International Journal of Engineering Research in Current Trends (IJERCT)
ISSN: 2582-5488, Volume-4 Issue-6, December 2022

Design and Analysis of Link Clamp

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Abstract:A fixture is a device used in the manufacturing industry to hold a work piece, position it appropriately in relation to a machine tool, and support it while it is being machined. Fixtures, which are widely utilised in manufacturing, have a direct influence on product quality, productivity, and cost. The cost of designing and constructing fixtures can account for 10% to 20% of the entire cost of the production system. The Design of Machining Fixture for Support Bracket for Machining on Body Contact Face Milling is shown in this project. Fixture Design includes a high product rate and a low cost of manufacturing operation. The fixture should be built in such a way that there is relatively little part/product change over time. Following that, the machining fixture concept is completed. The clamping and locating points have been decided. This covers accessibility, part loading and unloading sequences, and the material required for this fixture. The clamping system for the fixture is designed to hold the component in place and remove it quickly. Cad modelling was done in Catia, while analysis was done in ANSYS. The fixture's distinguishing characteristic is that it may be utilised for two distinct components. This fixture was created in such a way that it might be utilised for other vehicle fixtures in the future, saving money.

INTRODUCTION

A fixture is a tool that maintains a work component in the correct position throughout the manufacturing process. A device called a fixture is used to clamp and support the workpiece in its location. Fixtures remove the need for putting, frequent checking, non-uniform quality, and individual labelling in the production process. [1] Fixtures are used to locate, support, and entirely confine the work piece while it is being machined. A important step in process planning is to design a fixture that allows precise machining of the workpiece while limiting the contribution of work-piece/fixture elastic deformation to the machining error within the prescribed tolerance.

The optimization of the fixture arrangement, that is, the placements of locators and clamps, as well as clamping forces, is an important part of fixture design! The workpiece was distorted as a result of clamping and machining minimization. [2] Fixtures for manufacturing and assembly are designed to ensure unique, accurate, and repeatable placement of the item, as well as sufficient work-holding to prevent movement of the part during machining or assembly. Multiple clamps are commonly used to hold work in a fixture. [3]

Mechanical vices and other machining fixtures rely on a wide contact area to provide enough frictional resistance to keep the workpiece from moving about in the fixture. This type of fixture varies from traditional machining fixtures that employ point (spherical tip) and line (cylindrical) contacts in that it may limit a restraining moment/torque in addition to normal and tangential forces. [4]

1.2 Purpose of Fixtures

- The main purpose of the fixture is to locate the work quickly and accurate support it properly and hold it securely, thereby ensuring that all parts. Produced in the fixture will come out alike within the specified limits, in this Way accuracy and interchangeability of the parts are provided.[22]
- It also reduces working time in the various phases of the operation, in the setup and clamping the work in the adjustment of the cutting tool to the required dimensions, during the cutting operation itself by allowing heavier feeds due to more efficient work support.
- It serves to simplify otherwise complicated operations so that cheaper and relatively unskilled labor may be employed to perform operations previously reserved for skilled machines.
- By maintaining or even improving the interchangeability of the parts, a jig or fixture contributes to a considerable reduction in the cost of assembly, maintenance and the subsequent the potential of standard machines and the quality of the parts produced.
- One important goal is used to design a fixture in such a way as to make it Foolproof, and there by contribute to added safety for the operator as well for the work.[20]

1.3 Hydraulic Fixture

A machining fixture is a precise device used to locate and limit the work piece while it is being machined. The focus of this research is on machining fixtures. A machining fixture is used to establish and maintain a work-requisite piece's position and orientation so that cutting operations may be done on it. It's an important aspect of the machining system since it has a direct impact on operating safety and part quality. [7] A base plate with a number of locators and clamps make up a basic machining fixture.

Clamps are active fixture elements that can be actuated mechanically, pneumatically, or hydraulically to apply clamping forces onto the work-piece so that it can resist external forces generated by the machining operation. Locators are passive fixture elements that are used to position the work-piece while clamps are active fixture elements that can be actuated mechanically, pneumatically, or hydraulically to apply clamping forces onto the work-piece so that it can resist external forces generated by the

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machining operation. There are several fixture designs to choose from. For the contact zone between a fixture element and the workpiece, the geometry might be point, line, or plane. [16] In the fixture design process, it is necessary to design the fixture arrangement and optimise clamping forces. The elastic deformation of the work-piece is minimised by designing the best fixture configuration and clamping force. In terms of precision, accuracy, and surface smoothness of machined items, proper fixture design is critical.

