Design and analysis of hydraulic fixture for hydraulic lift housing

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Abstract. Fixtures are used to hold the work piece during machining operations. It is also used during the time of inspection, welding and assembling process. This paper presents, design analysis and development of hydraulic fixture for real industrial fixture. The component is hydraulic lift housing which is tractor part. The operations to be performed are milling, drilling, reaming & chambering on VMC. In existing design, the fixture set up is done by hydraulic. The existing fixture design is vibration occurs from the machining process, so product quality is less. From existing research analysis in this area, our project idea is extra hinge clamp device has to be added. Hydraulic fixture to reduce vibration and increase the product quality. In this research is analyzed by ANSYS we have found that the new fixture design will be better than existing model because the new model will give the less amount of vibration than existing model.

1. Introduction
Fixture is a device used to locate, clamp and support a work piece during machining, assembly or inspection. The most important criteria’s for fixturing are work piece stability, position accuracy and work piece deformation. A good fixture design is one that minimizes work piece geometric error [6-9]. A clamping system that uses high-pressure liquids to power clamps and hold a work piece in place. Hydraulically clamped fixtures have many advantages over manually clamped fixtures. In most cases, these benefits reduce costs for manufacturers allowing them to justify the initial investment for a hydraulic clamping system [11-15].

Komal Barge et. al [1] have done the work of Design & Development of Hydraulic Fixture for VMC a review in this research, the found that implementation of this project eliminates the need of human operator for clamping of manifolds. The suggested system helps in achieving sophisticated, precise, reliable, safe as well as accurate production methods. The clamping systems are designed such that they withstand the huge retention forces applied from the machining operations onto the work piece. Pachbhai et. al [2] have done the work of Design & Development of Hydraulic Fixture Machining Hydraulic Lift Housing a review in this research, the found that the proposed fixture will not only provides the repeatability and high productivity, but also offers a solution, which reduces workpiece distortion due to clamping and machining forces [3]. As per calculations, the proposed fixtures have a direct impact on product quality, productivity and cost. Yogesh et. al [4] have done the work of elimination of Rejection In Injector Manufacturing Process By Using Hydraulic Fixture a review in this research, the found that This fixture reduces the operator fatigue and a High degree of dimensional accuracy is achieved with high quality & customer satisfaction. Hereby declare
that the elimination of rejection in the production of Nozzle holder body using the hydraulic fixture is successfully implemented [16,17].

Rekha et. al [5] have done the work of Design and Analysis of External Expansion Collet with Hydraulic Movement a review in this research, the found that the main objective of the investigation of designs the fixtures to increase the productivity of CNC gear grinding machine is adopted. Bhavani et. al [10] have done the work of Design and Analysis of Lifting Fixtures for Centre Housing Unit a review on this research, we found that it is successfully optimized as the material of the Fixture. It is concluded that the material SAE-AISI 4130 is less deformed and is suitable for fixture manufacturing of unit.

2. Working of fixture

Hydraulic fixture is the work holding device to attain the maximum pressure 70bar. Work piece location are in term of the 3-2-1 mechanism is widely used method for the locating of prismatic parts and end butting block are fixed the component along with the rest pad, it gives the proper resting of the work piece component against deformation. The oil is supply through the valve to the fixture it consists of two valves that are inlet valve and outlet valve. The pressure gauge is fitted at the end of the fixture during the time of oil supply it maintains the constant pressure and the rest locator must move upward direction to give the basic support to the component. Through the hydraulic pipeline circuit initially oil is supplied to the inlet of the pusher cylinder, due to the oil supply maximum pressure is exhibited in the oil to the cylinder to give the forward motion to support the machining component. Then the oil is supplied to sequential controller, it is used in circuit to operate multiple actuators in a particular pressure dependent on the sequence. This sequential controller spring have to control the oil supply to the toggle clamp and hinge clamp.

