

“BIW Future Design and Manufacturing”

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Abstract-

BIW Fixture Design and Manufacture

Body-in-White (BIW) fixtures are essential tooling systems used in the automotive industry to accurately locate, support, and clamp sheet-metal components during body assembly and welding. The dimensional accuracy, repeatability, accessibility, and productivity of the final BIW structure depend significantly on proper fixture design.

SAE Mobilus +1

This research paper presents the design and manufacturing approach for a BIW fixture using computer-aided design (CAD) techniques. The study focuses on fixture layout, locating and clamping arrangements, fixture components, manufacturing considerations, and verification of the designed system. CATIA V5 can be used to develop 3D models and detailed drawings of components such as locator pins, clamps, supports, risers, and brackets. The fixture design also considers welding-gun accessibility, robotic movement, cycle time, and potential interference.

IRJCFM +1

The proposed approach aims to achieve accurate positioning, stable clamping, repeatable assembly, reduced deformation, and improved manufacturing efficiency. Proper BIW fixture design can therefore contribute to better dimensional quality, reliable welding operations, and reduced production problems in automotive body manufacturing.

Keywords:BIW, Fixture Design, Fixture Manufacturing, CATIA V5, CAD, Locating, Clamping, Welding Fixture, Automotive Body Assembly.

I. INTRODUCTION

Body-in-White (BIW) is an important stage in automobile manufacturing in which various sheet-metal components are assembled and joined to form the basic vehicle body structure. During this process, accurate positioning of individual panels is essential to achieve the required dimensional accuracy, structural integrity, and repeatability of the final body. BIW fixtures are specially designed tooling systems used to locate, support, and clamp these components during assembly and welding operations.

A properly designed BIW fixture controls the position of the component and restricts unwanted movement during manufacturing. Locating pins, support blocks, clamps, risers, brackets, and base structures are commonly arranged according to the component geometry and required datum scheme. The 3-2-1 locating principle is widely used to control the degrees of freedom of sheet-metal components and obtain repeatable positioning.

The design of a BIW fixture requires consideration of dimensional accuracy, clamping force, welding accessibility, robot movement, loading and unloading time, manufacturing cost, and maintenance. Improper fixture layout or clamping conditions can introduce dimensional variation into the assembled body. Research has shown that fixture layout and clamping strategy can significantly influence the geometric quality of BIW assemblies.

Computer-Aided Design (CAD) software such as CATIA is widely used to develop 3D fixture models, assemblies, and manufacturing drawings. CAD-based design also allows interference checking, accessibility evaluation, and optimization before the fixture is manufactured. Therefore, the objective of this study is to develop a systematic approach for BIW fixture design and manufacture that provides accurate positioning, reliable clamping, ease of manufacturing, and improved productivity in automotive body assembly.

Advantages: low tooling cost, suitable for complex shapes, economical for larger components, and suitable for producing rigid bases and support structures.

Limitations: comparatively rough surface finish, dimensional variation, possible casting defects, and the need for machining on precision surfaces.

2..Fundamentals of Sand Casting :

Sand casting is a basic metal casting process in which molten metal is poured into a mould cavity made from specially prepared sand. After the metal solidifies, the sand mould is removed and the required component is obtained. In BIW fixture manufacturing, sand casting can be used for producing selected fixture bases, brackets, supports, risers, and other rigid tooling components, which may subsequently be machined to achieve the required dimensional accuracy.

Basic Principle

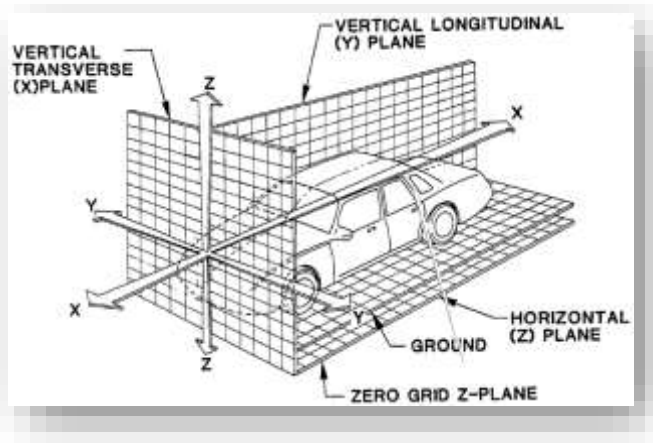
The main steps of sand casting are:

