International Journal of Recent Advances in Multidisciplinary Topics
Volume 4, Issue 3, March 2023
https://www.ijramt.com | ISSN (Online): 2582-7839

Design and Development of Body in White Fixture

Joshua Kumarasamy*

B.E. Student, Department of Mechanical Engineering, Bannri Amman Institute of Technology, Erode, India

***Abstract*: In a manufacturing unit, each panel requires a different type of fixturing. In this study, the design methodology corresponds to the steps followed in the conceptual design phase of fixture design. The steps involved in the design methodology, purchase order, customer input, percent complete criteria, and design output process are discussed. According to customer requirements, accessories will be planned and designed accordingly. The CAD model is designed in Catia v5 2016 with different features, and customers will provide references, such as material selection, component spacing, part naming, file orientation, software type, fixed standards, zone alignment, total assembly weight. Next, the 3D stimulation acknowledgment that may or may not be required depending on the station type. Since the geo station type has been selected for the project, the Gun motion will be stimulated. With the results, the matching model is complete. Before going to the manufacturing department, the design of the fixtures should be clearly and precisely described. All dimensions of the manufactured fittings must be indicated on the drawing. Different designs can be provided according to business requirements. Constructed on the data condition that's given by the client, all details must be provided. 2D details shall be subject to technical drawing data. A first or third angle projection must be implemented. Top, right and front views should show all dimensions. Isometric views should provide part names and details. The bill of material will be finalized, A bill of materials (BOM) is a comprehensive inventory of the raw materials, assemblies, subassemblies, parts and components, as well as the quantities of each, needed to manufacture a product. In a nutshell, it is the complete list of all the items that are required to build a product.**

***Keywords*: 2D drafting, bill of material, CAD model, fixturing, gun motion.**

1. Introduction

Body in white" (BIW) is a term used in the automotive industry to refer to the stage of manufacturing when a vehicle's body shell has been assembled but has not yet been painted or trimmed. The term "white" refers to the body shell's unpainted, uncoated surface. [1] The BIW is typically made up of stamped sheet metal components that are welded together to create a rigid structure that will form the basis of the finished vehicle. The BIW assembly process involves joining these individual sheet metal parts together using various welding techniques, such as spot welding, MIG welding, and laser welding. These techniques are used to join the parts together with precision and strength to create a robust, rigid structure. The BIW is a critical component of the vehicle as it provides the foundation for the finished car. It also plays a vital part in determining the vehicle's strength, rigidity, and crashworthiness. Therefore, automakers place a great deal of importance on the BIW assembly process and invest heavily in ensuring that it is done to the highest quality standards. Once the BIW is completed, it undergoes a series of tests and inspections to ensure that it meets the necessary quality standards before moving on to the next stage of production, which typically involves painting and trim.

Body in white fixtures, also known as BIW fixtures or welding fixtures, are specialized tooling used in the assembly process of the BIW. These fixtures are used to hold the sheet metal components in precise positions while they are being welded together.

2. Body in White

The BIW is typically made up of several different components, such as the roof, floor pan, side panels, door frames, and trunk/hatchback lids. These components are stamped out of sheet metal, and then welded together to create a rigid structure that will support the vehicle's weight and provide protection to the occupants. The welding techniques used to assemble the BIW depend on the sort of material used for the components. For example, if the components are thru of steel, then spot welding is commonly used. [4] This technique involves applying an electric current to the metal surfaces to be joined, causing them to heat up and melt together. MIG (metal inert gas) welding is also used for steel components, which involves melting a wire electrode to create the weld. If the components are made of aluminum, then laser welding is commonly used. This technique uses a high-intensity laser beam to melt the surfaces of the components to be joined, creating a strong bond. Aluminum components can also be joined using a technique called self-piercing riveting, which involves driving a rivet through the components to be joined, creating a mechanical bond. [3] The BIW assembly process is typically highly automated, with robots used to handle the sheet metal components and perform the welding. This helps to ensure consistent quality and precision in the assembly process. Once the BIW is assembled, it undertakes a series of tests and reviews to ensure that it meets the required class standards. These tests may include measuring the structural integrity of the

*Corresponding author: joshua.me19@bitsathy.ac.in

BIW, checking for leaks, and performing simulations of crash tests to evaluate the vehicle's crashworthiness.

