© 2015 IJEDR | Volume 3, Issue 3 | ISSN: 2321-9939

Designing a Fixture for Machining Gear Shifting Fork

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***Abstract* - The purpose of this work is to convey the basic idea on the gear shifting fork and its fixtures for machining. A fixture is designed and built to hold, support and locate every component to ensure that each is drilled or machined with accuracy and manufactured individually. In machining fixtures, minimizing work piece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. Tools required for the machining of fork is mentioned in this work along with the operations required for the machining of fork is also described here. This work also includes the basic about fixtures. The fixture set up for component is done manually and for that more cycle time is required for loading and unloading the material. So, there is need to develop system which can help in improving productivity and time. Fixtures reduces operation time and increases productivity and high quality of operation is possible. The design of the geometric model of fork is also developed. The new fixture design is carried out by using modeling software and simulated on Analysis software.**

***Index Terms* - Fork, Fixtures, Accuracy, Clamping, Reducing time, Increasing productivity, Simulation**

I. INTRODUCTION

A fixture is a work-holding or support device used in the manufacturing industry. Fixtures are used to securely locate and support the work, ensuring that all parts produced using the fixture will maintain conformity and inter changeability. Using a fixture improves the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement for skilled labour by simplifying how work pieces are mounted and increasing conformity across a production run. [2]

Fixture is required in various industries according to their application. This can be achieved by selecting the optimal location of fixturing elements such as locators and clamps. The fixture set up for component is done manually. For that more cycle time required for loading and unloading the material. So, there is need to develop system which can help in improving productivity and time. Fixtures reduce operation time and increases productivity and high quality of operation is possible. [7]

Purpose of using these fixtures: A fixture's primary purpose is to create a secure mounting point for a work-piece, allowing for support during operation and increased accuracy, precision, reliability and interchange ability in the finished parts. It also serves to reduce working time by allowing quick set-up and by smoothing the transition from part to part. It frequently reduces the complexity of a process, allowing for unskilled workers to perform it and effectively transferring the skill of the tool maker to the unskilled worker. Fixtures also allow for a higher degree of operator safety by reducing the concentration and effort required to hold a piece steady. Economically speaking the most valuable function of a fixture is to reduce labour costs. Without a fixture, operating a machine or process may require two or more operators; using a fixture can eliminate one of the operators by securing the work-piece. [9]

Location of fixtures: Locating the components ensures the geometrical stability of the work piece. They make sure that the work piece rests in the correct position and orientation for the operation by addressing and impeding all the degrees of freedom the work piece possesses. For locating work pieces, fixtures employ pins (or buttons), clamps and surfaces. These components ensure that the work piece is positioned correctly and remains in the same position throughout the operation.
Surfaces provide support for the piece, pins allow for precise location at low surface area expense, and clamps allow for the work piece to be removed or its position adjusted. Locating pieces tend to be designed and built to very tight specifications.

II. DESIGN APPROACH

Successful fixture designs begin with a logical and systematic plan. With a complete analysis of the fixture's functional requirements, very few design problems occur.
The workpiece, processing, tooling and available machine tools may affect the extent of planning needed. Preliminary analysis may take from a few hours up to several days for more complicated fixture designs.
Fixture design is a five-step problem-solving process. The following is a detailed analysis of each step. [3]

STEP 1: DEFINE REQUIREMENTS

On the basis of the functional requirement the different parameters like production capacity, Greater accuracy and faster cycle time are important.

So on the basis of that parameters we have to design the modal.

STEP 2: GATHER INFORMATION

Collect all relevant data and assemble it for evaluation. The main sources of information are the part print, process sheets, and machine specifications.

STEP 3: DEVELOP SEVERAL OPTIONS

This phase of the fixture-design process requires the most creativity. A typical workpiece can be located and clamped several different ways. A designer should brainstorm for several good tooling alternatives, not just choose one path right away.

The designer usually starts with at least three options: permanent, modular and general-purpose work holding. Each of these options has many clamping and locating options of its own. The more standard locating and clamping devices that a designer is familiar with, the more creative he can be.

