Desing and Optimization of Optimal Fixture Layout for Drilling Operation

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***Abstract*—Machining fixture is a precision device meant for locating and constraining the workpiece during machining. This work focuses on machining fixtures. A machining fixture is used to establish and maintain the required position and orientation of a workpiece so that drilling operations can be performed on the workpiece. we change the position of locaters and reduce deformation.**

INTRODUCTION

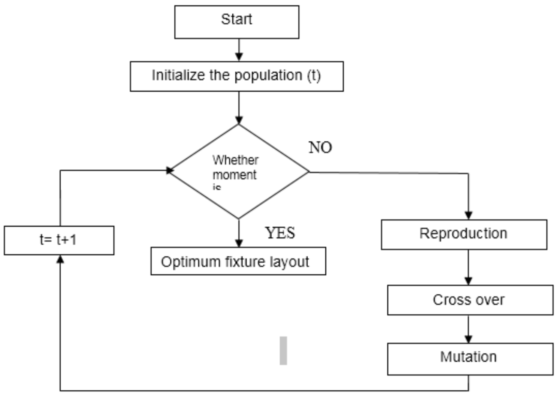
Machining fixture is a precision device meant for locating and constraining the workpiece during machining. This work focuses on machining fixtures. A machining fixture is used to establish and maintain the required position and orientation of a workpiece so that cutting operations can be performed on the workpiece. It is a critical link in the machining system as it directly affects operational safety and part quality. A typical machining fixture consists of a base plate and a number of locators and clamps. Locators are passive fixture elements used to position the workpiece while clamps are active fixture elements that can be actuated mechanically, pneumatically, or hydraulically to apply clamping forces onto the workpiece so that it can resist external forces generated by the machining operation. There are a variety of fixture designs. The geometry of the contact region between a fixture element and the workpiece can be a point, line, or plane. An important consideration in the fixture design process is to design the fixture layout.Design of fixture layout is a procedure to establish the workpiece fixture contact through positioning of clamps and locating elements such that the workpiece elastic deformation is minimized. Fixture design plays an important role at the planning phase before shop floor production. Proper fixture design is crucial to product quality in terms of precision, accuracy and surface finish of the machined parts.

GENERAL REQUIREMENTS OF A FIXTURE

In order to maintain the workpiece stability during a machining process, an operational fixture has to satisfy several requirements to fully perform its functions as a work holding device. The following constraints must be observed while designing a viable fixture

GENETIC ALGORITHM

Genetic algorithms are one of the best ways to solve a problem for which little is known. They are a very general algorithm and so will work well in any search space. All you need to know is what you need the solution to be able to do well, and a genetic algorithm will be able to create a high quality solution. Genetic algorithms use the principles of selection and evolution to produce several solutions to a given problem.

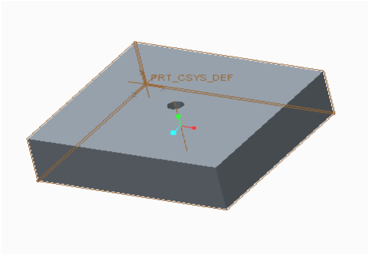


PROBLEM DEFINITION

In the fixture design, if the Fixturing elements such as locators and clamps are not placed in the optimal location the machining and clamping forces will cause more elastic deformation in the workpiece. It influences the dimensional and form accuracy of the workpiece. This problem can be solved by optimizing the several factors such as number of locators and clamps, position of locators and clamps, clamping and machining forces. In this work the problem is solved by selecting the optimal number of fixture elements with optimum location.

WORKPIECE GEOMETRY AND PROPERTIES

An example of clamping force optimization problem for a prismatic work piece shown in Figure 3.1 displayed by Li and Melkote (1999) is considered as example for the fixture layout optimization problem described in this work. The geometry and features of the workpiece are shown in Fig. The material of the workpiece is aluminum 7075-T6 with a Poisson ratio of 0.33, Young's modulus of 72 Gpa and the density of 2795 kg/m^3. The outline dimensions are 127 mm×127 mm×38.1 mm.10mm hole was drilled in the center of the workpiece.



SIMULATION OF MACHINING OPERATION

An drilling operation is carried out on the example workpiece. The machining parameters of the operation are given in Table . The entire tool path is discredited into 5 load steps and cutting force directions are determined by the cutter position.

Machining Simulation Parameters

Types of operation	Drilling
Spindle speed	660 (rpm)
Feed	0.2032 (mm/tooth)
Drill diameter	10mm
Machining force	F_x= -422.1N ;F_y= -1105.67N; F_z=283.56N
Clamping force	C_1=- -1105N ; C_2=-422N

FIXTURE LAYOUT OPTIMIZATION PARAMETERS INVOLVED

In the fixture layout optimization problem, we need to minimize the maximum deformation in the workpiece. Work piece fixture layout is shown in the The parameters which influence the deformation of the workpiece are

i. Clamping forces
ii. Machining forces
iii. Position of locators and clamps
iv. Material of the workpiece
v. Number of locators and clamps

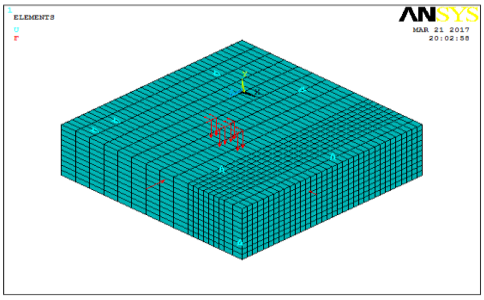
FINITE ELEMENT MODEL OF THE WORKPIECE FIXTURE SYSTEM

The software package of ANSYS is used for FEA calculations in this work. The Figure 5.3 shows the FE modal of the workpiece fixture system.

