Design of Fixtures: A Review

Nisarg Parmar
Mechanical Engineering department,
A. D. Patel Institute of Engineering,
Vitthal Udyognagar

ABSTRACT

Fixture is widely used to locate and support the workpiece in various industries. It is used for assembly, inspection and testing, heat treatment or mainly in manufacturing industry. While designing the fixture main purpose is to minimize the workpiece deformation due to clamping and cutting forces which is essential to maintain the machining accuracy. It can be achieved by selecting the optimum location or clamps and locators. Nowadays so much attention has already been paid to the research of computer aided fixture design (CAFD). Various methodology used for computer aided fixture design and also finding the optimum location of fixturing elements are reviewed in this paper.

Keyword: - *Fixture, Computer aided fixture design, Optimization, Finite Element Analysis*

1. Introduction

The fixture is a special tool for holding a work piece in proper position during manufacturing operation. For supporting and clamping the work piece, device is provided. Frequent checking, positioning, individual marking and non-uniform quality in manufacturing process is eliminated by fixture. This increase productivity and reduce operation time. Widely used in manufacturing, fixtures have a direct impact upon product quality, productivity and cost. Generally, the costs associated with fixture design and manufacture can account for 10%–20% of the total cost of a manufacturing system [1]. With the increasingly intense global competition which pushes every manufacturer in industry to make the best effort to sharpen its competitiveness by enhancing the product's quality, squeezing the production costs and reducing the lead time to bring new products to the market. Many academic and applications papers have been published in this area. In this paper, we will focus on an investigation of computer aided fixture design research. The following sections will give a survey on these researches.

1.1 Important Considerations while designing Fixtures

- The main frame of fixture must be strong enough so that deflection of the fixture is as minimum as possible. This deflection of fixture is caused because of forces of cutting, clamping of the workpiece or clamping to the machine table. The main frame of the fixture should have the mass to prevent vibration and chatter.
- Frames may be built from simple sections so that frames may be fastened with screws or welded whenever necessary. Those parts of the frame that remain permanently with the fixture may be welded. Those parts that need frequent changing may be held with the screws. In the situation, where the body of fixture has complex shape, it may be cast from good grade of cast iron.
- Clamping should be fast enough and require least amount of effort.
- Clamps should be arranged so that they are readily available and may be easily removed.
- Clamps should be supported with springs so that clamps are held against the bolt head wherever possible.
- If the clamp is to swing off the work, it should be permitted to swing as far as it is necessary for removal of the workpiece.
- All locator's clamps should be easily visible to the operator and easily accessible for cleaning, positioning or tightening.

- Provision should be made for easy disposal of chip so that storage of chips doesn't interfere with the operation and that their removal during the operation doesn't interfere with the cutting process.
- All clamps and support points that need to be adjusted with a wrench should be of same size. All clamps and adjustable support points should be capable of being operated from the fronts of the fixture.
- Work piece should be stable when it is placed in fixture. If the work piece is rough, three fixed support points should be used. If work piece is smooth, more than three fixed support points may be used. Support point should be placed as farthest as possible from each other.
- The three support points should circumscribe the center of gravity of the workpiece.
- The surface area of contact of support should be as small as possible without causing damage to the workpiece. This damage is due to the clamping or work forces.

2. Literature Review

The fixture set up for component is done manually which requires more cycle time for the loading and unloading the material. So, it was required to develop a system by which we can improve productivity and time. The positions of locators and clamps, and the values of clamping force should be properly selected and calculated so that the workpiece deformation due to clamping and cutting force is minimized and uniformed. Weifang Chen & Lijun Ni & Jianbi n Xue (2007) [1] developed a multi objective model for controlling the deformation of the workpiece. The main objective is to find an optimal layout or positions of the fixture elements around the workpiece and optimal clamping force. The objective is two folded and one of them is to minimize the maximum elastic deformation of the machined surfaces, and another is to maximize the uniformity of deformation. Authors have used the ANSYS software package to calculate the deformation of the workpiece under given clamping force and cutting force. In the developed methodology as shown in Fig.1 generating the machining process model is the first thing to do. The maximal cutting force is calculated in cutting model and the force is sent to finite element analysis (FEA) model along with the other boundary conditions. Then the optimization procedure is followed to get the optimum result. This process repeats itself until we get the optimum result.

