

DESIGN OF FIXTURE TO REDUCE LOADING –UNLOADING TIME ON VMC MACHINE

Yash V. Dalvi¹, Shailesh M. Kawale², Akshay A. Sathe³, Pushpak B. Desale⁴,

¹B.Tech Student, Mechanical Department, SOET Sandip University, Nashik, Maharashtra, India

²B.Tech Student, Mechanical Department, SOET Sandip University, Nashik, Maharashtra, India

³B.Tech Student, Mechanical Department, SOET Sandip University, Nashik, Maharashtra, India

⁴B.Tech Student, Mechanical Department, SOET Sandip University, Nashik, Maharashtra, India

ABSTRACT

The aim of this article is to design and analyze the fixture for a VMC machine i.e. Vertical Machining Center for an Industry. Various fixture designing steps are mentioned in the article. Fixtures play an important role in the machining process. They are mostly used in mass production as they can reduce the loading and unloading time. Most of the small-scale industries in India look forward to affordable and effective fixtures which will save total lead time for the machining process. There are many operations such as turning, shaping, drilling that require skilled workers and any error in it will directly or indirectly affect the quality of the workpiece which is not acceptable. The fixture designing itself may be a vital process as a fixture is customized for every product. The accuracy and precision in the dimensions of fixture are important. Fixtures thus help by reducing all these variables and attributes in operation by providing support to the workpiece or component. The workpiece must be fixed and supported in a proper way when any mechanical operations are performed over it. It will be beneficial as it will reduce labor efforts, reduce loading-unloading time and improve the production of the workpiece. The analysis is going to be done on software called SOLIDWORKS 2019 while the modeling on CATIA V5 R12 and the design of fixture will be as per the requirement of the Industry. The component for which the fixture is to be designed is an automobile component that is rectangular in shape. Milling, drilling and grooving are the main operations.

Keyword – Fixture, Vertical machining center, mass production, accuracy, operations, milling, efforts.

1. INTRODUCTION

Fixture is a mechanical equipment which is used in mechanical industries to hold, locate and support the work piece during the machining process or operation. Use of the fixture drastically reduce fatigue of the worker and also provide safe working conditions to worker. This will make the machine efficient and in design process of fixture one may gain the knowledge of design, fabrication, and also about manufacturing. The fixture designing is an important process as the whole operation depends on it as so does the quality of the part. The accuracy and precision in the dimensions of fixture are important otherwise the final product may get affected. This project will give us knowledge, experience, skill and new ideas of manufacturing. It is a design, analysis and manufacturing project and has guarantee of success. This project is Industry Sponsored project. The Industry needs useful fixture to reduce loading, unloading time and save overall time. Hence, we have selected this project [1].

1.1 Fixture

Fixture is a work holding device for holding, supporting and positioning the work piece for specific operations. It only provides a reference surface or device. Jig may be a work device that holds, supports, locates workpiece and guides the cutter during the operation. Fixture doesn't provide any help to guide the tool as that of jig. But it's always fixed during a particular position on the machine. Fixtures are mostly used in mass production. It saves time also as cost.

Types of fixture

- Adjustable fixture
- Grinding fixtures
- Welding fixture
- Assembly fixture
- Inspection fixtures
- Milling fixtures:
- Straddle milling fixture
- Indexing fixtures

