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Design and Development of Automobile Body Deviation Measurement Tool

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ABSTRACT: In the rapidly advancing field of automotive engineering, precision in maintaining the structural integrity of vehicles is crucial for safety, performance, and aesthetics. This project focuses on the "Design and Development of an Automobile Body Deviation Measurement Tool," aimed at revolutionizing repair and maintenance practices in automotive body shops. Given the industry's stringent requirements, traditional measurement methods often fall short in accuracy. Our tool addresses this gap by providing a highly precise, user-friendly, and efficient solution for detecting deviations in automobile body structures. The project involves the creation of a portable, adaptable tool that integrates seamlessly into automotive repair workflows, allowing technicians to restore vehicles to their original specifications accurately. This tool employs square pipes for the base and sliders, a spirit level for alignment, and a laser pointer for precise measurement marking. The fabrication process includes material selection, cutting, welding, alignment, laser pointer mounting, calibration, testing, and quality control. Testing was conducted on a Hyundai Xcent to verify the tool's accuracy in detecting deviations at critical body points. The results showed that the tool effectively measured deviations and ensured vehicle conformity to original dimensions. Future enhancements include integrating advanced sensors, automating measurement processes, customizing tools for specific vehicle models, and establishing continuous feedback loops for ongoing improvement. The developed tool is cost-effective, easy to use, lightweight, and portable, making it suitable for diverse automotive maintenance environments. This innovation not only enhances repair accuracy and efficiency but also significantly contributes to vehicle safety and performance, positioning it as a pivotal advancement in the automotive industry's ongoing evolution.

KEYWORDS: Automobile Body Deviation, Collision Repair Technology, Portable Measuring Devices, Vehicle Alignment Tools, Quality Control in Automotive Industry, Vehicle Inspection Technology.

I. INTRODUCTION

In the ever-evolving world of automotive engineering and technology, precision and accuracy are paramount. The integrity of an automobile's body structure plays a pivotal role in ensuring safety, performance, and aesthetic appeal. When vehicles require repair and maintenance, it is crucial that any deviations from the original specifications are identified and rectified with the utmost precision. To address this need, we present the "Design and Development of an Automobile Body Deviation Measurement Tool." This innovative tool is specifically tailored for use in automotive body shops, where it will revolutionize the way repair and maintenance tasks are performed.

The constant demand for improved vehicle safety, efficiency, and aesthetics has led to increasingly stringent tolerances and specifications for automobile body structures. Traditional methods of measurement and assessment often fall short of providing the level of accuracy required. As a result, the need for a highly precise, user-friendly, and efficient measurement tool has become more critical than ever. The development of this specialized tool fills a significant gap in the automotive industry, offering an invaluable solution for professionals in body shops, collision repair centers, and maintenance facilities.

This project aims to introduce a state-of-the-art, portable, and adaptable tool that can be seamlessly integrated into the workflow of automotive professionals. The "Automobile Body Deviation Measurement Tool" is designed to empower technicians to identify and address deviations in the body structure, ensuring that vehicles are restored to their original specifications. With its innovative features and capabilities, this tool promises to streamline the repair and maintenance process, reduce downtime, and enhance the overall quality of automotive services.

II. METHODOLOGY

The methodology for designing and developing the automobile body deviation measurement tool involves several stages: conceptualization, design, fabrication, and testing. Each stage is crucial for ensuring the tool meets the requirements of accuracy, usability, and cost-effectiveness.

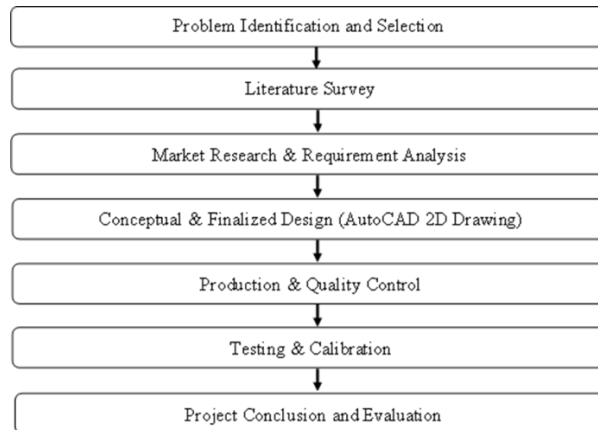


Fig 1. Methodology of Project

III. CONCEPTUALIZATION

The conceptual phase involved identifying the specific needs of small-scale workshops and determining the essential features of the tool. Key considerations included portability, ease of use, accuracy, and cost. The aim was to develop a tool that small workshops could afford and use effectively without extensive training.

