ABSTRACT

The term automation has many definitions. Apparently, it was first used in the early 1950s to mean automatic handling of materials, particularly equipment used to unload and load stamping equipment. It has now become a general term referring to services performed, products manufactured and inspected, information handling, materials handling, and assembly—all done automatically (i.e., as an automatic operation without human involvement).

At present, in order to solve the low efficiency and high cost problem in the process of CNC machines, Nowadays Manufacturers have always faced the challenge of constantly needing to find new ways to reduce the cost of their loading and unloading processes in machining centres. In today’s globally connected world, however, the game is much tougher and the stakes are much higher. In order to meet the new challenge of sharply increased global competition, manufacturers are now being forced to cut costs more drastically than ever before. Those who do not succeed in doing so risk not only losing market share, but going out of business entirely. Inevitably, such cost cutting means automating manual processes and increasing the level of automation of semi automated processes. It also means re-evaluating current automation solutions in light of newer, more economical technology.

The project title is “Low cost Automation for CNC Machining Center” now a day CNC machining center is widely used in all industry for continuous production, less cycle time and more accuracy. For achievement of high production, low cost and less cycle time the system has to be fully automatic like auto loading and unloading the component.

Key words: Design and Development, CNC, Automation, Fixture, PLC Controller.

1.0 INTRODUCTION:

The present work contains the auto loading plate, unloading plate, hydraulic fixture and rotary table. With the help of PLC ladder logic, control the whole system. The main overview
of the work is to design a system which automatically loads the component and finishes the desired operation, finally unloads the finished component [1, 2, 3, and 4].

**Working principle:**

In its first phase the component is loaded to the fixture with the help of loading plate. Finishing the operation on the component is with the help of rotary table where the component is rotated 60° for each operation. Diameter of the component is 19mm and six slots (2mm thickness *4mm width *20mm length) around 60° rotations for each operation. Once the operation is over, the component falls in to the unloading plate through coolant tank outside the machine.

**Application:**

The finished component is used for power steering in cars (eg- Indica, Santro, Ford etc). By supplying hydraulic fluid through slots in these components, sudden rotation of steering in cars can be controlled.

**Merits:**

It is a simple automation project, as compared to the gantry automation system. In this work main advantage is to reduce the cost investments and loading and unloading cycle time. Using this system one operator can load the component on the loading plate around 20 machines continuously. For this type of machine system skilled operator is not required, because loading and unloading component to the fixture is fully automatic

2. DESIGN FOR AUTO LOADING AND UNLOADING SYSTEM:

2.1 Need for auto loading and unloading system:

i. Substitute expensive gantry, robot with loading system on the machine guarding consisting of ladder and automatically operated by only M-codes through cnc controller.

ii. 26 number of cylindrical workpieces or components of diameter 20mm can be held in loading plate.

iii. Once the components are held in loading plate, Loading and unloading is completely automatic till the completion of all the operation on the components.

iv. Machine can be utilized to maximum extent as it can also be used in noon recess

2.2 Design Objective:

i. To minimize loading and unloading time of the component.

ii. To minimize the set up and clamping time of the component.

iii. To economize the machining operation by reducing idle time

iv. To maximize the utilization of machine, there by reducing the payback period

v. To achieve consistency and repeatability of components.

vi. Faster rate of production.

vii. Floor space consumption should be less as compare to gantry system.
2.3 Design methodology:

![Diagram showing design methodology]

3. TECHNICAL SPECIFICATION OF THE MACHINE SELECTED FOR THE PROJECT:

3.1 Design considerations:

- Strokes of x, y and z axes
  - x-axis = 525 mm
  - y-axis = 400 mm
  - z-axis = 350 mm
- Machine table size = 900* 450
- Machine day light area = 175 mm
- Job loading height = 960 mm
- Possibility of machining within stroke
- No fixture should project out of the table towards column side. Any projection can cause accident on the z axis telescopic cover when the saddle goes to the motor end in y-axis.
3.3 conceptual machine layout with auto loading and unloading system:

3.4 conceptual 2D layout of fixture:

4. WORKING PRINCIPLE AUTO LOADING AND UNLOADING SYSTEM

Above fig shows the machine auto loading and unloading system of the component for machining.
In its first phase the component is loaded to the fixture with the help of loading plate which is mounted in guarding. Once finishing the operation on the component is with the help of rotary table where the component is rotated 60° for each operation. Diameter of the component is 19mm and six slots (2mm thickness * 4mm width * 20mm length) around 60° rotations for each operation. Once the operation is over, the component falls in to the unloading plate through coolant tank outside the machine.