In summary, the BIW is a critical component of a vehicle that provides the structural foundation for the finished car. Its assembly process involves welding together stamped sheet metal components, and it undergoes extensive testing to ensure that it meets the necessary quality standards.

3. Body in White Fixture

BIW fixtures are typically custom-designed to match the exact specifications of the vehicle being produced. They are made up of a series of metal plates and brackets that are bolted together to create a rigid framework that holds the sheet metal components in place. [5] The fixtures are designed to position the components accurately, with a high degree of repeatability, to ensure that the final product meets the required dimensional tolerances. [2]

The fixtures are designed to be adjustable to accommodate changes in the design of the components being welded together. This allows for flexibility in the production process and ensures that the fixtures can be used for multiple vehicle models. The assembly of the BIW fixtures is typically done in-house by the automaker or by a specialized supplier. The process involves a high degree of precision, with measurements taken at each stage of the assembly to ensure that the final product meets the required specifications. Once the BIW fixtures are assembled, they are used in the assembly process to hold the sheet metal components in place while they are welded together. This process involves the use of automated welding robots, which use the fixtures as a guide to position the components accurately. [6]

In summary, BIW fixtures are specialized tooling used in the assembly process of the BIW. They are custom-designed to match the exact specifications of the vehicle being produced and are used to hold the sheet metal components in precise positions while they are being welded together. The fixtures are adjustable to accommodate changes in the design of the components being welded together, and they are assembled with a high degree of precision to ensure that the final product meets the required specifications.

4. Principle

The 3-2-1 principle in fixture design refers to a set of guidelines used to determine the placement and orientation of workpieces or components within a fixture. The principle states that:

- Three points of contact should be established between the workpiece and the fixture to ensure stability and prevent movement during machining or assembly.
- Two of the three contact points should be located as far apart as possible to further enhance stability.
- One of the contact points should be used as a reference or datum point for accurate positioning of the workpiece.

By following the 3-2-1 principle, fixtures can be designed to securely hold and accurately position workpieces or components, leading to higher quality and more efficient manufacturing processes.

5. Objectives

- Design a fixture to position the sheet metal components in the exact locations required for welding. This precision ensures that the components are accurately aligned and that the final product meets the necessary dimensional tolerances.
- The use of fixtures improves the quality of the BIW assembly process. The fixtures hold the sheet metal components in place, preventing movement during the welding process, which reduces the risk of defects and ensures consistency in the finished product.
- The use of fixtures reduces the time required for assembling the BIW. By holding the components in place, the fixtures eliminate the need for manual adjustment and ensure that the components are in the correct position for welding.
- The use of fixtures improves safety during the BIW assembly process. The fixtures hold the sheet metal components securely in place, reducing the risk of injury to workers from moving or falling parts.
- The fixtures can be adjusted to accommodate changes in the design of the components being welded together. This allows for flexibility in the production process and ensures that the fixtures can be used for multiple vehicle models.
- Overall, the use of fixtures in BIW manufacturing improves the quality, efficiency, and safety of the assembly process, and enables automakers to produce high-quality vehicles that meet the required dimensional tolerances.

The section title also can be copied and paste it, when you need new section and type the section heading as per your requirement.

6. Methodology

Fasteners are used in manufacturing to hold, position, and support parts called fasteners. The clamps ensure the stability of the part during any manipulation carried out on the part. The method can be, drilling, grinding, riveting, welding, etc. In the body-in-white luminaire design, the luminaire operates according to the 3-2-1 principle.

