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Body in White Layout Engineering

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***Abstract*: This paper presents a study on the layout and its constituents on automotive plant.**

***Keywords*: Layout engineering.**

1. BIW Assembly Station

BIW Station is the part of BIW assembly line. The BIW assembly line is divided into zones & these zones are again divided into stations.

A station consists of number of tools, grippers, stands etc., in which the loose panels are processed to join together to a sub assembly. This sub assembly will be taken to the next station on to which some other loose panels will get joined to form another assembly. Likewise, process continues till the final assembly is achieved through the entire zone.

An assembly line is the process by which automotive trim/body parts are joined while semi-finished assemblies move between stations until the finished product is manufactured.

As you join the assembly line, the panels move from one section to another. These sections are called stations. In BIW jig design, there are various stations used to position the panels so that the joining process can be performed.

2. Process Layout

A well-designed plant layout can provide several advantages to a manufacturing unit, including:

- *Increased efficiency:* Streamline the production process, eliminating unnecessary movement of materials, personnel, and equipment. This can reduce cycle times, improve productivity.
- *Better utilization of space:* Optimize the use of available space, making it easier to store materials and equipment and reducing the amount of wasted space.
- *Improved safety:* Enhance the safety of the manufacturing unit by reducing the potential for accidents and improving visibility. This can help to create a safer working environment for employees.
- *Reduced material handling:* Proper plant layout can reduce the movement of materials, making it easier to transport them from one stage of the production process to another. This can help to minimize the risk of damage to materials and reduce the amount of time spent handling them.
- *Enhanced quality control:* A good plant layout can facilitate the implementation of quality control measures, such as visual inspection stations, that can help to identify defects and reduce the amount of scrap or rework.
- *Improved flexibility:* Increase the flexibility of the manufacturing unit, making it easier to adapt to changes in production requirements or the introduction of new products.

Plant layout can provide several advantages to a manufacturing unit, including increased efficiency, better utilization of space, improved safety, reduced material handling, enhanced quality control, and improved flexibility. A proper plant layout is essential to optimize the production process, minimize costs, and increase productivity.

Zone:

Zone consists of number of stations in which the panels are processed to join together to a final sub assembly. Ex: Doors, Hood etc.

Station:

A station consists of a series of tools, grippers, stands, etc., to process the disjointed panels and assemble them into assemblies.

This subassembly is taken to the next station where several other disjoint panels are joined to form another assembly.

Similarly, this process continues until final assembly is achieved throughout the zone.

A. Process Involved in Assembling BIW Parts

1) Resistance spot welding (RSW)

Easy implementation, dependability, and affordability, spot welding is widely chosen to join sheet metal fabrications, stampings, and assemblies. However, a number of design factors, including the size of the spot weld, accessibility, location, the materials and thicknesses being joined, and the number of spots required to achieve the requisite strength, can have an influence on the weld's quality and cost.

Spot welding is frequently the preferred technique for putting together whole enclosures, cabinets, and multi-part assemblies.

2) MIG welding

Carbon steels, low-alloy steels, stainless steel, aluminum alloys from the 3000, 5000, and 6000 series, and magnesium alloys are all wieldable materials when using MIG welding.

High-zinc copper alloys, high-strength steels, and 2000 and 7000-series aluminum alloys are additional alloys that can be MIG-welded using particular techniques.

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3) TIG welding

Welding in Projections:

Resistance spot welding:

Resistance projection welding is an improvement over resistance spot welding (RPW).

It uses projections that have already formed on the work piece to lessen the amount of power needed to complete a resistance weld.

Laser welding is a high-cost process that can weld at up to 150 inches (3.8 m) per minute.

Fixture:

The tool that holds the work piece while it is being processed (welded) according to the 3-2-1 principle is called a fixture.

The fixtures of a BIW fixture are made to hold a number of pieces while welding. To prevent distortions and preserve the appropriate geometry of the pieces, it is important to retain the parts in the correct position.

It should prevent work piece distortions during welding operations.

The clamping has to be light but robust, which implies that the clamping force must be adequate to maintain the part in the desired position without damaging it.

Clamping placement must be away from the welding zone.

To tolerate the strains of welding, the fixture needs to be quite solid and stable.

The fixture must be stable in order to perform operations without errors.

3. BIW Fixtures

Production fixtures:

These fixtures are deployed in large-scale manufacturing. In order to retain the geometry of the parts, it requires excellent stability throughout operation; hence the materials used have undergone extensive inspection for hardness. The production equipment needs to be simple to maintain. After performing a certain amount of operations, the fixture needs some maintenance. The time requires for assembly & disassembly should be as low as possible which saves lots of time.

Pre-Production Operations (PPO) Fixtures:

These fixtures are designed as prototype fixtures to check first-run production feasibility and to see what needs improvement before production starts. These jigs can be considered foundational jigs that set benchmarks and standards to help troubleshoot bugs that may arise from pre-production operational jigs. There is a lot of manual work, and many engineers and quality personnel are required. Cycle time is longer than production equipment. Also, it requires a lot of time and money. We need to keep the cost of our cars as low as possible, so we go straight to our production facility, using standards and checklists to maintain error-free production.

