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# ASSESSING THE ROLE OF THE D63D SUN-VISOR JIG IN IMPROVING PRODUCT QUALITY AND REDUCING DEFECTS

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## ABSTRACT

*In automotive manufacturing, precision in component assembly is vital for overall product quality. The existing quality control process for the D63D sun-visor faced inefficiencies, accuracy limitations and safety concerns. This study evaluates a newly developed jig designed to improve inspection efficiency, accuracy and ergonomics. Using time-based comparisons, surveys and production output analysis the jig was found to reduce inspection time by about 20.4%, standardize operator performance, and enhance safety. The survey results indicate a highly positive reception of the new jig used in sun-visor manufacturing among Quality Control (QC) personnel. The data reveals that the jig has significantly enhanced quality control operations which 85.7% reported a substantial improvement in accuracy, 92.9% observed a significant increase in task efficiency, and 71.4% noted a marked reduction in defects and errors. Furthermore, the ergonomic evaluation was overwhelmingly favourable with 92.9% of respondents stating the jig is very comfortable and easy to use. Following implementation, production output increased while rejection and rework rates declined significantly. These results demonstrate that the jig contributes to higher productivity, improved quality control and a safer working environment.*

## 1. Introduction

Quality control processes are vital in ensuring that automotive components meet stringent industry standards for safety, functionality, and aesthetics. Quality control refers to the set of procedures and practices implemented to assure customers that the products and services delivered meet the required standards of quality (Grover, 2024). In spite of that, lean manufacturing is also playing an important role in manufacturing industry. Lean manufacturing is an industrial methodology aimed at minimizing waste in production processes. Its fundamental principle is to reduce overall product cost across all stage in design, fabrication and manufacturing by leveraging insights from prior business performance reviews (Gupta et al., 2015; Hines et al., 2004). Within this context, the D63D sun-visor plays a dual role, functionally shielding the driver from sunlight to reduce glare and enhance visibility and aesthetically contributing to the vehicle's interior appeal. Maintaining high-quality standards for this component is critical for fulfilling customer expectations and sustaining brand reputation in a highly competitive automotive market (Smith & Brown, 2017; Smith et al., 2022).

Despite the importance of quality control, the existing inspection process for the D63D sun-visor faces challenges related to efficiency, measurement accuracy, and operator safety. These shortcomings contribute to production delays, increased operational costs and potential workplace hazards. In response to these issues, a new jig was introduced into the quality control process with the intention of improving inspection speed, enhancing dimensional accuracy, and creating a safer working environment for operators. Across the literature, jigs are consistently recognized as vital devices that support and position workpieces while guiding cutting or assembly tools to achieve accuracy and repeatability in manufacturing (Chikwendu Okpala et al., 2024; Nanthakumar, K. and Prabakaran, 2014). Beyond precision, jigs contribute to efficiency by minimizing setup times, reducing errors and enabling standardized workflows (Pandit et al., 2023). Their application extends across machining, welding, and assembly, where they provide controlled working conditions that improve both productivity and product quality (Chavan-Patil, 2024). Collectively, these studies emphasize the role of jigs in ensuring precision, enhancing operational efficiency and supporting consistent manufacturing outcomes.

However, the effectiveness of the new jig implemented requires empirical evaluation to ensure that it addresses the identified limitations and delivers tangible improvements in production outcomes. Therefore, the aim of this study is to analyse the impact of the new jig on the quality control process for the D63D sun-visor, focusing on its influence on operational efficiency, measurement accuracy, and operator safety. While the study offers practical insights, its scope is limited by a relatively small participant sample and the specific context of a single manufacturing facility, factors that may influence the generalisability of the findings. The expected outcome is to generate evidence-based recommendations that not only optimise the inspection process for the D63D sun-visor but also contribute to best practices in automotive quality control.

## 2. Methodology

This study employed a mixed-method approach integrating quantitative and qualitative data collection to evaluate the effectiveness of the newly implemented D63D sun-visor jig within the quality control (QC) process. Three primary evaluation methods were utilised: (i) time comparisons, (ii) questionnaire surveys, and (iii) production output analysis. These methods were complemented by direct observations, structured interviews and a review of company records to ensure a comprehensive assessment.

### 2.1 Observation and Interviews

Direct observations were conducted to document the existing QC workflow, operator practices and equipment utilisation. Structured interviews with QC operators, supervisors and related personnel captured first-hand insights into the operational challenges of the prior system and anticipated improvements from the new jig.

