Design Analysis and Optimization of Fixture Layout -A Review

K. M. Arunraja[1]*, S. Selvakumar [2], P. Praveen[3]
[1]Department of Mechanical Engineering, Hindusthan Institute of Technology, Coimbatore, Tamilnadu, India.
[2] Department of Mechanical Engineering, Kongu Engineering College, Erode, Tamilnadu, India.
[3]Department of Mechanical Engineering, Excel Engineering College, Salem, Tamilnadu, India.

***Abstract*:- Machining fixture are essential elements in mass production and manufacturing industry. The suitable fixture design provides the accurate and quality finished product. The fixture design in the process of design and analysis the fixture in various machining conditions such as machining and clamping forces, finally optimize the number of fixture elements with optimal location. In this article describe the various design, analysis and optimization tools which are extensively used for fixture layout design and optimization problems.**

Keywords: Machining Fixture, Deformation, ANSYS, Point Contact, Surface Contact

I. INTRODUCTION

Fixtures are essential elements of production processes as they are required in most of the automated manufacturing, inspection, and assembly operations. Fixtures must correctly locate a workpiece in a given orientation with respect to a cutting tool or measuring device, or with respect to another component, as for instance in assembly or welding. Such location must be invariant in the sense that the devices must clamp and secure the workpiece in that location for the particular processing operation. There are many standard work holding devices such as jaw chucks, machine vises, drill chucks, collets, etc. which are widely used in workshops and are usually kept in stock for general applications. Fixtures are used in Turning, Milling, grinding, Shaping, Planning, Boring Welding and Inspections.

Machining fixtures are used for locating and constraining the workpiece during machining operations. In order to obtain accurate machining dimensions the position and orientation of the workpiece should be maintained firmly. The operational safety and quality is directly affected by machining fixture layout. Machining fixture contains many locators and clamps. Number of locators and clamps are present in typical machining fixture. Locators are used to support and positioning the workpiece, clamping elements are used to rigidly hold the workpiece by applying force. The positions of locators and clamps, number of locators and clamps and the magnitude of clamping forces are the three main aspects in fixture design optimization.

II. LITERATURE REVIEW

Li and Melkote (2001) analyzed that the workpiece location error was minimized by the optimization procedure and in addition, the improved fixture layout produces an overall workpiece deformation pattern that had a uniform and lower magnitude. Kulankara Krishnakumar et al (2000) shown that a technique for fixture layout uses the genetic algorithm to find the fixture layout that minimizes the workpice deformation Li. B and Melkote. S. N (2001) proposed a new method for determining the optimum clamping forces for a multiple clamp fixture–workpiece system subjected to quasi-static machining loads.

Sundararaman et al. (2014) proposed RSM based technique for 2D workpiece fixture system. RSM is used for develop the quadratic model. These values are compared with the FEM model. Elilraja et al. (2015) presented a fixture layout optimization method for 2D workpiece fixture system using PSO based integrated fixture layout optimization and continuous fixture layout optimization methods. The performance of both methods are compared. Vasundara et al. (2016) proposed a fixture layout optimization problem for Two Dimensional (2D) workpiece fixture system for milling operation. Fixture layout has been optimized using Artificial Bee Colony algorithm (ABC) and the value of workpiece deformation is predicted by ANSYS. Vasundara et al. (2014) presented a hybrid optimization procedure for a 2D workpiece fixture system using ANN and GA. A numerical model has been developed to train genetic algorithm using ANN. S. Kashyap and W. R. DeVries (1999) proposed that Finite element analysis is used in simulating the deformation of the workpiece at selected points and optimization algorithm is developed to minimize deflections at these selected nodal points by considering the support and tool locations as design variables. Selvakumar. S et al (2010) the deformation of the workpiece for the optimum clamping forces is determined by Harmonic analysis using FEM software. Selvakumar. S et al (2013) investigated the process employs a hybrid system of nonlinear finite element analysis and ANN.. ANN was trained with sufficient fixture layouts and their corresponding workpiece deformation, which is obtained from FEM, the layout which shows the minimum deformation is selected as optimal fixture layout & the maximum deformation value of the optimal fixture layout was found out by using FEA. After going through the above literatures it is found that all the previous researches were carried out by considering the clamping and locator load as point load for analysis purpose and the tools for optimization are GA, and ANN. Das, Franciosa et al. (2015) proposed a new approach to improve the probability of joining the feasibility index by determining an N-2-1 fixture layout optimized for a production batch of non-ideal sheet metal parts. The