2.1 Design of fixture–location and clamping considerations

Work holding is an important feature of machining, and fixtures are the elements responsible for achieving this aim. In most cases, one or more physical parts are employed to create a fixture solution; nonetheless, the complete intended fixture solution must fulfil all FRs and related Cs. The fixture's functional requirements include centering, locating, orienting, clamping, and supporting. Many factors must be considered when considering constraints, including the shape and dimensions of the part to be machined, tolerances, sequence of operations, machining strategies, cutting forces, number of set-ups, set-up times, amount of material to be removed, batch size, production rate, machine morphology, machine capacity, cost, and so on.

Finally, the solution's correctness, simplicity, dependability, rigidity, and economy are used to characterise it. [6]. The primary goal is to design, build, and test a hydraulic fixture for machining engine cylinder blocks on a vertical milling machine. Keeping machining precision and tolerances by minimising fixture and workpiece deflections caused by clamping forces. [7]

S. K. Hargrove and A. Kusiak [8] identify four general requirements of a fixture: I accurate work-piece position, (ii) total work-piece constraint during machining, (iii) limited work-piece deformation, and (iv) no machining interference. Dynamic machining circumstances, as defined by R. T. Meyer and F. W. Liou [9], occur when machining forces travel across or along the surface of a work piece. A viable fixture for dynamic machining of a work part must ensure the following: the work part is restrained at all times, the clamping forces are not excessively large or small, deterministic positioning, accessibility, stability of the work part in the fixture when no external forces are applied, and a positive clamping sequence.

Fixture design and manufacture is a complicated process that necessitates a thorough understanding of a variety of topics, including geometry, tolerances, measurements, procedures, and manufacturing processes. Design concepts are constrained by the machine's requirements and constraints. A designer has to be familiar with production techniques in order to create a fixture and collet. He must be able to envision the finished product in detail. He should be able to assess the advantages and disadvantages of various approaches. Standards and processes must be familiar to him. He needs to be unique and imaginative. He needs to be able to put his thoughts into design layouts. He has to be aware of how tools work. He'll need a solid foundation in mechanics and arithmetic. He should also be aware of the physical characteristics of the materials used in tool manufacturing. [10] The term "functional requirement" (FR) "represents what the product needs to or must perform regardless of any conceivable solution." A constraint (C) is described as "a limitation that impacts some form of need in general, limiting the range of feasible solutions while meeting the criteria." [11]. Various aspects of fixture design, such as machining fixture knowledge, optimising work-piece setups, force modelling, enhancing workpiece position, and high-efficiency tools [8, 12-14].

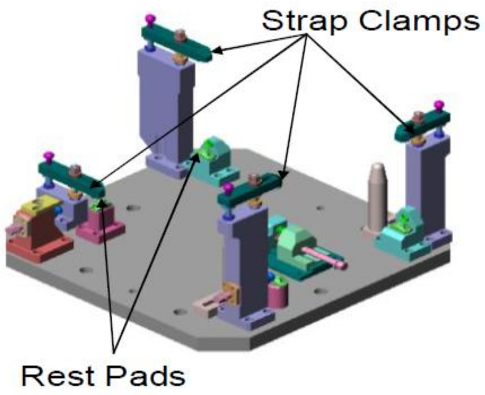


Fig 1.1: Mechanical Fixture

3.1 Procedure for fixture design

• Design of Fixture

• 3D modelling

• Finalize Layout

• Detailing Bill of Materials (SAP)

• Indent Requirements from Planning Dept. (APL) **Steps Involved in Fixture Design**

- Study of component
- Development of conceptual layout considering loading of component for fixture.
- Apply 3-2-1 principle, orientation mechanism and clamping elements has to consider.
- Fool Proofing of component during loading has to consider.
- Modeling of various parts on 3D software.
- Assembly of individual parts
- Approval of the Design by the Team Leader.
- Detailing and documentation of fixture.

Technical Parts List (TPL) ON SAP

For each fixture, it's critical to prepare the TPL. A technical parts list is a document that contains all of the necessary information about a fixture, such as the work order number, drawing location, quantity to be ordered, and materials. [17] While preparing the TPL, there are a few recommendations to keep in mind.

