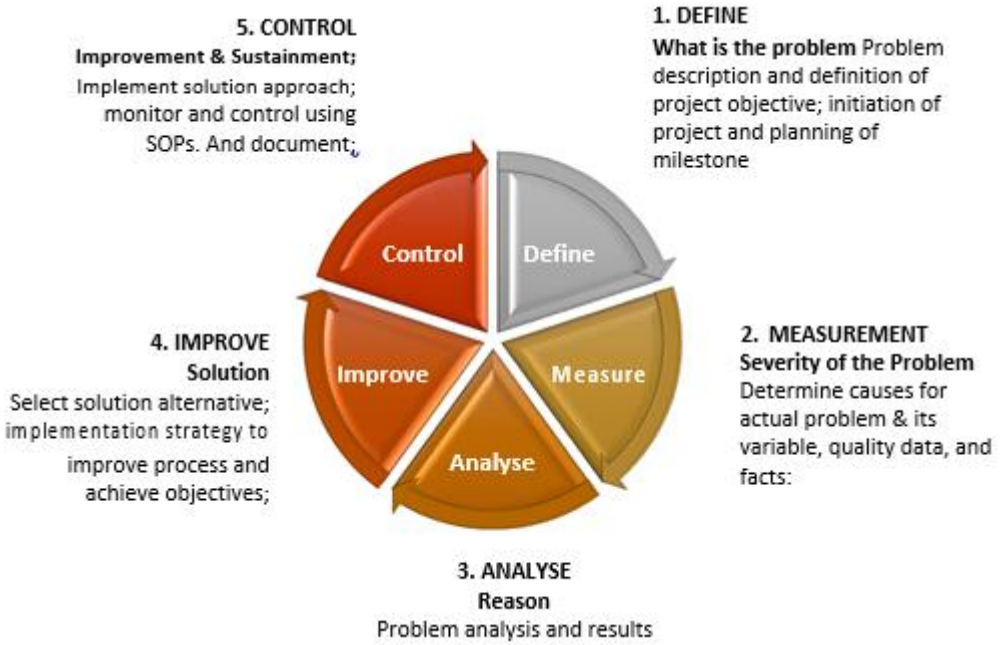
Sources : Saadiah Kaspin, 2008

Methodology

As discussed earlier, SS is a fundamental quality management approach for process improvement that focuses on process standardisation and variability reduction. DMAIC, which stands for Define, Measure, Analyse, Improve, and Control, is a realistic plan that Six Sigma initiatives follow. These logical stages, which are strengthened by Industry 4.0 tools, are used to identify, and solve various problems. The DMAIC Six Sigma framework is utilised in this research to improve the process flow and final product quality in the small-scale jewellery business. The diagram below depicts the conceptual framework for the gold scrap collection process in the small-scale jewellery business.

DMAIC Six Sigma Roadmap: Gold/Scrap Waste Management Procedure

Figure 1.0 : The DMAIC Six Sigma Framework



The Define phase tries to identify issues with the current small-scale scrap management method. A descriptive statistical analysis using SPSS is undertaken to determine the level of knowledge among jewellers regarding gold

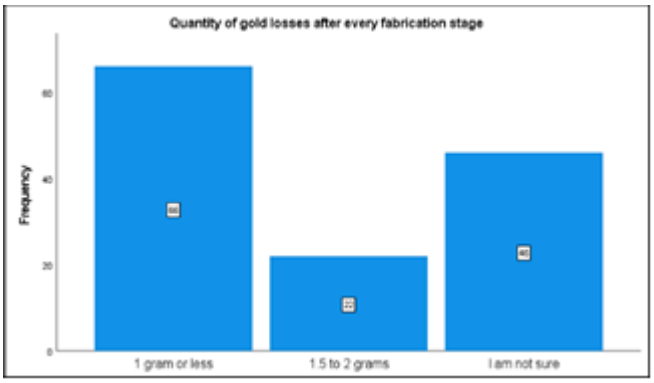
losses, the amount of gold lost, and the actions taken by companies to address the issue. The Measure phase will discover the underlying cause of the problem and provide remedies through extensive observation and data collecting of the step-by-step gold scrap collection procedure. The Measure phase collects and analyses data. Throughout the root cause and improvement procedures, attention to detail is critical. The Define phase analysis guides the selection of participants in this phase.