Basically, the 3-2-1 principle is used to lock all six degrees of freedom. The 3-2-1 principle is a principle of fixing components in which three pins are at the first main level, namely XY, YZ, ZX. Thus, two pins are located on a second plane perpendicular to the first plane, and the last pin is located on a plane perpendicular to the first and second planes. Using this approach, the Component can be constrained in all six degrees of freedom.

An assembly line is the process of assembling automotive body panels/parts while moving semi-finished components from station to station until the final product is manufactured. Panels are moved from section to section when adding on an assembly line. These sections are called stations. In the white jig body design, we have several stations to position the panels so that the assembly process can be carried out.

Some of these stations are:

1. Loading Station
2. Respot Station
3. Sealing station
4. Geo Station
5. Buffer Station
6. Pedestal Weld/Rivet
7. Marriage station
8. Curing station

The fixture used in the project is geo station. In the automotive manufacturing industry, a "Geo Station" is a specific location on the assembly line where a vehicle undergoes a series of operations, such as welding, painting, or assembly, before moving on to the next station. Each Geo Station is designed to perform a specific task, and the assembly line is organized in a way that maximizes efficiency and minimizes waste. In the context of Body in White (BIW) assembly, Geo Stations are often used to refer to the location on the assembly line where the BIW fixtures are located.

The BIW fixtures are used to hold the sheet metal components in precise positions while they are being welded together. In this project the fixtures are conceptually designed for welding process in which the weld gun motion is pre-determined based on the panel given. The fixtures are modeled the standard guidelines

After the model completion the simulation will under gone for the gun movements and the fixtures is finalized. The 2D drafting will take place according to the customer guidelines. Then the bill materials will be prepared for the materials for which will make the product complete ready for manufacturing.

7. Sample Customer Guidelines

All mechanical designs will use only the “Available Materials” list. If is necessary to use another material that is not on this document, inform direct to PMM of project for validation. When choosing an angle bracket out of the “Available Materials” list stock, try to design a welded construction instead (if possible). If the project doesn´t belong to BMW, VW, or Mercedes, try not to use plates bigger than 3 inches (due to design standards).

A. Balancing Clamp

Exist two main points to develop these concepts and there are:

Reduce the clamps quantity in order to have a better torch weld access. Avoid pusher adjustment every time that exist a new batch product. For this clamping arrangements FFT has marked std parts to be used in all stations as much as possible. The STD parts are included on the library and the parts name are the next ones.

FMX_SWCL_02 (2 contact points),

FMX_SWCL_03 (3 contact points)

These std parts could be used when the “A” datums are no tanner 300mm distance for the 2-contact points clamp, and 250mm distance for the 3-contact points clamp.

8. Procedure

A. Fixturing Modelling

Determine the requirements: The first step in designing a BIW fixture is to determine the requirements. This includes understanding the part dimensions, the number of parts to be assembled, the assembly sequence, and the production volume.

Create a concept design: Based on the requirements, create a concept design. This design should consider factors such as part location, assembly sequence, accessibility for welding, and ease of part loading and unloading. [10]

Detail the design: Once the concept design is complete, it's time to detail the design. This involves specifying the materials, tolerances, and dimensions of all the fixture components.

Validate the design: Before proceeding to manufacturing, validate the design using simulation and testing. This will help identify any design flaws and ensure that the fixture meets the required specifications.

Manufacture the fixture: Once the design has been validated, it's time to manufacture the fixture. This involves machining, welding, and assembling the fixture components.

Test the fixture: Before using the fixture in production, it's important to test it. This involves verifying that the fixture holds the parts securely, allows for accurate welding, and can be loaded and unloaded easily.

Optimize the fixture: After testing the fixture, make any necessary adjustments to optimize its performance. This may involve tweaking the design or making changes to the manufacturing process.

In summary, designing a BIW fixture requires careful consideration of the part dimensions, assembly sequence, and production volume. It's important to create a concept design, detail the design, validate the design, manufacture the fixture, test the fixture, and optimize the fixture for optimal performance.