IV. LITERATURE REVIEW

The development of precise measurement tools for assessing automobile body deviation is an essential area of research within automotive engineering. Accurate measurement tools are critical for ensuring that vehicles maintain their structural integrity and aesthetic appeal after manufacturing processes or collision repairs. This literature review explores existing research and technologies related to automobile body deviation measurement tools, focusing on their design, development, and application in the automotive industry.

1. Vehicle Deviation Measuring Device and Measurement Method (2018)

A significant advancement in vehicle deviation measurement is detailed in a 2018 article describing a laser-based measurement device. This device includes a laser range finder mounted on a rotatable pedestal and a range finding plate that can be positioned on the vehicle or a measuring dolly. Key features include adjustable positions for the laser range finder (left, right, up, down) and a rotation angle reading apparatus. This setup allows for precise measurements of vehicle body deviations by adjusting the laser to various angles and positions, providing a comprehensive assessment of the vehicle's structural alignment. The simplicity and cost-effectiveness of this device make it a promising solution for automotive repair shops. The use of a trigger device and a funnel mechanism for stabilizing the dolly further enhance the accuracy and reliability of measurements (Patent CN105134690B).

2. Vehicle Body Size Measuring Device (2018)

Another notable device is the vehicle body size measuring device introduced in 2018, which incorporates two parallel Y-direction sliding rails on a base. Each rail is equipped with three-direction measurement components, enabling precise 3D measurements of vehicle body dimensions. This device addresses the challenge of user convenience, providing a more streamlined and efficient measurement process compared to traditional methods. By integrating a display and processor on the base, this tool allows for real-time data visualization and processing, which aids in immediate assessment and decision-making during vehicle inspections (Patent CN105681301A).

3. Laser Scanning Technology in Automotive Manufacturing

Laser scanning technology has emerged as a pivotal tool in the automotive industry for its precision and versatility. In the context of automobile body deviation measurement, laser scanners offer high-resolution data capture and the ability

to measure complex geometries with minimal manual intervention. Studies have demonstrated the effectiveness of laser scanners in detecting surface deviations, panel gaps, and misalignments in automotive bodies. These devices typically employ triangulation or time-of-flight principles to generate accurate 3D models of vehicle surfaces, facilitating detailed analysis and quality control (Gielsing Th. et al., 2019).

4. Photogrammetry-Based Measurement Systems

Photogrammetry, the process of obtaining reliable measurements from photographs, has also been explored for vehicle body deviation assessment. This technique involves capturing multiple images of the vehicle from different angles and using software to reconstruct a 3D model. Photogrammetry-based systems are valued for their non-contact nature and the ability to cover large areas quickly. They are particularly useful in situations where traditional measuring tools may struggle, such as capturing the contours of curved surfaces or assessing damage on irregularly shaped parts. Advances in digital imaging and computer vision have significantly improved the accuracy and usability of photogrammetry in automotive applications (Dabov, K. et al., 2018).

5. Coordinate Measuring Machines (CMM)

Coordinate Measuring Machines (CMM) are another cornerstone in precision measurement for the automotive industry. CMMs use a probing system to determine the coordinates of points on a vehicle's surface, providing highly accurate measurements of geometrical properties. These machines are especially useful for quality control in manufacturing, as they can verify that parts meet specified dimensions and tolerances. Modern CMMs are equipped with touch-trigger probes or laser scanners, enhancing their ability to measure complex shapes and surfaces. While highly accurate, the use of CMMs in automotive body shops is often limited by their cost and the need for specialized training to operate the equipment (Hoffmann, J. et al., 2017).

