

Development of a Fixture for Robotic Assembly Station for an Automotive BIW (Body in White) Line

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Abstract

In the 21st century, Manufacturers will increasingly face frequent and unpredictable market changes. These changes include the frequent introduction of new products, increased demand for new products and new process technologies. To produce variety of product and suit to new processes automated/semi automated machine tools and fixture are required.

In this paper present a fixture design for automotive “Rear axle Panel”. First, an introduction is given about automotive industry and then about fixture design and fixture modeling using CATIA software.

Keywords: Automotive, BIW (Body in White), 3-2-1 locating system, FMS (Flexible- Manufacturing System), A = piston area, p = pressure, FR = frictional resistance, A' = (piston area - piston rod area)

1. Introduction

Fixture is special tool or work holding device used for locating and firmly holding the work piece in the proper position during manufacturing operation. Fixture design work is time consuming and tedious.

In the automotive industry, the typical structure of an assembly plant involves four stages: stamping, body shop, paint and final assembly. The majority of assembly operations take place in the body shop and final assembly. In the first section, the discussion about the automotive industry and different types of fixtures. In second section, the discussion about 3-2-1 locating principle for fixture design. In the third section, the discussion about, design of fixture units and its assembly.

1.1 Automotive Industry

The automotive industry designs, develop, manufacture, market and sell vehicles. Automotive industry has different divisions like R&D department, press shop, body shop, paint shop etc. in the production area. Body shop, where the BIW is manufactured; various sheet metal panels are joined together and made a body frame before going to paint shop.

BIW refers to the stage in automotive design or automobile manufacturing in which the car body sheet metal (including doors, hoods, and side closers) has been assembled or designed but before the components (chassis, motor) and trim (seats, electronics items etc.) have been added. All activities in the production of a vehicle body before it goes to the paint shop are done in a body shop. The equipment used in the automotive industry has to meet the requirements related to the part's weight and dimensions but also to the high production rates and high precision.

2. Literature Review

Now a days much more attention given on the field of fixture design and its manufacturing then the past decades. Many applications papers and literature have been published in this area.

According to the fixture's exhibility, fixtures can be classified as dedicated fixtures and general purpose (modular) fixtures. As the FMS has been adopted by more and more manufacturers who are trying to remain competitive in this rapidly changing market by running production with short lead times and well controlled cost; modular fixtures have gained in popularity because of its performance on easy usage, versatility, and its adaptability to product changes. The dedicated fixtures are also important in manufacturing, for advanced, sophisticated and precise part and mass production.[1]

Methodologies for rapid reconfiguration and part positioning which are fundamental for the development of automated fixturing systems. The approaches are based on a fixturing system that is independently controllable modules consisting of sensors and actuators which can be relocated for different applications.[2]

The fixture design problem into two main parts: Fixture Layout problem and Fixture Setup problem. In these, the first task of determining the number, type, and location of fixture elements and the latter as an appropriate fixture assembly designed and constructed from the layout with concerning the collision and interferences between tool path and fixture.[3]

The components of fixture as per different application and also about the 3-2-1 rule for fixture designing approach. It gives little idea about the modular fixture and its application.

Djordje et al.[5] proposed the importance of fixture design automation. It presents a general structure of the automated design system with a special highlight on the fixture design systems and their main characteristics. It also shows a structure and a part of output results of the automated modular fixture design system.

The effect of clamping sequence on workpiece location error is modeled analytically for a fixture workpiece system where all major compliance sources and fixture geometric error are considered. Such as fixture geometric error and elastic deformation of the fixture and part due to clamping forces, the clamping sequence used can also influence part position and orientation. The part location model is developed based on the following assumptions:

The workpiece is prismatic and undergoes only rigid body motion.

The fixture has a 3-2-1 layout.

Deflection and geometric errors at all the locators are known.[7]

3-2-1 locating principle:[4]

Every part has 6 degrees of Freedom (3 Linear + 3 Rotary) which need to be arrested to ensure proper location of the part in space.

3 Stands for - Minimum 3 Rests with clamps to establish a part plane thus restricting 1 Up-Down motion + 2 Rotary motions.

2 Stands for - A Round locating pin in a round hole that restricts motion in the 2 directions in the established plane.

1 Stands for - A Round locating pin in a slot that restricts the rotary motion in the established plane about the round pin.

2.1 Types of Fixture

According to Flexibility Two types of Fixture:

- Modular Fixture
- Dedicated Fixture

Modular Fixture accepts the parts of different shapes and sizes. Modular fixtures became popular because of its performance on easy usage, versatility, and its adaptability to change in product. application of modular fixtures contributes Considerably to shortening the lead time and reducing the cost in small-volume production with versatile products.

The dedicated fixtures are also important in manufacturing for advanced and precise part. Dedicated fixture is designed for a specific product, the designer can carefully make the design to not only meet the basic fixture requirements such as the locating accuracy, stability, stiffness but also optimally facilitate the operational requirements

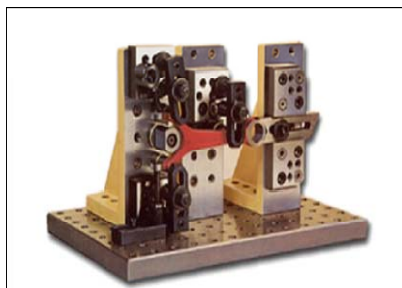


Fig. 1: Modular Fixture[1]

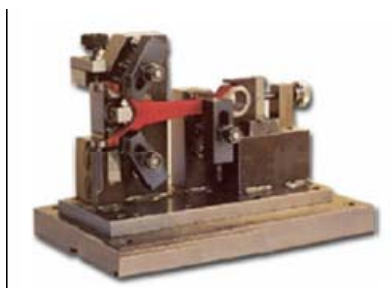


Fig. 2: Dedicated Fixture[1]

Now for automotive BIW line,

- Geostationary Fixtures (Geo Fixtures)
- Respot Fixtures
- Inspection Fixtures
- Hemming Fixtures

Other devices in BIW line:

Gripper, Deposits, Racks, Pallets, Conveyers, Skids, Trolley, Gun stand, Gripper stand, Tip dresser, glue stand etc.