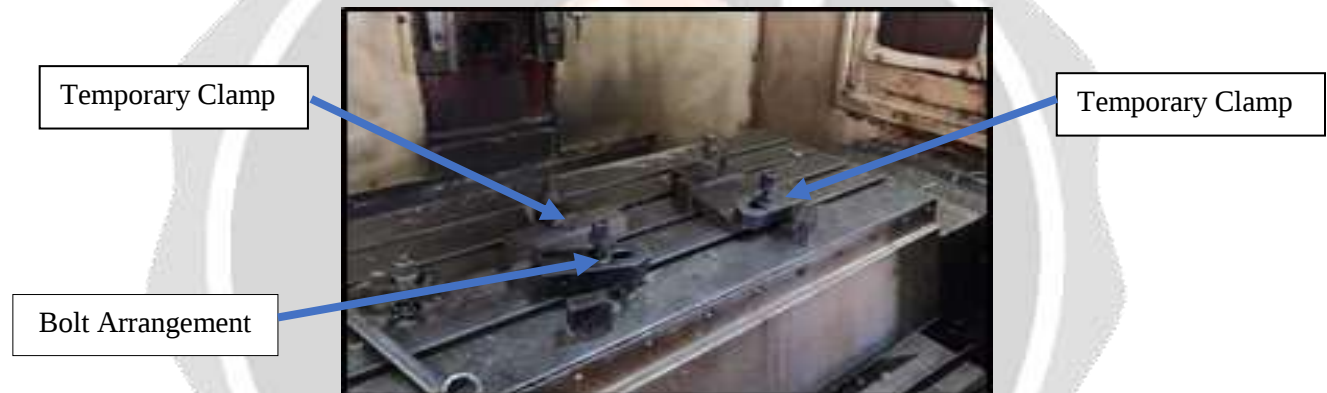


Fig -1: Current clamping method

1.2 Need of Fixture

The main purpose of the fixture is to locate the work piece quickly and accurately, Support it properly and hold it securely, thereby ensuring that all parts machined in VMC will be within the specified limits. In this way, we can improve accuracy and also the production rate of the parts. If there is improvement in the inter changeability of the parts, then the fixture will contribute to a considerable reduction in the cost of assembly, maintenance and improve the quality of the parts produced. The main goal is to save time, money, efforts and also to design a fixture in such a way as to make it foolproof, and there by contribute to add safety for the operator as well as for the machine tools and other parts being used [2].

1.3 Objective of the Project

1. To reduce loading and well as unloading time of the workpiece.
2. To reduce the Labor efforts
3. To improve the production of the workpiece.
4. To design such a fixture that can hold more than one workpiece.

1.4 Limitations of the Project

1. This project mainly focuses on design part only.
2. Manufacturing of the fixture will be done by the Industry after getting sufficient orders of the workpiece.
3. The Testing and result will be approximate rather than accurate.

1.5 Expected outcome

1. Designing a proper and suitable fixture for the workpiece.
2. Know the steps / procedure involved in Fixture Designing.
3. Understand the concept, function and application of Fixture.

2. LITERATURE REVIEW

Bhaskar Patil et al have explained in brief the overview of fixture design for Indian industries. They have discussed about the general process of designing a fixture and the functions of it in application to the product manufacturing in mechanical industries [1].

Sanket, Ambadas et al, they have focused on the design and analyzing the special fixture used to hold, support and guide the component body which is used in defence application. Fixture modeling of each component and its assembly is done in software called solidworks and FE analysis is conducted using ANSYS [2].

Harshita S. Umale et al, in their paper have reviewed literature survey about Computer Aided Fixture Design and its approaches. It includes the basic importance of fixture and proper fixturing techniques, also the design aspects and requirements that are needed while fixture designing [3].

Giovanni Moronia et al, have proposed the robust design of fixture configuration. In this paper, they have investigated on how the fixture element deviations and machine tool errors affects machining operations quality. This work proposed a methodology for robust design of fixture configuration considering the random error of locator position [4].

