



**ENHANCEMENT OF PRODUCT QUALITY THROUGH
STABILITY IN GAGE REPEATABILITY AND REPRODUCIBILITY
AT BEVERAGES INDUSTRY**



**MUHAMMAD KHAIRUL ASRAF BIN ZAINAL
B091810056**

**BACHELOR OF MANUFACTURING ENGINEERING
TECHNOLOGY WITH HONOURS**

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**Faculty of Mechanical and Manufacturing Engineering
Technology**



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**A thesis submitted
in fulfillment of the requirements for the degree of
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Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this Choose an item. entitled “ Enhancement of Product Quality Through Stability in Gage Repeatability and Reproducibility at Beverages Industry” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature



Name

: Muhammad Khairul Asraf Bin Zainal

Date

: 17 January 2022



APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours.

Signature :  TS. DR. AMIR HAMZAH BIN ABDUL RASIB
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan Pembustan
Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Supervisor Name : Ts. Dr. Amir Hamzah Bin Abdul Rasib

Date : 17 January 2022



DEDICATION

To my dear father, mother, siblings, and friends, who have always been there for me
spiritually and emotionally.

Ts. Dr. Amir Hamzah Bin Abdul Rasib, my supervisor, for mentoring, instructing, and
assisting me in finishing my thesis.



ABSTRACT

Due to the numerous challenges competitors face in similar industries, particularly in the food business, industrial sectors focus their efforts on performance improvement. Measurement systems refer to a process's ability to provide a high-quality product or service that fulfills the standards of the client. The issue is that numerous small and medium-sized manufacturing enterprises are struggling to satisfy their customers while maintaining a high level of product quality. To improve product quality, the first objective of this research is to uncover issues with product quality related to the measuring method. Before initiating this study, a literature review using the GR&R technique was undertaken to acquire data and convert it to knowledge. When developing a collective term on a manufacturing system, it is necessary to collect production data from the selected food industry as an actual case study. Additionally, the second objective of this study is to undertake GR&R to improve product quality in the food and beverage business through stability. As a result, data collecting is critical to the study's completion. Interviews are conducted, photographs are taken, and measurement data is entered into a spreadsheet. The study's ultimate objective is to recommend an improvement activity based on the findings from the GR&R system analysis. The analysis is conducted utilising the data that has been gathered. This analysis is necessary to evaluate whether the measuring system is affected by Appraisal Variation (AV) or Equipment Variation (EV). Additionally, GR&R is utilised to decide whether the analysis is appropriate or not. These identify the most impacted element based on the GR&R evaluation and use it to make an improvement proposal. These ideas are discussed with the industrial representative concurrently with the research presentation for evaluation.

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ABSTRAK

Disebabkan oleh pelbagai cabaran yang dihadapi pesaing dalam industri yang sama, terutamanya dalam perniagaan makanan, sektor perindustrian menumpukan usaha mereka pada peningkatan prestasi. Sistem pengukuran merujuk kepada keupayaan proses untuk menyediakan produk atau perkhidmatan berkualiti tinggi yang memenuhi piawaian pelanggan. Isunya ialah banyak perusahaan pembuatan kecil dan sederhana sedang bergelut untuk memuaskan hati pelanggan mereka sambil mengekalkan tahap kualiti produk yang tinggi. Untuk meningkatkan kualiti produk, objektif pertama penyelidikan ini adalah untuk mendedahkan isu-isu kualiti produk yang berkaitan dengan kaedah pengukuran. Sebelum memulakan kajian ini, kajian literatur menggunakan teknik GR&R telah dijalankan untuk memperoleh data dan menukarnya kepada pengetahuan. Apabila membangunkan istilah kolektif pada sistem pembuatan, adalah perlu untuk mengumpul data pengeluaran daripada industri makanan terpilih sebagai kajian kes sebenar. Selain itu, objektif kedua kajian ini adalah untuk melaksanakan GR&R bagi meningkatkan kualiti produk dalam perniagaan makanan dan minuman melalui kestabilan. Akibatnya, pengumpulan data adalah penting untuk penyiapan kajian. Temu bual dijalankan, gambar diambil, dan data ukuran dimasukkan ke dalam hampan. Objektif utama kajian ini adalah untuk mengesyorkan aktiviti penambahbaikan berdasarkan penemuan daripada analisis sistem GR&R. Analisis dilakukan dengan menggunakan data yang telah dikumpul. Analisis ini perlu untuk menilai sama ada sistem pengukuran dipengaruhi oleh Variasi Penilaian (AV) atau Variasi Peralatan (EV). Selain itu, GR&R digunakan untuk memutuskan sama ada analisis itu sesuai atau tidak. Ini mengenal pasti elemen yang paling terkesan berdasarkan penilaian GR&R dan menggunakannya untuk membuat cadangan penambahbaikan. Idea ini dibincangkan dengan wakil industri serentak dengan pembentangan penyelidikan untuk penilaian.

