

Factors Affecting the Reconfigurable Fixtures

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Abstract – The function of a fixture is to hold a part in order to keep it in a desired position and orientation while the part is in manufacturing, assembly or verification process. Custom-oriented dedicated fixtures are not only time-consuming and costly to build, but they also do not have the flexibility to deal with parts or assemblies of different shapes and sizes. To reduce the cost of a manufacturing system, the fixture system should be designed to be competent in fixturing as many work pieces as possible. Reconfigurable fixtures have ability to be changed or reconfigured to suit different parts and products. The main objective of this paper is to identify factors affecting the reconfigurable fixture.

Key words: Flexibility, reconfigurable, factors, manufacturing

I. INTRODUCTION

A fixture is a production tool that securely locates and holds a workpiece so that the required manufacturing operation can be performed. Fixtures can be classified as dedicated and reconfigurable.

- Dedicated fixtures are designed and manufactured for specific product or manufacturing operation. They are usually manufactured by installing conventional locators and clamps on a baseplate depending on the type of operation.
- Reconfigurable fixtures consists a variety of standard components such as locators, v-block, and clamps assembled on a baseplate. They are reconfigurable according to product design or manufacturing operation changes, thus they are suitable for batch production.[1]

Today, fixtures are mostly dedicated, i.e. they are manufactured for a specific part and a specific purpose. This single-purpose approach is costly due to the long lead time and effort required for design and manufacture, but also often due to manual set-up or modifications when a manufacturing process is completed or parts and operations are modified. Cost is also induced by the need to store and retrieve dedicated fixtures. For a manufacturing system to be truly flexible, all of its components have to be flexible, including the fixtures.[8]

In the manufacturing industry, the design and manufacture of fixtures and other dedicated tooling for locating and positioning workpieces or products are among the major cost drivers in product industrialization. The design and manufacture of dedicated fixtures typically amount to 10–20% of total manufacturing cost [4].

II. BASIC DESIGN REQUIREMENTS OF THE RECONFIGURABLE FIXTURES:

- 1) Modularity: the fixture must be composed of standard modules, which can be assembled on a baseplate
- 2) Automatic reconfigurability: the fixture must automatically reconfigurable
- 3) Sensory feedback controllability: the fixture components must be integrated with sensors for feedback controllability
- 4) Programmability: the operations of fixtures must be programmed by the computer.[3]

A. Factors Affecting the Reconfigurable Fixtures

Reconfigurable fixtures that can be repositioned within a working envelop to conform to a wider variety of products. There exist a number of factors which affects designing and working of the reconfigurable fixtures, which are defined as follows:

1) Mechanical Design Of Fixture Components:

The first decision to be considered in designing the reconfigurable fixture was the interface between modular components like locators, clamps etc. and the base plate. The two types of base plates are used are T-slot type and hole type.[5] Hole types base plates are more advantageous than T-slot type base plates because of following reasons

- Easier sensor integration in hole type base plate because the interface can be located at the fixed locations under the hole
- More accuracy in holding the component since hole locations are known w.r.t. reference.[3]

2) Sensor integration:

Sensor integration is vital to design the programmable reconfigurable fixtures. Sensor allows real time information transfer between the fixture and its controller. The fixture components must be integrated with sensors for feedback controllability. The purposes of sensor integration is to

- Verification of proper insertion of fixture components into base plate
- Detection of workpiece presence
- Control of clamping process[3]

3) Computer interface:

Sensing & clamping operations of reconfigurable fixtures are to be controlled by a personal computer through a remote interface circuit. The digital commands are to be send from personal computer to remote interface to control the clamping operations. Software programs have to be developed for input output processing and the control of the fixturing process.[3]

4) Method of reconfiguration:

To reposition a reconfigurable device, a force to achieve movement is needed along with a measuring system to

achieve the desired position. Several different approaches have been tested to position reconfigurable devices. One approach is to use robots to set up and configure fixtures for assembly. The robot is used to place the fixture components on the base plate. Here, the robot is used as both actuator and measuring system.[8]

5) *Automation:*

The self-adaptability of the fixtures improves the flexibility towards the customized production, reduces human presence and work in production environment rising safety and security, avoids fixturing tasks, reduces fixturing setup time improve plant efficiency.[10]

6) *Reconfigurable fixture control system:*

Manual reconfiguration of such fixtures is tedious and time consuming. Thus it is preferable that such fixtures have a self-reconfiguration capability. The number of supports can be reduced if they can relocate themselves during machining.[15]

7) *Cost:*

The various costs associated with reconfigurable fixtures are as follows:

- Design cost: Design cost of reconfigurable fixtures is high. The designer has a wide range of the possible design choices. So designer has to look for the optimum design solution
- Fabrication cost: Fabrication cost includes the cost of the materials, bought in components, machining, heat treating, finishing, assembly etc.
- Commissioning costs: commissioning costs are the costs involved in trying out a new fixture, inspecting it to ensure it meets design specifications and making any adjustments found to be necessary.[9]

8) *Limited flexibility:*

Only limited combinations are available from standard fixture components to construct fixture configurations for different workpieces. In many cases, dedicated fixtures are needed for complex workpiece geometry and operations.[2]

9) *Human factor:*

Along with the various technical factors, human factor also affect the reconfigurable fixture utilization. The role of human factor starts from fixture planning and then also involve in designing, fabrication and then utilization. [7] In reconfigurable fixtures there is need of increased level of knowledge to determine the various configurations to locate different components of different configurations on it. [2]

10) *Computer aided fixture design:*

Computer aided design systems are most commonly used as general design aid. The CAD system serves the designer only as a toll to create and manipulate geometric models of the emerging design, and for communicating the design to other users of design information. A CAD system can be used in this manner to design fixtures. Integration is needed for the design methodology for active fixturing system with more general Computer Aided Fixture Design & fixture and Production Planning.[9] All knowledge concerning the design is limited by knowledge of the designer. Various CAD system available for designing of the fixtures are AutoCAD, CATIA, proE, CRIO and many more options are available.[6]

11) *Design of component:*

Workpiece specifications are usually the most-important factors and have the largest influence on the work holder's final design. Typically these considerations include the size and shape of the part, the accuracy required, the properties of the part material, locating and clamping surfaces, and the number of pieces.[13]

12) *Safety:*

The fixtures must guarantee optimum safety during production and offer good ergonomics and ease of use to machine operators.[14]

13) *Accessibility/detachability:*

The concept of fixturing accessibility/detachability covers the aspects of interference free conditions, and spatial geometric constraint satisfaction. Two types of accessibility/detachability should be considered. The first is the reachability of an individual workpiece surface; the second one is the easiness of loading and unloading the workpiece into a fixture.[2]

14) *Deformation constraints:*

Workpiece deformation during fixture set-up and process operation is the most important consideration in the fixture design process.[2]

III. CONCLUSIONS

The major objective of this paper is to identify the factors that significantly affect the reconfigurable fixture. These factors affect the adaption of the reconfigurable fixture. Hence it becomes very much necessary to evaluate the impact of these factors for their better treatment. The study can be used as an aid to develop a suitable strategy for the implementation of Reconfigurable fixture based on the effect of each factor. This would help the industrial managers to infer the improvements needed in the adaption of reconfigurable fixtures.

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