# Design and Fabrication of CNC Lathe Fixture for Square Block

Vivek Khond[1], Vicky R. Gedekar[2], Himanshu S. Rewatkar[3], Kunal L. Parate[4]

[1] *Assistant Professor, Mechanical Engineering Department, G.H. Raisoni College of Engineering, Nagpur, Maharashtra, India*
[2] *Student, Mechanical Engineering Department, G.H. Raisoni College of Engineering, Nagpur, Maharashtra, India*
[3] *Student, Mechanical Engineering Department, G.H. Raisoni College of Engineering, Nagpur, Maharashtra, India*
[4] *Student, Mechanical Engineering Department, G.H. Raisoni College of Engineering, Nagpur, Maharashtra, India*

## ABSTRACT

*Manufacturing industries have brought lot of revolution in manufacturing technology, as a consequence of which several developments like CNC lathe, CNC machine center, flexible manufacturing system, fabrication center, transfer machines, robotics etc. took place. Even with these advancements in the manufacturing industries, there is a continued use of jigs and fixture in some form or the other either independently or in combination with other systems.*

*Fixture is a device for locating, holding, and supporting a component or work piece securely in definite position for a specific operation but it does not guide the cutting Tool. Fixture is required in various application. The various methodology uses for clamping operation use in different application by author revived in this paper. This paper present design and development of fixture for real industrial square block components. The operations to be performing are front facing and boring. Actually, four jaw chuck is best solution for performing required operation but four jaw chuck cost around 80 thousand rupees, whereas CNC fixture cost about 4000 rupees. Fixture reduces operation time and increases productivity and high quality of operation is possible. Fixtures are specially designed so that large number of component can be machined or assembled identically, to ensure interchangeability of components. Fixture hold or grip a work piece in the predetermined manner of firmness and location to perform a manufacturing operation on the work piece.*

**Keyword: -** *Fixture, square block, facing and boring, CNC-machine, four jaw chuck*

## 1. INTRODUCTION

If a component is to be produced in small numbers, then procedure adopted is marking out, setting on machine, clamping to machine table. But it would not be suitable for producing same component in large quantities because of economic reasons. A faster and more profitable method called for a device (fixture) on which component can be quickly positioned in the correct relationship to the cutting tool and quickly clamped before machining.

The fixtures are the economical ways to produce a component in mass. So, fixtures are used and serve as one of the most important facility of mass production system. These is special work holding device. Quality of the performance of a process largely influenced by the quality of jigs and fixtures used for this purpose. What makes a fixture unique

is that each one is built to fit a particular part or shape. The main purpose of a fixture is to locate and in the cases, hold a workpiece during an operation. Correct relationship and alignment between the tool and work must be maintained. Fixtures are designed to hold, support, and locate every part to ensure that part is machined within the specific limits

### 1.1 Problem Statement

The selection of chuck for manufacturing processes is mainly depend upon the size and shape of component or part which is to be manufactured. For cylindrical component, we used 3 jaw chuck, for square component we may use 4 jaw chuck or independent jaw chuck etc. In our industry where we done our internship, facing a problem of purchasing 4 jaw chuck for processing of square block component which is in Batch production type. Till now company processing mainly cylindrical component so they only having 3 jaw chuck and for some batch production of square block components they want to purchase 4 jaw chuck whose market prize is around 70k-80k which is not affordable. So, we suggested to fabricate a fixture/attachment to 3 jaw chuck so that it will processed square block component also in minimum cost of 4k.

### 1.2 Objective

The objectives of this project are to:

- Design a fixture that hold and process square block component on 3 jaw chuck.
- Evaluate the design in terms of force applied to fixture
- Fabricate the evaluated design

## 2. LITRATURE REVIEW

[Reference No.1]

Koji Teramoto, Masahiko Anasoto, and Kazuaki Iwata state that the objective of this project is to find an optimum design for a multi-purpose fixture for lathe bed (SBCNC 80/2000). Suitable clamping mechanism is also to be designed. The SBCNC 80/2000 lathe bed and its angle distribution.