- Machining allowance should be given to the size of the raw material
- Entry of BOM under main TPL header (200,600,900,500 items)

Programs used for Technical Part List (TPL)

MM01 =Creation of Material Master
MM02 =Modification of Material Master
MM03 =Display only of Material Master
CC01 =Creation of Change No.
CC02 =Release of Change No.
CC03 =Display only of Change No.
CS01 = First time entry of Bill of Material
CS02 =Modification or Second time entry of Bill of Material
CS03 =Display Only of Bill OF Material

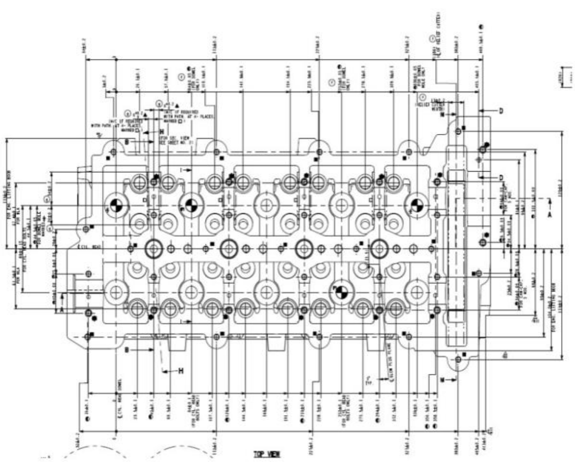
Gas Cut Tracings

The gas cut must be drawn for nonstandard base plates. The metal is sliced with oxyacetylene gas. It passes through a very small hole at a high temperature, and the substance is removed. The pointer follows the line of the gas cut, and the cutting is carried out appropriately. [4] As a result, it's critical to stick to the guidelines while drawing the gas shutoff. To be followed are the following guidelines:

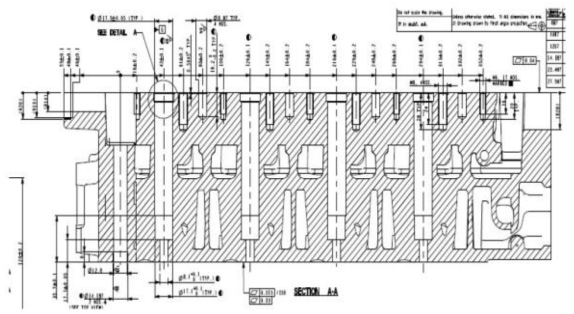
1. A machining allowance of 3mm is given for plates having thickness less than 30mm.
2. An allowance of 5mm is given for plates having thickness from 30 to 50mm.
3. No machining allowance to be given if the plate has no machining process.
4. Drawing line thickness should be 1mm.
5. No sharp corners to be present. A fillet radius of 3mm is to be given at all corners. [22]

Component Details

- **Component :** Cylinder Head
- **Material** : Aluminium Alloy.
- **Input Condition** : cast part
- **Weight** : 11.7 kg



Component Drawing (Cover contact face)



Component Drawing

Result & Discussion

Stress Plot for Link

The Link exerts force on the component in order to keep it in place. Link is exerting a 2000N force. The Static Stress Plot for Link is shown in Fig. 5.1 below.

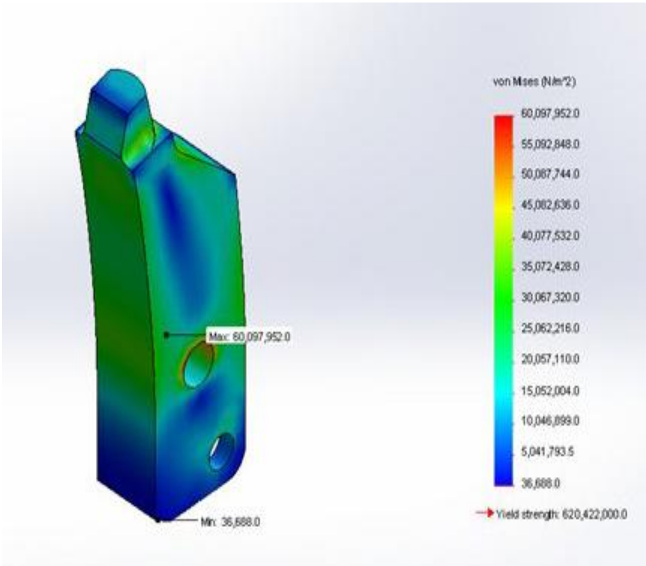


Fig. Static Stress Plot for linkMaterial Properties

Material: Plain Carbon Steel
Mass: 0.33 kg
Volume: 4.34779e-005 m^3
Elastic modulus: 2.1e+011 N/m^2
Poisson's ratio: 0.28
Shear modulus: 7.9e+010 N/m^2
Mass density: 7800 kg/m^3
Tensile strength: 3.9983e+008 N/m^2
Yield strength: 2.2059e+008 N/m^2