4.1 LOADING SYSTEM:

![Fig 3D model of the loading system.](image)

The fig shows the loading system it contains many subparts are plate mounting, slider, linear bush along steel rod, left side component guiding block, two hydraulic cylinder, pins, nylon pad and spring.

4.1.1 Plate mounting:
Plate mounting is made of the c-45 material and mounted on the ladder through guarding in to the machine
- Linear tolerance for all tapped/free/counter holes to be within ±0.1mm.
- Linear tolerance b/n pair of 10h7 holes to be within ±0.01mm.

4.1.2 Slider plate:
It used to support and can be adjusted accordingly for different size of the component on the plate mounting. It is made of EN 354 material. It is divided into two parts because during production time, in case of fouling between slider and tail stock, we have to replace whole slider part. Instead of that we can replace the extended part very easily and even cost and time can be reduced. Specification:

<table>
<thead>
<tr>
<th></th>
<th>Slider plate</th>
<th>Extended plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>30<em>94</em>580</td>
<td>10<em>40</em>60</td>
</tr>
<tr>
<td>Material</td>
<td>EN-354</td>
<td>EN-354</td>
</tr>
</tbody>
</table>

Table 4.1.2 slider plate specification

Note: for while designing component.
- Chamfer all sharp edges to 1x45°, to be toughened 22-24 HRC, to be blackened.

4.1.3 Linear bushing along steel rod:
It is used for slide plate which slides over steel rod and it can be adjusted for different size of the component. It is made of steel material.
Steel rod | linear bush pad | supporting for steel rod plate
---|---|---
Size | 20mm (Ø) | 33*32*37 | 18.5*45*208
Material | steel | EN-354 | aluminum

Table 4.1.3 linear bushing along steel rod specification

4.1.4 Left side Block guides on loading plate:

The block guides support and slide the component. These three guides are made up of same material EN-354. Here also in the bottom, block guide is divided in to two parts instead of one solid part. Because during production time if there is any chance of fouling between bottom block guide and rotary table dead centre, instead of replacing the whole part we can replace only the extended part. We can save the material and production time. specification:

<table>
<thead>
<tr>
<th>Top block guide</th>
<th>Middle block guide</th>
<th>Bottom block guide</th>
<th>Bottom Extended strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size-</td>
<td>10<em>22</em>610</td>
<td>12.2<em>20</em>580</td>
<td>11<em>24</em>582</td>
</tr>
<tr>
<td>Material</td>
<td>EN-354</td>
<td>EN-354</td>
<td>EN-354</td>
</tr>
</tbody>
</table>

Table 4.1 Left side block guides on loading plate specification

4.1.5 Nylon pad and torsion spring:

It is fitted with torsion spring to stop the component at the end of the loading plate. It is made of the nylon material. It is flexible to rotate when component picking position. It rotates 80 degree during picking condition. In nylon pad assembly contain two parts one is fixed in the loading plate another one is change the nylon pad with respect to the component length. The different size of the component we are going to change additional part of the nylon pad, because in picking condition may be chances fouling to fixture. Once if we assembled the whole nylon assembly to loading plate no need change the spring and fixed part for next different size of the component. Instead of that we have change the additional part with help of two screws. It will save the fouling and time in mass production.
### Specification:

<table>
<thead>
<tr>
<th></th>
<th>Fixed nylon pad</th>
<th>Additional nylon pad for 150mm size component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>15<em>28</em>75</td>
<td>6<em>15</em>150</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>Nylon</td>
<td>Nylon</td>
</tr>
</tbody>
</table>

Table 4.1.5 Fixed nylon pad and additional nylon pad specification

### 4.1.6 Torsion Spring:

It is used to rotate the nylon pad up to $120^0$ when fixture pick the component from the loading position and again retain to initial position to stop the next component in loading position.

**Specification:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>$\Phi 6mm$</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>Spring steel c80 grade-3</td>
</tr>
</tbody>
</table>

Table 4.1.6 torsion spring

### 4.1.7 Compact Cylinder:

These cylinders are used for work holding fixtures and are very compact enabling compact design of the fixture. Compact cylinders are generally used in CNC machines because

- It is of very compact design. Fits in tightest areas of fixture
- Easy assembly and disassembly. It can be used for push and pull application
- It can be used for clamping, locating, ejecting and butting

**Features:**
• Has internal threaded piston rod, has compact height, maximum operating pressure 150bar.

![Fig 4.1.7 compact cylinder](image)

4.2 UNLOADING PLATES:
These plates are used to unload the component when operation is over. Here two unload plates are used. One is mounted on the fixture base and it moves along with the axis motion. Second plate is mounted on guarding and ladder support. When operation of the component is over, 1st component falls into the plate which is mounted on fixture base and then it rolls on to the guarding mounted plate. And finally it falls into the outside coolant tank which is mounted on outside ladder. Below fig shows the two unloading plates.

