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Design and Analysis of Milling Fixture for HMC

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Abstract—*The goal of any manufacturing organisation is to achieve minimum non productive time and activities. Setup time also falls in the same category. Therefore it becomes necessary to have a device which reduces the efforts in such activities; such device is called as fixture. Designing of fixture was considered to be lengthy and complicated procedure. Because it needs a good knowledge about manufacturing processes, dimensioning and tolerances and cutting forces during operations. But now a day the work becomes less difficult due to introduction of intelligence in the field. The computer aided fixture design technique avail the model of designed fixture to the designer before getting manufacture and can show deficiency and designer can made modification accordingly without getting it manufacture, which saves a great amount of money and time. In this paper the same methodology is adopted for designing analysing the designed fixture. The fixture is designed for heavy component to perform various milling operations using Pegard Horizontal boring machine. Static workbench analysis is carried out using ANSYS package. Cutting forces and clamping forces are taken into consideration during analysis. Analysis is carried out at different tool positions to calculate the maximum deformation occurred.*

Keywords*: Milling fixture, CAFD, fixture analysis*

1. INTRODUCTION

The fixture is a workpiece holding device which sets workpiece in proper position during manufacturing operation. Frequent checking, positioning, individual marking and non-uniform quality during manufacturing process is eliminated by fixture. This increase productivity and reduce operation time. Fixture is widely used in the industry practical production because of feature and advantages.

To locate and immobilize work pieces for machining, inspection, assembly and other operations fixtures are used. A fixture consists of a set of locators and clamps. Locators are used to determine the orientation and position of a workpiece, whereas clamps exert clamping forces on the workpiece so that the workpiece is pressed firmly against locators. Clamping has to be appropriately planned at the stage of machining fixture design. The design of a fixture is a highly complex and intuitive process, which require knowledge. Fixture design plays an important role at the setup planning phase. Proper fixture design is crucial for developing product quality in different terms of accuracy, surface finish and precision of the machined parts. In existing design the fixture set up is done manually, so the aim of this project is to replace with hydraulic fixture to save time for loading and unloading of component. Hydraulic fixture provides the manufacturer for flexibility in holding forces and to optimize design for machine operation as well as process functionability.

To ensure that the workpiece is manufactured according to specified dimensions and tolerances, it must be appropriately located and clamped. Minimizing fixture and workpiece deflections due to clamping and cutting forces in machining is critical to the machining accuracy. An ideal fixture design maximizes locating accuracy and workpiece stability, while minimizing displacements.

By implementing FEA in a computer-aided-fixture-design (CAFD) environment, unnecessary and uneconomical “trial and error” experimentation in the machine shop is eliminated.

2. LITERATURE REVIEW

Hui Wang et al. reviewed recent research and trends in the field of computer aided fixture design. The importance of the fixture in the manufacturing industries and different types of fixtures which are used are discussed. The procedure of designing the fixture is discussed through various steps as setup planning, fixture planning, unit design and verification. The emerging trends in field of CAFD are reviewed with the help of different literatures by the authors.[1]

Ian Boyle et al. proposed different approaches for CAFD in their A review and analysis of current computer aided fixture design approaches. Approaches for different fixture design steps such as setup planning, fixture planning, unit design and verification are discussed. Over seventy five CAFD tools and approaches are reviewed by the authors in terms of fixture design phases they support. The authors concluded that there are primarily two research issues that require further effort one of which is current CAFD research is segmented in nature. And the second one is that a greater focus is required on supporting the detailed design of a fixtures physical and mechanical structure.[2]

S. Selvakumar et al. in their clamping force optimization for minimum deformation of workpiece by dynamic analysis of workpiece fixture system worked on achieving optimum clamping force which gives minimum workpiece deformation. The balancing force moment and coulomb static friction law methods are used to calculate the minimum clamping force required to hold the work piece. During milling operations forces at five various positions is taken into consideration. Using harmonic analysis the behavior of workpiece under loading is observed by the author. [3]

Y. Wang et al. in their Deformation Analysis of Fixturing for Workpiece with Complex Geometry studied the special features of the deformation analysis between complicatedly shaped components and fixture elements. Finite element analysis is used to calculate the deformation of the workpiece. The case study of turbine blade fixture is done by the author in this paper. [4]