The Analyse phase seeks to identify and prioritize the problem's core causes. In many cases, Root Cause Analysis (RCA) yields satisfactory results . Six Sigma technologies will analyse and interpret data from the Define and Measure phases. The Ishikawa Fishbone Underlying Cause Analysis Tool is used to analyse and determine the root cause of problems. The Ishikawa Fishbone Diagram, identifying the components and sub-factors that contribute to the identified problem and improves the possibility for analysis and optimization. During the Improve phase, the action plan must be focused on eliminating major underlying causes, and it must be monitored and maintained throughout time. This Analysis is required to fix the discovered issue and improve overall performance. It is critical to identify indicators that will help to focus on the project's goals. The process mapping and flowchart are used to change the process. An improved mapping technique and flowchart will be provided. A control plan and documentation monitor and verify that performance improves while functions remain stable. Small-scale jewellers, makers, and goldsmiths can use Standard Operating Procedures (SOPs) to control and maintain a sustainable process. They can control and monitor the process quality and reduce gold losses while increasing the finished product quality.

Results

The case study results were not compatible with the quantitative data on the types of methods used (Table1.0) in the fabrication process based on the kinds of techniques utilized in the fabrication process. The amount of gold lost in quantitative data indicates that the highest amount of gold lost during the creation process is 1 gram or less, with 66 respondents reporting 1 gram or less. The jewellers, on the other hand, we're unable to estimate the exact number of gold losses through observation. According to the findings, the improper analysis and unverified actual figures of gold losses will harm the profit margin in the long run. The quantity of gold scrap is not documented, the second-highest response from the 'unknown' amount of gold losses is compatible with qualitative data. Through the brainstorming session, root cause analysis (RCA), Cause-Effect Diagram and 5 Why Analysis, the ideas on possible causes of the problems is determined.

Table 1.0 Quantity of gold losses in every jewellery making stage



As a result, the issues must be explored to have a deeper knowledge of the fundamental cause. Identifying the problem in the gold scrap collection process is made based on the data interpretation and integration performed. Based on the Root Cause Analysis (RCA) of the unsystematic gold scrap collection procedure used by small-scale jewellers and the interpretation and integration of data from a survey and a case study, five elements that contribute to small-scale jewellery's unsystematic collection of gold scrap is revealed. The 'Why-Why Analysis'

investigates those causes in greater detail. The primary reason for unskilled workers is their inability to manage all the variables during the process . The findings are grouped into five categories, which are as follows:

- poor data collection
- nonstandard routine schedule
- lack of quality control
- lack of a competent scrap handling system
- data that has not been correctly examined on the gold scrap losses

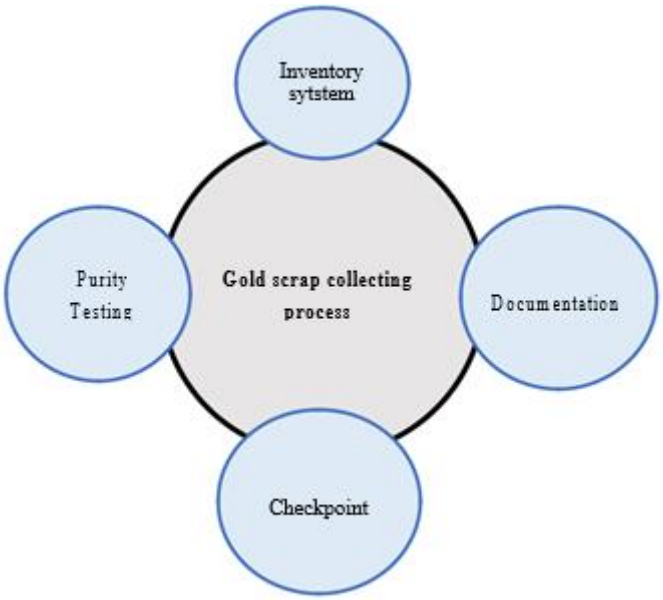
Figure 2.0 : The 'WHY' exploration in identifying the major factors involves

Improvement Process

The inventory system, quality testing, documentation, and checkpoints in gold scrap gathering operations need improvement. The inventory system's purpose in the jewellery creation process is to assist jewellers or goldsmiths in tracking the amount of gold used throughout the process and locating products, supplies, and equipment in the workshop or workbench. This method establishes the gold's stock level, and frequent (monthly, yearly) stock takes made to monitor the gold's utilisation. Each equipment and fabrication area component will be cleaned, including the exhaust system, drain, walls, roofs, floors, and working clothes, to ensure that they can cover all gold waste. In contrast, quality management is critical in determining the quality of a product following the gold purity standard.