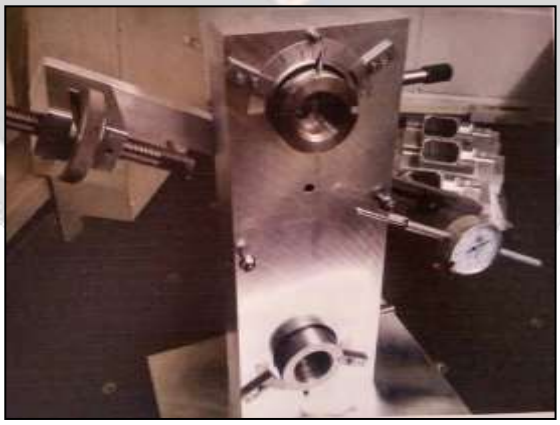

**Fig -1:** Multi-Purpose Fixture

[Reference No.2]

R. Hunter, J. Rios, J. M. Perez, and A. Vizan, says this fixture provides locating and clamping provisions for as large as 28 numbers of operations to be performed on support plate, one of the components of color mixing machine. The real-time application of the research reflects from the fact that a real industrial component is taken for fixture designing. The designed fixture has the important characteristic of allowing.

**Fig -2:** Milling Fixture for CNC

[Reference No.3]

Bo Li, and Shreyes N. Melkote presents design and Development of rotary fixture for real industrial component. The component is Flow TEE body of petroleum refinery. The operations to be performed are front facing, outside diameter turning, grooving, boring and back facing. Actually, HMC is the best solution for performing the required operations, but HMC costs around 12.5 million rupees whereas CNC turning center costs only about 2.5 million rupees.

**Fig -3**: Rotary Fixture for CNC

## 3. DESIGN DETAILS

### 3.1 Martial selection

For designing and fabricate the CNC machine fixture following parts are required for supporting, locating and clamping purpose.

It consists of following parts

- Base plate: - It is a mild steel material circular base plate .at 250mm diameter and 40 mm thickness with facing and machining operation. Three holes are creating at 1200 in 16mm diameter for fixing fixture in machine. Four holes are creating at a 5mm diameter for locator. And eight holes are creating for mounting the supporting block.

- Supporting Block: - It is mild steel flat plate 100*60 mm steps. Four supporting plates are used with milling and machining operation. It is mounted on base plate at the center 12mm diameter hole are created from which bolts are passes. Supporting block is used to
- Allen bolt: - It is made of high tension high carbon steel requirement of M16, M8 and M5 bolts.
- Cylindrical Locators: - Four cylindrical locators used to locate the workpiece and maintained the height of workpiece.
- Hexagonal Bolts: - for clamping purpose M12 mm bolts are required. For clamping the bolts need to tighten and for de-clamping bolts need to loosen.

**3.2 Design Details**

Force Calculations: -

Fixture load is 25 kg at loading condition so we have to convert kg into N.

25,000grams * 9.81(Gravitational Force) = 245000 N or 25 KN

Calculating Bending Stress For this force: -

Bending Force = 4/3 x F / ∏ x r2

= 4/3 x 245 x 103 / ∏ x 1302

= 6.15 N/mm2

Permissible Bending stress = 6.15 x 1.25

= 7.69 N/mm2

Shear Force = F/A

= 245 x 103 / ∏/4 x (260)2

= 4.614 N/mm2

Permissible Shear Stress = 4.614 x 1.25

= 5.77 N/mm2

So, we consider Plane Carbon Steel material for Designing Purpose, let's check design is safe or not: -

For Plane carbon steel: -

Sut = 503 and Syt = 421 (From Design Data Book Pg.39 table No. II-7)

So, we need to multiply Sut by 0.18 and Syt by 0.30 and consider the minimum Value of Stress.

Sut = 503 x 0.18 = **90.54 N/mm2**

Syt = 421 x 0.30 = **126.3 N/mm2**

So, minimum Value is **90.54 N/mm2.**

We divide it by Factor of safety (for Mild Steel F.O.S = 2)

Design Stress = Stress/ F.O.S = 90.54/2 = **45.27 N/mm2**

Permissible Stress is less Than Design Stress, so Design is safe and Mild Steel Material is Use for Further Design.

