Design Of Fixture To Measure Internal Contours Of A Casted Component

Femin Singh R, Shibu G

Abstract— A contour is labeled as an outline, boundary or border which is mainly seen in curved shape. Measuring contour of the casting components is an essential one. Generally this is carried out using surface texture measuring instruments which can only be used for measuring external contours. For measuring internal contours either the casting component has to cut or have to use laser technology. This will leads high cost and less productivity. So, proposed work mainly concentrates on the design of a fixture, which holds the casting component to measure the internal contour without a cut section. This will reduce the cost and leads high productivity. For these four different proposed concepts the properties and specifications of the design are also mentioned in this paper. Among four different fixture designs, one of the concepts is selected for development. The properties of selected fixture design for development are partially manual operated, linear motion along with X and Y direction and in-between stoppage at any point. The device pitch and yaws are also specified.

Index Terms— Casting Component, Contour, External Contour, Fixture, Internal Contour, Linear Motion, Pitch, Yaw.

1 INTRODUCTION

FIXTURE can be said as any base device which helps to hold or support any working machine or a component in industry of manufacturing. The main need of having a fixture in the work place is to firmly locate and support the work piece to guarantee that all parts produced using the fixture will maintain conformity and interchangeability. The fixture helps in the increase in the production of different components by allowing smooth operation and quick transition. It simplifies the work to be done and thus reduces the need of a skilled labor. By using a fixture it can minimize the work load of the operations to be done and increase accuracy, precision, reliability, and interchangeability in the finished parts. The main advantages of using a fixture in the work place are reducing work time, fast set-up and smoothing the transition from initial part to final part. Fixtures also permit higher operator safety in holding a piece steady and this result in the increase in manufacturing of high quality products.

1.1 Types of Fixture

Fixtures are classified into two according to the design of machine. They are milling fixtures and drill fixtures.

1. Milling fixtures are mainly used to perform milling operations such as straight cuts. This is mainly applicable for large objects since the fixture size is commonly large and strong. For this strong clamps are required to hold the finished products for measuring the size precise and accurate. Due to the vibration of the machine, positive stops are preferred over friction to keep the work piece safe from any type of destruction. Hydraulic and pneumatic clamps are mainly used for high-volume and automated processes.

2. Drilling fixtures have wide range of design set compare to milling fixtures. Usually drill is used to perform drill operations. In addition to drill operation, the drilling fixture can also be used to hold components by providing jigs. Hole and bush are the two common elements of drilling fixtures. In the drilling fixture holes are designed to allow space for the drill bit itself. This will help the work piece from damaging. Bushes in the drilling fixtures are simple bearing sleeves inserted into the holes to protect them and guide the drill bit.

2 LITERATURE REVIEW

A brief review of literature pertaining to the present work is explained below sections. The different types of existing systems related to the measuring of contours using different fixture model are explained below.

A. External Contour measuring system

It is a method of measuring the external features of the finished component. It is applicable only to measure the external contour. The below given Figure 1 shows the method of measuring external contour [4].

![Figure 1. External contour measuring systems [4]](image)

B. Internal Contour measuring system by Cut - Section

The internal contour measuring system measures the internal contour of the finished component by using cut section. The main advantage of this system is precise measurement. Disadvantages are high cost, less productivity and wastage of the component. The below given Figure 2 shows the method of measuring internal contours using cut section [5].

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C. Internal Contour measuring system by using lasers

This system measures the internal contour using lasers. Now a day’s it’s common that lasers are used as measuring system. The laser measuring can also be used for the calibration of Computer Numerical Control (CNC) machine. The main advantage of using lasers in measuring system is reliable, accurate and faster performance. The laser interferometer is directly interfaced with a computer. This method is quite easy and fast compared with other methods. Laser measuring system can also be used to measure some other movements like yaw, pitch, flatness, velocity etc. The advantages of this system are rapid measurement and high productivity. The demerits in this system are high cost and less accuracy.

3 PROPOSED CONCEPTS

Nowadays the contour of the casting components is measured by the surface texture measuring instruments. It is good enough to measure the external features with the finished components. But in the case of measuring the internal features of machined casting component there is a need of cut section. It leads to high cost and less productivity. So there is a need to design a fixture to measure the internal contour without cut section the component. This will reduce the cost and improve the productivity.

3.1 Proposed Fixture

The proposed fixture is a holding device which helps to hold the machined casting components to measure its internal as well as external features. The fixture helps the component to move in linear motion and rotator motion [1].

3.2 Required properties of the proposed fixture

i) X-Y Linear Motion Control

In the recent technology in manufacturing, working with 2D motions are in high demand. The X-Y linear motions are the 2D motions commonly used for parts assembly, machining and component insertion while manufacturing. The X-Y motion is monitored by using a X-Y table. In the X-Y table a rotary motor perform coupling to generate output from shaft to mechanical translators. In X-Y table 2D movement is achieved by utilizing gears to perform linear motion [2]. In x-y linear motion 3 different rotations are possible as yaw, roll and pitch. The different X-Y linear motions are described below.

