DESIGN AND ANALYSIS OF FIXTURE FOR FLANGE DRILLING OPERATION

[1]Praveen H S, [2]Suhas Y S, [3]Nauman Rasheed, [4]Shivaprakash B Budihal, [5]Dr. Dushyanth Kumar K R,

[1,2,3,4] Final Year UG Student, Dept of Mechanical Engineering, Malnad College of Engineering, Hassan, India
[5]Associate Professor, Department of Mechanical Engineering, Malnad College of Engineering, Hassan, India.

Abstract: As per the company's requirement the fixtures are designed . The operations should be such that there should be less wastage, less cost in production, improved quality, increase in the overall production, reduction in cycle time. To design any fixture for a component for any operation, a detailed study has to be made. Here, the flange is placed on two adjustable v blocks. Now the fixture is to be designed such that the axis of the flange placed on the v blocks should get aligned with the tool axis for carrying out the drilling operation .The basic design starts with screw jack, which lifts the flange placed on v-blocks in getting aligned with the drilling tool axis. The best way to drill this flange is by designing a new fixture instead of conventional method designs. This will make easier to machine the work piece and reduction in cost per work piece.

Index terms: Cycle time, Fixture Design, Static Analysis

I. INTRODUCTION

Now a days, the Industries are trying to increase the demand of the product and increase the mass production. To meet these challenges, it has become very important for companies to increase their production rate. The successful running of any mass production depends upon the interchangeability of the work parts to facilitate easy assembly and reduction of unit cost. Mass production demands a fast and easy method of positioning work for accurate operation on it. The main intention of any company is to provide good quality product and increase in production rate in order to get profit over it. This can be achieved by minimizing manufacturing cycle time and cost of production by using work holding guiding device. This work holding device is fixture.

Fixtures are designed such that large number of components can be machined or assembled identically. Fixtures are special purpose tools which are used to facilitate production when work piece are to be produced in mass production scale. Advantages of fixtures are, once the fixture is properly setup, any number of duplicate parts can be readily produced without any additional setup.

1.1 Purpose of Fixture

A fixture is a device for locating, holding and supporting a workpiece during a manufacturing operation. Fixtures are essential elements of production processes as they are required in most of the automated manufacturing, inspection, and assembly operations.

Fixtures must correctly locate a workpiece in a given orientation with respect to a cutting tool or measuring device, or with respect to another component, as for instance in assembly or welding. Such location must be invariant in the sense that the devices must clamp and secure the workpiece in that location for the particular processing operation.

There are many standard work holding devices such as jaw chucks, machine vises, drill chucks, collets, etc. which are widely used in workshops and are usually kept in stock for general applications.

Fixtures are normally designed for a definite operation to process a specific workpiece and are designed and manufactured individually. Jigs are similar to fixtures, but they not only locate and hold the part but also guide the cutting tools in drilling and boring operations.

1.2 Classification of Fixtures

Based on operation
- Vice fixture
- Milling fixtures
- Facing fixture
- Drilling fixture
- Turning Fixture

Based on Atomization
- Hand operated
- Power driven
- Semi-automatic
- Automatic

Based on Application
- Tool holding
- Work holding
- Fitting

1.3 Fixture Elements

All fixtures consist of the following elements:
a) Locators
b) Clamp
c) Supports
d)Fixture body

1.4 V-Block

V-Blocks are precision metal working jigs typically used to hold round metal rods or pipes for performing drilling or milling operations. They consist of a rectangular steel or cast iron block with a 90-degree channel rotated 45-degrees from the sides, forming a V-shaped channel in the top. A small groove is cut in the bottom of the "V". They often come with screw clamps to hold the work.

1.5 Types of V-Blocks

- V-blocks for square and round stock
- Micro v-block
- Four-way v-blocks
- Magnetic v-blocks
- Tilting v-blocks
- Standard v-blocks

1.6 Screw Jack

A jackscrew, or screw jack, is a type of jack that is operated by turning a leadscrew. It is commonly used to lift moderately heavy weights, such as vehicles; to raise and lower the horizontal stabilizers of aircraft; and an adjustable supports for heavy loads, such as the foundations of houses.