proposed methodology is based on (i) generation of composite parts to model shape variation within given production batch; (ii) selection of composite assembly representing production batch; (iii) parameterization of fixture locators; and (iv) calculation of analytical surrogate model linking composite assembly model and fixture locators to the probability of joining feasibility index. Sivakumar et al (2016) proposed a fixture layout optimization problem for rigid body components. The workpiece deformation is analyzed by experimental setup and ANSYS approach Selvakumar et al (2016) proposed a method for elastomer material in drilling operation. Ansys software is used for calculating the workpiece deformation during drilling operation.

Gameros & Lowth (2017) proposed a systematic review in the field of fixture design and optimization. In this work, fixture design problem has been classified into three groups, (1) fixture and work holding (2) fixture for single part and (3) fixture for multi parts. Finally the conclude most of the case fixture has developed and designed for single component and importance of fixturen design for modern manufacturing land space.

Subba rao et al. (2018) Fixture configuration plays a virtual role in workpiece deformation. Three case studies have been considered for drilling operation and deformation of each case is analyzed for various fixture configurations using the finite element method (ANSYS). Xi Zhanga, Hui Wang et al. (2018) proposed the influence of fixture layout in machining process selection on tolerance allocation. The interaction between fixture layout and process tolerance design has been investigated.

In this paper, optimal fixture layout has obtained by combining all the process design variables.

Shuja Ahmed, Probir Saha (2018) proposed an experrmental study of sheet metal component on friction stir welding process. The feasibility analysis has been made at five different levels of speeds. A simple mechanical fixture has developed for holding the sheet metal workpiece. Minh Duc Do & Younghoon Son (2018) proposed an N-2-1 flexible fixture system for thin-walled component. In this paper, the geometry based method is used for optimizing fixture layout for aerospace sheet metal workpiece. Finally, results are verified with fixture verification module. Arunraja et al (2019) presented fixture layout optimization technique for sheet metal components under welding process. Design of Experiments based optimization procedure is established for optimizing the position of the fixture elements. FEA based analysis is used for predicting the work piece elastic deformation. Jeya Jeevahan et al 2015 presented the effectiveness of particle swarm optimization in the fixture layout optimization towards minimizing the geometric error on the workpiec during machining. PSO provides better results in a faster, cheaper way compared with other traditional methods. Elilraja et al 2015 proposed a technique for fixture layout optimization for minimum workpiece deformation. Continuous fixture layout optimization method (CFLOM), Discrete fixture layout optimization method (DFLOM) and Integrated fixture layout optimization method (IFLOM) based optimization procedures are established and compared. The minimum workpiece deformation is achieved PSO based integrated fixture layout optimization method. FEM is used for calculating the workpiece deformation.

Xingsong et al 2013 presented particle swarm optimization (PSO) algorithm based machining fixture layout optimization problem. 2D workpiece is considered for analysis, ANSYS parametric design language (APDL) of finite element analysis is used for compute the deformation. Doglas Negri et al (2017) proposed PSO based optimization procedure for minimizing workpiece error. Experimental set up has been conducted for various fixture layout. Workpiece deformation is calculated under impact hammer force. Ming-hui Pan et al (2016) presented ASA, MIGA and PSO based clamping position and deformation analysis for Antenna Thin Wall Parts Assembly. ASA based clamping position yields better result compared with PSO and MIGA.

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2.1 Summary of Literature review

- ✓ Most of the studies Finite Element Software (ANSYS) used for predicting Workpiece elastic deformation.
- ✓ The fixturing elements such as locating and clamping positions are considered as point contact.
- ✓ *The position of fixture elements plays major role in locational and form error.*
- ✓ *Locational and form error can be minimized by optimizing the fixture layouts.*
- ✓ *The prediction of workpiece deformation using ANSIS is reliable, because only 4% of deviation between experimental setup and ANSYS analysis.*
- ✓ *GA, ANN, ACA, Taguchi, RSM and PSO based optimization techniques are suited for fixture layout optimization problems.*

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