STEP 4: CHOOSE THE BEST OPTION

The fourth phase of the tool-design process is a cost/benefit analysis of different tooling options. Other factors, such as tooling durability, are difficult to estimate.

STEP 5: IMPLEMENT THE DESIGN

The final phase of the fixture-design process consists of turning the chosen design approach into reality. Final details are decided, final drawings are made and the tooling is built and tested.

The following guidelines should be considered during the final-design process to make the fixture less costly while improving its efficiency. These rules are a mix of practical considerations, sound design practices and common sense. [4] [8]

- Use standard components.
- Use prefinished materials.
- Eliminate finishing operations.
- Keep tolerances as liberal as possible.
- Simplify tooling details.
- Keep the function and operation of a fixture as simple as possible.
- Reducing design complexity also reduces misunderstandings between the designer and the machine operator.

III. DEVELOPMENT OF FIXTURE ASSEMBLY FOR MACHINING

The steps involved for development of fixture are as follows: [1]

• Analytical design for fixture.
• 3 - D Modeling
• Fixture assembly
• Analysis
• Time Calculation

❖ **Analytical design and 3 D Modeling for fixture :**

A CAD system also can be useful during the initial phase of the work holder design as numerous tooling options are developed. CAD is sometimes faster than sketching by hand, especially when detailed cost estimates are required. [5] [6]

Analytical Design and 3 D modeling of a fork modal is as shown in figure 1 & 2.

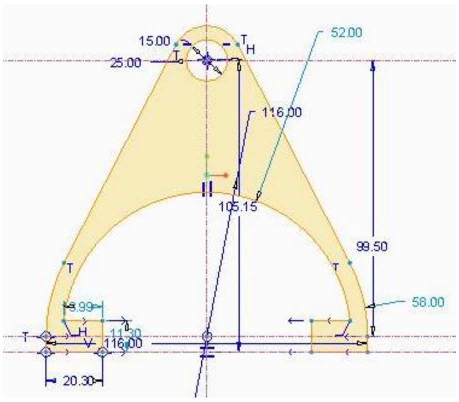

Fig. 1: Drawing view for the Fork Modal


Fig.2: Cad modal of Fork

- **Fixture assembly :**

As the operations to be carried out are in 2 different planes, so we decided to make 2 different fixtures. The fixture design is categorized in 2 types for machining gear shifting fork. The fixture is to be designed for Vertical Milling Machine (VMC)
i.e 1) Base Plate Fixture
2) Angle Plate Fixture

Base Plate Fixtures are constructed from plate with a variety of support, clamps and locators. They are the most common type of fixture because their versatility make them adaptable to a wide range of machine tools. [10]

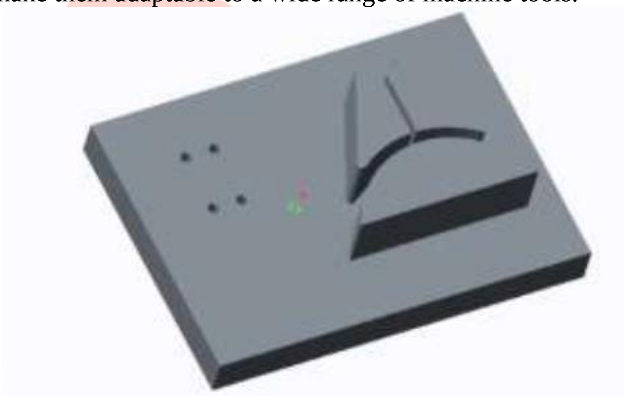
Fig. 3: Base plate fixture

As shown in figure 3, the pads are made on the base plate so that fork can be mounted on it. After the mounting of fork it will be clamped with the toggle clamp as shown in figure 4, operations like drilling of 16.5 mm hole, chamfering, boring of 16.5 mm hole to 16.60 mm, Slotting of end arms can be carried out.

