Design And Optimization Techniques Using In Turning Fixture

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Abstract—Fixtures are work holding devices designed to hold, locate and support work pieces during manufacturing operations. Turning fixtures are wildly used in manufacturing industries. Here we design the turning fixture for machining the filter head. Filter heads are widely used in hydraulic machineries. The main objective for developing the turning fixture is to reduce the cycling time, setting time and production cost by changing the existing fixture in VMC machine into Turning Centre.

Keywords—VMC, Turning Centre, fixture,

I. INTRODUCTION

A fixture is a work-holding or support device used in the manufacturing industry. Fixtures are used to securely locate (position in a specific location or orientation) and support the work, ensuring that all parts produced using the fixture will maintain conformity and interchange ability. 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 workpieces are mounted, and increasing conformity across a production run.

A fixture differs from a jig in that when a fixture is used, the tool must move relative to the workpiece; a jig moves the piece while the tool remains stationary.

It is also used in inspection welding and assembly. Fixture does not guide the cutting tool, but is always fixed to machine or bench. By using fixture, responsibility for accuracy shifts from the operator to the construction of machine tool. When a few parts are to be machined, workpiece clamp to the machine table without using fixture in many machining operations. However, when the numbers of parts are large enough to justify its cost, a fixture is generally used for holding and locating the work.

II. MODIFY STATEMENT

A vertical machining centre (VMC) is a machining centre with its spindle in a vertical orientation. High-end VMCs are high-precision machines often used for tight-tolerance milling, such as find die and mold work. Low-cost vertical machining centres are among the most basic CNC machine tools. A low-cost VMC is often a new machine shop’s first machine tool purchase.

A turning centre is a machine tool with computer numerical control whose basic form factor shows lath ancestry, meaning that the workpiece is mounted to the main spindle and is rapidly rotating for many of the cuts. They began as conventional metalworking laths retrofitted with CNC control. Their tooling was all of the non live type, meaning that tool bits, drill bits, end mills, and so forth where used without rotating (with their motion relative to the workpiece being provided by the workpiece’s own rotation).

Generally the component has four machining operation. First, Second, Third operations are prepared in Vertical Machining Centre. And the fourth operation prepared in the Turning Centre. We design a new turning fixture for 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> machining operations in the turning centre. We design a turning fixture according to the machining operation for the component so we change the machining operation from vertical machining centre into turning centre. Due to changing the machining operation from VMC into turning centre the cycle time of the component is totally reduce and tools usage, setting time, Production cost are reduced. So the production rate is increased.

III. DESIGN OF FIXTURE – METHODOLOGY

A fixture is a production tool that locates, holds, and supports the work securely so the required machining operations can be performed. A fixture should be machine upon which the work is done. Fixtures are essential elements of production processes as they are required in most of the automated manufacturing, inspection, and assembly operations.

In mass production fixture have key aspects:

- Reduce the cost of production.
- Maintain consistent quality.
- Increase production rate.
- Reduce the time
- Improve the overall safety to the part, operator, and machine

Fixture planning is conceptualize by a basic fixture configuration through analysing all the available information regarding the specification of the workpiece such as its shape, dimensions and tolerances, material and geometry of the workpiece operations required, processing equipment for the operations, and the operator.
Typically the design process by which such fixtures are created has major four phases such as fixtures planning, fixture layout, fixture element design, fixture body design.

**Phases of fixture design**

The following inputs are included in the fixture plan:

- Fixture type and complexity
- Number of work piece per fixture
- Locating datum faces
- Clamping surfaces
- Support surfaces

Fixture element design is either to detail the design drawings. Fixture body design is to produce a rigid structure carrying all the individual fixture elements in their proper places.

**IV. FIXTURE DESCRIPTION**

**A) Turning Fixture**

It is generally used for facing turning and boring operation. These are generally special face plates. Their swing should be lesser than the swing of the machine. These are used for quick location and clamping. The workpiece rests on angle plate and its boss is centralized with machine axis by sliding v-block which can be operated with knurled screw. The overhang of turning fixtures should be minimum bare necessary for the operation. Fixture should be balanced with workpiece in position. The clamping arrangement should be capable of withstanding the various forces developed during operation.

- Cutting force tangential to cutting circle.
- Axial force and radial force due to feed of tool.
- Bending forces due to pressure of tool on workpiece.