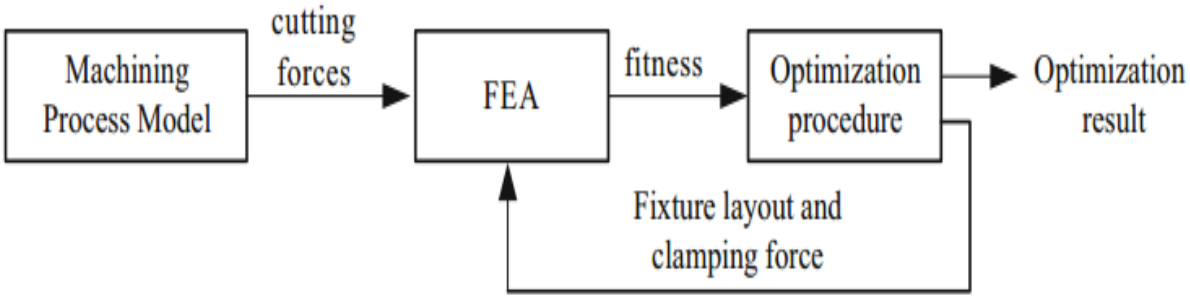

Fig-1: Fixture layout and clamping force optimization process [2]

The model for the FEA analysis is a semi-elastic contact model considering friction effect, where the materials are assumed linearly elastic. Hollow workpiece as shown in Fig-2 is used for the FEA analysis. The material of the hollow workpiece is aluminium 390 with a Poisson ration of 0.3 and Young's modulus of 71 Gpa. The outline dimensions are 152.4 mm×127 mm×76.2 mm. The fixture plan for holding the workpiece in the machining operation is shown in Figure. Generally, the 3–2–1 locator principle is used in fixture design.

In FEA, machining deformation under the cutting force and the clamping force is calculated using finite element method under a certain fixture layout, and the deformation is then sent to optimization procedure to search for an optimal fixture scheme. The software package of ANSYS is used for FEA calculations in this study.

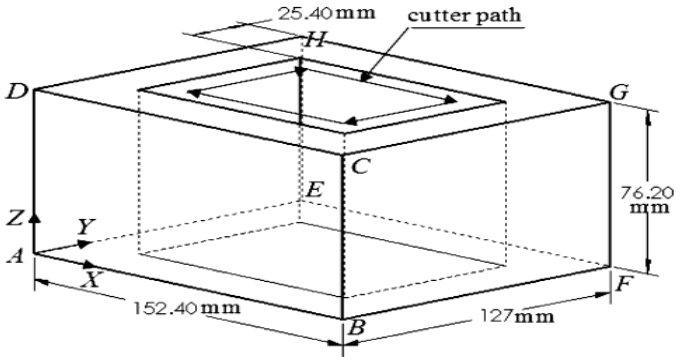

Fig-2: Hollow Workpiece [2]

As shown in Fig-2 shows the result of all the 3 models in which the graph is plotted for deformation vs. distribution of the deformation. The maximum deformation has reduced by 57.5%, the uniformity of the deformation has enhanced by 60.4% and the maximum clamping force value has degraded by 49.4%. Obviously, the deformation from that of multi-objective optimization method distributes most uniformly in the deformations among three methods.

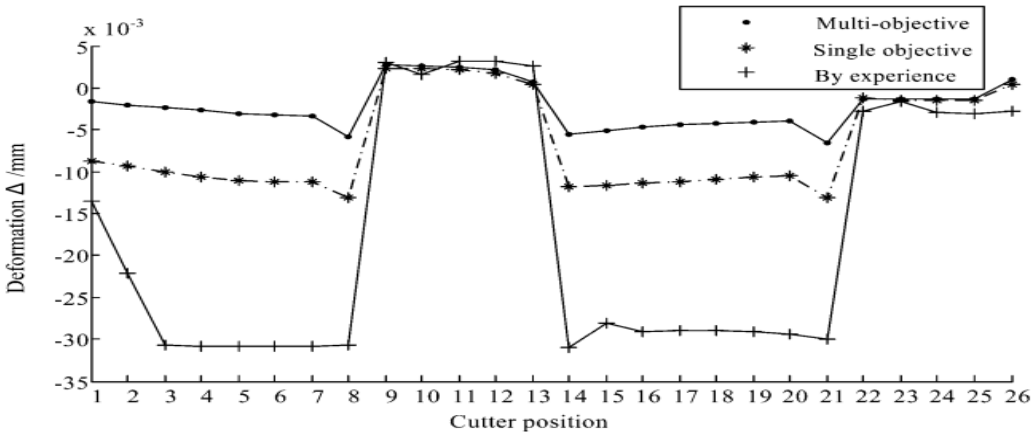

Fig-3: Distribution of the deformation along cutter path

R. Hunter et al. has developed a functional approach for the formalization of the fixture design process. They have proposed five phase methodology for the fixture design process as shown in Fig-4.

Phase 1: The first phase, development of functional requirements (FR), comprises the capture of the knowledge needed to perform the design process for machining fixtures. It has two main tasks, first filling in the MOKA forms, and second formalization of the functional requirements according to the structure.

Phase 2: The second phase, definition of fixture functions (FF), is aimed to complete a set of high level software function templates that implemented in a knowledge-based application allows to generate fixture solutions which are Compliant with the functional requirements defined in the previous phase. The fixture functions have been defined graphically using a method based on the IDEF0 modelling. The representation notation permits to embody graphically the attributes and operations needed for the implementation of a function.