### 2.2 Company Data Review

Historical QC records, defect logs and production reports were analysed to establish a baseline performance profile. These data were instrumental in identifying recurring defects, process inefficiencies and associated cost implications.

### 2.3 Time Comparison

Four QC operators each inspected and tested 10 boxes of D63D sun-visors (12 units per box) under two conditions: before and after jig implementation. Inspection times were recorded, averaged and statistically analysed using a paired t-test to determine the significance of differences.

### 2.4 Questionnaire Survey

A structured questionnaire was administered to 14 QC staff to assess the jig's ergonomic impact, ease of use, safety improvements and perceived effect on inspection accuracy. Responses were rated on a Likert scale and analysed using descriptive statistics to identify trends.

### 2.5 Production Output Analysis

Monthly production metrics, including total units produced, rejection counts and rework rates were compared for one month prior to and one month following jig implementation. Statistical tests such as chi-square was applied to determine the significance of observed changes.

### 2.6 Participants and Ethics

Participants comprised QC personnel directly involved in D63D sun-visor inspection. Informed consent was obtained from all respondents, and confidentiality of personal and company data was maintained through anonymisation during analysis.

## 3. Result and Discussion

The results section outlines the study's findings regarding the effectiveness of the newly implemented jig in enhancing the efficiency, accuracy, and operator safety within the quality control process for D63D sun-visor production. The outcomes provide a comprehensive evaluation of the jig's impact on quality assurance procedures and underscore its potential to contribute significantly to improved manufacturing performance and product quality in D63D sun-visor production.

### 3.1 Staff Inspection Time Before and After Implementing Jig

The comparative analysis of inspection times before and after the implementation of the new D63D sun-visor jig reveals a clear and substantial improvement in operational efficiency. Table 1 and Figure 1 presents the total and average recorded times for four quality control (QC) staff, designated Staff A through Staff D, who each inspected and tested ten boxes of sunvisors under both conditions.

Before jig implementation, the total time required by all four staff to complete the assigned inspections was 12,021 seconds, averaging 300.53 seconds per box. After implementation, the total time decreased to 9,566 seconds, corresponding to an average of 239.15 seconds per box. The paired t-test revealed a t-statistic of ≈ 63.74 and a p-value of $\approx 8.51 \times 10^{-6}$, indicating a highly significant decrease in inspection time after the jig's implementation. On average, inspection time fell from 3005 seconds to 2392 seconds per operator, a reduction of approximately 613 seconds or 20.4% improvement. This efficiency gain is consistent across all staff members highlighting the jig's role in standardizing the inspection process and reducing operator variability.

Table 1. Time taken of staffs to complete the assigned inspections before and after implementing jig

| | Time Taken Before Implement Jig for D3D Sun-Visor (s) | Time Taken After Implement Jig for D3D Sun-Visor (s) |
|---|---|---|
| **Staff A** | 3004 | 2410 |
| **Staff B** | 3008 | 2368 |
| **Staff C** | 3039 | 2426 |
| **Staff D** | 2970 | 2362 |
| **Total Time (s)** | **12021** | **9566** |

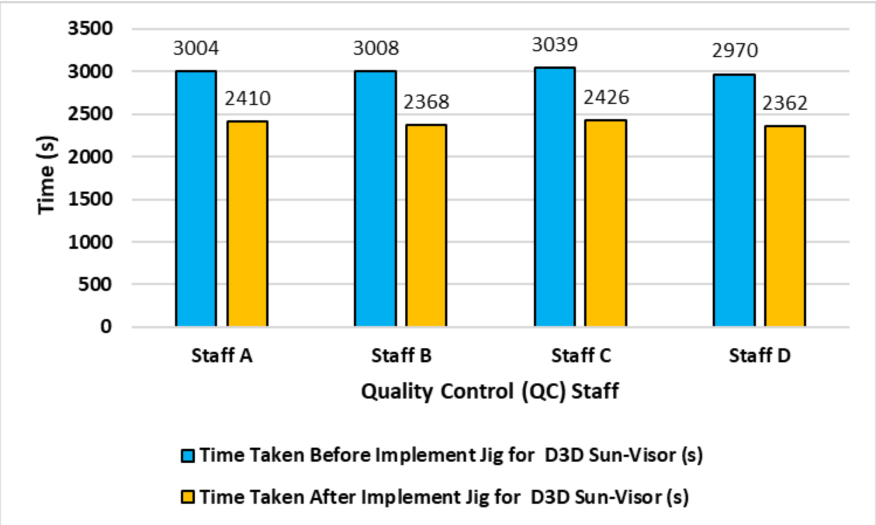


Figure 1. The bar chart of inspection time before and after implementating jig

These findings indicate that the jig's design improvements such as enhanced component positioning, stability during measurement and ease of handling contributed directly to faster inspection cycles.