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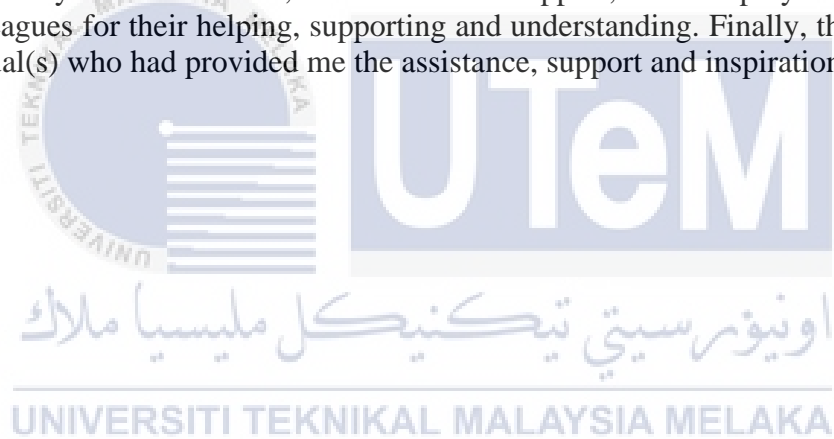


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LIST OF SYMBOLS AND ABBREVIATIONS

GR&R	-	Gage Repeatability and Reproducibility
MSA	-	Measurement System Analysis
QA	-	Quality Assurance
QC	-	Quality Control
AIAG	-	Automotive Industry Action Group
GM	-	General Motor
AV	-	Appraiser Variance
EV	-	Equipment Variance
PV	-	Process Variation
TV	-	Total Variance
NDC	-	Number of Distinct Categories
K	-	Constant
UCL	-	Upper Control Limit
LCL	-	Lower Control Limit
EMP	-	Evaluating the Measurement Process
F&B	-	Food and Beverage
DMAIC	-	Define, Measure, Analyze, Improve & Control
SIRIM	-	Standard and Industrial Research Institute of Malaysia
Sdn. Bhd.	-	Sendirian Berhad
Mardi	-	Malaysian Agricultural Research and Development Institute
FAMA	-	Federal Agricultural Marketing Authority

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CHAPTER 1

INTRODUCTION

1.1 Research Background

In this technological era, the quality of a product is very important to satisfying and retaining their customer's trust in the product. So, when customers get a good product, they will return, make a repeat purchase and recommend it to others. In order to achieve a good product, a good measurement system must be emphasized. Al-Refaie et al., (2010) stated that to assess the precision and quality of goods, a variety of measurement methods have been developed, with the majority of them focusing on the total variance of measurement, also known as measurement uncertainty. In other words, to produce high quality product, variety of measurement method must be concern to ensure the productivity by the manufacturer.

Parts are weighed in certain production processes to ensure that such standards are met. These measures, however, can be deceiving if the measurement method is inadequate (Cox et al., 2013). The measurement instruments, appraisers, objects measured, and the measuring atmosphere may all contribute to measurement errors. Thus, this issue will lead to poor quality of product then will drop the production demand. In this sense, gauge variability is critical for quality improvement since the adequacy of a product's measurement process can only be calculated with a gauge that has reasonable repeatability and reproducibility.

