Evaluation of the Weight Measurement System in a Manufacturing Process Using MSA (Gage R&R)

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Master of Engineering in Manufacturing Engineering
Graduate Project EXPO, May 2026

Abstract

Measurement systems are essential in manufacturing because decisions depend on accurate data. This study evaluates a digital weighing system using Measurement System Analysis through a Gage Repeatability and Reproducibility (Gage R&R) study. A crossed design was conducted with ten parts, three operators, and three repeated measurements. Statistical analysis using ANOVA showed a total Gage R&R value of 3.97%, indicating the system is acceptable. Most variation was due to part-to-part differences rather than measurement error. The results confirm that the system is stable, reliable, and suitable for manufacturing process control and quality applications.

Introduction

In manufacturing processes, decision-making depends on accurate and reliable measurement data. Variability in measurement systems may originate from equipment or operator influence, affecting product quality and process control. This research focuses on evaluating the performance of a digital weighing system to ensure it provides consistent and reliable measurements for quality-related decisions.

Background

Measurement System Analysis (MSA) is a fundamental component of quality engineering used to ensure the reliability and accuracy of measurement systems in manufacturing environments. The literature shows that inadequate measurement systems can introduce errors that affect process control, product acceptance decisions, and overall quality performance. Gage Repeatability and Reproducibility (Gage R&R) is one of the most widely used methods to evaluate measurement variation by separating the contribution from equipment and operators. Previous studies have demonstrated its effectiveness in analyzing different types of measurement devices and improving data reliability across industries. Additionally, factors such as operator technique, calibration, and environmental conditions can influence measurement results. Therefore, applying statistical methods to validate measurement systems is essential to ensure data integrity and support accurate and consistent decision-making in manufacturing processes.

Problem

In manufacturing processes, reliable measurement data is essential for accurate decision-making. However, the weighing system used has not been formally validated, which may introduce measurement errors. This can lead to incorrect quality decisions and reduced process control. Therefore, this study aims to evaluate the measurement system using a Gage R&R analysis to determine its reliability and suitability for manufacturing applications.

Methodology

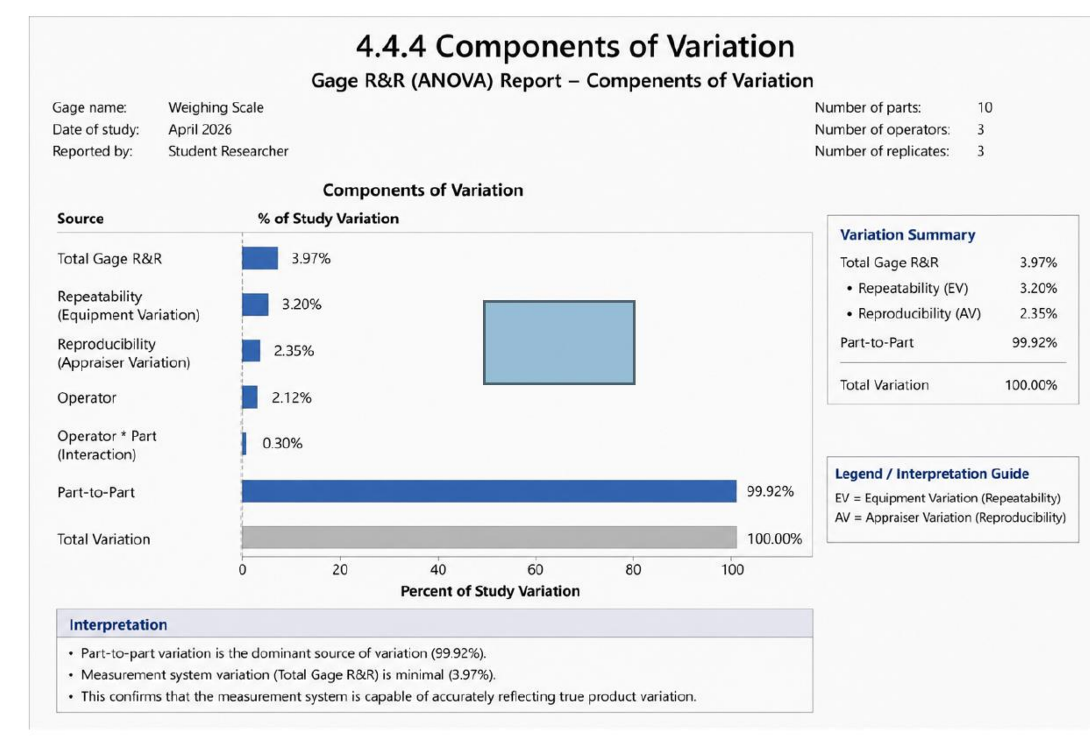
A crossed Gage Repeatability and Reproducibility (Gage R&R) study was conducted to evaluate the performance and reliability of a digital weighing system used in a manufacturing-type environment. The purpose of this methodology was to quantify the variation introduced by the measurement system and determine its suitability for quality-related decision-making. The experimental design included ten parts selected to represent the expected range of variation within the process, three operators, and three repeated measurements per part. This resulted in a total of ninety observations. The crossed design allowed each operator to measure all parts multiple times using the same measurement device, enabling the separation of variation due to equipment (repeatability) and variation due to operator differences (reproducibility). All measurements were performed independently by each operator using a calibrated digital weighing scale with a resolution of 0.01 grams. To ensure realistic manufacturing conditions, operators followed a standardized procedure while working independently. The order of measurements was randomized to minimize bias and reduce the potential influence of measurement sequence or operator learning effects. Data were recorded in a structured format, including part identification, operator identification, and trial number. Prior to analysis, the dataset was reviewed to verify data integrity, ensuring the absence of transcription errors, missing values, or significant outliers. The collected data were analyzed using the Analysis of Variance (ANOVA) method to quantify the contribution of repeatability (equipment variation), reproducibility (operator variation), and total Gage R&R. Additionally, part-to-part variation and the Number of Distinct Categories were evaluated to assess the measurement system's discrimination capability.