1.7 Types of Screw Jacks

- **Translating Screw Jacks**, these types of screw jacks use a lift shaft or screw that travels into or out from the worm gear box. The lift shaft can either protrude from the mounting flange side of the gearbox or from the top side of the worm gear box.
- **Rotating Screw Jacks,** the lift shaft remains stationary and a lifting nut moves along the lift shaft.

II. PROBLEM STATEMENT

In current system, the flange is mounted on two v-blocks and drilling operation is done using horizontal boring machine. During flange drilling operation the operator must align the axis of holes with respect to tool(Indexing). So, operator must place the shim and make it align. During this process, lifting of heavy job frequently consumes more production time. These operations have to be done hundreds of times per day this may cause considerable fatigue to the operator, thereby reducing his efficiency. Also, the time spent in this activity can seriously affect the production.

These problems can be overcome by making the v-block adjustable in height. This is done by providing suitable jack mechanism and clamping arrangements, in this way we can provide reliable and fast aligning system which will reduce the cycle time of drilling operation with the increase in accuracy thus decreasing the possible damages to the work piece and operator is able to perform machining operations accurate.

2.1 Objectives of Project

The objective of the project is

- To design and develop flexible fixture for flange drilling operation
- To reduce the production time
- To enhance machine utilization
- To reduce manufacturing cost of flange
- To reduce rejection rate
- To facilitate mass production
- To increase the efficiency of operation
- To precisely locate the workpiece with machine tool
- To help management to gauge the production
- To increase the accuracy of the product effectively
- To develop the flexibility in machining operation

2.2 Methodology

Following methodology is adopted while designing the fixture .

- Understanding of problem statement
- Understanding of machine and its characteristics
- Understanding of operations
- Discussion with company engineers
- Researching the probable solution
- Finding out the most feasible solution
- Optimization through the different methods
- Design and development of fixture model
- Static structural analysis of fixture
- Rendering prototype using 3d printer
- Results and analysis
- Conclusions
- Drafting a process plan for entire solution and implementing it accordingly

Actual procedure followed during the fixture design

1) The study of the geometry of the machine and workpieces loaded

- Dimensions of bed: 500*455 mm
- Maximum diameter of flange loaded on machine:250mm

2) After taking into consideration all the geometric parameters, the characteristics of the machine were studied.

- Maximum weight of the workpiece- 1 ton
- Maximum length of the pipe- 3 meters
- Direction of feed- horizontal

3) Observation of all the locating devices mounted on the machine was made. Position of all the mountings must to be known as the new fixture shouldn't hamper the working of any other device.

4) Types of clamps available on machine.

5) Accuracy of the indexing devices was noted. Indexing gives quick and accurate location of the fixture or workpieces mounted on the machine. High accuracy means finding the specific location of the same.

6) Repeatability of operation is necessary to design the fixture.

7) Study of available safety devices. Safety devices are required to protect employees and safeguard against machine hazards.

8) After designing the fixture, we check if the required quality and accuracy (0.05mm) is achieved or not.

III. LITERATURE REVIEW

Sridharakeshava K. B. et. al., [3] has discussed about the General Requirements of a Fixture which includes constraints of Deterministic location, contained deflection, geometric constraint in order to maintain the work piece stability during a machining process. They also discussed three broad stages of fixture design, Stage one deals with information gathering and analysis, Stage two involves product analysis, and Stage three involves design of fixture elements.

N. P. Maniar et. al., [2] reviews locating and clamping considerations, taxonomy of fixture planning & design, also shows an example of fixturing alternatives and characteristics for three types of fixtures i.e. Modular fixturing, General fixturing, Permanent fixturing. They provide a system view of fixture planning and Design for data & information exchange also gives detailed discussion on CAFD- Computer Aided Fixture Design.