1.2 Problem Statement

A good measurement system determines the product quality in the manufacturing company. A stepwise decision is the key to success to have a smart measurement system. Therefore, in a manufacturing factory, they keep on using Measurement System Analysis (MSA) to improve their manufacturing system. MSA is a comprehensive examination of a measurement process that usually involves a specially designed experiment to determine the sources of variance in the measurement process (Yeh & Sun, 2013). MSA also is one of the quality control methods that examines a set of instruments, processes, methods, software, and personnel that influence the assignment of a number to a measurement attribute.

Nevertheless, as technology advances, many small and medium manufacturing firms are finding it difficult to satisfy their consumers while maintaining high product quality. To help them thrive in this competitive society, they must keep evolving and improving especially in the measurement system to make it more productive and smoother. An evolving method exposes manufacturing companies to a certain amount of risk.

Until launching the new management, it's critical to ensure that the new system's enforceability generates a profit for the business. Therefore, the Gage Repeatability and Reproducibility (GR&R) is the best way in measurement system in enhancing the quality of the product in the manufacturing industry. GR&R can be used to determine the degree of uncertainty within a system of measurement and is an appropriate tool for gauges or instruments used to collect variable continuous data.

1.3 Research Question

Three research issues have been defined as a result of the problem statement.

RQ1: How to improve product quality in food and beverage industry?

RQ2: What are the method used in order to solve product quality?

RQ3: How GR&R helps in making sure that the measurement system process are stable and precise?

1.4 Research Objective

The main goal of this case study is to improve product quality through stability in manufacturing industry by using GR&R measurement system. This project has a set of underlying objectives:

- i) To identify product quality issue that related to measurement system.
- ii) To conduct the GR&R in order to enhance product quality through stability in food and beverage industry.
- iii) To propose an improvement activity based on GR&R system study.

1.5 Research Scope

This study will focus on performance measurement or called the measuring system in manufacturing production. The primary task is to enhance the quality product of the measurement system in the industry. Gage Repeatability and Reproducibility is an approach for determining the amount of variance in measurement data caused by the measuring system. Therefore, the average and range method is used in this study to do the improvement of the product quality in the manufacturing industry.

1.6 Expected Result

The expected result for this study is to identify the factors that have an effect on product quality as a result of GR&R measurement system. After define and have solutions in ameliorating the production control, validate new ideas of improvement via GR&R system study. After done substantiation, present the improvement activity to the manufacturing industry. This study helps to gain an opportunity to apply the knowledge and study in a real case. This is a good chance to get the experience apart from learning in the school.

This study helps to determine the measurement system that used in the industry. Based on the measurement analysis system in the manufacturing industry, identify the weakness of measurement analysis then do the improvement based on the finding. Apart from these, the expected result for this study is to enhance quality product using GR&R system through stability to the manufacturing company.

1.7 Thesis Frame

The first part of the chapter is devoted to its introduction. This chapter describes the research history that informed this report. In this chapter, the study's problem statement is discussed. Following that, the research issue is developed based on the three problem statements. While from the research question, the research objectives are also written down in this chapter, and yet the research scope also explained in this chapter by using K-chart. This study's expected outcome as well as the thesis framework are mentioned. Finally, in this chapter, the study's description is presented.

Next, the second chapter is all about preparing the study's literature review. In this chapter, all the related knowledge about this study which are product quality, Measurement System Analysis (MSA), measurement variation and Gage Repeatability and Reproducibility (GR&R) were found and read to prepare the writing of this chapter. Method of writing this chapter is finding the past journals and articles, gain information from these past journals and articles. Then write down the finding knowledge to this chapter topic by topic. Therefore, in this chapter, there will have many subtopics and each topic is relating to this study.

Moreover, in chapter three, the methodology launch in this study is implemented. In this chapter, the tools and techniques were defined and had the guideline on doing this study. The tools and techniques will give a detailed explanation in this study. The problem-solving techniques are also explained in this chapter.

After that, chapter four will show the result and discussion of this study. In this chapter, the tools and techniques explained in chapter three will be used in this study. Further information on applying the tools and techniques is described. Next, the result of using these tools and techniques will be discussed in this chapter. The discussion will base on the findings result and achieve the objectives of this study.