Check Fixtures:

As the name suggests, these fixtures are used for testing purposes. Welding, gluing, hemming and other operations are not performed in these devices. Gauges are used on these fixtures to obtain the dimensions and tolerances of the part, and the data is compared to the design dimensions to see if the part is optimum condition. The geometry of the welded parts is also checked with these fixtures to ensure that the parts maintain the required dimensions and geometry.

3-2-1 Principle:

Basically, we lock all 6 degrees of freedom using the 3-2-1 principle.

The 3-2-1 principle is the component retention principle with 3 pins at the first main level, XY, YZ, or ZX. Two pins are on the second level perpendicular to the first level, and the last pin is on the level perpendicular to the first and second levels. This method allows the component to be locked in all six degrees of freedom.

(3): Three positioning blocks for framework part planes. Three locators or supports are placed under the work piece. Three locators are typically placed on the primary location surface. This limits two axial movements and four radial movements up and down. The three locators in sync limit the six degrees of freedom.

(2): Round Locating Pin A round hole that defines four-way (four-way) positions perpendicular to the plane specified above. This restricts movement in the four axial directions.

(1): A round locating pin in a slot that defines two directional pins (bidirectional). This limits movement in two radial directions.

Layout shows depiction of the following elements:

Tool Station

Geo Fixture

BIW takes tack/geo fixtures into account. With geo jigs, tack welding is performed on all parts to be assembled on this jig. A Geo Fixture defines the shape of the part. These devices have strict accuracy standards.

Respot Fixture

The incomplete tack operation is carried out with the help of re spot fixtures. The respot machine completes the rest of the stitches.

Marriage Fixture

As the name suggests, in this device a marriage of various assemblies takes place. Various assembly lines such as underbody, side body are completed in each zone. Then all parts arrive at the station where all these parts are assembled using various connection techniques such as welding, gluing and riveting

Framer Fixture

Framer Fixture is the next destination for Marriage Fixture. The framer attachment is called a framer tool because the roof is attached to the exit of the marriage attachment and formed like a frame.

Checking Fixture

These are used to check the assembly of parts, tolerances, dimensions and coordinates. A fixed inspection fixture is used where the work piece is fixed with clamps and pins and the CMM is used to measure the coordinates of various points on the plate or assembly. After that, the data is compared it CAD data and report it.

Gripper:

A gripper is a device that allows the operator to hold an object to manipulate. Grippers are used to hold, clamp, manipulate, and release objects. The gripper can be attached to a robot or

part of a stationary automation system. Different grippers are used in BIW are,

Material handling Gripper:

As the name suggests, these grippers are used for material handling. These grippers can take assemblies from one station and place them at another station.

Process Gripper:

These grippers are used to perform specific processes such as gluing, welding, riveting, in addition to material handling. The gripper moves under the gluing stand during the gluing process and under the welding stand during the welding process.

Combo Gripper:

A combo grapple is one that can perform multiple tasks. B. We can also perform material handling and certain processes such as gluing, welding, etc. welding gun + gripper

Duel Gripper:

Double-sided gripper. These grippers are used when left and right parts are required. Material can be transported from one station to another. - Gripper + Gripper.

Stand:

A stand is used to hold the part when not in use. It is also used to attach some parts and bodies.

Pedestal Stand:

The welding gun is mounted on a fixed stand that is permanently installed on the floor. A gripper can carry the panel under the stand to perform the operation.

Adhesive/Seal Stand:

Glue gun or caulking gun attaches to a welding stand or a standard stand that is permanently cast into the floor.

Docking Stand:

Robot cannot do both tasks at the same time due to limitations. In this case, add a docking stand for placing devices that are not used for the current operation but required for the next operation. So, the robot can drop the grapple or pistol and select the next operating device to complete the task from the docking stand.

Date Stamp Stand:

Some panels must be stamped or embossed on each product as follows: A stamping device is attached to the stand, and the necessary data is stamped.

Miscellaneous Stand:

Curing Stand:

After gluing, it takes some time to cool, so the assembly is stuck on some tape and the board is moved to another station while the gluing cools.

Buffer Stand:

After some operations, you can get the number of assemblies on the stand. This is buffer stock can be easily moved to another station. It is also used to store inventory while machines are being repaired.

Takeout Carriage:

Take out trolley is used to take the car panel out of the robotic working cell between the cycle for inspection purpose.

Conveyor:

Conveyor is a rotating path that transports the parts held on it to the next station.

Robot:

Robots are typically used for tasks like welding, painting, assembly, disassembly, pick-and-place operations for printed circuit boards, packaging and labeling, palletizing, product inspection, and testing.

Robot Controller:

The system that allows robots to operate is termed as robot controller. This comprises mechanical elements and programmable technologies that enable robot control. There are several techniques to operate robotics, including manual control, wireless control, semi-autonomous control (which combines fully automatic and wireless control), and fully autonomous control.