The testing process, which must be documented and justified in an inventory system, will explain the product's quality. The checkpoint will aid in identifying critical risks and issues that may arise during the process. Meanwhile, documentation serves to track a process during the manufacturing of a product. The objective is to learn from the implementation process to adjust the strategy and procedure as necessary. The figure (3.0) illustrates the areas for improvement in the gold scrap collection process

Figure 3.0 : Area Improvement of Gold Scrap/Waste Management Procedure in Jewellery Making Process



The Control Plan

To sustain the process, a new mapping method and flowchart for the gold scrap collection process for the small-scale jewellery sector. The documentation, checkpoints throughout the process, quality testing processes, and inventory system are all areas that may make improvements to make the process more efficient (Kaspin, S. 2022 and 2021) The flowchart will be separated into sections based on the role and the working function to provide a clear explanation. As a result, the proposed change may be clearly described and supported by the importance of implementing standard operating procedures (SOPs) in the gold scrap collection process. The adjustment of the mapping process entails four working processes, which are listed in Table 2.0 below.

Table 2.0 The area improvement and working process of new mapping process in gold scrap colleting process

No	Working process	Area of improvements
1	Designing process (DP)	Documentation Inventory
2	Ingot making process (IMP)	Purity testing procedure Documentation Inventory Checkpoints
3	Jewellery making process (JMP)	Purity testing procedure Documentation Inventory

		Checkpoints
		Documentation
	Scrap Collecting Process (SCP)	Inventory
4		
		Checkpoints

Discussion

The techniques utilised during the jewellery manufacturing process, with particular attention to the types and sources of scrap generated due to this operation, must be improved. For example, (Kittichok Nithisathian et al. 2012) expressed that the Thai fine gold jewellery industry lacks research, development, and production attention. He claimed they still rely on traditional jewellery crafting techniques that result in a higher population of gold scrap and waste; this mysterious way of management makes it difficult to develop and manage. For this reason, in comparison, Thai fine gold jewellery needs to improve its information technology systems and processes, advance its management methods, and introduce new ideas to these companies to keep up with economic development. These ideas include customer orientation, information management system, flexible operational process, and remaining competitive (Ibid.).

The researcher investigated the root causes of each primary variable to design and propose a new standard operating procedure (SOPs) in gold scrap collection methods for the small-scale jewellery manufacturing business. The findings indicate that the primary emphasis should be concentrated on improving the current practices. The elements that contribute to the formation of SOPs have been successfully identified and classified into six categories that must be regulated. People, Methods, Materials, Equipment/Tools, Measurement, and Environment are all factors that contribute to the outcome. Each element contributed to the sub-causes and explained how standard operating procedures (SOPs) can be formatted and organised to reduce the number of gold losses, improve the product quality or process, and increase the profit margin of small-scale jewellery industries, among other things. The deployment of new standard operating procedures (SOPs) will directly impact the improvement of the gold scrap collection process. As a result, areas for improvement in gold scrap collection techniques are proposed, and these will be linked with the data analysis findings. Last but not least, the expectation of Chris Corti (2014) that old technologies would revive. Innovations in 2024 can realise if the public's knowledge of particular difficulties in small scale industries is raised. The motivation to improve operational efficiency in materials and yields is clear to ensure long-term business sustainability (Mohamad, N., et al, 2017) , (Kaspin S. 2013). The right attitude, approach, and systematic procedures may help SMEs gold producers and fabricators, leading to a reduction in costs, widening of design opportunities and customising design, following the perspectives and views of Chris Corti (2014).

Conclusion

This article aims to demonstrate how a Six Sigma strategy is used to improve the efficiency, level of performance, and quality of the gold waste/scrap collection process. It is concluded from the analysis that Six Sigma, i.e., the (DMAIC) strategy to improve product quality and scrap reduction, can help to improve quality. From the beginning of the design phase, it is also possible to determine the optimal levels for minimising gold losses and a comprehensive strategy for handling waste/scrap. This study able to optimise the documentation process and analyse the number of golds used throughout the jewellery manufacturing process. It has helped us reduce gold losses, reduce the amount of scrap/waste, and improve the quality of the product to ensure customer satisfaction.

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