Manoj Patil (2014) [1]: In this general article, screw jack is developed to overcome the human effort. It is actually difficult job to operate for pregnant women and old person. Changing the tyre is not a pleasant experience. Especially women can't apply more force to operate. For that, electric operated car jack is introduced. With the industrial revolution of the late 18th and 19th centuries came the first use of screws in machine tools, via English inventors such as John Wilkinson and Henry Maudsley The most notable inventor in mechanical engineering from the early 1800s was undoubtedly the mechanical genius Joseph Whitworth, who recognized the need for precision had become as important in industry as the provision of power.

Thirugnanam, Amit Kumar &Lenin Rakesh (2014) [5]: -This paper studies design and analysis of screw jack using Pro-E and ANSYS under torque and compressive force as loads, in this analysis determines shear stress induced at the cross section square thread under bearing pressure. Objective of this paper is to study shear stress state of power screw have been considered following design values, Pitch = 6, Dc = minor diameter = 30 mm, do = major diameter = dc + pitch = 30 + 6 = 36 mm, with the help of this the power screw is designed according to the design process and analyzed using ANSYS software. Model developed is to be validated using theoretical calculations.

LokhandeTarachand (2012) [4]: -As per this research paper they have used square threaded screw with different helix angle and manual operated screw jack. To quantify the effect of changing helix angles Mathematical prototype model has been done. Conclusion of this work is that efficiency become optimum at helix angle 3.69 for 10000 Kg of jack. Based on the various input parameter & mathematical model, the effect of helix angles upon various parameters studied core diameter, outer diameter, efficiency, critical load, torque to be transmitted, and pitch of threads. Friction angle of screw jack is 11.30, coefficient of friction μ=0.20 for whole study & bearing pressure were kept constant throughout the study.

IV. DETAILS OF FIXTURE

Solid works has been used to sketch 2D diagram of fixture for Flange drilling. Later on the 2D sketch is converted into 3D modelling in the solid work and assembly has been done. Individual parts of fixture are given below:

Sl. No.	COMPONENT	MATERIAL	NO
1	V-Block	Tool Steel	2
2	Bed	Cast Steel	1
3	worm	Hardened Steel	2
4	Worm wheel	Phosphor Bronze	2
5	Ball bearing	Chrome steel	4
6	Axial thrust bearing	Chrome steel	2
7	Gear box	Cast Iron	2
8	Screw rod	Mild Steel	2
9	Pedestal	Mild Steel	2

Table 1: Components used in Fixture Design

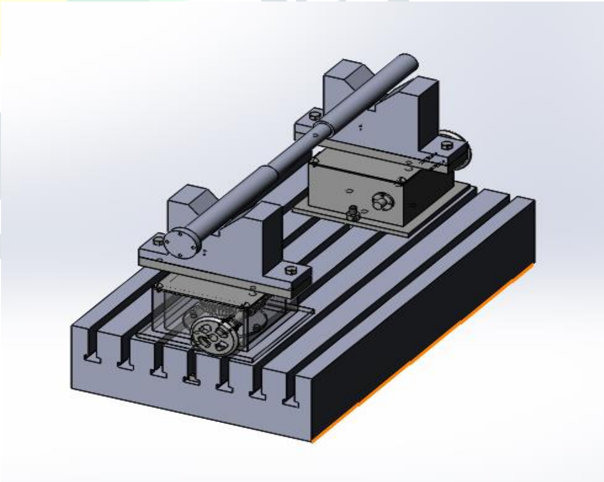


Figure1. Isometric view of Assembly of Fixture

4.1 Analytical Calculations

Input Torque:

$$T = \left(\frac{F\times p}{2\pi\times i\times \eta}\right) + T_0$$

(F) Load acting = 10 KN

(p) Screw pitch = 4 mm

(i) Gear ratio = 20

(η) Efficiency = 12%

(T_0) Idle torque ratio = 0.29 Nm

$$T = \frac{10\times10^3\times4\times10^{-3}}{2\pi\times20\times.12} + 0.29$$

T=2.94×10³ N/mm

Input Power:

$$P = \frac{T\times n}{9550}$$

(n) Jack input speed =50 rpm

$P = \frac{2.94\times50}{9550}$=15 w

Travel Speed:

$V = \frac{n\times p}{i}$

$V = \frac{50\times4\times10^{-3}}{20}$

V= 0.16 mm/s

Hand turning force:

$HF = \frac{T}{R}$

(R)Radius of hand wheel= $42 * 10^{-3}$mm

$HF = \frac{2.94}{42\times10^{-3}}$= *70 N*

Total equivalent load:

$W(s) = W_{max} * F_1$

(W_{max}) Maximum dynamic load = 10 KN

(F_1) Factor for driven machine = 1.2

W(s) $= 10\times 10^3 \times 1.2$

W(s) $= 12\times 10^3$ N

Equivalent load of single jack:

$$W = \frac{WS}{arrangment\ factor \times number\ of\ Jacks}$$

Numbers of jacks in arrangement = 2

Arrangement factor: 1, 0.95, 0.90, 0.85, 0.80.

$W = \frac{12\times10^3}{0.95\times2}$= *6315 N*

4.2 FE Analysis

In this case, Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by the loads that do not induce significant inertia and damping effects.

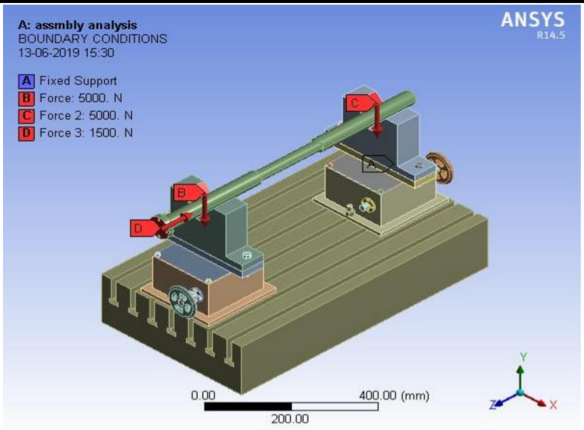
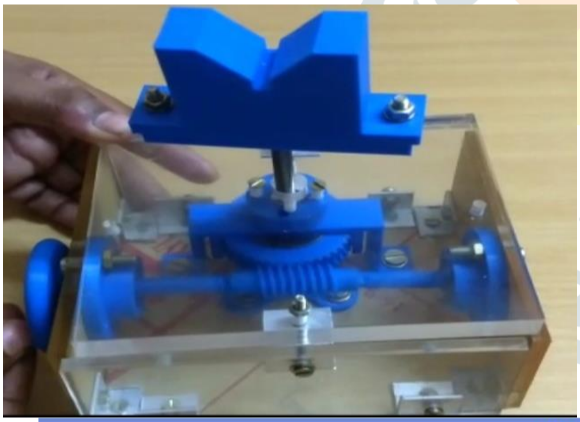


Figure2: Application of Force

The model is constrained at the bottom surface of base structure and force is applied at the top portion as shown in above figure.



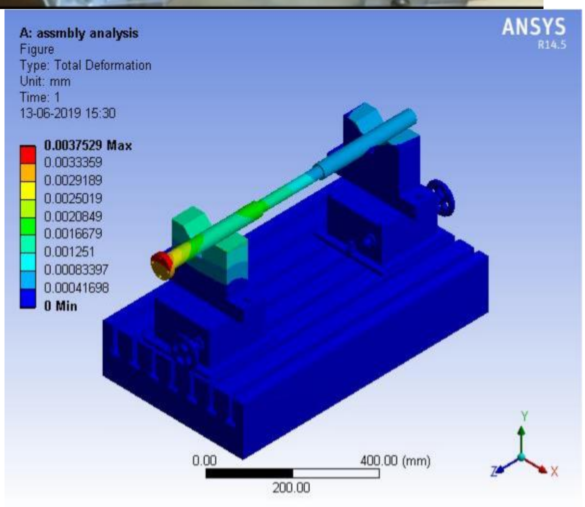


Figure3: Total deformation

The displacement of the v-block due to loading is shown in above figure. The maximum static deflection is found to be $3.75*10^{-3}$ mm.