Shorter inspection times can have downstream benefits, including:

- Reduced work-in-progress (WIP): Faster inspection turnover can prevent bottlenecks at the QC stage.
- Improved scheduling flexibility: Lower inspection durations allow reallocation of QC resources to other quality-critical areas.
- Lower operator fatigue: Reduced handling time may decrease cumulative strain, supporting improved ergonomics.

These results align with prior studies on jig-assisted quality control in manufacturing, which have shown that purpose-built fixtures can significantly reduce inspection cycle times while maintaining or improving measurement accuracy (Johnson & Williams, 2019). The observed efficiency gains are therefore consistent with established manufacturing engineering principles that emphasise tool optimisation as a driver for productivity improvement.

### 3.2 Survey Findings

Table 2 expose that the majority of respondents (71.4%) were Quality Control Inspectors followed by Quality Control Leaders (21.4%) and other roles (7.1%). In terms of experience, 42.9% had worked in quality control for between one to three years, 35.7% for more than three years and 21.4% for less than one year. This profile indicates that the feedback represents both seasoned and relatively new personnel, providing a balanced perspective on the jig's implementation.

Table 2. Respondants for jig implementation survey

| Survey Item | Response 1 | Response 2 | Response 3 |
|---|---|---|---|
| Role in Quality Control | 71.4% Quality Control Inspector | 21.4% Quality Control Leader) | 7.1% Other Roles |
| Experience in Quality Control | 42.9% 1–3 years | 35.7% >3 years | 21.4% <1 year |
| Used New Jig | 100% Yes | - | - |

Full adoption was recorded with 100% of respondents reporting that they had used the new jig in sun-visor manufacturing. Such a rate of acceptance aligns with established technology adoption research, where ease of use and perceived usefulness are critical drivers for uptake (Venkatesh & Davis, 2000). This suggests that the jig was seamlessly integrated into existing workflows without significant operational resistance.

Respondents' perceptions of the jig's impact on quality control were strongly positive as presented in Figure 2. In terms of accuracy, 85.7% reported significant improvement with the remaining 14.3% indicating moderate improvement. Efficiency received even higher ratings, with 92.9% noting significant improvement and 7.1% reporting moderate gains. Additionally, 71.4% of respondents observed a significant reduction in defects while 21.4% noted a moderate reduction. These outcomes are consistent with findings in the manufacturing literature showing that jigs and fixtures reduce human variability, improve alignment and increase process standardisation, all of which lead to higher product quality (Pandit & Pandit, 2023).

Ergonomic performance was another strong point with 92.9% of respondents stating that the jig was very comfortable and easy to use. Ergonomic research consistently shows that well-designed fixtures reduce operator fatigue, improve task repeatability and support sustained performance (Helander, 2006). The high ergonomic ratings in this survey imply that the jig's design not only supports quality improvements but also contributes to operator well-being which can positively influence long-term productivity.