<table>
<thead>
<tr>
<th></th>
<th>Loading plate on guarding</th>
<th>Loading plate on fixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>size</td>
<td>3<em>251</em>680</td>
<td>2<em>220</em>270</td>
</tr>
<tr>
<td>material</td>
<td>CRCSS</td>
<td>CRCSS</td>
</tr>
</tbody>
</table>

Table 4.2a unloading plates mounted on the machine guarding and on fixture

![Fig 4.2a 3D model of unloading plate which is mounted on guarding](image) ![Fig 5.4b 3D model of unloading plate which is mounted on fixture](image)

5. TYPES OF COMPONENTS:
Below fig 5 shows the three different lengths of the cylindrical components that can be machined in this CNC machine. These three components are used in power steering rotation in cars. The material type is steel.
1. Smaller length of the component is (indica) -93.5mm
2. Medium length of the component is (santro) -140mm
3. Larger length of the component is (ford) -152mm.

![Fig 5 different length of component used for machining](image)
6. FLOW CHART FOR SEQUENCE OPERATION ON THE COMPONENT:

- Load the component on loading plate
- Fixture picks the component from the loading plate
- Fixture moves to the cutting zone
- Machining the key way slot operation on the component
- Check next component present at loading position
- CNC controller gives the message no component at loading position make sure the component
- Unload the component at unloading position
- Inception component
- Reject
- Accept

7. TYPE OF OPERATION ON THE COMPONENT

Above fig 7 shows the different length of components. Those components are semi-finished components from turning center. For next operation i.e. key way slot machining on component takes place in milling machine. The dimension of key slot (2 mm depth * 4 width * 20 mm length). These key way slots supplies hydraulic fluid for sudden rotation power steering in cars. With help of rotary table, the fixture component is rotated 60° for 6 key way slots on the component. Below fig shows the key way slots on the component. For loading the component of different length, adjust the slider plate on the loading system. The maximum size of 160mm length of component can be loaded in the loading system.

![Fig 7 after key way slot machining on the component](image-url)
8. CYCLE TIME CALCULATION

8.1 Time taken for loading and unloading system

Load the 26 components on loading plate. First component reaches to the picking position fixture comes and pick the component from the loading plate to the key way machining operation on the component. After finishing the operation, the fixture comes to the unloading position to unload the component on the unloading plate (system). Finally component falls in to the coolant tank through unloading plate.

Total time taken for loading and unloading component is = 15 seconds

8.2 Total time taken for one finish component

Total time taken for one finish component output = Loading and unloading time + Indexing time for component rotation (Idle time) + Component cutting time

Total time taken for one finish component output = 15sec+20sec+15sec =50sec

9. CONCLUSION AND SCOPE FOR FUTURE WORK:

9.1 CONCLUSION:

 ✓ The result of cycle time of loading and unloading of component is very less as compared to gantry auto loading system.
 ✓ Due to an optimized and pre-analyzed design, space consumption and cost of investment is made very less as per the requirement.
 ✓ For operating this system, skilled operator is not required, and if it is necessary to change the component of different length for operation, one just needs to change the tail stock position and nylon pad, and there are no modifications to be done in programming and logic side.
 ✓ There is not much of manual intervention and hence lot of human errors is reduced.
 ✓ The entire system is accurate due to the reduction of human errors.

9.2 SCOPE FOR FUTURE WORK:

1. This loading and unloading system can also be adapted to horizontal machining centre and other machining centres.
2. As per design calculation, now we can load 26 components at a time. To increase the number of components to be loaded, we can do it by increasing the length of the loading plate (with suitable design calculations).
3. If we choose the wider guarding machine and higher stroke machine, we can adopt this system on both the sides of the machine. Hence by loading 26 components (as per project) each at two different positions saves the operator loading time.
4. Instead of operator loading the component on the loading plate, we can interface the conveyer system for continuous loading.
5. Wrong/defective component detection with the help of machine vision.
6. If we change the loading plate design, we can load different kind of components.
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