**Table-1:** Material selection and cost estimate of each component

| Sr.No. | Part Name | Material | Size | Quantity | Cost Estimate (Rs) |
|---|---|---|---|---|---|
| 1 | Base Plate | M.S. Plate | 250*40 | 1 | 1450 |
| 2 | Supporting Block | M.S. Flat | 100*65 | 1 | 500 |
| 3 | Hex Bolt | H.T Bolt | M12*30 | 4 | 200 |
| 4 | Cylindrical Locator | M.S. Round Bar | 55*15 | 1 | 60 |
| 5 | Allen Bolt (button) | H.C. Steel | 5*20 | 4 | 40 |
| 6 | Allen Bolt (Chuck Fixture) | H.C. Steel | M16*30 | 3 | 150 |
| 7 | Allen Bolt | H.C. Steel | M8*30 | 8 | 160 |
| 8 | Face Plate | M.S. Flat | 30*30 | 2 | 80 |
| 9 | Machining Process | - | - | - | 1360 |
| | **Total** | | | | **4000** |

**3.3 Principal of Location**

The principle of location is being discussed here with the help of a most popular example which is available in any of the book covering jigs and fixtures. It is important that one should understand the problem first. Any rectangular body many have three axes along x-axis, y-axis and z-axis. It can more along any of these axes or any of its movement can be released to these three axes. At the same time the body can also rotate about these axes too. So, total degree of freedom of the body along which it can move is six. For processing the body, it is required to restrain all the degree of freedom (DOF) by arranging suitable locating points and then clamping it in a fixed and required position. The basic principle used to locate the points is desirable as follows: -

Six Points Location of a Rectangular Block Considering the six degree of freedom of a rectangular block as shown in Figure 4.1. It is made to rest on several points on the jig body. Provide a rest to work piece on three points on the bottom x-y surface. This will stop the movement along z-axis, rotation with respect to x-axis and y-axis. Supporting it on the three points is considered as better support then one point or two points. Rest the work piece on two points of side surface (x-z); this will fix the movement of work piece along y-axis and rotation with respect to z-axis. Provide a support at one point of the adjacent surface (y-z) that will fix other remaining free movements. This principle of location of fixing points on the work piece is also named as 3-2-1 principle of fixture design as number of points selected at different faces of the work piece is 3, 2 and 1 respectively. Body to be restrained (each of the axis can be divided into two halves positive and negative)

Available Degree of Freedom of Rectangular Block

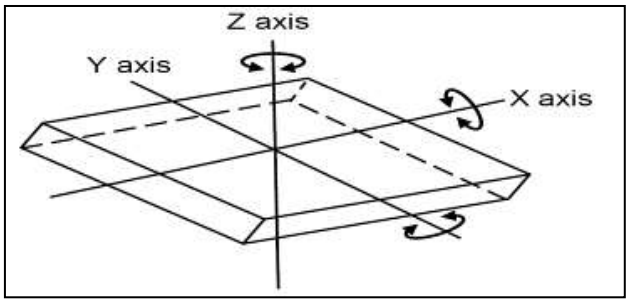


**Fig -4:** Degree of Freedom of Rectangular Block

Essentially Factors Considered During Design, Fabrication and Assembly of Jigs and Fixtures:

- Easy, quick and consistently accurate locating of the blank in fixture in reference to the cutting tool
- Providing strong, rigid and stable support to the blank
- Quick, strong and rigid clamping of the blank in the jig or fixture without interrupting any other operations
- Tool guidance for slender cutting tools like drills and reamers
- Easy and quick loading and unloading the job to and from the jig or fixture
- Use of minimum number of parts for making the jig or fixture
- Use of standard parts as much as possible
- Prevention of jamming of chips, i.e. wide chips-space and easy chip disposal
- Easy, quick and accurate indexing system if required.
- Easy and quick removal and replacement of small parts
- Manufacturability i.e. ease of manufacture
- Durability and maintainability
- Service life and overall expenses