3. METHODOLOGY

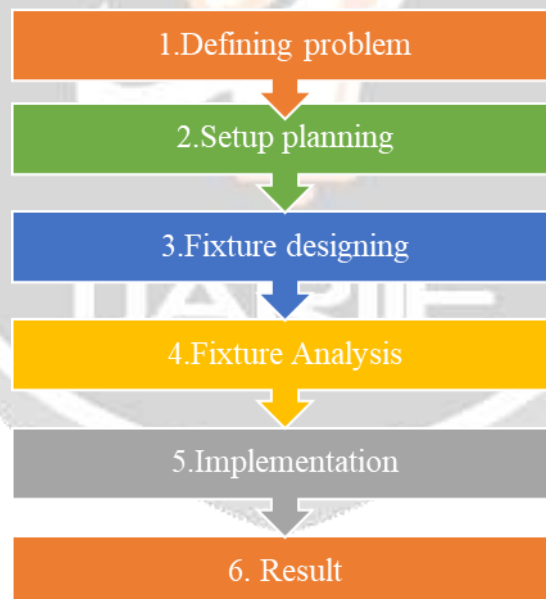


Chart -1: General Methodology

First we started for selection of project and finalization, we started understanding the problem and observed the processes and operation done on workpiece. The Literature survey was done where we searched and collected research papers in which previous work was done in fixture design. After brainstorming and discussion we started designing the fixture. We came up with various designs, further we presented the designed to the industry and then they finalized the design and made a 3D model using CATIA V5 R1. The analysis part was done in SOLIDWORKS 2019 after that.

4. OBSERVATIONS

Table -1: Time required for Task

Sr.no	Task	Time		
		Reading 1	Reading 2	Reading 3
1	Loading time taken by operator	43 sec	38 sec	45 sec
2	Total Program Time	19 min 50 sec	19 min 50 sec	19 min 50 sec
3	Unloading Time	12 sec	13 sec	15 sec
4	Miscellaneous (Cleaning & Inspection time)	28 sec	30 sec	38 sec

Table -2: Tool operations

Sr.no	Tool No.	Tool Diameter (mm)	Operation	Feed (mm/min)	Speed (rpm)
1	T1	Ø12 mm	Centre Punch & Drilling	40	1000
2	T2	Ø20 mm	Drilling & Milling	50	400
3	T4	Ø40 mm	Drilling	1800	1800
4	T6	Ø16 mm	Grooving	2200	4500
5	T5	Ø12 mm	Finishing	1500	3000

Machine for which fixture is to be Designed: VMC JYOTI 1050 (3-AXIS) (1000 mm x 600 mm x 500 mm)