1. Yaw – Rotation around the vertical axis
2. Roll – Rotation around the front to back axis
3. Pitch – Rotation around the side to side axis

The below Figure 3 shows orthogonal axis and 3 rotating (roll, pitch and yaw) motion and table 1 defines the mechanical parameters needed for the X-Y table construction.

![Figure 3. Orthogonal axis and 3 rotating motion](image)

Table 3.1: Parameters of X-Y table

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameters</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mass at X direction</td>
<td>1.5 kg</td>
</tr>
<tr>
<td>2</td>
<td>Mass at Y direction</td>
<td>1.0 kg</td>
</tr>
<tr>
<td>3</td>
<td>Stroke of X direction</td>
<td>40 mm</td>
</tr>
<tr>
<td>4</td>
<td>Stroke of Y direction</td>
<td>40 mm</td>
</tr>
<tr>
<td>5</td>
<td>Length</td>
<td>120 mm</td>
</tr>
<tr>
<td>6</td>
<td>Width</td>
<td>20 mm</td>
</tr>
<tr>
<td>7</td>
<td>Clearance for X direction</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>8</td>
<td>Clearance for Y direction</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>9</td>
<td>Pitch</td>
<td>24 mm</td>
</tr>
<tr>
<td>10</td>
<td>Tooth width</td>
<td>3 mm</td>
</tr>
<tr>
<td>11</td>
<td>Resolution</td>
<td>1.5 μm</td>
</tr>
</tbody>
</table>
fitted with dividing plates in which index plates are available for normal work position which is not available at divisions and this type of fixture is termed as dividing head or indexing head.

iii) Holding Device

Holding device can also be called as vice, which is a mechanical tool mainly utilized to keep an object safe when it is kept in the work position [8,9]. A common type of vice consists of two parallel jaws, in which one is fixed and the next one is movable. This can be stranded in and out by using a screw and lever. Usually a machine vice is mounted on grinding machines, drill presses and milling machines. The below given Table 2 shows mechanical parameters of the holding device.

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Max. jaw opening</th>
<th>Weight (kg)</th>
<th>Packing Master cartons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fixed</td>
<td>Swivel</td>
</tr>
<tr>
<td>75</td>
<td>75</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>125</td>
<td>125</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>150</td>
<td>150</td>
<td>6</td>
<td>7.0</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>8</td>
<td>9.5</td>
</tr>
</tbody>
</table>

Properties of the proposed fixture 1 are as follows:
- Manually operated fixture.
- Linearly moves along with X and Y direction stops either at 0 mm (starting point) or at 20 mm (specified point) and it cannot be halt at any of the other in-between points.
- The device pitch (Y-axis) up to 20° (anti clockwise) and 45° (clockwise).
- The device yaws (Z-axis) up to 20° (anti clockwise) and 40° (clockwise).

4.2 PROPOSED DESIGN 2

The below given Figure 5 shows the proposed fixture design 2.

The requirement of this design is used to assist the measuring instrument to read the measurements accurately. This three dimensional model is created by using PTC Computer Aided Design software version 3.0. This design consists of two linear motions and two auxiliary motions. The linear motions are controlled by using rail principle. The yaw rotation is controlled by the swivel bearing lock. The pitch rotation is controlled by the push type stopper and handler. The maximum bed distance of holding jaw is 130 mm.

Properties of the proposed fixture 2 are as follows:
- Partially manual operated fixture.
- Linear motion is controlled by a stepper motor in X-Y direction.
- Linearly moves along with X and Y direction from 0 mm (starting point) to 20 mm (specified point) and it

3.3 Required Specifications for the proposed fixtures

Below listed are the common specifications required for the construction of the four different proposed fixtures. The values of the different specifications only will differ from one type of fixture to the other [6,7]. These are the basic needs to be framed to start the designing of fixtures to be used for the internal measuring contours.

1. Maximum clamping dimension : 127 mm
2. Swivel with fixed x axis : 20deg both CW & CCW
3. Swivel with fixed y axis : 45 deg CW & 20 deg CCW
4. Linear movement through x & y axis : max

4 PROPOSED DESIGN – RESULTS

4.1 PROPOSED DESIGN 1

The below given Figure 4 shows the proposed fixture design 1.

![Figure 4 Proposed Fixture Design 1](image-url)

Figure 5 Proposed Concept Design 2

![Figure 5 Proposed Concept Design 2](image-url)
can be halted at the programmed points in stepper motor.
- The device pitch (Y-axis) up to 20° (anti clockwise) and 45° (clockwise).
- The device yaws (Z-axis) up to 360° anti clockwise and clockwise.
- Rolling position is controlled manually and so it can’t be accurate at all the extends.