Analysis Results
Maximum Stress: $6.009x10^6$
Deformation Scale: 263.201

Stress Plot for Link 2

Link length is 97 mm. Link is applying the force of 2N. The below Fig 5.3 shows the Static Stress Plot for Link.

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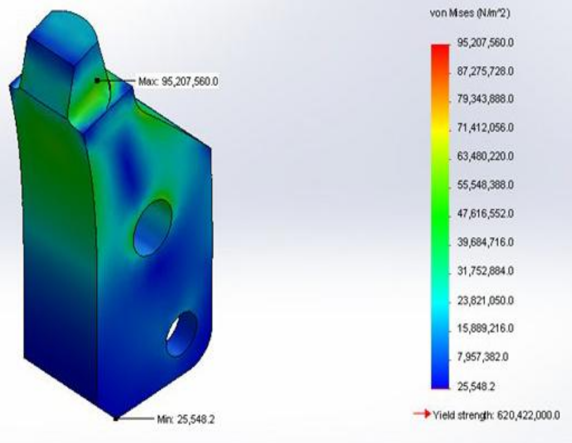

Fig. Static stress plot for link 2

Material Properties

Material: Plain Carbon Steel
Mass: 0.2022kg
Volume: 2.6272e-005 m^3
Elastic modulus: 2.1e+011 N/m^2
Poisson's ratio: 0.28
Shear modulus: 7.9e+010 N/m^2

Analysis Results
Maximum Stress: $9.5207 x 10^7$
Deformation Scale: 312.9

Displacement Plot for Link 2
Link length is 97 mm. Link is applying the force of 3000N. The below Fig 5.4 shows the Static Stress Plot for Link.

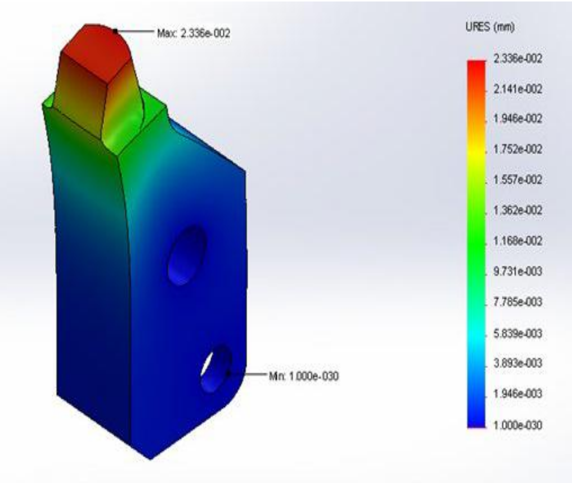

Fig. Static Displacement Plot for link 2

Meshing Properties:

Mesh Type: Solid mesh
Smooth Surface: On
Jacobian Check: 4 Points
Element Size: 2.97384 mm
Tolerance: 0.1486 mm
Quality: High
Number of elements: 8187
Number of nodes: 12944

Analysis Results:

Deformation Scale : 133.493
Max. Displacement : 0.0233552mm

The maximum stress at the link and the maximum deflection at the link end are both within the limit, according to the aforementioned study. As a result, Link can exert a force of 3000N.

CONCLUSION

Tata Motors Pune has successfully developed and built a fixture for machining the Contact Covering Face. This fixture was created for Srinivas Engineering, one of Tata Motors' primary suppliers. The following are the outcomes of the fixture's design and testing.

The fixture has the unusual property of being able to be utilised for two distinct components.

The entire assembly accuracy was within the required limit thanks to rigid clamping and correct loading sequence, with no part deformation.

Because this fixture is utilised for two components, it saves money on fixture manufacture, which is one of the company's most beneficial and lucrative characteristics. One fixture might cost anything between Rs 12 and Rs 14 lakhs. Thus, the firm saved roughly Rs 8 to Rs 10 lacs by changing the prior fixture to fit the new component.

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