1. Pattern Preparation – A pattern having the required component shape is prepared.
2. Mould Preparation – Sand is compacted around the pattern to form the mould cavity.
3. Pattern Removal – The pattern is carefully removed from the mould.
4. Core Placement – Cores are used when internal cavities or passages are required.
5. Melting of Metal – Suitable metal is heated above its melting temperature.
6. Pouring – Molten metal is poured into the mould through the gating system.
7. Solidification – The molten metal cools and solidifies inside the cavity.
8. Shakeout – The sand mould is broken and the casting is removed.
9. Cleaning and Fettling – Extra material, runners, risers, and surface imperfections are removed.
10. Machining and Inspection – Critical surfaces are machined and inspected according to the fixture drawing.

Application in BIW Fixture Manufacturing

For BIW fixtures, the cast component must provide sufficient rigidity, dimensional stability, and strength. After casting, important mounting and locating surfaces are generally machined .

Fig. 2: Basic Sand Casting Process for BIW Fixture Components



3. METHODOLOGY

The methodology adopted for BIW Fixture Design and Manufacture consists of a systematic sequence of design, manufacturing, assembly, and inspection activities. The main objective is to develop a rigid, accurate, and repeatable fixture capable of positioning and holding BIW components during assembly and welding.

3.1 Study of BIW Component

The geometry and engineering requirements of the BIW component are studied first. Important features such as holes, edges, surfaces, datums, and welding locations are identified.

3.2 Fixture Concept Development

A suitable fixture layout is developed based on the component geometry and manufacturing requirements. The locations of locators, locator pins, supports, clamps, risers, and brackets are selected to provide stable positioning.

3.3 CAD Modelling

The fixture components are modelled using CATIA V5. Individual components are created and assembled into a complete fixture. Interference checking and accessibility of welding tools are also considered during the design stage.

3.4 Locating and Clamping

The BIW panel is positioned using appropriate locating elements. Clamps hold the component firmly while allowing sufficient access for welding operations. The

Manufacturing drawings are prepared from the CAD model. Fixture components are produced using suitable machining, fabrication, and, where applicable, casting processes. Critical surfaces and mounting holes are machined to the specified tolerances.

3.6 Fixture Assembly

The manufactured components are assembled on the base plate according to the design. Locators, supports, clamps, and brackets are aligned and securely mounted.

3.7 Metrology and Inspection

The completed fixture is inspected using suitable measuring equipment such as CMM, height gauge, vernier caliper, micrometer, and dial indicator. The measured values are compared with the CAD model and engineering drawings.

3.8 Validation

Finally, the BIW component is loaded into the fixture and its positioning, clamping, accessibility, and dimensional accuracy are verified. Any deviation is corrected before the fixture is released for production.

Methodology Flow:

BIW Component Study → Fixture Concept → CATIA V5 Design → Locating & Clamping → Manufacturing → Assembly → Metrology Inspection → Validation → Final BIW Fixture

locating scheme is designed to minimize movement and dimensional variation.

3.5 Manufacturing

4. SIMULATION AND ANALYSIS

Simulation and analysis are important stages in BIW fixture design and manufacture. They help to verify the fixture design before manufacturing and identify possible problems related to strength, deformation, interference, and accessibility.

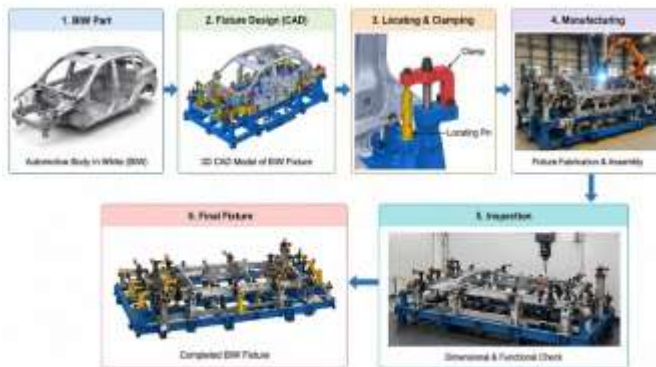


Fig. 1. Basic process of BIW fixture design and manufacturing.