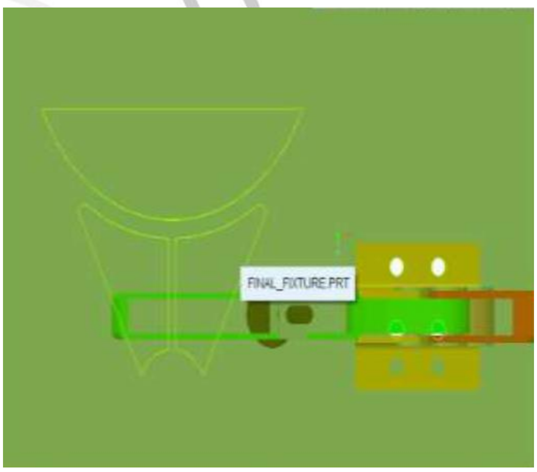

Fig. 4: Clamping of fork with toggle clamp.

The purpose of making angle plate fixture is to perform a drilling of 6 mm hole & reaming of 6.35 mm hole as shown in figure 5.

Fig.5: Angle plate fixture

To reduce the number of fixture, a concept of turning table fixture is introduced. Turning table can be useful to carry out operations at 2 different planes and also there is reduction in material and machining time.

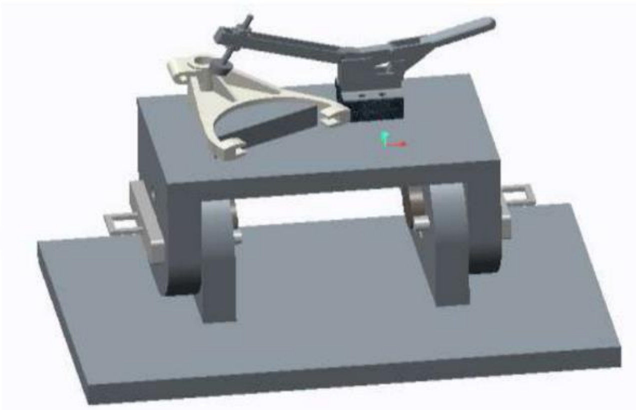

Fig.6: Designed at 0 degree

The purpose of designing the fixture at 0 deg. shown in figure 6 as to carry out the following operations:
1) Drilling of 16.5 mm hole
2) Boring of this hole by 16.660 mm
3) Slotting of end arms
4) Chamfering

As shown in figure 7, the fork is assembled on the pad so that the operations can be carried out very easily without any shocks or vibrations.

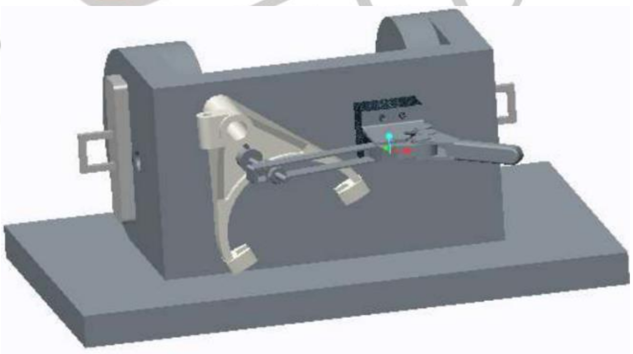

Fig.7: Turn at 90 degree

The above figure 7 shows the rotation of fixture through 90 degree to carry out the following operations:
1) Facing
2) Drilling of 6 mm hole
3) Reaming of 6.35 mm hole

It is included that assemble of all the details part of fixture step by step is carried out. [15]

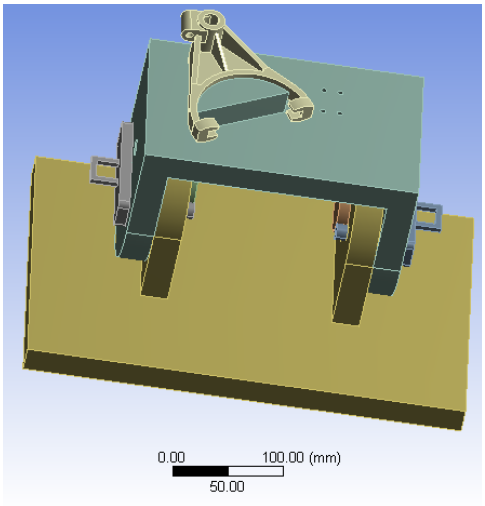

Fig.8: Assembly of Fixture Modal

❖ **Analysis :**

It is included that static analysis is carried out for the Assembly of a Fixture Modal. [11] [12]

