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Design of a Machine Fixture for a Shifting Fork for Minimum Cycle Time for Machining Operations in Vertical Machining Center

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Abstract

In order to perform the machining operations on a work piece, it is necessary to hold it firmly so that it does not get dislocated which may damage the work piece for which an arrangement is used known as Fixture. Fixtures are the production tools used for the accurate manufacturing of duplicate and interchangeable parts. This research paper is related to the design of a machine fixture for a component named Shifting Fork so as to optimize the cycle time on a "CNC Vertical Machining Center (VMC)". The component is a raw material which is of the Die casting Aluminum. The work piece and fixture design has been described. The fixture design is based on five operations to be performed on the work piece. The 3D model of the work piece and the fixture has been designed with the aid of the Solid Modeling software "Creo 2.0" using the Machining dimensions as well as the Geometrical dimensions of work piece. The details of the fixture such as its components, assembly, design considerations and bill of materials have been specified.

Keywords- *Fixture; Design; Fork; Vertical; Machining; Center; Creo 2.0*

I. INTRODUCTION

The main requirement of the fixture is to hold and guide the work piece during machining operations for precise location as well as to produce uniform products. Without fixture, the parts produced are not identical which may lead to non-interchangeability and inaccuracy of the products. The fixtures make the standard machine tool, more versatile to work as specialized machine tool. They are used in large scale as well as small scale industries.[1] The fixture also provides greater worker safety and easiness, optimization of cycle time and increase in economy of the industries.

A cycle time is a time which involves the loading and unloading of the component, machining operations, tool changing and miscellaneous activities during the processing of the work piece.

A Shifting fork is a component which is attached to the shift lever in the transmission to move the transmission gears into synchronization with the help of the clutch. They are used to choose the gear ratio. They are used for the shifting the gears for the proper mesh so as to get the desired speed.

II. SHIFTING FORK DESIGN

This paper commences with the design of the shifting fork based on the machining and geometrical dimensions. The geometrical dimensions were measured using the standard measuring instruments such as Vernier Caliper and Micrometer screw. The following figures show the un-machined and machined drawing of the work piece and the dimensions of the geometries and the machining processes.

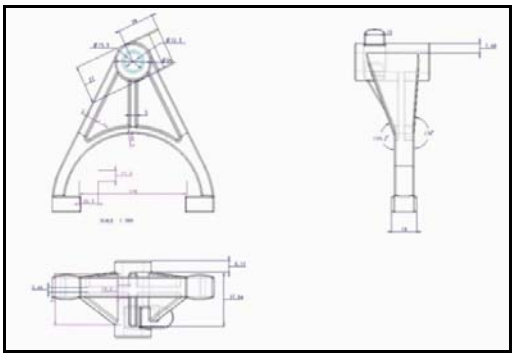

Fig. 1 2D Drawing of Un-machined Component

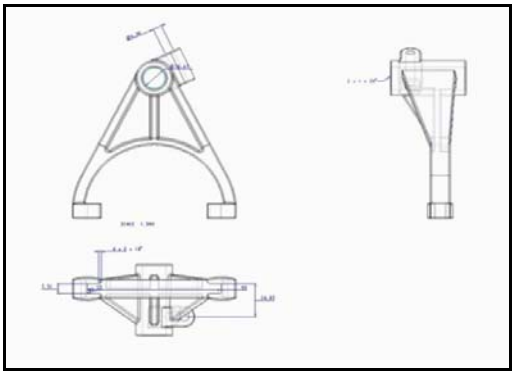

Fig. 2 2D Drawing of Machined Component

The figure-1 indicates the geometrical dimensions of the work piece while figure-2 indicates the machining dimensions of the various machining operations such as Boring, Chamfering, Slotting, Facing and Drilling. These dimensions play an important role in the design of fixture.

III. FIXTURE DESIGN

For designing a fixture, various factors are to be considered as given below:-

- Principle
- Work piece dimensions
- Machining operations and dimensions
- Worker convenience
- Fool Proofness
- Materials and properties
- Cost
- Cycle time

3.1. (3-2-1) Principle of fixture design

For designing a fixture, a major time is spent in deciding how to locate the work piece in the fixture. It is known that any free body has 12 degrees of freedom, six translational and six rotational along X, Y and Z axis. In order to locate the work piece in the fixture, 9 degrees of freedom excluding three translational (-X, -Y and -Z) are to be fixed.