Determine the part location and orientation: Before designing the fixture, it's essential to determine the location and orientation of each part to be assembled. This information helps identify the clamping and locating points on the fixture.

Consider the welding process: The fixture design should also consider the welding process, such as spot welding or MIG welding. This includes providing clearance for the welding gun and ensuring that the fixture does not interfere with the welding process.

Choose the right materials: The material selection is an essential aspect of fixture design. The materials should be strong, durable, and corrosion-resistant. Common materials used for fixture construction include aluminum, steel, and composite materials.

Ensure accessibility for maintenance: The fixture design should allow for easy maintenance and repair, such as replacing worn components or adjusting clamping mechanisms.

Consider ergonomics: The fixture design should consider ergonomics to ensure that operators can load and unload parts easily and safely.

Use modular design: Modular fixture design allows for easy reconfiguration of the fixture for different part assemblies. This approach can save time and cost in fixture design and manufacture.

Verify compatibility with other tools and equipment: The fixture design should consider compatibility with other tools and equipment used in the assembly process. For example, the fixture should provide clearance for robotic arms used in the welding process.

In summary, designing a BIW fixture requires attention to detail, understanding of welding processes, material selection, and consideration of ergonomics and compatibility with other tools and equipment. A well-designed fixture can improve production efficiency, reduce downtime, and ensure consistent quality in part assembly.

9. Payload Calculation Method

Payload calculation for a Body-in-White (BIW) fixture is an essential aspect of fixture design. It involves calculating the maximum weight that the fixture can support during the manufacturing process without breaking or failing. Here are the steps involved in payload calculation for a BIW fixture:

Determine the maximum weight of the vehicle body that the fixture will hold during the manufacturing process. This weight will include the weight of the vehicle body, any attached components, and any additional tools or equipment required for the manufacturing process. Calculate the weight of the fixture itself, including the weight of any clamps, brackets, or other components used to hold the vehicle body in place. Determine the maximum force that will be exerted on the fixture during the manufacturing process. This force can be calculated by considering the weight of the vehicle body, any additional tools or equipment, and the force exerted by the manufacturing process itself, such as welding or bending. Calculate the moment of force exerted on the fixture, which is the force multiplied by the distance between the point of application of the force and the fixture's center of gravity. Determine the maximum stress that the fixture will be subjected to during the manufacturing process. This can be calculated by dividing the maximum force by the cross-sectional area of the fixture. Determine the material properties of the fixture, such as its modulus of elasticity and yield strength.

Calculate the safety factor for the fixture by dividing the yield strength of the material by the maximum stress that the fixture will be subjected to during the manufacturing process. The safety factor should be greater than one to ensure that the fixture can safely support the maximum payload. Adjust the fixture design or material selection if the safety factor is too low to ensure that the fixture can support the maximum payload safely

Payload calculation for a BIW fixture requires a detailed understanding of the manufacturing process, material properties, and fixture design. It is essential to ensure that the fixture can safely support the maximum weight of the vehicle body during the manufacturing process to prevent accidents, delays, or quality issues.

To calculate the payload for a BIW fixture, the following factors must be taken into consideration:

Maximum weight of the vehicle body: This is the total weight of the body and all attached components, such as doors, fenders, and hood. The weight of any tools or equipment required for the manufacturing process should also be included. Fixture weight: This is the weight of the fixture itself, including any clamps, brackets, or other components used to hold the vehicle body in place. Force exerted on the fixture: This is the force that will be exerted on the fixture during the manufacturing process, such as the force exerted by welding or bending. This force can be calculated by considering the weight of the vehicle body, any additional tools or equipment, and the force exerted by the manufacturing process itself. Moment of force: This is the force multiplied by the distance between the point of application of the force and the fixture's center of gravity. Maximum stress: This is the maximum stress that the fixture will be subjected to during the manufacturing process, which can be calculated by dividing the maximum force by the cross-sectional area of the fixture. Material properties: The material properties of the fixture, such as its modulus of elasticity and yield strength, must be taken into consideration to calculate the maximum stress that the fixture can withstand. Safety factor: The safety factor is the ratio of the yield strength of the fixture material to the maximum stress that the fixture will be subjected to during the manufacturing process. The safety factor should be greater than one to ensure that the fixture can safely support the maximum payload. Refer fig: 1 & 2