Phase 3: The third phase, functional design (FD), is aimed to create a set of functional solutions for the fixture design. A functional solution is independent of any particular commercial fixture component, and it is represented by means of a set of fixture functional elements. A fixture functional element satisfies at least one of the functions identified as inherent to a fixture, i.e.: centre, position, orientate, clamp, and support.

Phase 4: The fourth phase, detailed design (DD) comprises the creation of detailed solutions from a functional one. To undertake this phase the mapping tables previously mentioned and the corresponding interpretation rules have to be used.

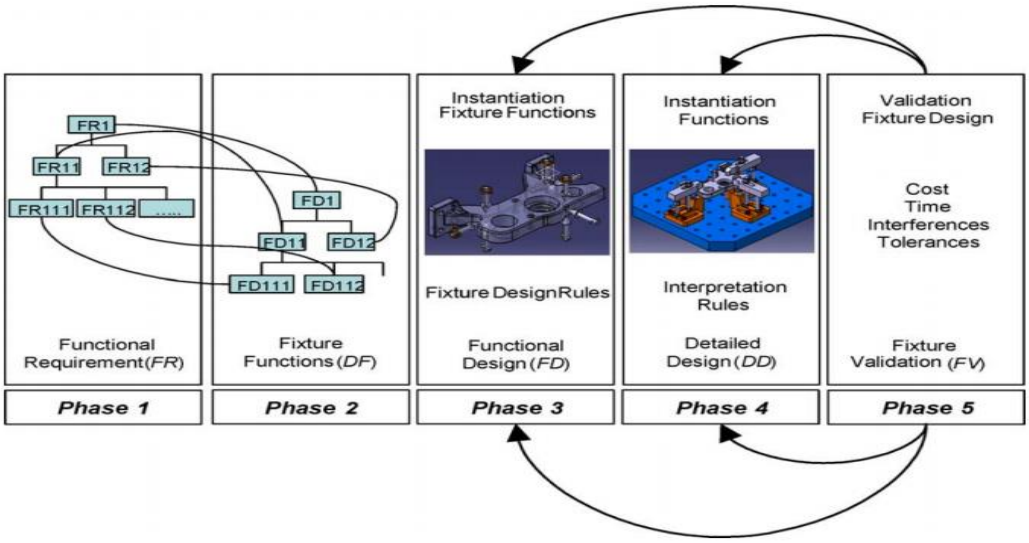

Fig-3: Fixture design process methodology

Phase 5: Finally, the fifth phase, validation of the design (FV), is aimed to make a final evaluation and validation of the functional requirements and their associated constraints defined in the first phase.

3. CONCLUSIONS

To reduce cycle time required for loading and unloading of part, this approach is useful. If modern CAE, CAD are used in designing the systems then significant improvement can be assured. To fulfill the multifunctional and high performance fixturing requirements optimum design approach can be used to provide comprehensive analyses and determine an overall optimal design. An integrated approach to the design process of machining fixtures has been adopted in this research. The basic aim was to formalize a methodology to facilitate the automation of such design process. The proposed methodology for fixture design process will fulfilled researcher production target and enhanced the efficiency, Hydraulic fixture reduces operation time and increases productivity, high quality of operation, reduce accidents.

4. REFERENCES

1. Bi ZM, Zhang WJ. Flexible fixture design and automation: review, issues and future direction. International Journal of Production Research 2001;39(13): 2867–94
2. Weifang Chen ,Lijun Ni & Jianbin Xue "Deformation control through fixture layout design and clamping force optimization" Int J Adv Manuf Technol 38:860–867 DOI 10.1007/s00170-007-1153-2,2008.
3. Shailesh S Pachbhai and Laukik P Raut (2014), "A Review on Design of Fixtures", International Journal of Engineering Research and General Science, Vol. 2, No. 2, ISSN, pp. 2091-2730.
4. J. Cecil "A Clamping Design Approach for Automated Fixture Design" Int J Adv Manuf Technol 18:784–789,2008
5. Nicholas Amaral,Joseph J. Rencis,Yiming (Kevin) Rong "Development of a finite element analysis tool for fixture design integrity verification and optimization" Int J Adv Manuf Technol 25: 409–419, 2005
6. Y. Wang, X. Chen. N, Gindy "Surface error decomposition for fixture development" Int J Adv Manuf Technol DOI 10.1007/s00170-005-0270-z, 2007
7. R. Huntera, J. Riosb, J.M. Pereza, A. Vizan, "A functional approach for the formalization of the fixture design process", International Journal of Machine Tools & Manufacture 46 (2006) 683–697
8. A. Senthil Kumar, V. Subramaniam, T.B. Teck, "Conceptual design of fixtures using machine learning techniques" , International Journal of Advanced Manufacturing Technology 16 (2000) 176–181