4.3 PROPOSED DESIGN 3
The below Figure 6 shows the proposed fixture design 3.

This design is used to adjust the component to measure the contours of the completed parts. It consists of two linear motions and one rotational motion. This concept is used to place the rotational features as base activities. It is controlled by the spring type lock by rotating through handle. The linear motions are controlled by stepper motor. The stepper motor is running continuously and it can stop at any point by manual operation. In this design, the flat surface object can only place to measure. This three dimensional model is modeled by using PTC Creo version 3.0 Computer Aided Design software.

Properties of the proposed fixture 3 are as follows:
- Partially manual operated fixture.
- Linear motion is controlled by a stepper motor in X-Y direction.
- Linearly moves along with X and Y direction from 0 mm (starting point) to 20 mm (specified point) and it can be halted at any points manually.
- The device yaws (Z-axis) manually from 20° (anti clockwise) to 20° (clockwise).
- The roll and X-Y rotation interfere in some points and so the fixture can’t be works for all extends.

4.4 PROPOSED DESIGN 4
The below Figure 7 shows the proposed fixture design 4.

This concept is modeled to assist the measuring instrument to measure the values for quality check. It consists of two linear motions and one rotational motion. The linear motions are controlled by the guide rail function and screw gauge principle. The rotational motion is worked by the swivel bearing working condition and the movements are controlled by the worm gear principle. This screw gauge principle is not able to move the heavy objects. It is best to use for three dimensional printing objects like bracket, clamp etc. This model is design by PTC Creo-O 3.0 Computer Aided Design software.

Properties of the proposed fixture 4 are as follows:
- Partially manual operated fixture.
- Linear motion is controlled by a lead screw in X-Y direction.
- Linearly moves along with X and Y direction from 0 mm (starting point) to 20 mm (specified point).
- The device yaws (Z-axis) manually from 20° (anti clockwise) to 20° (clockwise).
- The fixture is designed specifically for light weight objects.

4.5 CONCEPT SELECTION
All the proposed fixture designs are analyzed and compared with each other and the best among them (Concept 2) is selected. The fixtures for the internal contour system are designed and different selection criteria are measured by using Creo software. The values for the different criteria are categorized within the range of 1 to 10 according to its performance. All the essential features are listed and the respective categorized values given for the final decision. The final fixture design selection is done by comparing the sum of all feature values [10]. The design with highest net score will be processed for next level. The criteria used for the concept selection is shown in Table 3.3.
Table 3.3 Concept Selection Procedure

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Proposed Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>BOM</td>
<td>9</td>
</tr>
<tr>
<td>Compact design</td>
<td>8</td>
</tr>
<tr>
<td>Ease of mechanical control</td>
<td>6</td>
</tr>
<tr>
<td>Durability</td>
<td>5</td>
</tr>
<tr>
<td>Accuracy</td>
<td>7</td>
</tr>
<tr>
<td>Linear motion</td>
<td>9</td>
</tr>
<tr>
<td>Roll motion</td>
<td>8</td>
</tr>
<tr>
<td>Yaw motion</td>
<td>8</td>
</tr>
<tr>
<td>Maintainability</td>
<td>9</td>
</tr>
<tr>
<td>Interface with other elements</td>
<td>8</td>
</tr>
<tr>
<td>Quality</td>
<td>10</td>
</tr>
<tr>
<td>Strength</td>
<td>6</td>
</tr>
<tr>
<td>Ergonomics</td>
<td>5</td>
</tr>
<tr>
<td>Ease of manufacture</td>
<td>9</td>
</tr>
<tr>
<td>Cost</td>
<td>9</td>
</tr>
<tr>
<td>User friendly</td>
<td>8</td>
</tr>
<tr>
<td>Average Net Score</td>
<td>7.75</td>
</tr>
<tr>
<td>Rank</td>
<td>2</td>
</tr>
</tbody>
</table>

In the first concept, there is no in-between stoppage, so only particular component can be checked. That means, this design is not suitable for all types of casted component. The cost of this design is high in case of production. So it is rejected. In the concept 2, it is designed in such a way to hold all type of casted components. The lock function is done by applying external torque and the bed distance is very less. But it fulfills the requirements. So this concept can be developing using minor changes. In concept 3, pitch motion is not available. The stepper motors used in this design stops only at certain fixed points. So this concept is rejected. Concept 4 is suitable only for light weighted objects like the output of 3D printers like prototype components. So it is rejected.

6 CONCLUSION

The present work, designs four different fixture models for the measurement of internal contours of casting components. Each proposed fixture design has its own mechanical specifications and working principles. Proposed concept 1 is manually operated fixture but difference in the in-between stoppages in linear motion along with X-Y direction. Concept 2, 3 and 4 are partially manual but difference in fixture size and rotary options. All the four proposed concepts are compared together and the proposed concept 2 (better design) is selected with properties - partially manually operated, linear motion along with X and Y direction and in-between stoppage at any point with the help of stepper motor. The device rolls (Y-axis) up to 20° (anti clockwise) and 45° (clockwise) and yaws (Z-axis) up to 360° anti clockwise and clockwise.

7 REFERENCES