Ex Data needed for gripper payload:
Weight of panel = kg
Weight of Gripper with Pneumatic box = kg
Weight of Hose connection = 15 kg
7% additional weight of gripper = kg
Weight of Hardware = 10 Kg
Total weight Considered = A+B+C+D+E= Kg

10. 2D Drafting

2D drafting is an important aspect of fixture design as it helps to accurately and clearly communicate the fixture design to manufacturing teams. Here are some of the key considerations for 2D drafting in fixture design:

Accurate dimensions: Accurate dimensions are critical for a successful fixture design. The 2D drawings should include all necessary dimensions, including the size and location of features such as holes, slots, and mounting points.

Clear and concise labeling: All features and components of the fixture should be clearly labeled on the 2D drawings. This includes part numbers, material specifications, and any relevant notes.

Tolerances: Tolerances are important to ensure that the fixture components fit together properly. The 2D drawings should include tolerances for all critical dimensions and features.

Material callouts: The 2D drawings should include the material specification for all fixture components. This helps to ensure that the correct materials are used during manufacturing.

Assembly instructions: The 2D drawings should include clear and concise instructions for how to assemble the fixture. This includes details such as the order in which components should be assembled, torque specifications for fasteners, and any other relevant instructions.

Consideration of manufacturing processes: The 2D drawings should take into consideration the manufacturing processes that will be used to produce the fixture. This includes details such as sheet metal thickness, welding specifications, and machining requirements.

Revision control: It is important to maintain revision control for the 2D drawings to ensure that everyone is working from the same version of the drawing.

Overall, 2D drafting is an important aspect of fixture design that helps to ensure accurate and clear communication of the fixture design to manufacturing teams. Accurate dimensions, clear labeling, tolerances, material callouts, assembly instructions, consideration of manufacturing processes, and revision control are all key considerations for effective 2D drafting in fixture design.

11. Bill of Material

A Bill of Materials (BOM) is an important document in fixture design as it lists all the components required to manufacture the fixture. The BOM is typically created during the design phase and is used by manufacturing teams to source the necessary materials and components for the fixture.

Accurate component descriptions: The BOM should include accurate and clear descriptions of each component, including its part number, name, quantity required, and any other relevant details.

Material specifications: The BOM should include the material specification for each component. This helps to ensure that the correct materials are used during manufacturing.

Cost estimates: The BOM can also include cost estimates for each component. This can be helpful for budgeting purposes and for determining the overall cost of the fixture.

Supplier information: The BOM can include information about where to source each component, including supplier names and contact information.

Revision control: It is important to maintain revision control for the BOM to ensure that everyone is working from the same version of the document.

Assembly instructions: The BOM can also include assembly instructions for the fixture. This can help manufacturing teams understand how the various components fit together.

Quality control requirements: The BOM can include quality control requirements for each component, such as inspection or testing requirements. This helps to ensure that the fixture meets the required quality standards.

Overall, a well-designed BOM is an important tool for effective fixture design and manufacturing. It should include accurate component descriptions, material specifications, cost estimates, supplier information, revision control, assembly instructions, and quality control requirements. By providing a clear and detailed list of components required to manufacture the fixture, the BOM helps to ensure that the fixture is manufactured correctly and to the required standards.