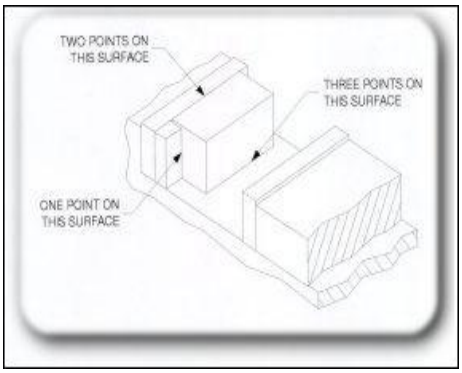

Fig. 3 (3-2-1) Principle [2]

The methodology of this principle is given below:

- The work piece is rested on three non-collinear points of the bottom surface (XY), by which +Z, CROT-X, ACROT-X, CROT-Y and ACROT-Y degrees of freedom are fixed.
- The +Y and ACROT-Z degrees of freedom are fixed by resting the work piece at two points of the side surface (XZ).
- The +X and CROT-Z degrees of freedom are fixed by resting the work piece at one point of the adjacent surface (YZ). Hence the 9 degrees of freedom has been fixed. [2].

The other parameters like the Fool provides precise location of the work piece which further exhibits accuracy and uniformity to the work pieces. The following figure shows the 3D model of the fixture design. The materials must be such that the overall cost of fixture is reduced but increased strength. And the last parameter, the cycle time must be the least. The following figure shows the 3D model of the fixture design.

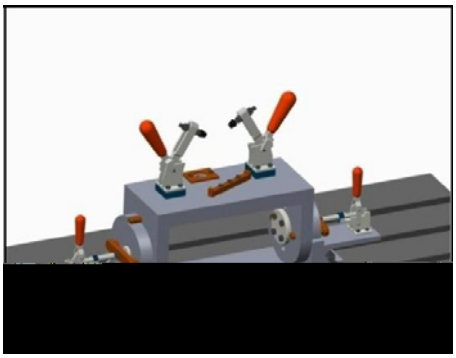

Fig. 4 3D Model of Fixture

The components, assembly, bill of materials, materials of components, tolerances, clearances and fits have been explained below:-

3.2. Components of the fixture

3.2.1. Base Plate and Support. The base plate and the support are the supporting components of the fixture. The base plate is fixed to the VMC table using a bolt-Washer-nut assembly. The support is mounted on and welded with the base plate. The base plate is provided with the provision to support the table and push-pull type toggle clamp. An arrangement in the form of cut is provided on the support to constrain the movement of the table within 0^0 to 90^0 .

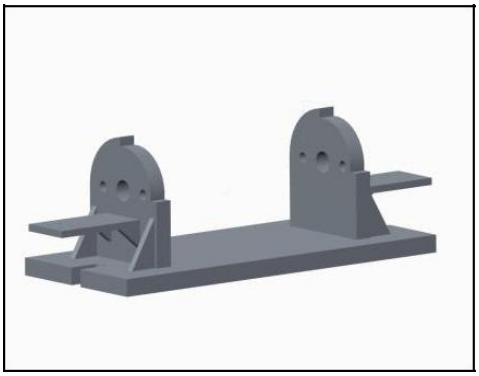

Fig. 5 Base plate and support

3.2.2. Turning table. The turning table is the component on which the other components like shifting fork, supports for fork, horizontal toggle clamps are mounted using the bolts-washer-nut assembly. The table is connected to the support using the main pin and the locking pins.

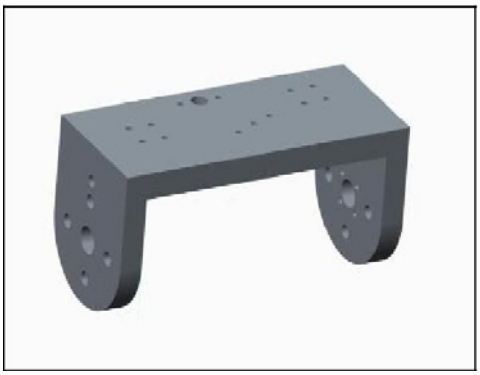

Fig. 6 Table

3.2.3. Main Pin. The main pin is the component along which table rotates and also supports the table. The pin is connected to the table using the bolts.