Workpiece Part: Tractor Rod

Dimension of the Part: 649 mm * 66.4mm * 16mm

Material of Part: M.S



Fig -1: Actual Workpiece



Fig -2: Actual VMC machine

4. DESIGN

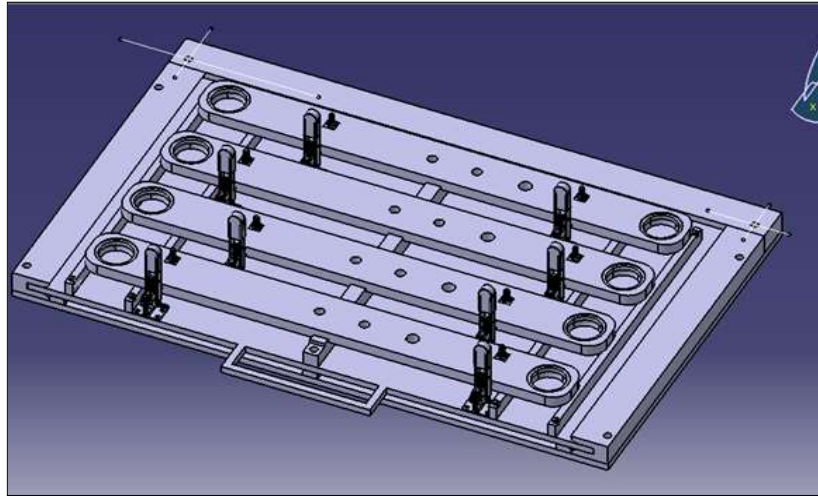


Fig -3: 3D Model of Designed Fixture

The design consists of a sliding trolley or tray in which we will be able to fix more than one workpiece on the machine. The design is shown in the previous page. After some modification and changes, the final design was fixed. The idea for design was got from the Refrigerator tray, the sliding action was desirable as it will be easy for the operator to load and unload the workpiece and with less efforts. The other feature of the fixture is that if the component changes or the workpiece changes, most of the parts will remain same, just the tray part need to be designed as per the workpiece, rest of the components will remain the same. The design can thus be flexible as per the workpiece, only the tray component is to be designed and manufactured. The other advantage of the fixture is that it has the capacity of 4 workpiece which means that 4 workpiece can be machined at one go and it will also save time and improve.

The components of the fixture are as follows:

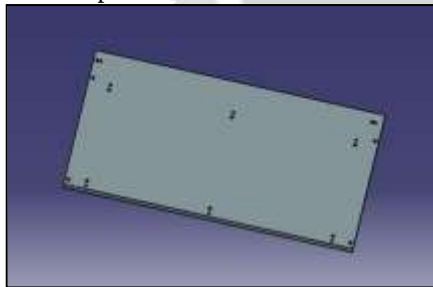


Fig -4: Base Plate

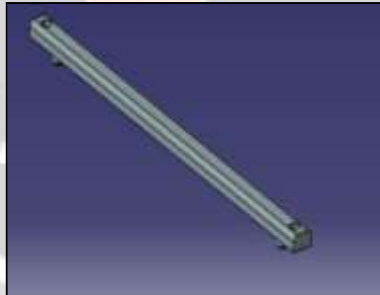


Fig -5: Base Plate Support



Fig -6: Tray

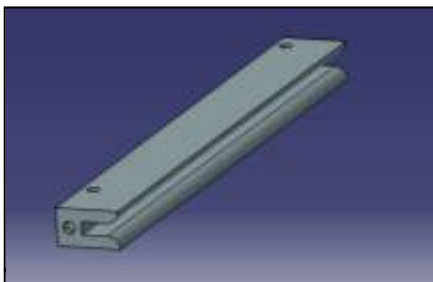


Fig -7: LHS/ RHS Slot



Fig -8: Tray Side Support rib

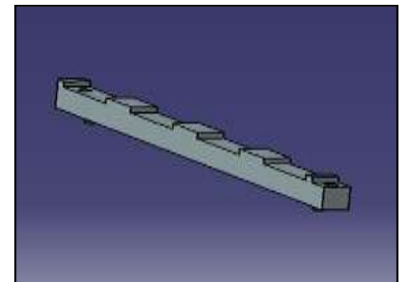


Fig -9: Tray Center Support

5. CALCULATIONS

Machine Torque = 40 N m (spindle torque)
 Maximum diameter of tool = ϕ 50 mm = d
 Radius (r) = diameter/ 2 = 50/2 =25 mm= 0.025m.
 External Force = 0
 Cutter force on workpiece
 $T = F \cdot r$
 $F = T/r$
 $= 40/0.025$
 $= 1600 \text{ N}$
 $F = 1600 \text{ N}$

Torque on Fixture (T)
 $T = \text{Force} \times \text{Perpendicular distance}$
 $= 1600 \times 312.5 \text{ (mm)}$
 $= 1600 \times (312.5/1000)$
 $= 1600 \times 0.3125$
 $T = 500 \text{ N. m}$

For 1600N force, we selected Toggle Clamp of 1000N
 Thus, for 2 Clamps,
 Toggle Clamp Force (F) = 1000+ 1000
 Toggle Clamp Force (F) = 2000 N

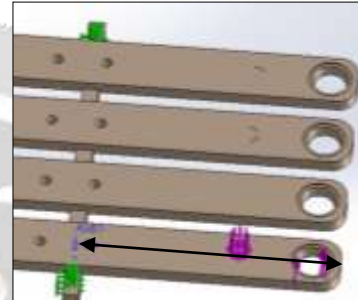


Fig -10: Torque application

6. ANALYSIS

Condition: Toggle force = 2000 N
 Torque applied = 1600 N. m
 Supported by center and side ribs on both sides