3. COMPONENT DETAILS

The fixture design procedure includes two steps basically. First one represents the knowledge about part geometry, machining processes, functional and detailed fixture design, whereas the second includes knowledge about fixture layout design and interpretation rules to get first solution of machining fixture. Therefore to understand detailed component, geometry is discussed here. The workpiece is basically a rectangular shape having length 1000mm, width 600mm n breadth 700 mm. The workpiece weights around 700 kg. The job is of high pressure fluid pump end, used as valve in Halliburton Pump. The component is in forged condition in raw state with 5 mm machining allowance on all sides. The whole operations are carried out on Pegard horizontal machining centre. The component undergoes various machining processes such as boring, end milling, pocket milling, drilling, chamfering. Fig. 1 shows the model of work piece generated using Unigraphics.

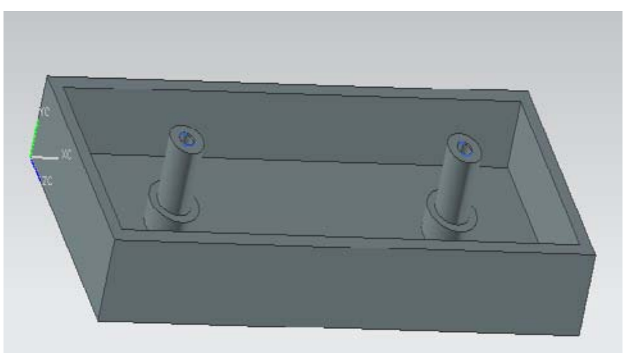

Fig. 1: Model of work piece

4. DESIGN OF FIXTURE – LOCATION AND CLAMPING CONSIDERATIONS

Workpiece location in a fixture is significantly influenced by localized elastic deformation of the workpiece at the fixturing points. The clamping forces applied are caused to deform the workpiece It is therefore important to minimize such effects through optimal design of the fixture layout . In machining, work holding is a key aspect, and fixtures are the elements responsible to satisfy this general goal. Centering, locating, orientating, clamping, and supporting, can be considered the functional requirements of fixtures. There are many constraints in the designing of fixture regarding shape and dimensions of the part to be machined, tolerances, sequence of operations, machining strategies, cutting forces, number of set-ups, set-up times, volume of material to be removed, batch size, production rate, machine morphology, machine capacity, cost, etc. At the end, the solution can be characterized by its: simplicity, rigidity, accuracy and reliability.

The provision for clamping and holding the work

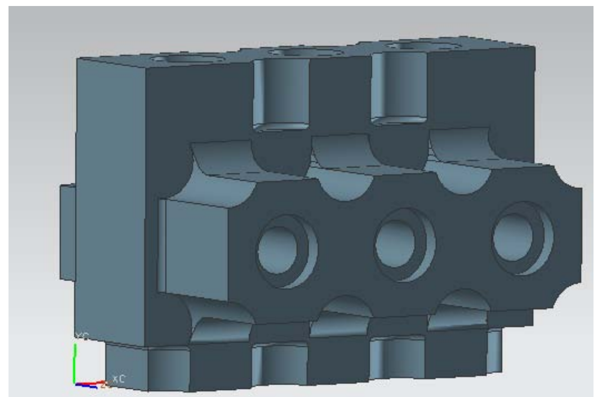

Fig. 2: Model of fixture

piece is made up from the centre of the workpiece where two initial holes are provided for trepanning operations. These holes can be utilized for clamping purpose. Two locators are placed as shown in fig. The stay rods are passed through these holes and threaded in locators to clamp the workpiece rigidly

5. CALCULATION OF CUTTING FORCE

As main operation to be performed on component is end milling and maximum cutting force acts for this operation; calculation [5] is made for the same. The data of cutting conditions are as under:

D = Diameter of cutter=160 mm

N= revolutions per minutes=200 rp,

V= cutting speed=100 m/min

Z= number of teeth=10

t=depth of cut=0.5

b= width of cut=160

Q= material removal rate,

$$Q = \frac{b \times t \times S_m}{1000} \quad \text{.................(1)}$$

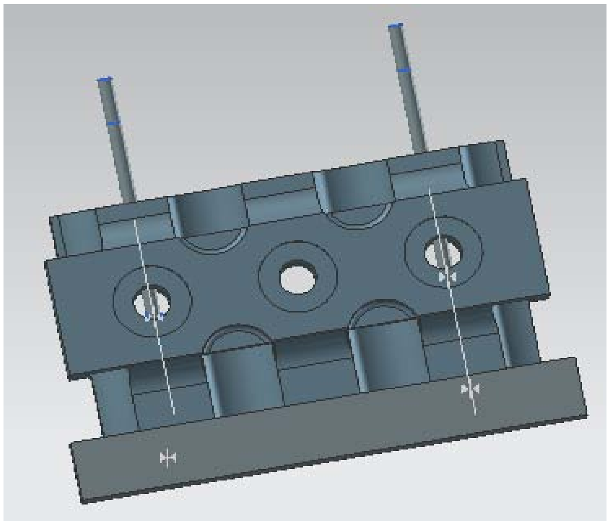

Fig. 3: Assembly model of fixture and workpiece

$$Q = \frac{160 \times 0.5 \times 350}{1000}$$

Unit power for alloy steel and 0.1 chip thickness, can be calculated as,

$U = 56\times10^{-3}$ kW/cm^3/min.

Assuming flank wear 0.2 mm and for average chip thickness 0.1 mm , and workpiece hardness 350 BHN, Correction factor for flank wear, k_h=1.21.

Radial rake angle=10^0, correction factor for radial rake angle=1

Power at spindle,

$$N = U\times K_h\times K_r\times Q \quad (3)$$

$N=56\times10^{-3}\times1.21\times1\times28$

N= 1.897 kW

Assume efficiency of transmission (E) is 80%

Tangential cutting force,

$$P_z = 6120\frac{N}{V} \quad (4)$$

$$P_z = 6120\frac{1.897}{100}$$

=116 kgf

=1137.74 N

As the cutting force is 1137.74 N, Clamping force should be greater than the cutting force So, Let as assume clamping force is 2500 N. (approximately 2 times of cutting force) Total no of clamps = 2 At each clamp, clamping force should be 1250 N. To get the 2500 N clamping force the bolt diameter was chosen from the force exerted by bolts table [5] the M20 bolt is used which found safe according to the design data.

6. STRESS ANALYSIS

Fig. 3 shows the assembly of workpiece and fixture on which analysis is going to be carried out. Static analysis is carried out on the fixture and workpiece to calculate the deformation of the workpiece at the located points.. Workbench analysis is carried out on the component.

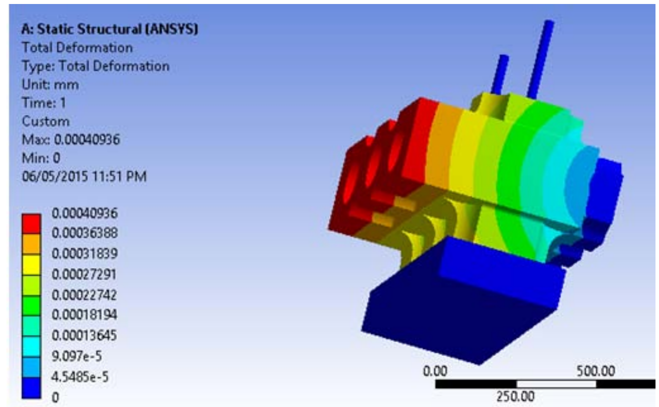

Fig. 4: Stress distribution

The Fig. 4 shows the stress distribution of the workpiece under the cutting load and clamping load conditions. The maximum stress is observed at cutting face.

Static analysis is carried out to calculate the maximum deformation of the workpiece. The maximum stress and deflection recorded is 0.15437 MPa and 0.4 microns respectively, which is recorded as safe values for the fixture and workpiece and for machining process too. The table 1 shows the ansys result of maximum stress and maximum deflection in the workpiece.

Table 1: Maximum stress and deflection calculation

Results		
Minimum	0. MPa	0. mm
Maximum	0.15437 MPa	4.0936e-004 mm
Minimum Occurs On	fixture	model
Maximum Occurs On	model	

7. CONCLUSION

In this paper, the design requirements of the fixture were studied and cutting forces were calculated. This paper addresses the fixture design verification for milling operations. Verification of the fixture design is carried out using ANSYS workbench. Meanwhile clamping force and cutting forces are taken into consideration during the static analysis of the fixture and workpiece. The findings of the work can be illustrated as

i) The values of stress obtained from the analysis result are far within the allowable values.
ii) 0.4 micron maximum deformation is observed which is in tolerance with machining allowance.
iii) CAFD greately reduces the time for designing the fixture which are hard to design manually.

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