In addition to the robot arm, the controller is also responsible for the end-effector and to prevent interference from occurring within the robots work area.

All industrial robots are paired with a controller in order to be able to operate.

Robots Used in Industry:

Leading high precision and high efficiency robots used in mass automotive manufacturing plants.

1. ABB
2. FANUC
3. KUKA
4. COMAU, etc.

7th Axis Robot:

The seventh axis is an additional external axis built into the robot that moves the robot from one stage to another while maintaining the orientation of the part.

Safety Doors:

These doors are installed for the operators to go inside the workstation, If the operator goes inside the plant white the process the floor sensor (sensor installed to detect motion) will tend to immediate stop the process of the whole assembly process. Minimum 1m space required for door opening, as per the standardization the layout do not allow any components to be placed on that 1m hatched space for safety reasons.

Cable Tray:

Cable tray is used to pass electrical cables, pneumatic and other cables that are going to be used by the robot, stand, etc. The cable tray must pass through all equipment's, where ever we don't have space we can pass decrement size of 500,400,300,200 & 100mm.

Normally robot/motor areas demands 200mm KK & other small equipment with 100mm KK (if it is an extension).Avoid forming an acute angle KK which may lead to accident in plant. Worker may place his legs between KKs. Cable tray must start from main electrical cabinet with 600mm & there must be continuity throughout the zone.

Cable tray can be placed in air also if situation demands.

Gangway:

A gangway, which is a narrow platform or walkway, is a secure way to embark logistics

Gangways are widely used for 2 distinct purposes: either to make it easier to transport people and/or cargo to and from ports, docked marine vessels, or aircraft, or for maintenance and to load and unload trucks and trains that are on land.

Fencing:

There are moving parts in machines. Workers may be injured by the motion of moving parts if there is enough force involved. Everywhere there is a machine, fencing is employed as a safety barrier to prevent operators or other uninvited visitors from entering the work area.

Typically, customers specify a standard fence length of 2000, 1500, 1000, 750, 500, 250, or 100 (in mm).

The height ranges from 2000 to 2400 mm. (Small or large sizes, unique fences are utilized for various applications while keeping safety in mind.

HMI (Human Machine Interface):

A human-machine interface includes both the hardware and software components required to exchange information between a human operator and a machine (in this case an industrial system or machine or equipment).

Low-Cost Automation (LCA):

Low-cost automation (commonly known as LCA) is the introduction of simple pneumatic, hydraulic, mechanical, and electrical equipment into existing production machinery with the goal of improving productivity.

The investment cost is low, and the ROI such as productivity improvement and operational efficiency is high. It offers quality and flexibility, increases productivity, reduces costs, and is easy and affordable to implement for small businesses.

BINS:

Bins are used to place panels.

The pane details are provided by the customer.

Minimum space between the bins should be 50mm

For effective cycle time the bins are needed to be placed near by the operator.

Bin's location must be allocated minimum 800 mm from the door or operator entrance of the cell.

Cabinets:

BIW assembly lines use different types of cabinets to control the process.

Control Cabinets, HMIs, Welding Controllers, Stud/Rivet Welding Controllers, Feeders, Adhesive Pumps and more.

Electrical Cabinets:

Electrical cabinets receive power from a power source and distribute it to specific areas or equipment. They also play an important role in electrical safety, regulating power with built-in circuit breakers, fuses, and/or other oversight equipment.

No safety fence behind electrical cabinets. Check the door behind Electrical Cab. & provide space from behind.

TIP Dresser and TIP Changer:

If the robot does welding, we need a combination of both a tip dresser and a tip changer.

After the welding tip has been finished, the tip changer's job is to switch out the tip.

The tip dresser's job is to remove any chips from the welding tip.

HIP (Air and Water Arrangement):

The main function of HIP is to supply water and Zone compressed air supply.

HIPs are always placed outside the fence and near security door.

Manipulator:

The manipulator's basic task is to lift large, heavy panels. The layout engineer fixes allocate the manipulator's position. The dimensions for the manipulator position must be provided by the layout engineer.

Every component are named and labeled in various layers and denoted in different colors on CAD software for easy access i.e., freezing the layout, moving the line in the correct plane for layout foundation planning. A well-furnished layout have accurate simulation, design parameters and it is done for 'n' numbers of iterations for good efficiency in production flow and it helps in building a manufacturing plant without any setbacks while in operations and while in maintenance.

The body in white (BIW) plant layout is a crucial element in the production of automobiles. The layout of the BIW plant determines the efficiency of the manufacturing process, the safety of the workers, and the overall quality of the final product.

4. Conclusion

In conclusion, the BIW plant layout is a critical component of the automotive manufacturing process. It requires careful planning and design to ensure optimal productivity, safety, and quality. A well-designed BIW plant layout can result in cost savings, increased production, and improved product quality. The BIW plant layout must consider the workflow, material handling, ergonomics, safety, and sustainability of the manufacturing process to achieve these goals.

References

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