The following assumptions are made for the finite-element formulation: Workpiece is an elastic body whereas the fixturing elements are rigid body.

i. Workpiece is discretized into hexahedra element.
ii. The number of degrees of freedom per node is three.
iii. Locators are modelled as displacement constraints that prevent workpiece translation in the normal direction.
iv. The clamping forces are modelled as a point force acting over the workpiece–clamp contact point.
v. Machining forces are modelled as harmonic forces.

Number of elements = 73675
Number of nodes = 98532
Type of Element = solid 45 (structural element)
Type of mesh = Mapped mesh

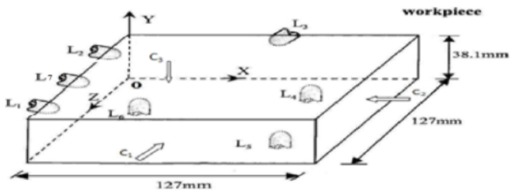


FE model of workpiece fixture system

3-3-1 LOCATING SCHEME

Here, removed the newly added locator on X axis and add the new locator on the Z axis, this is called 3-3-1 locating schemes. Figure 5.5 shows the 3-3-1 locating configuration. Then varying the position of newly added locator on Z axis to determine the various deformation values of workpiece at initial load step.

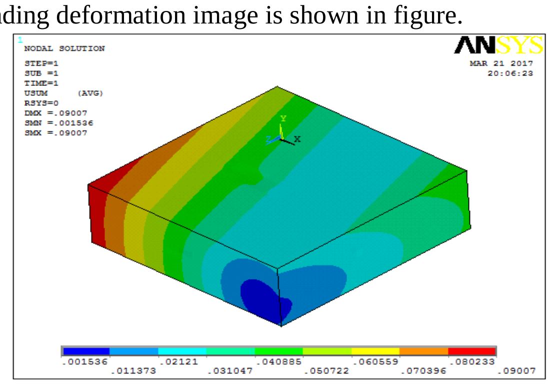
Table shows the various locators position and their corresponding deformation values of workpiece. Figure shows the minimum workpiece deformation of 3-3-1 locating scheme.



3-3-1LOCATING SCHEMES

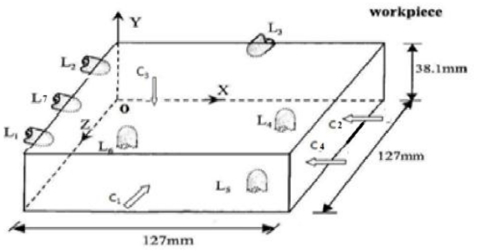
DEFORMATION OF WORKPIECE AT INITIAL LOAD STEP

The deformations of the workpiece while machining at initial load step for the above fixture layout configuration are calculated by using finite element analysis (FEA) software. The minimum deformation occurred when the newly added locator position is 92.5 mm in the X axis, and their corresponding deformation image is shown in figure.

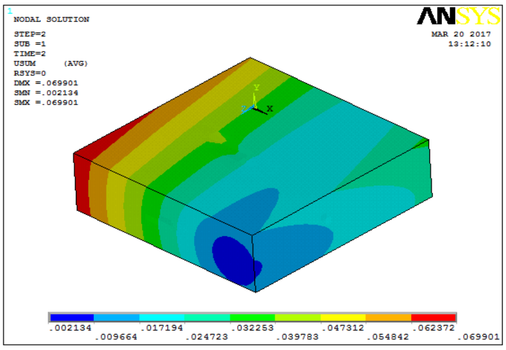


NUMBER OF CLAMPS ON 3-3-1

Here with 3-3-1 locating scheme the number of clamps are varied. Then the position of newly added clamps are varied on Z axis to determine the deformation of the workpiece. Figure shows the clamps added in the 3-3-1 locating schemes. Table shows the various locater position and their corresponding deformation values of the workpiece. Figure shows the minimum deformation of 3-3-1 locations with four clamps.

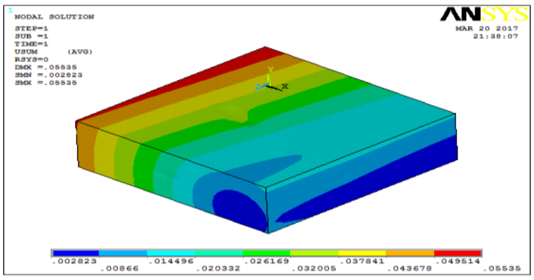


Clamp Added on 3-3-1



MINIMUM DEFORMATION OF WORKPIECE

L_1 (mm)	L_2 (mm)	L_3 (mm)	L_4 (mm)	L_5 (mm)	L_6 (mm)	L_7 (mm)	C_1 (mm)	C_2 (mm)	D (mm)
93.83	100.85	29.63	120.6	79.0	63.5	70.79.	59.26	120.7	0.0533



CONCLUSION

Thus the 3-3-1 locating scheme is best suited than 3-2-1 locating scheme constraining the movement of prismatic components while machining. Comparatively 20% of reduction in elastic deformation has been achieved by using 3-3-1 locating scheme than the 3-2-1 locating scheme. It reduces the dimensional and form errors of the workpiece caused by the clamping and machining force acting on the workpiece while machining. Hence it has been proved that, we can achieve more accurate product by using the 3-3-1 locating scheme for the prismatic components.

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