**COMPONENTS:**

**Back plate for Turning Fixture**

It consists of workpiece locating and clamping elements. These fixtures are generally used for facing turning and boring operation. The workpiece should be located correctly with respect to rotating machine spindle for all these operations.

For boring and turning, the axis of the bore or the outside diameter to be machined must be aligned with the machine spindle axis. Most of machines are provided with back plate, which is permanently mounted on the machine spindle. This plate is used to locate and clamp turning fixtures. Generally, outside diameter of rotation of fixtures with machine spindle. Back plate is provided with three or more equally spaced holes for clamping turning fixtures. Turning fixtures give quick loading, locating and clamping of workpiece in mass production.

**Base plate**

It is a device to establish and maintain the position of a part in a fixture to ensure the repeatability of the work holder.

**Cylindrical locators**

Cylindrical locating pins used to locate a workpiece from a hole produced by previous operations. In these diameter of a pin is made a push fit with a hole in the workpiece. The top portions of these pins is given a sufficient lead by chamfering.

**Basic rules for locating**

While designing a fixture, the following points are to be considered.

- Positioning the locators
- Accuracy and tolerance
- Fool proofing
- Duplicate location
• Motion economy

Locating methods
There are different locating methods available with respect to surface of the workpiece.
• Locating from plane surface
• Locating from circular surface
• Locating from irregular surface

Clamping
Once a workpiece is located, it is necessary to press it against the locating surfaces and hold it there against the force acting upon it. The tool designer refers to this action as clamping and the mechanism used for this action are known as clamp.

Clamps should be positioned above the points supporting the component in order to minimize distortion and they should be strong enough to resist bending. Quick acting clamps should be used whenever possible. Avoid the necessity of lifting a clamp by hand if the job can be done by fitting a spring to lift it.

Screw clamp
These are simple clamps which make use of threaded rod equipped with some method of tightening. They are used commonly in fixtures. Screw clamp uses the torque developed by a screw thread to hold the workpiece.

Stoppers
This is mostly used to prevent the motion of the workpiece inside the fixture. In our design two stopper pins are used to arrest the motion of the workpiece along the linear direction.

Setting block
The setting block is used to reduce the clamping time during the machining operation. The setting block is placed in between the workpiece and the clamping screw.

V. FIXTURE DESIGN

A) The fixture design for 2nd operation:

During the second operation the fixture has a supporting pin in each side of the component. Which arrest the all kind of vibration during machining operation, without supporting pin the machining operation was totally misaligned.

The workpiece is located on the fixture in a correct position with the help of locator. The supporting pin is tightening the workpiece in each side, is to arrest the vibration during operation. The setting block is placed on the top of the workpiece. By using the setting block the clamping time is reduced.

B) The fixture design for 3rd operation:

During the third operation the opposite face of the work will be machined, so the supporting pins are removed and fine setting block is fixed inside the fixture instead of supporting pins.

VI. OPTIMIZATION

In this chapter we show about comparison and optimization details by our proposed design instead of existing design.
The following table contains the comparison of operation sequences between existing and current operation.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>OPERATION SEQUENCE</th>
<th>EXISTING OPERATION</th>
<th>CURRENT OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I</td>
<td>TURNING CENTRE</td>
<td>TURNING CENTRE</td>
</tr>
<tr>
<td>2.</td>
<td>II</td>
<td>VMC</td>
<td>TURNING CENTRE</td>
</tr>
<tr>
<td>3.</td>
<td>III</td>
<td>VMC</td>
<td>TURNING CENTRE</td>
</tr>
<tr>
<td>4.</td>
<td>IV</td>
<td>VMC</td>
<td>VMC</td>
</tr>
</tbody>
</table>

Here we change the II & III machining operation from VMC into Turning Centre for reducing cycling time, setting time, production time and production cost also.

1) **TOOL COMPARISON**

a) **VMC machine tools**

The tools listed below are commonly used in existing operation in VMC machine for II & III operations.