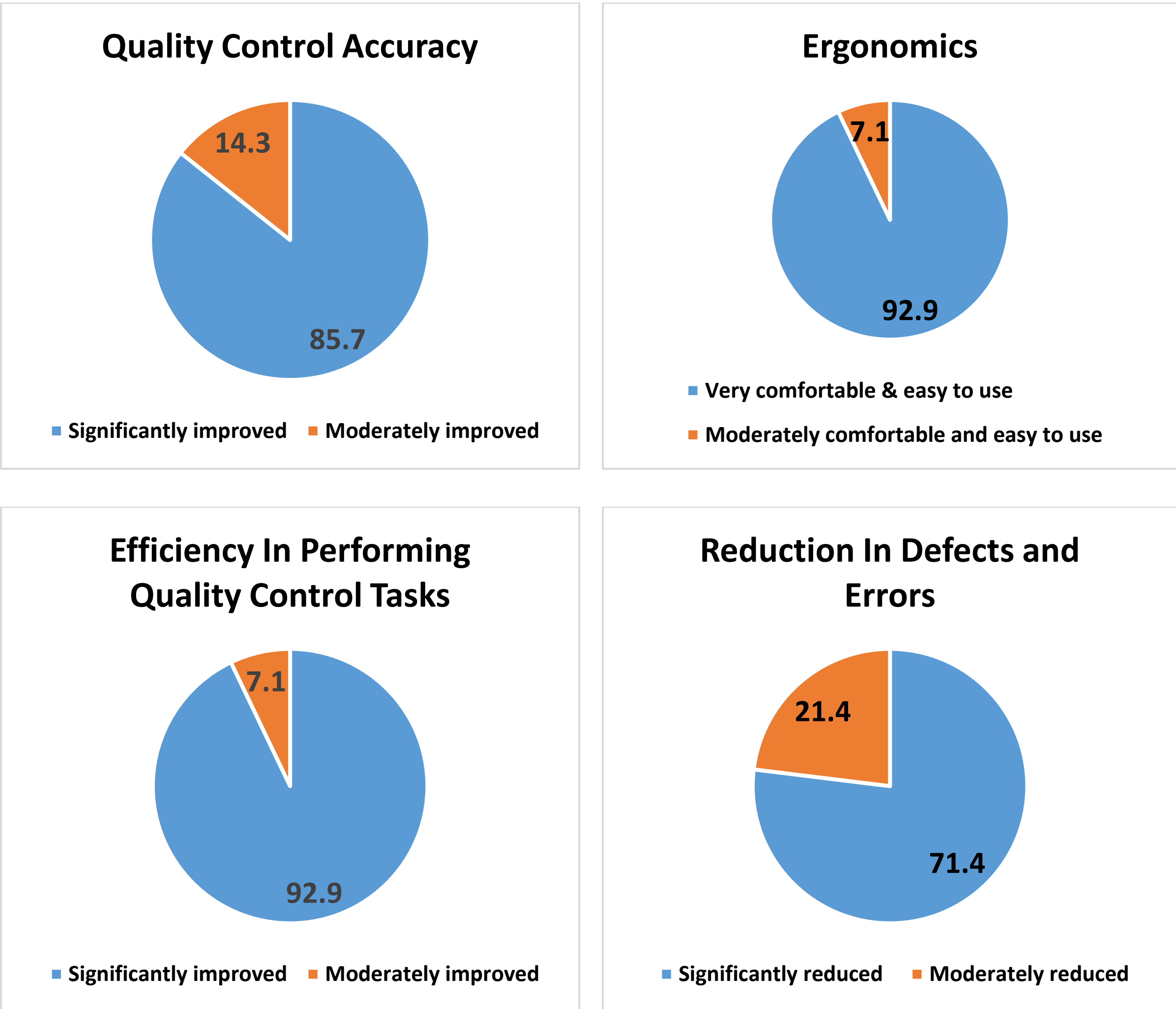


Figure 2. Effectiveness and ergonomics of jig in jig implementation survey

From a managerial perspective, the combination of complete adoption, strong perceived performance gains and high ergonomic approval suggests that the jig implementation is likely to yield sustained benefits. Such conditions with high usability, visible impact and worker acceptance, are commonly associated with successful process improvement in manufacturing environments (Venkatesh & Davis, 2000; Pandit & Pandit, 2023).

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### 3.3 Production Efficiency Analysis

The production performance data as shown in Table 3 and Figure 3 reveal that the implementation of the jig positively impacted output and quality metrics. Before the jig's introduction, the actual output was 6,280 units against a target of 6,000 units, with 131 rejected units and 1,014 units requiring rework. After the jig was implemented, the actual output increased to 6,480 units, exceeding the target by 8% and representing a 3.2% increase over the previous production period. Simultaneously, the number of rejected units decreased from 131 to 93, indicating a 29.0% reduction in rejections, while rework units dropped from 1,014 to 728, representing a 28.2% reduction in rework.

These improvements can be attributed to the jig's ability to standardise the assembly process, reduce human error and ensure consistent component positioning. This finding aligns with Singh and Kumar's (2017) assertion that jigs and fixtures improve repeatability and accuracy, resulting in higher-quality outputs.