Lastly, in chapter five, the conclusion of this study will be implemented. In this chapter, the finding of the entire study will summarize in this study. The improvement of this study will present. The future proposals on enhancing the quality of product through stability are presented. The enhancement will illustrate and the overall conclusion is written in this chapter as concluded in the thesis.

1.8 Summary

To summaries, for a manufacturing company to produce high-quality products, continuous improvement, especially in the measurement system, is important. Measurement System Analysis (MSA) will help the improving measurement system more stable and accurate. Besides, the stability to conduct the measurement system are important to enhance the quality and productivity of the product of the company. The implementation of MSA such as GR&R technique is one of the solutions to improve the quality of product become well. The aim of GR&R is to improve measurement equipment efficiency. This technique is also used as a criterion for evaluating new measurement instruments.

CHAPTER 2

LITERATURE REVIEW

2.1 Preliminaries

Nowadays, manufacturers are constantly working to improve the quality of their products and processes, as well as to minimize part variation. Every production process contains some degree of variation. One of the key goals of manufacturing industries is to achieve good product quality (Papadimitriou et al., 2009). Controlling the stability of production processes is crucial in achieving these conditions. Assigning a tolerance range to their print dimensions is a standard way that many design engineers employ to deal with variance. Unfortunately, there is some fluctuation in all measurement data. The gap between real and observed values is referred to as variance. The variance represents the level of measurement imperfection.

In addition to measurement imperfection, there is the premium product or process volatility. The GR&R's purpose is to determine how much of the overall process variation is caused by the measurement system and how important it is in relation to part-to-part variation (Hawary et al., 2019). According to Bottani et al., (2021) was defined reproducibility is the variability caused by different operators using the gauge (or, more generally, various settings), and repeatability as the gauge's basic intrinsic precision.

2.2 Quality

As explained by Ma et al., (2017) defines the sum of various interconnected properties such as design, measurement, composition, durability, craftsmanship, adjustability, finishing, and color constitutes product quality. Similarly, Quality (2015) defined the amount through which a product satisfies specifications as well as craftsmanship requirements. Those definitions make it apparent that quality refers to a product's different features and their excellence. Quality is a subjective definition that has never been ideal and also is defined either by the original purpose of the products as well as the conditions under which it is used (Bhakhri & Belokar, 2017). All things related to quality are product quality, quality control, and quality assurance.

2.2.1 Product Quality

In general, whether the product satisfies the customer or client, it is said to be of satisfactory quality. Customers will indeed consume services or products if they fulfill their requirements. As a consequence, the marketing department initially analyses customer's demands before making a quality selection based on the statistics obtained. Product quality is a benefit that a product or service should provide to a potential customer (Suchánek et al., 2014). Similar to Hoe & Mansori (2018), in the manufacturing industry, product quality is crucial for maintaining competitiveness and providing remarkable customer service. Product quality refers to the incorporation of functionality that can satisfy consumer demands and provide customer loyalty by enhancing products (goods) and removing any flaws or defects.

In addition, Runje et al., (2017) found that more comprehensive idea of quality, which incorporates all of a product's or service's qualities and quantities. This may have an impact on its ability to achieve specified targets or implied customer requirements. It is possible to assume that quality is a critical factor that customers consider when evaluating goods or services. As a consequence, it's everybody's responsibility in a firm should fulfill the total demands of every customer. Regardless of who that customer is, which again is inspired by market considerations such as competitiveness and, most significantly, the customer.

Quality is defined as a product's ability to perform following the producer's promise to the customer. Such a commitment might be communicated directly or indirectly, for example, in a written agreement or terms of the quality control criteria of the typical product consumer. As identified by Crosby (1979), product quality is defined as conformance to a requirement or specification. Product output is concerned with the ultimate purpose and service that the product must provide to the final ways which are customers.

2.2.2 Dimension of Quality

Garvin (1996) proposes that eight dimensions for investigating product quality which are performance, features, reliability, compliance, durability, serviceability, aesthetics, and product attributes. Garvin's eight-dimensional framework had been initially published in 1984, but its importance in determining product quality is obvious, as proven by its continuous usage in this industry.