12. Result

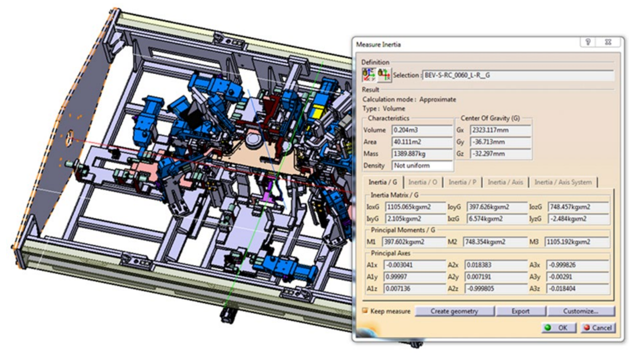

Fig. 1. CAD measurements

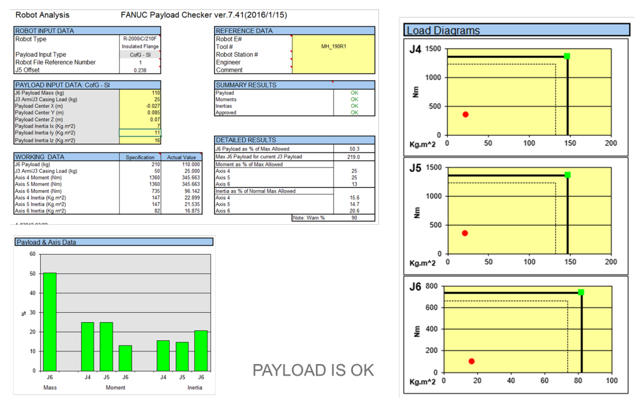

Fig. 2. Result

Improved fixture design: The primary result of a fixture design paper could be an improved design for a specific fixture or class of fixtures. The paper may propose new design principles, materials, manufacturing techniques, or other improvements that could lead to better-performing or more cost-effective fixtures. Increased efficiency or productivity: Another possible result of a fixture design paper could be improved efficiency or productivity in manufacturing processes. The paper may propose fixture designs that reduce manufacturing time, improve accuracy, or reduce waste. These improvements could lead to cost savings, higher throughput, or other benefits for manufacturing operations. New knowledge or insights: A fixture design paper could also contribute new knowledge or insights to the field of fixture design. For example, the paper may propose new ways of thinking about the design process, or provide experimental evidence to support or challenge existing design principles. These contributions could advance the state of the art in fixture design and inspire further research. Validation of existing design principles: Finally, a fixture design paper could aim to validate or confirm existing design principles or best practices. The paper may provide experimental evidence to support the effectiveness of certain fixture design techniques, or describe case studies that demonstrate successful implementation of fixture designs. This validation could help to establish a more solid foundation for fixture design practice and improve confidence in the efficacy of existing design principles.

Overall, the results of a fixture design paper will depend on the specific goals and objectives of the research or project. The paper may aim to achieve improvements in fixture design, manufacturing efficiency, or knowledge, or may seek to validate existing design principles.

13. Conclusion

This paper presented a study on the design and development of body in white fixture.

References

[1] Insider, The Auto. "GM Performance Parts to Offer $7,000 Body-In-White New Camaro". Jalopnik. Retrieved 2018-03-22.

[2] Plastics Today Staff (8 March 2012). "Carbon fiber body-in-black wins design accolade". Plastics Today. UBM Indians. Retrieved 1 July 2018.

[3] How Porsche ensures the quality of its products: What do the terms cubing, exterior master jig and body-in-black mean? Insights into the production process at Porsche". Porsche News. F. Porsche AG. 5 April 2016. Retrieved 13 April 2018.

[4] Huntsman Features High-Performance Materials for Fabricating Composite Parts at CAMX 2017" (Press release). The Woodlands, Texas: Huntsman Corporation. 11 December 2017. Retrieved 13 April 2018.

[5] Colvin, Fred H.; Haas, Lucian L. (1938). Jigs and Fixtures: A Reference Book. New York and London: McGraw-Hill Book Company.

[6] Henriksen, Erik K. (1973). Jig and Fixture Design Manual. New York, N.Y.: Industrial Press Inc.