3. Hydraulic fixture design and calculation

![Figure 1. Shows Existing Model of Hydraulic Fixture](image)

![Figure 2. Shows Newly Designed Model of Hydraulic Fixture](image)
3.1 Design calculation for the hinge clamp

Clamping force (F) = \frac{\text{Load}}{\text{Area}}

Pressure (P) = 70 \text{ bar} = 70 \times 10^5 \text{ N/mm}^2

Area (A) = \frac{\pi}{4} \times (d^2) = \frac{\pi}{4} \times (26^2) = 530 \text{ mm}^2

Clamping force (F) = \frac{\text{Load}}{\text{Area}} = \frac{(70 \times 10^5)}{530} = 13.20 \text{ KN}

3.2. Bending stress calculation:

Bending Stress (\sigma_b) = \frac{(M \times y)}{I}

Where,

\sigma_b - Bending stress in N/mm\(^2\)
M_b - Bending moment in mm
I - Moment of inertia in mm\(^2\)

Bending Moment (M_b) = \text{force} \times \text{distance}
= 1000 \times 161
= 161000 \text{ N.mm}

Moment of Inertia (I) = \frac{\pi}{64} \times (d^4)
= \frac{\pi}{64} \times (25^4)
= 19165.03 \text{ mm}^4

Distance (y) = \frac{d}{2} = 25/2 = 12.5 \text{ mm}

Bending Stress (\sigma_b) = \frac{(M \times y)}{I} = \frac{(161000 \times 12.5)}{19165.03} = 105.05 \text{ N/mm}^2

\sigma_b = \frac{E \sigma}{E}

Young’s modulus (e) = \frac{\sigma_b}{E} = \frac{105.05}{2 \times 10^5} = 5.25 \times 10^5 \text{ N/mm}^2

Yield Stress = 250 \text{ Mpa}

As the geometry is complex in nature 5% of up and down result are decay as it is less than the yield stress.
4. Analysis of hydraulic fixtures by using analysis

![Assembly view of Designed Model of Hydraulic Fixture](image)

**Figure 3.** Shows Assembly view of Designed Model of Hydraulic Fixture

4.1. Functional area of hydraulic fixture

![Non-Functional Area of Hydraulic Fixture Setup](image)

**Figure 4.** Shows Non-Functional Area of Hydraulic Fixture Setup

The Objective is to find Stress and strain acting on the functional area we can neglect other supporting parts and replace it with a required Constraints (or) Boundary Conditions. We can consider it as a rigid body so that it will not contribute any energy and load distribution for the structural analysis.
5. Stress and strain analysis

5.1 Stress analysis

The Maximum Strain actually occurring in the Clamp lever backside. The load applied along Y-axis and displacement along Z-direction in these four areas on both the sides. In this functional area the maximum strain attained through back side of the clamp due the high pressure of the oil supply power transmitted connecting rod. Back side of the clamp is fixed at the one end and actuates at the other end to clamp. Through
the structural analysis the strain in the blue colour that it indicates the minimum deviation along the Z-axis of 2.423 e-11 it may not produces any effect on the equivalent strain. the equivalent green colour indicates the strain at the Y axis does not produce the maximum defect at the end of the fixed block of 0.00035599. the theoretical calculation the maximum attained of 0.008 of within the elastic limit the X axis and produced under the certain boundary condition. The maximum force applied on the connecting rod of 150 to 225 mm along the Z axis.

![Figure 7. Shows Stress Analysis of Hydraulic Fixture](image)

### 5.2 Strain analysis

The Maximum Stress actually occurring in the Clamp lever backside. And the maximum stress obtained is less than the Yield Stress of the Steel Material. In this functional area the clamp which it produces the maximum stress and minimum stress attained through the structural analysis. the back lever which produces the maximum stress through the hydraulic force. The minimum stress produced along the Z-axis range of 2.62e-6 Mpa. The equivalent von mises stress at the Y-axis direction which indicates by green colour by 63.2 Mpa. The maximum stress produced at the X axis due the hydraulic pressure of which transmit the force through the vertical movement is then the yield stress produced of 114 Mpa.