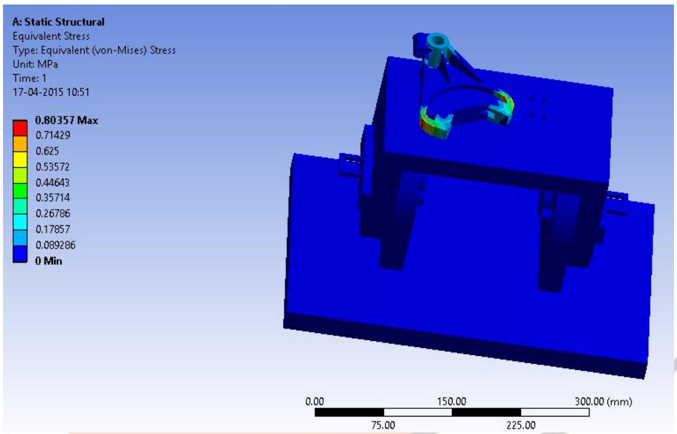

Fig.9: Stress Analysis for Fixture Assembly

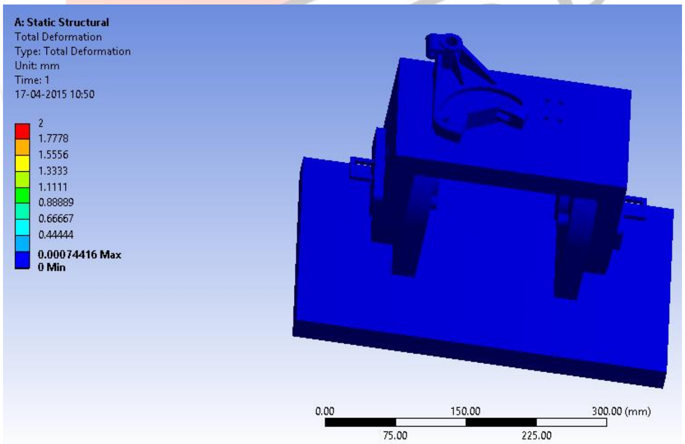

Fig.10: Total Deformation of the Fixture Modal

The simulated graph shows that the results are within the permissible design limits.

❖ **Time Calculation :**

Time can be reduced by reducing the following:
1) Productive time
2) Non Productive time

1. Productive time :

- *Time for drilling 16.5 mm hole :*

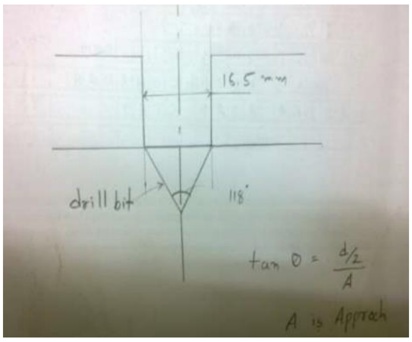

Fig.11: Time Calculation for Drilling

Total length L =length of slot + approach (A) + over travel

Tan α = (d/2) / A
Where α is drill bit angle =118 degree
Diameter of drill bit (d) = 16.5 mm
Here over travel is taken as 1 mm

Approach (A) = 9.9 mm
= 10 mm (approx.)
Total length L = 50 + 10 + 1
L = 61 mm
Time for drilling =L/f*N
= 61/ 100
= 36.6 sec
Where; N = rev/min
f = feed rate