**3.4 Working**

The Fixture is mounted on a CNC lathe machine the aim of fixture design is to maximize the production with minimum time duration. Firstly, we mount the fixture on the CNC lathe machine with the help of M16 Allen bolts which is attached to base plate of the fixture. After that we mount the workpiece on the cylindrical locator which is used to reduce or eliminate the contact between base plate and workpiece, resulting in reduced wear and tear of base plate and increasing the fixture life. There are four supporting blocks are mounted on the base plate with the help of Allen bolt of size M8. At the center of supporting blocks, we dill the hole of diameter of 12mm, through this hole we pass the Hexagonal bolt of size M12. For tightening the workpiece hexagonal bolt of size M12 is used. Out of four hexagonal bolts two are adjustable and other two are fixed to solve the purpose of center mounting of the workpiece. This may lead to reduce the changeover time of workpiece and setting time for new job. Spanner is used for overhauling the bolts and Nuts of the supporting blocks. For tightening the workpiece spanner rotates in clockwise direction and for loosening purpose spanner rotates in anti-clockwise direction. Firstly, for tightening of job we rotate spanner in clockwise Direction. Now workpiece is ready for machining process. We need to perform two processes on the workpiece, first one is Enlarging Diameter by grooving tool and second one is Surface Finishing by facing tool. After successfully mounting the workpiece, operator runs the program which he feed in machine according to the sequence of operations. After machining two hexagonal bolts are loosen with the help of spanner then finished workpiece is easily removed. The same cycle is repeated for same work. For the single cycle 9-10 mins are required including clamping of workpiece, processing of operations, and de-clamping of workpiece after machining is completed. In this way, the total working of fixture is done.

**Fig -5:** Actual Fixture

**Fig -6:** Actual Fixture

## 4. RESULT

**Table -2:** Comparison of 4-Jaw chuck & Fixture

| Sr. No | Parameter | 4-Jaw Chuck | Fixture |
|---|---|---|---|
| 1 | Time | More time required for clamping of workpiece because of independent jaws | Less time required as 2 hexagonal bolts are already fix so it's easy to clamp and de-clamp the workpiece |
| 2 | Cost | More cost, approx. Rs. 80k | Less cost Rs.4k only |
| 3 | Manpower | Skilled Operator required | Unskilled Operator also handled it Easily |
| 4 | Design | More Complicated Design | Less Complicated |
| 5 | Production Rate | As Clamping& De-clamping Time is more so less Production Rate | More Production rate, as time required for clamping & de-clamping is less |
| 6 | Speed | Same | Same |
| 7 | External Devices | Not Needed | Needed (ex. Bolts) |
| 8 | Jig | Not Needed | Needed (locator is used for giving exact workpiece position to tool) |

## 5. CONCLUSION & FUTURE SCOPE

### 5.1 Conclusion

- From this project, we have learned how to detect the problems in industry and how to minimize this problem.
- We have learnt about how to design a Fixture and the problem created during manufacturing and resolved it.
- During the purchasing of raw material, we know more information about the market.
- Getting a practical knowledge about the various operations like milling, tapping, drilling, and welding which used in manufacturing.
- Getting realistic knowledge about CNC machine and CNC Programming.
- Saving money of industry by giving them new idea about the fixture.

### 5.2 Future scope

- We can replace four jaw chuck of CNC lathe machine by introducing this fixture.
- Instead of spending more money on 4 jaw chuck for CNC lathe machine they can use this fixture at minimum cost.
- It is beneficial in cost saving as there is no need of skilled labor to operate this fixture as it's not so complicated, so unskilled labor can operate it easily.

## 6. REFERENCES

[1] Koji Teramoto, Masahiko Anasoto, and Kazuaki Iwata, Coordinative Generation of Machining and Fixturing Plans by a Modularized Problem Solver, CIRP Annuals, Manufacturing Technology, 47, 1998, 437–440.

[2] R. Hunter, J. Rios, J. M. Perez, and A. Vizan, A functional approach for the formalization of the fixture design process, International Journal of machine tools and manufacture, 46, 2006, 683–697.

[3] V. Arakelian, and M. Dahan, Dynamic balancing of mechanisms, Mechanics research communication, 27, 2000, 1-6.

[4] Khurmi Gupta, S. Chand Publication, "Machine Design", PN 377-430.

[5] Khanna Publication, "Production Technology", PN 773-805.

[6] Ibrahim M. Deiab, and Mohamed A. Elbestawi, "Experimental determination of the friction coefficient on the work piece-fixture contact surface in work holding applications", International Journal of Machine Tools & Manufacture, 45, 2005, 705-712.

[7]. Bo Li, and Shreyes N. Melkote, Improved work piece location accuracy through fixture layout optimization, International Journal of machine tools and manufacture, 39, 1999, 871–883.

[8]. S. K. Hargrove, and A. Kusiak, Computer-aided fixture design: a review", International Journal of Production Research, 32, 1994, 733–753.