Permissible Stress = $2.206 \times 10^8 \text{ N/m}^2$
 Analyzed Value of Stress = $4.28 \times 10^6 \text{ N/m}^2$
 Analyzed Displacement = 0.0075 mm
 Analyzed Value < Permissible Value (**Safe**)

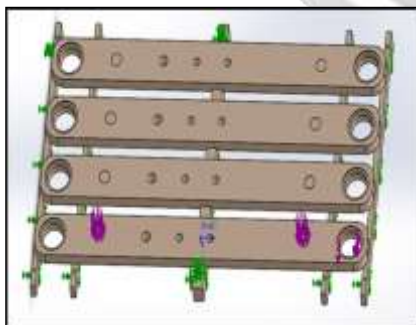


Fig- 11: Initial Condition

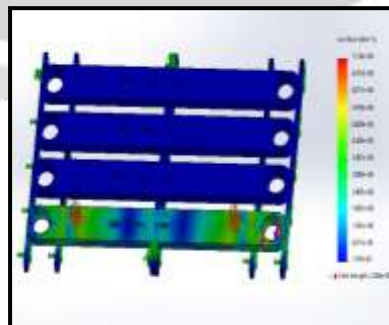


Fig-12: Stress Analysis (von misses)

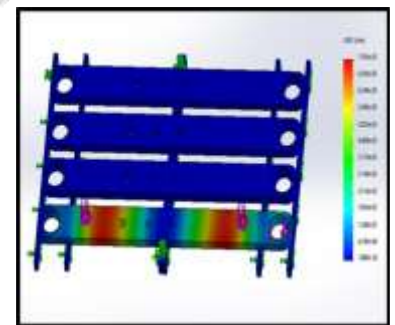


Fig -13: Displacement Analysis

8. RESULTS

The value of stress and displacement were within the limit and thus the design is safe from design point of view.

Stress Developed = $4.20 \times 10^6 \text{ N/m}^2$

Maximum Displacement = 0.0075mm

In this case, stress and displacement is safe.

9. CONCLUSIONS

In the Analysis, the value of stress and displacement is within the limit and thus the design is safe. The use of fixture can reduce the loading and unloading time. For 1 job, 53.3 sec is required. Now, for 4 jobs same 53.3 sec are required. Earlier the effort required for 1 job is now equivalent to the amount of effort required for 4 jobs. As a result, productivity will improve.

10. REFERENCES

- [1]. Patil B. Sambhaji, Mhatre S. Sudhakar, Gaikar R. Bhausaheb, Chaudhari A. Digamber, Prof. S. S. Chikshe. "Overview of Fixture Design for Indian Industries". International Journal of Innovations in Engineering Research and Technology. Issn: 2394-3696 Volume 7, Issue 5, 2020.
- [2]. Sanket, Ambadas, Babu Reddy. "Design and Analysis of Fixture for component Body in HMC-800" International Research Journal of Engineering and Technology. eISSN: 2395-0056 Volume: 04 Issue: 10. 2017.
- [3]. Harshita S. Umal, Nilesh H. Khandar, Rajkumar D. Palhade. "Recent Trends in Computer aided Fixture Design Review on approaches". International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308, 2016.
- [4]. Giovanni Moroni, Stefano Petro, Wilma Polini. "Robust design of fixture configuration". Procedia CIRP 21 189 – 194 2212-8271 Elsevier. doi: 10.1016/j.procir.2014.03.120 24th CIRP Design Conference, 2014.
- [5]. Shailesh S.Pachbha, Laukik P.Raut. "A Review on Design of Fixtures". International Journal of Engineering Research and General Science Volume 2, ISSN 2091-2730. Issue 2, 2014.