6. Hybrid Measurement Systems

Recent research has explored hybrid measurement systems that combine multiple technologies to leverage the strengths of each. For example, integrating laser scanning with photogrammetry can provide comprehensive data sets that enhance measurement accuracy and detail. Hybrid systems can also automate the measurement process, reducing the potential for human error and increasing throughput in automotive body shops. These systems are designed to offer flexibility, allowing for rapid adaptation to different vehicle models and measurement requirements. The development of such systems represents a significant step forward in the quest for precise and efficient automobile body deviation measurement tools (Martínez, P. et al., 2020).

The literature on automobile body deviation measurement tools highlights the continuous evolution of technology in this field. From laser-based devices and 3D measuring components to advanced laser scanning and photogrammetry systems, each method offers unique advantages and addresses specific challenges in automotive measurement. Future developments are likely to focus on enhancing the accuracy, ease of use, and cost-effectiveness of these tools, making them indispensable for ensuring the quality and safety

IV. PROBLEM STATEMENT

Develop a precise and efficient measurement tool for assessing automobile body deviation. The tool should accurately detect any misalignment or deviation in the automobile body during the manufacturing process or after collisions, providing detailed measurements to aid in corrective actions. This tool must be user-friendly, cost-effective, and adaptable to various vehicle types and sizes, ensuring consistent and reliable assessments for automotive manufacturers and repair shops.

V. PROJECT OBJECTIVE

The objective of this project is to design and develop a highly precise and user-friendly measurement tool for detecting deviations in automobile body structures. The tool will enable efficient assessment of misalignments occurring during manufacturing or as a result of collisions. It aims to provide automotive manufacturers and repair facilities with a cost-effective solution for identifying and correcting body deviations promptly, thereby enhancing vehicle quality and safety.

VI. DESIGN & FABRICATION PROCESS

1. Hand Drawing

The hand drawing provided a basic visual guide for the initial fabrication process, outlining the placement of key components and the overall structure.

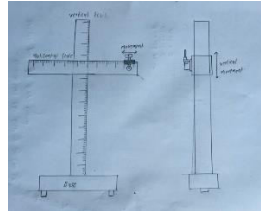


Fig 2. Hand Drawing of Product

2. 3D Drawing

3D drawings offered a detailed view of the tool from multiple angles, ensuring all components were correctly aligned and integrated.



Fig3. Front view (3D) 4. Side view (3D) 5. Base top view (3D)

Project Model Dimensions

- Height: 7 feet
- Width: 6 feet

Materials

- Square Pipe: Hollow square pipe with a suitable strength-to-weight ratio
- Laser Pointer: For precise marking
- Spirit Level: To ensure horizontal level
- Wheels: For mobility

Components

1. Vertical Square Pipe:

- Height: 7 feet
- Material: Hollow square pipe with high strength and durability
- Function: Supports the horizontal slider and provides vertical dimension measurements

2. Horizontal Square Pipe (Slider):

- Width: 6 feet
- Material: Hollow square pipe
- Function: Measures horizontal dimensions and supports the laser pointer and spirit level

3. Slider with Pointer and Laser:

- Function: Moves along the horizontal pipe to mark and measure deviations precisely

4. Nut and Locking Mechanism:

- Function: Locks the horizontal pipe's position on the vertical pipe

5. Spirit Level:

- Function: Ensures horizontal alignment for accurate measurement

6. Base with Cross Design and Wheels:

- Material: Same hollow square pipe for consistency and strength
- Function: Provides stability and mobility

Design Calculations

1. Vertical Square Pipe:

- Height: 7 feet (84 inches)
- Load Calculation: Assume the weight of horizontal pipe, laser pointer, and slider is about 10 lbs.
- Factor of Safety (FoS): 1.5
- Total Load = 10 lbs \times 1.5 = 15 lbs
- Selecting a square pipe with sufficient strength to support this load

2. Horizontal Square Pipe:

- Width: 6 feet (72 inches)
- Load Calculation: Assume the weight of the laser pointer and slider is about 5 lbs.
- Factor of Safety (FoS): 1.5
- Total Load = 5 lbs \times 1.5 = 7.5 lbs
- Selecting a square pipe with sufficient strength to support this load