Table 3. Production of D63D sun-visor for March and April 2023

| Item | Before Jig | After Jig | % Change |
|---|---|---|---|
| Actual Output | 6,280 | 6,480 | +3.2% |
| Rejected Units | 131 | 93 | −29.0% |
| Rework Units | 1,014 | 728 | −28.2% |

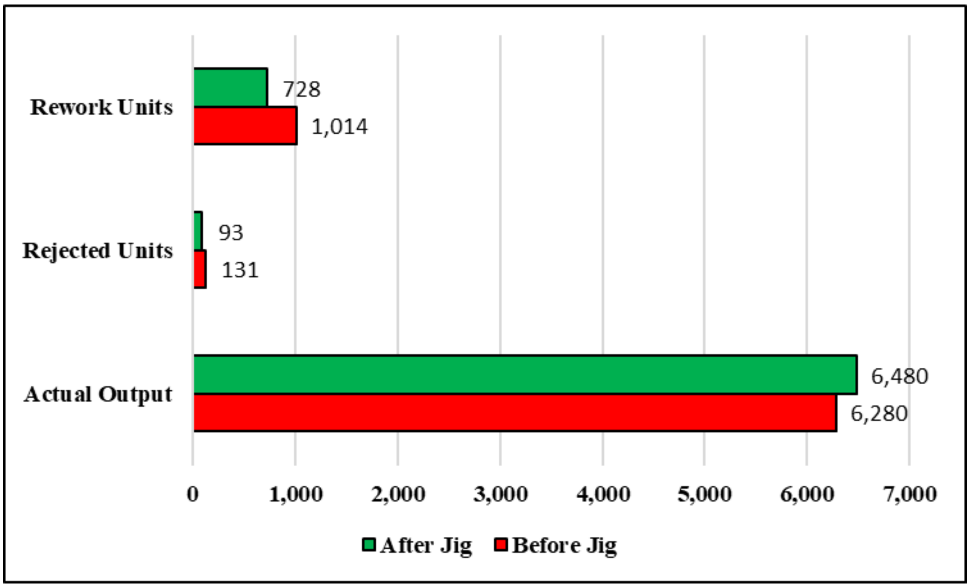

Figure 3. Production performance data of D63D sun-visor

Similar outcomes have been reported by Ahuett-Garza and Kurfess (2018), who found that precision tooling not only enhances production rates but also stabilises quality performance by minimising process variation. Therefore, the present data provide empirical evidence that the jig served as both a productivity booster and a quality improvement tool, contributing to better compliance with production targets and reducing the non-value-added activities associated with rework.

Furthermore, the Chi-square test was conducted to evaluate whether the implementation of the jig had a statistically significant impact on production outcomes as tabulated in Table 4. The results revealed a highly significant difference between the pre- and post-jig conditions ($\chi^2$ = 75.72, df = 2, p < 0.001). Specifically, the number of accepted units increased markedly, while both rejected and rework units decreased beyond what would be expected by chance. This indicates that the jig implementation substantially improved production efficiency and quality, thereby validating its effectiveness as a process improvement intervention.

The significant improvement in production outcomes following jig implementation is consistent with prior research on lean manufacturing and process control, which emphasizes the role of tooling and fixture design in reducing variability and enhancing product quality (Fiedler et al., 2024).

Table 4. Chi-Square Test results for production outcomes before and after jig implementation

| Outcome | Before Jig (n=6280) | After Jig (n=6480) | Expected (if no difference) |
|---|---|---|---|
| Accepted Units | 5135 | 5659 | 5312.41 / 5481.59 |
| Rejected Units | 131 | 93 | 110.24 / 113.76 |
| Rework Units | 1,014 | 728 | 857.35 / 884.65 |

Chi-square statistic ($\chi^2$) = 75.72
Degrees of freedom (df) = 2
p-value < 0.001

By providing stable workholding and guiding tool movement, the jig reduced sources of error that commonly contribute to product rejection and rework. This aligns with findings by (Chikwendu Okpala et al., 2024) who noted that precision tooling is critical in achieving interchangeability and minimizing defects in mass production systems. The observed reduction in rejected and rework units not only validates the effectiveness of the jig but also supports broader lean manufacturing principles, where systematic elimination of waste leads to improved efficiency and cost savings (Womack & Jones, 2003).

## 4. Conclusion

The analysis of the three survey datasets reveals a consistent pattern of operational improvement following the implementation of the new jig system in sunvisor manufacturing. Data from inspection time demonstrated a clear reduction in inspection time per unit, indicating enhanced process efficiency and better alignment with lean manufacturing principles. These time savings translate into higher throughput potential without compromising quality.

Findings from survey confirmed that user perceptions were overwhelmingly positive, with all respondents having adopted the jig and most reporting significant improvements in QC accuracy, operational efficiency, defect reduction and ergonomics. The high ergonomic satisfaction rates suggest that the jig's design supports sustained operator comfort, reducing the likelihood of fatigue-related errors.