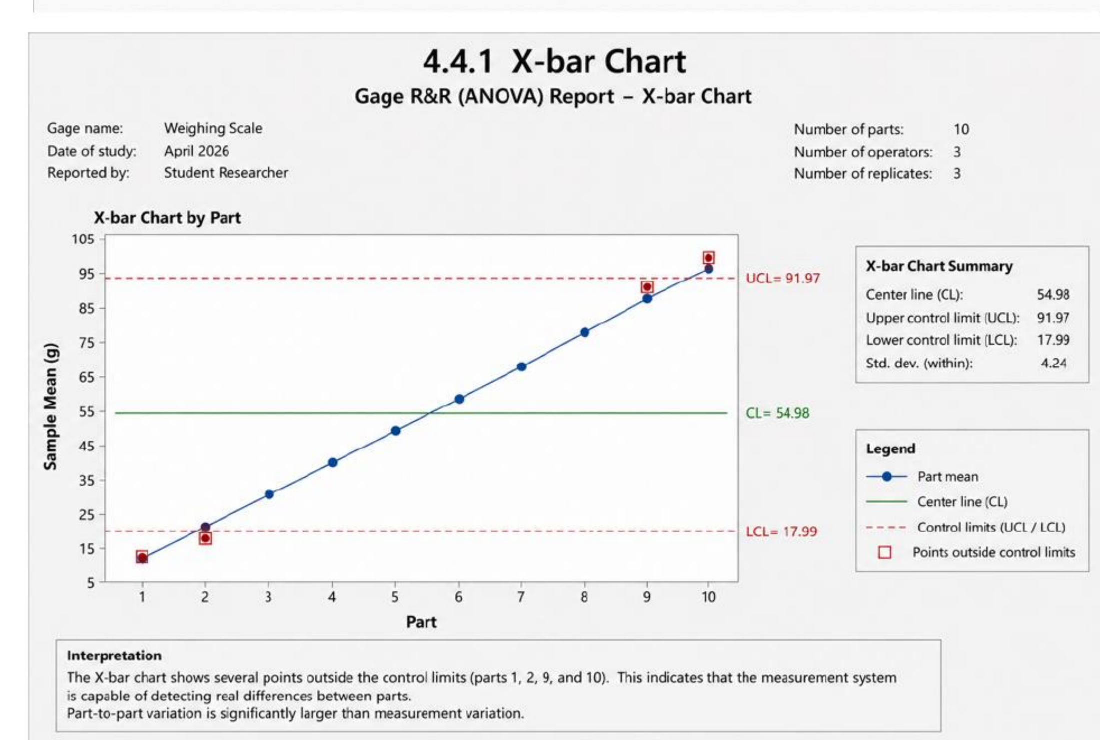
Experimental Design

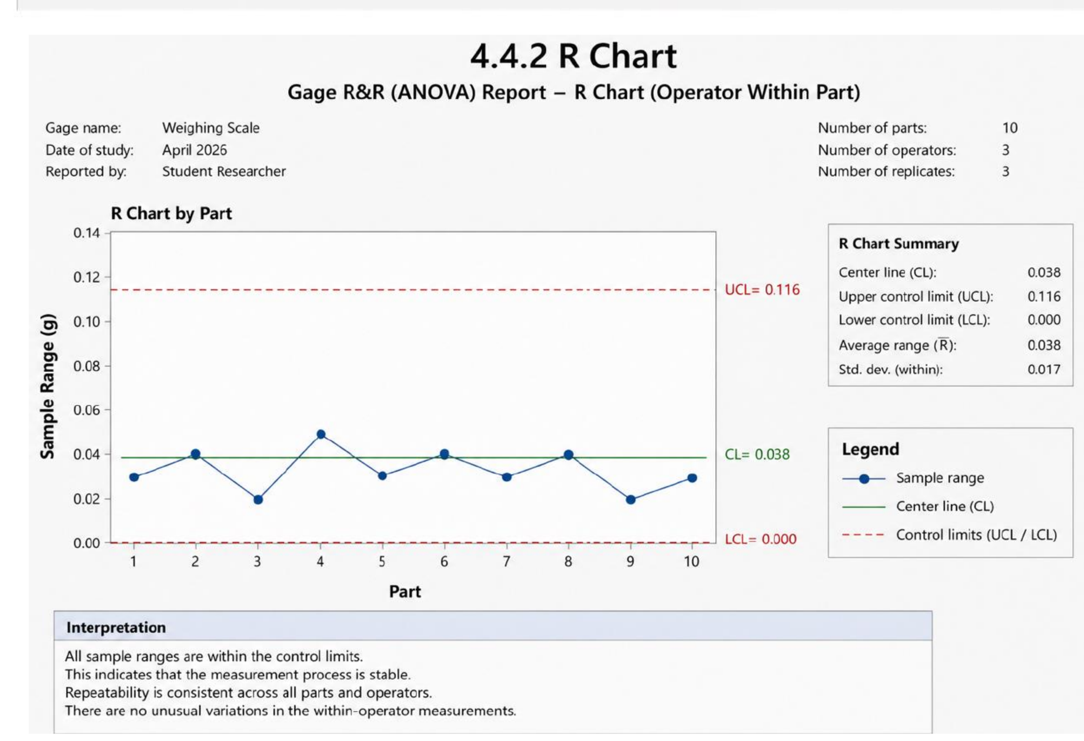
Parameter	Value
Number of Parts	10
Number of Operators	3
Number of Trials	3
Total Measurements	90

Results and Discussion

The Gage R&R analysis showed a total variation of 3.97%, which is below the 10% threshold, indicating an acceptable measurement system. Most of the variation (99.92%) was attributed to part-to-part differences rather than measurement error. Repeatability and reproducibility values were low, confirming consistent equipment performance and minimal operator influence. Graphical analysis supported these results, showing stable measurements and strong discrimination capability. These findings demonstrate that the measurement system is reliable and suitable for manufacturing process control and quality decision-making.







Conclusions

The results of this study demonstrated that the measurement system is acceptable for manufacturing applications, with a total Gage R&R value of 3.97%, which is well below the 10% threshold established by industry standards. This indicates that the measurement system contributes only a small portion of the total observed variation. Most of the variation was attributed to actual differences between parts, confirming that the system accurately reflects true product variability. Additionally, low repeatability and reproducibility values indicate stable equipment performance and minimal operator influence. Overall, the findings confirm that the measurement system is stable, reliable, and suitable for process control, quality assurance, and decision-making in manufacturing environments.

Future Work

Future work may include evaluating the measurement system under different environmental conditions, such as temperature and humidity, to assess its impact on performance. Additional studies could involve increasing the number of parts and operators to improve the robustness of the analysis. Further research may also compare different measurement devices or technologies to identify opportunities for improved accuracy. Finally, integrating Measurement System Analysis with Statistical Process Control (SPC) could provide deeper insight into overall process stability and performance.

Acknowledgements

The author would like to express sincere gratitude to José Morales, Ph.D., for his guidance, support, and mentorship throughout the development of this research project. Appreciation is also extended to the faculty of the Polytechnic University of Puerto Rico for their academic support. Additionally, special thanks are given to all individuals who contributed to the successful completion of this project.

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