3. Design of Fixture

Fixture design for the Rear Axle Panel as shown in Fig.3. The fixture is designed using CATIA software.

Panel Mass	2.924 kg
Panel Surface Area	1.44 m ²
Panel is symmetric about both side (left & Right).	

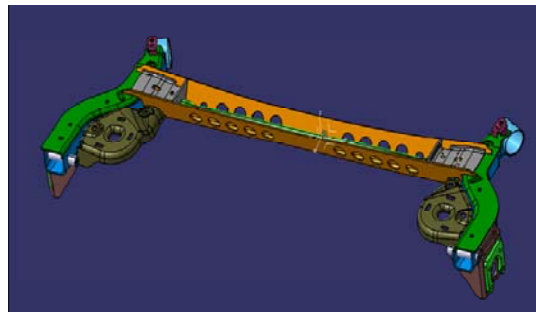


Fig. 3: Rear Axle Panel.

Frame structure for supporting the components of fixture used for different parts of panel. The components like Pin Unit, Clamping Unit, and Slide Unit.



Frame

Pin Unit

Fig. 4: Frame & Pin Unit.

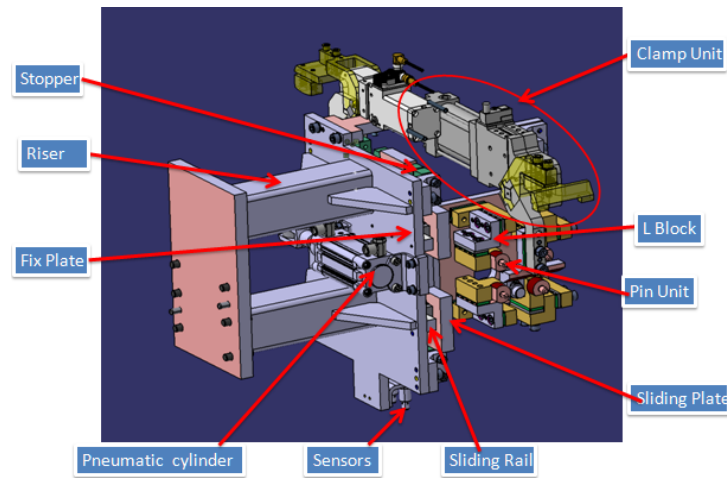


Fig. 5: Slide Unit.

Calculation of selecting the Cylinder for Slide Unit:

Mass on slide (M) 71 kg., Distance = 80mm = 0.08 m time of travel = 0.5 sec.

$$\begin{aligned} \text{Clamping Force } F^1 &= (M \cdot g \cdot \sin 90) \\ &= 71 \cdot 9.81 \cdot 1 = 696.5 \text{ N} \end{aligned} \quad (1)$$

Now,

Frictional force between slide & shoe,

$$F^2 = \mu \cdot F \text{ (take } \mu=0.1 \text{ for smooth surfaces)} \quad (2)$$

$$= 0.1 \cdot (696.5)$$

$$= 69.65 \text{ N} \quad (3)$$

So,

To initiate acceleration of slide,

$$F^1 + F^2 = \text{Reqd. force to initiate acceleration} = 696.5 + 69.65$$

$$= 766 \text{ N (force required to initiate acceleration)}$$

For Ø63 mm cylinder,

$$F = P \cdot A = 5 \cdot 10^5 \cdot \pi / 4 \cdot (0.063^2 - 0.020^2) = 1400.0 \text{ N (force generated by cylinder)}$$



Fig. 6: Clamp Units.

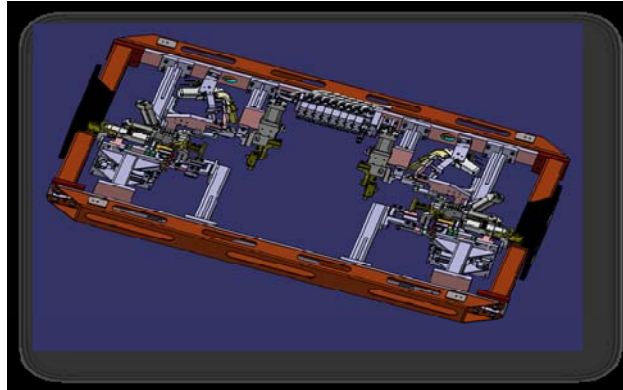


Fig. 7: Fixture Assembly.

4. Conclusion

The automotive industries are moving from manual process to automatic and robotic manufacturing process. Using this type of concept; improve in quality of product, improve efficiency of plant, reduce in rework and scrap cost. Utilization of same components when there will be change in product. Thus from the presented work it can be concluded that, For better design, use of standard components is advisable so that tooling requirement of assembly is less. For eliminating finishing operation pre finished material is used. For ease of assembly keep liberal tolerances for the fixture components.

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