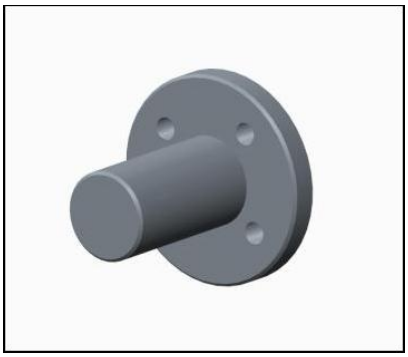

Fig. 7 Main pin

3.2.4. Locking Pin. The locking pin is the component used to lock the table in a fixed position. The pin is connected to the push-pull type toggle clamp by the means of which the pin moves in and out of the table in order to permit the table movement.

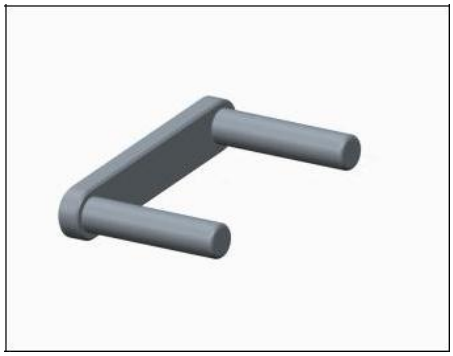

Fig. 8 Locking pin

3.2.5. Dowel Pin. The dowel pin is the component which is connected to the table to restrict the motion of the table from 0 to 90 by the means of the cut provided on the support.

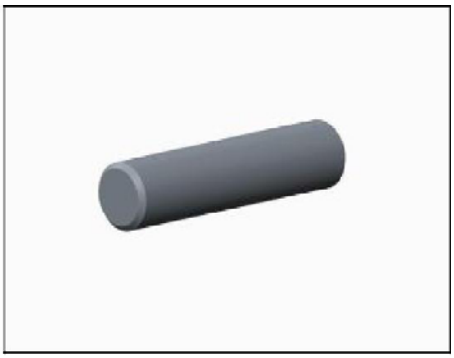

Fig. 9 Dowel pin

3.2.6. Push-Pull type toggle clamp. The push-pull type toggle clamp is used to push and pull the locking pin in and out of the table to permit its movement. This clamp is customized to permit the pin in and out movement of 35mm.

Fig. 10 Push-Pull type Toggle Clamp

3.2.7. Horizontal Toggle clamp. The horizontal toggle clamp is used to hold the work piece firmly to the table without allowing any movement of the work piece during the machining operations. These clamps are provided with a rubber cap at the clamping point to prevent damage to the work piece.

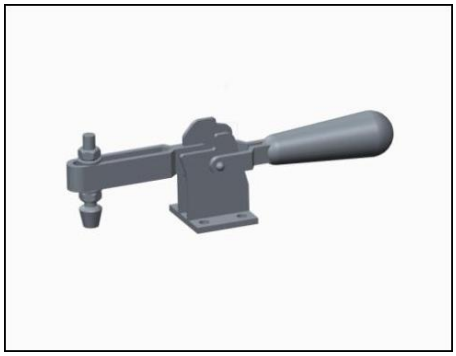

Fig. 11 Horizontal Toggle Clamp

3.2.8. Support for the fork. These supports are provided to support and hold the work piece in such a way that it cannot be held in any other position. These supports are fool-proof. There are two supports, one for the head section of the work piece and the other for the leg section of the work piece.

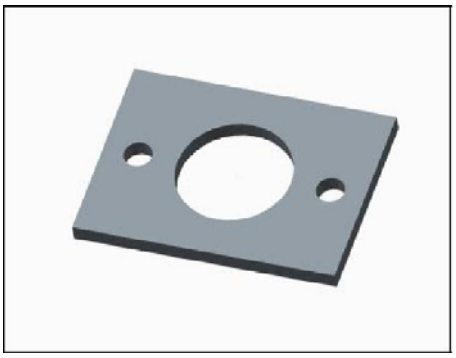

Fig. 12 Support for work piece head

The support for work piece head provides a circular slot in which the top circular surface is placed. The support for the leg provides a slot where the legs of the work piece are placed. Hence these supports are used for the precise location of the work piece.

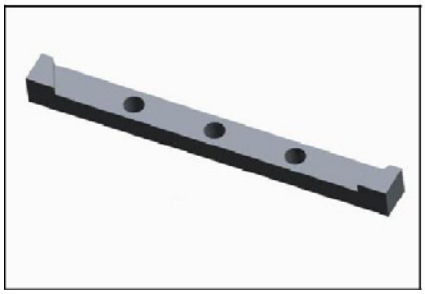

Fig. 13 Support for work piece leg

3.2.9. Fasteners. The fasteners consist of bolts, nuts and washers of sizes M5, M6, M8 and M20.

Fig. 14 Bolt

Fig. 15 Nut

Fig. 16 Washer

3.3. Assembly of fixture

The assembly of fixture is described in detail.