- *Time for boring 16.66 mm :*

Time for boring = L/f*N
= (50 + 1)/100
= 30.6 sec

- *Time for slotting :*

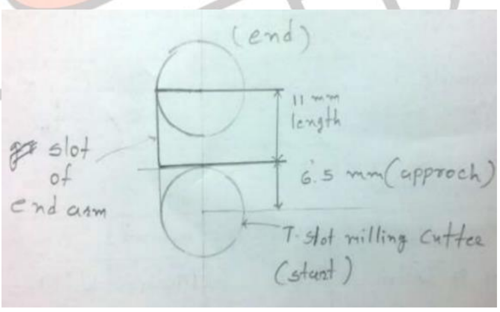

Fig.12: Time calculation for slotting

Total length L = length of arm + approach + over travel
= 11 + 6.5(diameter of T slot cutter) + 1
L = 18.5 mm
Time for machining two slot = 2 * (L/F*n) + Time required for traveling one jaw to another jaw
= 2 *(18.5/400) + 2
= 6 sec (approx.) + 2
= 8 sec

- *Time for chamfering :*

Time required for chamfering two slot = L/F*n + Time required for traveling one jaw to another jaw
= 2 * 2/100 + 2

= 2.5 sec + 2
= 4.5 sec

- *Time for facing (using face milling) :*

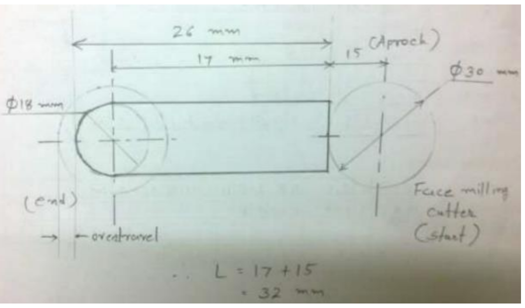

Fig.13: Time Calculation for Facing

Total length L = length of workpiece + approach and over travel
= (26 – 9) + 15
= 32 mm

Time required for facing = L/f*n
= 32 / 1400
= 2 sec

- *Time for Drill 6 mm hole:*

Time required for drilling = L / f*n
= (15 + (6/3) + 1) / 250
= 4 sec (approx.)

- *Time for Reaming:*

= (15 + 1)/60
= 15 sec

Total productive time = Summation of all machining time
= 36.6 + 30.6 + 8 + 4.5 + 2 + 4 + 16
=101.7 sec

2. Non Productive time

• The time required for changing the tool for one operation is 4 sec and there are total 7 operations carried out in the machining of the fork so the tool needed to be changed for 7 times and hence the total time required will be 28 sec.

• The time required for clamping & tightening of the fork will be 5 sec

• Converting the position will be 5 sec.

Total Non-productive time = Summation of all machining time
= 7*4 + 5 + 5
= 38 sec

According to the calculations, it was concluded that the time taken for doing the productive work i.e to drill 16.5 mm hole is 36.6 sec, for boring 16.6 mm hole is 30.6 sec, for chamfering, slotting and facing time required will be 4.5 sec, 8 sec and 2 sec respectively. For drilling 6 mm hole, time required will be 4 sec and for reaming it is 16 sec. So the total time required for doing productive work is 101.7 sec.

The time required for doing the non-productive work like tool changing, clamping and unclamping, changing position will be 38 sec. So the total time required for doing productive and non-productive work will be 139.7 sec i.e 2.32 min.

After the fixture is completed and inspected, it should be tested. The fixture is set up on the machine tool and several parts are run. When the fixture proves itself in this phase, it is ready for production. [13] [14]

Fig.14: Fork Modal

IV. CONCLUSION

The design of the geometric model of fork and fixture is developed and it is analyzed on software. So the final design assembly of the Fixture for Machining gear shifting fork is developed in such a way that the production time and Material requirement is less and the efficiency is more.

The main purpose, objective and also the necessity of a fixture have been clearly presented in the introduction of this paper.

In this paper, a fixture is modelled by using CAD Tools, which is one of the software used for modeling components in most of the design based industries. While the modeling of the components the material selection is carried out simultaneously based on the design considerations related to loads, etc. Later the stress and strain concentration, deformation on fixture using the Finite Element Analysis (FEA) by using CAE Tools that provides best output.

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