Complementing these results, production analysis provided quantitative evidence of defect rate reductions across multiple defect categories after the jig's introduction. This aligns with prior research highlighting the role of jigs and fixtures in standardising inspection, reducing operator variability, and increasing overall product conformity (Pandit & Pandit, 2023).

Taken together, the results indicate that the jig has delivered measurable and perceived benefits across quality, efficiency and ergonomics. The convergence of objective data (time and defect reduction) and subjective data (positive user perceptions) strengthens the case for its continued use and potential replication in other production lines. Future work should expand the scope of evaluation by including longitudinal tracking and cross-departmental feedback to ensure that benefits are sustained over time and that possible areas for further optimisation are identified.

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**Declaration of generative AI and AI-assisted technologies in the writing process**

During the preparation of this manuscript, the author(s) used OpenAI's ChatGPT to assist in improving the readability and language of the text. All content generated by ChatGPT was subject to thorough review, editing, and revision by the authors to ensure its accuracy, completeness and alignment with the research objectives. The author(s) take full responsibility for the integrity and content of the published work. This declaration complies with ICGESD 2025 guidelines on the use of generative AI in scientific writing.

**References**

Ahuett-Garza, H., & Kurfess, T. (2018). A brief discussion on the trends of habilitating technologies for Industry 4.0 and smart manufacturing. *Manufacturing Letters, 15*, 60–63. https://doi.org/10.1016/j.mfglet.2018.02.011

Chavan-Patil, A. S. (2024). *A review on jig manufacturing techniques*. *10*(11), 43–48.

Chikwendu Okpala, C., Chidiebube Igbokwe, N., & Nwankwo, C. O. (2024). The Evolution and Impact of Jigs and Fixtures in Modern Manufacturing. *International Journal of Engi-Neering Inventions*, *2024*(7), 125–131. www.ijeijournal.com

Fiedler, F., Ehrenstein, J., Höltgen, C., Blondrath, A., Schäper, L., Göppert, A., & Schmitt, R. (2024). Jigs and fixtures in production: A systematic literature review. *Journal of Manufacturing Systems*, *72*(December 2023), 373–405. https://doi.org/10.1016/j.jmsy.2023.10.006

Grover, R. (2024). *International Journal of Central Banking January 2024 Vol. 20 No. 1*. *20*(1), 168–181.

Gupta, V., Mota, P., Kumar Bansal, R., Hisar, O., & Goel, V. K. (2015). Lean manufacturing: A Review. *International Journal of Science Technology & Management*, *3*(2), 2321–2774.

Helander, M. G. (2006). *A guide to ergonomics of manufacturing tasks.* CRC Press.

Hines, P., Holwe, M., & Rich, N. (2004). Learning to evolve: A review of contemporary lean thinking. *International Journal of Operations and Production Management*, *24*(10), 994–1011. https://doi.org/10.1108/01443570410558049

Johnson, A., & Williams, B. (2019). Enhancing quality control processes through jig implementation. *International Journal of Manufacturing Engineering*, *12(3)*, 45-58.

Johnson, R., & Chen, Y. (2019). Visual inspection methods for sun visor quality control in automotive manufacturing. *In 2019 International Conference on Industrial Technology (ICIT)* (pp. 874-879)

Nanthakumar, K. and Prabakaran, V. (2014). Design and Fabrication Testing of Combined Multipurpose Jig and Fixture. *IOSR Journal of Mechanical and Civil Engineering*, *11*(4), 86–91. https://doi.org/10.9790/1684-11478691

Pandit, H., Rajwardhan Pandit, K., & Chandrakant Pandit, H. (2023). Advances in Jig Manufacturing: A Comprehensive Review of Techniques, Technologies, and Applications. *Harshwardhan Chandrakant Pandit. International Journal of Engineering Research and Applications 13*(July), 1–10. https://doi.org/10.9790/9622-13070110

Singh, R., & Kumar, S. (2017). Jigs and fixtures for manufacturing: A review. International Journal of Engineering Research and Applications, 7(4), 45–49.

Smith, C., & Brown, D. (2017). Understanding the importance of sun visors in vehicles. *Journal of Automotive Design, 25(4)*, 56-67.

Smith, J., Anderson, R., & Wilson, L. (2022). Quality control challenges in the automotive industry. *Journal of Quality Engineering, 30(2),* 78-92.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186–204.

Womack, J. P., & Jones, D. T. (2003). Lean thinking: Banish waste and create wealth in your corporation. Free Press.