4.1 Fixture Assembly Simulation

The complete fixture assembly is simulated using the CAD environment. The movement of clamps, locators, supports, and BIW components is checked to ensure that all components operate correctly without interference.

4.2 Interference Analysis

Interference checking is performed between the BIW panel, fixture components, clamps, and welding tools. This helps identify collisions and allows the fixture geometry to be modified before manufacturing.

4.3 Structural Analysis

Finite Element Analysis (FEA) can be used to evaluate the fixture under applied loads. The main parameters considered are stress, deformation, and factor of safety. The analysis helps determine whether the fixture has sufficient rigidity for production.

4.4 Clamping Analysis

The clamping arrangement is evaluated to ensure that sufficient force is applied to hold the BIW component securely. Excessive clamping force should be avoided

dimensional accuracy and tolerance are achieved.

4.7 Expected Results

Simulation and analysis help to:
Reduce design errors before manufacturing.
Identify interference and collision problems.
Improve fixture rigidity and stability.
Minimize BIW panel deformation.
Improve welding accessibility.
Reduce manufacturing rework and cost.
Improve dimensional accuracy and repeatability.

Simulation Flow:

3D CAD Model → Assembly Simulation → Interference Check → Structural/Clamping Analysis → Accessibility Check → Design Modification → Final Fixture Design

5. EXPERIMENTATION AND RESULTS

The experimentation was carried out to evaluate the performance and dimensional accuracy of the BIW fixture designed and manufactured for automotive body assembly. The manufactured fixture was assembled according to the CATIA V5 design and inspected before conducting the final validation.

5.1 Experimental Procedure

The manufactured fixture components were assembled on the base plate.

Locators, locator pins, supports, and clamps were checked for proper positioning.

The BIW component was placed on the fixture using the specified datum points.

Clamps were applied to hold the component firmly.

Fixture accessibility and possible interference with welding equipment were checked.

Critical dimensions and locator positions were measured using suitable metrology equipment.

The measured values were compared with the Interference check

No major interference

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Dimensional inspection

Within specified limits

5.3 Discussion

The experimental results indicate that proper fixture layout, accurate locating, and effective clamping are

because it may cause deformation of thin sheet-metal components.

4.5 Accessibility Analysis

The accessibility of welding guns, robots, and operators is checked. The fixture should provide adequate clearance for welding and loading/unloading operations.

4.6 Dimensional Analysis

The fixture dimensions and datum locations are compared with the CAD model and engineering drawings. This helps ensure that the required

specified CAD dimensions and tolerances.

Necessary corrections were identified and verified.

5.2 Results

The inspection showed that the fixture provided stable positioning and repeatable clamping of the BIW component. The locating and supporting elements maintained the required position during the assembly process. Interference between major fixture components and the BIW panel was not observed during the validation check.

Sr. No.

Parameter Checked

Result

1Locator position

Within specified tolerance

2Clamp operation Satisfactory

3Component positioning

Accurate and repeatable

4 Fixture rigiditySatisfactory

5Welding accessibility Satisfactory

essential for maintaining BIW dimensional quality. The use of CAD modelling and metrology inspection helps identify errors before the fixture is introduced into production. The designed fixture therefore provides a suitable arrangement for accurate, repeatable, and efficient BIW assembly.

6. CONCLUSION

The study of BIW Fixture Design and Manufacture demonstrates that fixture design plays an important role in achieving accurate, repeatable, and efficient automotive body assembly. Proper selection and arrangement of locators, clamps, supports, brackets, and datum points help maintain the required position of BIW components during welding.

The use of CATIA V5 provides an effective platform for 3D modelling, assembly development, interference checking, and preparation of manufacturing drawings. Simulation and analysis help identify potential design problems before manufacturing, while metrology and dimensional inspection ensure that the manufactured fixture conforms to the specified requirements.

The experimental evaluation showed satisfactory component positioning, clamping, rigidity, and accessibility. dimensional quality, minimize rework, and increase manufacturing productivity. Future improvements can include flexible fixtures, automated clamping, robotic integration, and advanced digital inspection techniques

Software Support for the Development of Flexible Plant Technology in Highly Automated and High-Rate Body-in-White Production. Procedia CIRP, Vol. 118, 2023, pp. 918–923. Overall, an appropriately designed and manufactured BIW fixture can reduce assembly errors, improve

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