![Figure 8. Shows Strain Analysis of Hydraulic Fixture](image)
6. Directional deformation

The Deformation in Y direction is actually Less and permissible which is under 1 mm. usually the deformation of the steel material will be lesser. During the clamping the minimum deformation attained at the top of the clamp arm this on the Y axis of -0.764 mm. The deformation produces on the y axis which is 0.0101mm it indicated by the green colour at the centre position of the fixed position. the maximum deformation attained at the end of the piston cylinder due to the hydraulic power along the Y axis which is 0.97845 mm the permissible position. the maximum force attained at the 150 – 200 mm in the connecting rod of the functional area.

Figure 9. Shows Directional Deformation in X Direction

The Maximum Deformation in X direction is actually more and not permissible which is greater than 1 mm. But in our case, it is not considered because that area is under the moving area. That deformation is showing for displaced length.

Figure 10. Shows Directional Deformation in X Direction
As from the above boundary conditions and Loads applied in the Functional parts, the Results obtained in the form of Stress and, Strain and Deformation is under Permissible limit. This Clamping Structure is safe to use

7. Results and discussion

7.1 Milling operation

In this milling operation, the existed fixture have the high vibration and the component have the very less accuracy in the surface finish value of Ra 11.55 which it is measured by the surface comparator. By adding the extra clamp the vibration have been arrested and produce the high quality of the surface finish value of Ra11.69

![Graph showing surface finish comparison](image1)

**Figure 11.** Shows comparison of surface finishes between the existing fixture and new fixture units in Ra

7.2 Boring operation:

In this boring operation, the existed fixture attains the low surface finish with the value of Ra 1.4 due the vibration it is measured by the surface comparator. In the new fixture this problem has been overcome by hinge clamp and its secure high surface value of Ra1.5

![Graph showing bore diameter comparison](image2)

**Figure 12.** Shows comparison of bore diameter between the existing fixture and new fixture units in Ra

7.3 Drilling operation:

In this drilling operation the due the high vibration produced in the existing design it attain the very low accuracy of drill it was measured by plug gauge with vernier caliper having value of 11.55 mm. The new fixture that the vibration was reduced and increase in quality of value is 11.66 mm.
Figure 13. Shows comparison of drill hole diameter between the existing fixture and new fixture units in mm.

7.4. Threading operation
In this threading operation, the existing fixture have the thread depth have varied in 13 mm due to the vibration and the problem is overcome in the new fixture have produced the high accuracy of 15 mm.

Figure 14. Shows comparison of thread depth between the existing fixture and new fixture units in mm.

Figure 15. Shows comparison of bore diameter between the existing fixture and new fixture units in mm.
7.5. Boring operation

In this operation, existed fixture attained the low accuracy of 58 mm measured by bore dial gauge due to the vibration, the new fixture attained the maximum accuracy produced 60mm.

8. Conclusion

- This fixture designed newly and implemented to reduce the vibration and improve the quality of the work piece during the machining operation. these considerable outcomes are observed by comparing the existing fixture and proposed fixture. The existing fixture have the rejection rate of 3 work piece per shift and the proposed fixture have no rejection of work piece. The vibration has been reduced by adding of the hinge clamp it increases in the clamping force.
- From the analysis report that the stress, strain and directional deformation have been calculated in the proposed fixture. Through the design calculation yield stress is 250 Mpa. stress attained in the analysis of this hinge clamp is 114 Mpa less than the yield stress this design is safe and highly effective than the existing fixture and the strain value is very minimum of 0.0008 this value is permissible. The directional deformation along the y axis is 0.97 mm is less than one mm, so it does not affect the design. From the analysis value that the is very safe to use.
- From the graph comparison that the quality of the work piece has been improved in the proposed fixture then the existing fixture during the milling, drilling and the boring operation. The quality of the work piece is measured by using the measuring instruments and the comparison between the fixture are tabulated as the dimensional description. This implementation of the fixture will reduce the vibration and increase in the accuracy of the work piece.

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