

Design of Hydraulic Fixture for Machining of Automobile Component

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Abstract— Fixture is a work holding element which is used to hold the work part firmly during the machining operation time & also helps in clamping and de-clamping the workpiece during the loading and un-loading of work part so as to not harm the work part and fixture elements during the machining operation. Pitman Arm is very important part of Steering system. It should be accurately machined with the given acceptable tolerance limits. At present scenario productivity and economics of machining workpiece in large quantity is greatly affected with the work holding devices such as fixtures. Fixture reduces the production cost and interchangeability of machined workpieces. The design of fixture is done by using software SOLIDWORKS 2019. The purpose of the Hydraulic fixture is preferred it reduces the cycle time and increases the production rate with accuracy & precision of the product being produced. The main purpose of a fixture is to locate and hold the workpiece during the operation, to increase the quality and production rate & reduce the production cost.

Index Terms— Hydraulic Fixture, Pitman Arm, Elements of fixture, Locators, Clamps, Force calculations & 3-2-1 principle.

1 INTRODUCTION

Fixture is a special work holding device which is used to hold the workpiece in position during operation. A hydraulic fixture is to be designed for machining the pitman arm work component which is used in the steering mechanism to control the direction of the vehicle. In this work component the face milling machining is to be done. To perform the face milling operation on the work component a fixture is required, as the productivity and economics of machining the work part would be in large quantity is affected with the use of work holding device such as fixtures. So, to perform the face milling operation a hydraulic fixture is to be designed to perform the operation's on work part.

1.1 Pitman Arm

The pitman arm is a steering arm which is hooked up at one aspect to the steering box at rock bottom of the hand wheel shaft and on the opposite side to the track rod that is hooked up at the opposite finish to the non-worker arm. When the steering wheel is turned left or right, a worm gear at the bottom of the steering shaft turns a set of teeth. That action moves a gear that activates the pitman arm, inflicting the mechanism to manoeuvre the wheels. A properly functioning pitman arm includes,

At one end of the steering system pitman arm is used to control the steering action, and on the counter side part the

Steering system is connected with an idler arm to control the action and force in steering system, which is in turn connected with the wheel assembly to control the steering action.

1.2 Fixture

The fixture is a special tool for holding a work piece in correct position throughout production operation. Frequent checking, positioning, individual marking and non-uniform quality in producing method is eliminated by fixture. Fig 1 shows the basic construction in the general fixture.

Fixtures are also used to securely locate and support the work, ensuring that all parts produced using the fixture will maintain uniformity and interchangeability. Fixtures should always be designed with value effectiveness in mind. The most purpose of those devices is to scale back prices, so it is often designed in such the simplest way that the value reduction outweighs the value of implementing the fixture

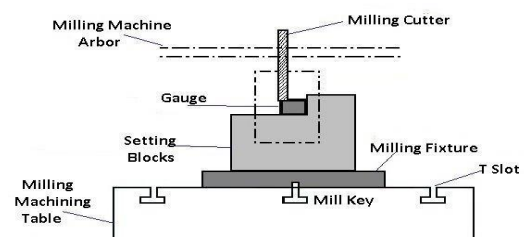


Fig 1: Fixture components

The essential features of jigs and fixtures include:

- Clamps position
- Neatness of work-piece
- Standardization
- Idle time reduction
- Set up time reduction
- Hardened surfaces.

A fixture consists of a set of elements such as,

- Locators:** are used to determine the position and orientation of a workpiece.
- Clamps:** exert clamping forces so that the workpiece is pressed firmly against locators.
- Supports:** A support is a fixed or adjustable element of a fixture.
- Fixture Body:** Fixture body is the major structural element of a fixture.

Fixture is one of the effective tools used to hold the work piece to perform the suitable operations. Hence suitable study on fixture & fixture elements is to be done and based on the work to be performed there are some of the objectives which is to be achieved by the end of design of fixture for pitman arm.

2 LITERATURE REVIEW

Sridharakeshava K. B. et. al., [1] had discussed about 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. S.D.V.V.S.B. Reddy et. al.[2] have designed hydraulic fixture for AVTEC Transmission Case Component and analyzed the fixture for various cutting forces acting on it. Effective design requires various principles like locating principle, clamping principle and 3-2-1 principle. These principles were effectively used by Shailesh S Pachbhai et.al [3][4] for designing hydraulic fixture for machining of hydraulic hoist crane. They also discussed about various stages in fixture design. Nagaraj Anand Shet et.al [5] had discussed on the methodology of fixture design and 3-2-1 principle for design of hydraulic fixture for machining of Basak Cylinder Head. And, also analyzed various forces acting on the fixture. Therefore 3-2-1 principle can be effectively used for designing of fixture.

3 OBJECTIVES

The design of a hydraulic fixture, to perform the machining operations on work part should be carried based on the principles of locators, clamps, supporting elements & 3-2-1 principle, to arrest the work part in rest position. To perform the suitable operation without disturbing the work part else the work part, tool, fixture and machine failures can be raised. To

overcome such events, it is necessary to do the required research, calculations and proper design of the fixture. Below are some of the objectives of the project.

- Study of Forces associated with the machine part.
- Selection of material for designing fixture.
- Design of fixture for Production of Pitman Arm.
- Understand the conception of Design & Procedure used for coming up with fixture.