A) **II operation tools – used in VMC**
   1. Face mill cutter (Ø 80mm) for facing
   2. Boring bar (Ø 21mm)
   3. Boring bar (Ø 21.5mm) for rough boring
   4. Chamfer tool (Ø 40"
   5. Reamer (Ø 21.9mm)
   6. Boring bar (Ø 30.7mm)
   7. End mill cutter (Ø 16mm) for Ø45mm spot face
   8. Chamfering tool (for spot face and thread bore)
   9. GI thread milling cutter

B) **III operation tools – used in VMC**
   1. Face mill cutter (Ø80mm) for facing
   2. Boring bar (Ø30.7mm)
   3. End mill cutter (Ø16mm)
   4. Chamfering tool
   5. GI thread milling cutter

b) **Turning Centre tools**

The tools only needed to finishing the same II & III operation in turning centre are given below.

A) **II operation tools – used in TC**
   1. Rough boring bar (Ø16mm)
   2. Finish boring bar (Ø16mm)
   3. ID threading bar

2) **OPERATION AND CYCLING TIME COMPARISON**

<table>
<thead>
<tr>
<th>S.NO</th>
<th>OPERATION</th>
<th>CYCLING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial facing (Ø80mm)</td>
<td>40sec</td>
</tr>
<tr>
<td>2</td>
<td>Initial boring (Ø21mm)</td>
<td>36sec</td>
</tr>
<tr>
<td>3</td>
<td>Rough boring (Ø21.5mm)</td>
<td>21sec</td>
</tr>
<tr>
<td>4</td>
<td>Chamfering (40)</td>
<td>24sec</td>
</tr>
<tr>
<td>5</td>
<td>Reaming (Ø21.9mm)</td>
<td>42sec</td>
</tr>
<tr>
<td>6</td>
<td>Boring (Ø30.7mm)</td>
<td>45sec</td>
</tr>
<tr>
<td>7</td>
<td>End mill cutting (Ø16mm) for Ø45mm spot face</td>
<td>52sec</td>
</tr>
<tr>
<td>8</td>
<td>Chamfering (for spot face and thread bore)</td>
<td>48sec</td>
</tr>
<tr>
<td>9</td>
<td>Final thread milling</td>
<td>2min 30 sec</td>
</tr>
</tbody>
</table>

**II operation in VMC machine**

The following table gives the sequence of II operation and its cycling time for VMC machine

Total time consumption for one complete operation is 458sec that is equal to 7min 38 sec.

**II operation in turning centre**

The following table gives the operation sequence and cycling time for same II operation in turning centre.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>OPERATION</th>
<th>CYCLING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rough Boring (Ø16mm)</td>
<td>2min 16sec</td>
</tr>
<tr>
<td>2</td>
<td>Finish Boring</td>
<td>1min 35sec</td>
</tr>
<tr>
<td>3</td>
<td>ID Threading</td>
<td>36sec</td>
</tr>
</tbody>
</table>

Total time consumption for one complete operation is 267sec that is equal to 4min 27sec.
III operation in VMC machine

The following table gives the operation sequence and cycling time for same III operation in VMC machine.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>OPERATION</th>
<th>CYCLING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Initial facing (Ø80mm)</td>
<td>40sec</td>
</tr>
<tr>
<td>2</td>
<td>Boring for (Ø30.7mm)</td>
<td>45sec</td>
</tr>
<tr>
<td>3</td>
<td>End milling for (Ø16mm)</td>
<td>52sec</td>
</tr>
<tr>
<td>4</td>
<td>Chamfering</td>
<td>48sec</td>
</tr>
<tr>
<td>5</td>
<td>GI Thread milling</td>
<td>2min 30sec</td>
</tr>
</tbody>
</table>

Total time consumption for one complete operation is 335sec that is equal to 5min 35sec.

III operation in turning centre

The following table gives the operation sequence and cycling time for same III operation in turning centre.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>OPERATION</th>
<th>CYCLING TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rough boring</td>
<td>1min 18sec</td>
</tr>
<tr>
<td>2</td>
<td>Finish boring</td>
<td>1min 02sec</td>
</tr>
<tr>
<td>3</td>
<td>ID Threading</td>
<td>36sec</td>
</tr>
</tbody>
</table>

Total time consumption for one complete operation is 176sec that is equal to 2min 56sec.

3) COST SAVINGS AND COMPARISONS

<table>
<thead>
<tr>
<th>S.NO</th>
<th>OPERATION</th>
<th>COST FOR VMC</th>
<th>COST FOR TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>II</td>
<td>Rs 44.52/-</td>
<td>Rs 18.54/-</td>
</tr>
</tbody>
</table>