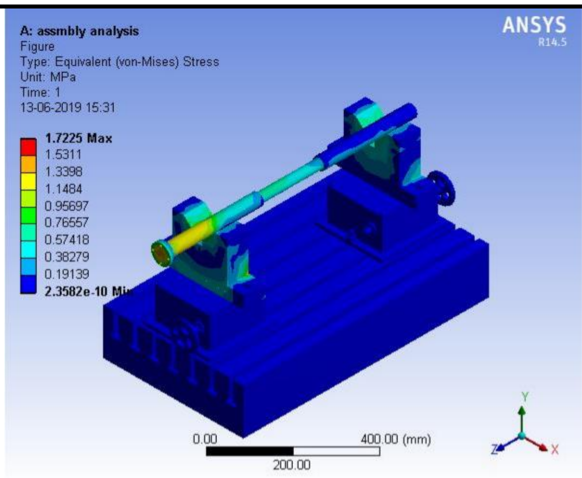


Figure4: Von-Mises Stress Plot

The von-Mises stress is shown in figure. The maximum von-Mises stress of the v-block subjected to loading is found to be 1.725 Mpa.

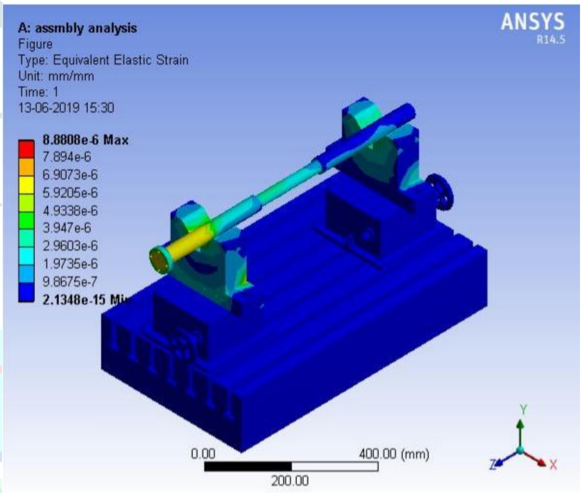


Figure5: Elastic Strain plot

The Equivalent Elastic Strain is shown in figure. The maximum Elastic Strain of the v-block subjected to loading is found to be $8.88*10^{-6}$ Mpa.

V. RENDERING PROTOTYPE

5.1 3D printing

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object.

5.2 3D Model details

Figure7: Prototype generated using 3D Printer

5.3 3D Model details

- Material used : polylactic acid (PLA)
- Weight of material: 130 grams
- 3D printing type: Fusion deposition modelling

CONCLUSION

The following conclusions have been resolved after design and analysis of the Fixture,

1. This fixture reduces 45% of labor cost in loading and unloading period
2. As fixed v blocks are used for supporting the limited diameter header pipes, but not suitable for elbow, tee and matching reducers, so it is replaced with this fixture
3. This fixture will likely be a high priority for industries in coming years. Thus, an efficient model is designed
4. This fixture use jack mechanism for each movement either upward or downward, so time can be saved during drilling operation
5. The vee blocks are capable are capable for high loading above (10 tones to 25tonnes)
6. This project is made to decrease time taken for each operation
7. This project reduces the labor cost and enhance machine utilization
8. This fixture helps management to gauge the production rate and schedule the related work
9. It reduces manufacturing lead time

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