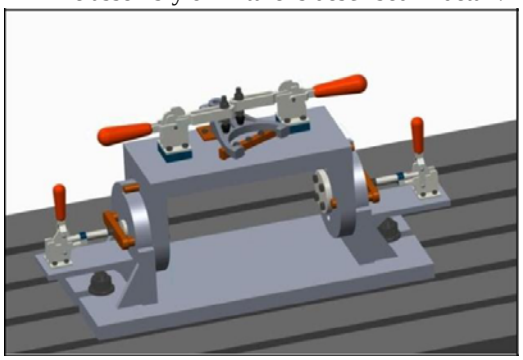

Fig. 17 0^o Position of fixture

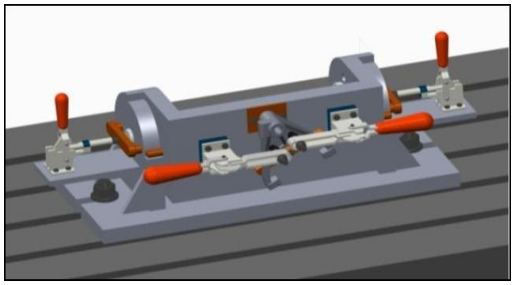

Fig. 18 90^o Position of fixture

The Fixture assembly starts with attachment of the support with the base plate by welding. The table is then connected to the support using the main pin. The dowel pins are force fitted to the table. The Locking pin - push pull type clamp assembly is then mounted on the extended surface provided on the support. Thereafter, the supports for fork and the horizontal toggle clamps are fitted on the table.

3.4. Material Considerations

The material used for all the components of the fixture is Mild steel as it is of considerable strength which is sufficient for the machining operations. Also the work piece is of die cast aluminum, hence mild steel is the best option. Moreover, Mild steel has also been selected considering the costing.

3.5. Fits

The fits used for the main and locking pins are sliding fit designated as H7g6 while the fit for dowel pin is interference fit designated as H7k6**.** [3]

3.6. Clearance

The clearance is provided between the bolts and the holes to avoid clashing between them. The clearances for the bolts of various sizes are given in the below table.

Table 1. Hole Clearance for Bolts **[4]**

Bolt Designation	Clearance (mm)
M5	5.3
M6	6.4
M8	8.4
M20	21

3.7. Bill of Materials

The bill of materials is a tabular representation of the components used in assembly and the quantities of the corresponding components.

Table 2. Bill of Materials

Component	Quantity
Base plate and Support	1
Table	1
Main Pin	2
Locking Pin	2
Dowel Pin	2
Horizontal Toggle Clamp	2
Push-Pull type Toggle Clamp	2
Supports for Shifting Fork	1
M5 Bolt	8
M5 Nut	8
M5 Washer	8
M6 Bolt	13
M6 Nut	13
M6 Washer	13
M8 Bolt	8
M8 Nut	8
M8 Washer	8
M20 Bolt	2
M20 Nut	2
M20 Washer	2

3.8. Tools

The following tools have been used in the machining operations:-

- Drill tool:- For drilling operation of diameter 16.5 mm
- Boring bar:- For drilling operation of diameter 16.67 mm
- Chamfer tool:- For chamfering operation of 1mm at 20^{o}
- T-Slot Cutter:- For slotting operation of width 7.5 mm
- Face milling cutter:- For face milling operation of 15 mm
- Drill tool:- For drilling operation of diameter 6.2 mm
- Reamer:- For drilling operation of diameter 6.37 mm

IV. CONCLUSION

The Current fixture design has the following features:-

4.1. Reduction in Cycle time

This fixture design helps in the reduction of the cycle time which is 2 minutes and 52 seconds. The operations to be done are on the horizontal and vertical faces of the work pieces for which two fixtures have to be designed, one for holding the work piece in horizontal position and the other fixture to hold it in the vertical position, but this fixture eliminates the need of two fixtures, as the fixture can be turned and locked in both the vertical and horizontal position, hence the time involved in the change between the fixtures is reduced.

4.2. Accuracy of operations

This fixture design provides the precise location of the work piece, thereby increasing the accuracy of the operations. Provisions are also made so as to reduce the vibrations and eliminate damage to the work piece.

4.3. Cost and Strength

The material used for the components of the fixture are mild steel, which is of considerable strength as well as of low cost.

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