3. Nut and Locking Mechanism:

- Material: High-strength steel
- Function: Securely locks the horizontal pipe's position on the vertical pipe

4. Base with Cross Design:

- Dimensions: Designed to provide a stable base
- Load Calculation: Assume total load on the base, including the weight of pipes and measurement tool components, is about 50 lbs.
- Factor of Safety (FoS): 1.5
- Total Load = 50 lbs \times 1.5 = 75 lbs
- Selecting a square pipe for the base that can handle this load with ease

Construction Steps

Material Selection:

- Choose hollow square pipes with suitable dimensions and wall thickness to handle the calculated loads.
- Hollow Section Pipes: Chosen for their strength and lightweight properties.
- Laser Pointers: Used for precise measurement marking.
- Spirit Levels: Ensured accurate alignment.

Cutting:

- Cut the vertical pipe to 7 feet.
- Cut the horizontal pipe to 6 feet.
- Cut additional square pipes for the base and cross design.

Welding and Assembly:

- Weld the vertical pipe to the center of the cross-designed base.
- Attach wheels to the base for mobility.
- Weld brackets or mounts for the nut and locking mechanism on the vertical pipe.
- Assemble the horizontal pipe (slider) with the pointer, laser, and spirit level.

Mounting and Calibration:

- Mount the laser pointer on the horizontal slider.
- Ensure the spirit level is securely attached and calibrated.
- Test the locking mechanism to ensure it holds the horizontal pipe at various heights securely.

VII. TESTING & VALIDATION

- Position the model on a level surface.
- Use the spirit level to ensure the horizontal pipe is perfectly level.
- Adjust the laser pointer to mark precise measurements on the vehicle body.

Testing was conducted on a Hyundai Xcent car, involving the following steps:

1. Setting Reference Points: Identifying critical body points for measurement.

2. Measurement: Using the tool to measure deviations from factory specifications.
3. Comparison and Validation: Comparing results with factory data and validating tool accuracy.

Results

The testing results for the Hyundai Xcent car showed minimal deviations from factory specifications, confirming the tool's accuracy and reliability.

Model: Hyundai xcent Registration No. : MH10CN4521

Sr. No.	Parameter	Center (Vertical distance)	Left (Horizontal distance)	Right (Horizontal distance)	Factory Specification
1.	Ground Clearance	23 cm	22 cm	22 cm	22 cm
2.	Head light position	70 cm	34 cm	34 cm	35 cm
3.	Head light alignment	77 cm	54 cm	54 cm	54 cm
4.	Bonnet corner point	104 cm	72 cm	71.5 cm	72 cm

Table 1: Details of measurement during test

The testing process for automobile body deviation measurement on the Hyundai Xcent car ensures that the vehicle meets the stringent quality standards set by Hyundai. By accurately measuring deviations at critical body points and validating them against original dimensions, any assembly discrepancies can be identified and addressed promptly, resulting in a high-quality, precisely aligned vehicle.

VIII. FUTURE SCOPE

Future enhancements for the automobile body deviation measuring tool include:

- **Advanced Sensors:** Integrating 3D scanners and LiDAR for real-time data capture.
- **Automation:** Developing automated systems for simultaneous measurement of multiple body points.
- **Customization:** Tailoring tools to specific vehicle models for optimized measurements.
- **Predictive Analytics:** Implementing predictive maintenance features for proactive problem-solving.

IX. CONCLUSION

The development of automobile body deviation measuring tools as a final year project has culminated in a solution that addresses critical maintenance needs within the automotive industry. Designed with a focus on affordability, ease of use, portability, and lightweight construction, these tools offer a practical and accessible solution for maintaining the structural integrity and alignment of vehicles. This user-friendly approach not only reduces training costs but also minimizes the learning curve, allowing maintenance tasks to be performed swiftly and efficiently. The automobile body deviation measuring tools developed under this final year project represent a significant advancement in maintenance technology for the automotive industry. Their low-budget, easy-to-use, portable, and lightweight features make them accessible to a wide range of users, from small-scale workshops to large manufacturing facilities. Moving forward, continued refinement and optimization of these tools will further solidify their role in ensuring the quality, safety, and performance of vehicles across the automotive sector

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