The design procedure is also one of the important parameter's which is to be studied to design a Fixture.

4 METHODOLOGY

From the Literature survey, it was found that there are certain steps to be followed for such kind of design process of fixture in order to achieve the required outcome of the project. The steps involved in design of fixture is from fig 2.

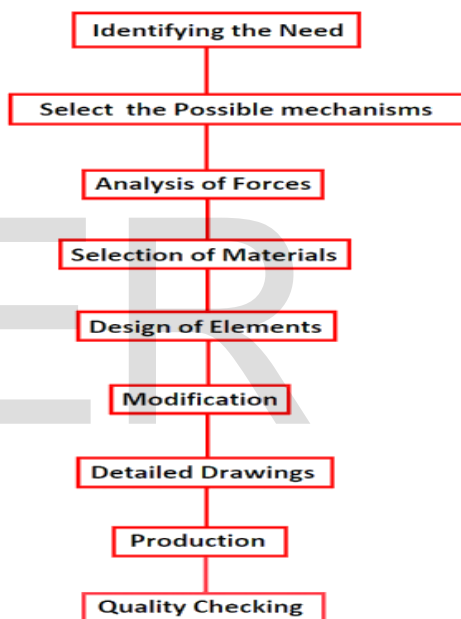


Fig 2 Steps involved in fixture designing

4.1 Identifying the Need

A fixture's primary purpose is to make a secure mounting purpose for a work piece, allowing support throughout operation and increased accuracy, precision, reliability, and interchangeability within the finished components. It additionally serves to scale back operating time by permitting fast set-up, and by smoothing the transition from part to part it often reduces the complexness of a process, allowing unskilled employees to perform it and effectively transferring the talent of the tool maker to the unskilled employee. Fixtures also allow for a better degree of operator safety by reducing the concentration and effort required to hold a piece steady. The basic purposes of developing and using suitable fixtures for batch production in machine shops are:

- To produce the pitman arm work component.
- To eliminate marking, punching, positioning, alignments etc.
- Easy, quick and consistently accurate locating, supporting and clamping the blank in alignment of the cutting tool
- Guidance to the cutting tool like drill, reamer etc.
- Increase in productivity and maintain product quality consistently
- To reduce operator 's labour and skill – requirement
- To reduce measurement and its cost
- Reduction of overall machining cost and also increases in interchangeability.

4.2 Selecting the Possible Mechanism

To select the suitable possible mechanism for the fixture that is to be used is based upon the type of fixture used and various parameters such as,

- Component input, & type of Component.
- Study of Customer 3-D model.
- Study of forged/ casting drawing.
- Machine parameters.
 - Type of machine VMC, HMC or Special Purpose.
 - Machine table Size.
 - X, Y, Z Stroke.
 - Spindle Diameter.
 - ATC Tool change over.
 - Max spindle speed and Torque.
- Study of Component Drawing.
- Split of operations.
- Study of Critical Dimensions.
- Cutting force & Cycle time Calculations.
- 3-2-1 Principle.
- Hydraulic Lines.
- 2-D Drawing.
- Customer Drawing Approval Process (DAP).

4.3 3.2.1 Principle and Calculation cutting force

3-2-1 Principle is used to locate the work piece & restrict all the Degree of Freedom (DOF) in a fixture, so as to hold the workpiece firmly in the position and during machining on the workpiece and after machining process for loading and unloading of the work piece.

In this work two factors are considered for designing

1. Accurately position the part at the desired coordinates.
2. Restrict all six degrees of freedom so that the part cannot move.

3-2-1 principle is defined as follows

- First plane: Geometry tells us that three points are required to define a plane, the "3" in 3-2-1.
- Second plane: A second plane, if it is perpendicular to the first, can be defined by two points, the "2" in 3-2-1.
- Third plane: If it is perpendicular to both of the first two planes, can be defined by one point, the "1" in 3-2-1.

Cutting force and clamping force are the two forces acting on the fixture. The fixture has to withstand these two forces for effective machining. Cutting forces are exerted in three planes to deform and shear away material in the form of a chip. Clamping force is used to securely hold the work part during the operation. The resulting forces are shown in table 1.

Table 1: Cutting Forces

Parameters	Analytical Calculations
Spindle Speed in rpm	900
Feed rate in mm/min	270
Material Removal Rate in cm ³ /min	10.8
C/s Area of the chip in mm ²	0.05
Number of inserts in the cut	1.5
Ratio of radial width of cut to cutting diameter	0.5
Tangential cutting force in N	110
Torque in N-mm	4244.2
Power at cutter in KW	0.44
Power at Motor in KW	0.4

4.4 Design of Fixtures

Fixtures are manually or partially power operated devices. To fulfil their basic purposes, jigs and fixtures are comprised of several elements:

- Base and body or frame with clamping features
- Locating elements for proper positioning and orientation of the blank
- Supporting surfaces and base
- Clamping elements
- Tool guiding frame and bushes (for jig)
- Indexing plates or systems, if necessary
- Fastening parts

The above-mentioned elements are some of the major elements which plays an important role in fixture. Other than this there are some of the elements such as De-copular unit, Sequence valve in hydraulic system, etc., which are used based on the type of fixture and requirements in a fixture.

The above components were modeled using CAD software SOLIDWORKS2019. The detailed assembly of the fixture is shown in figure 3.

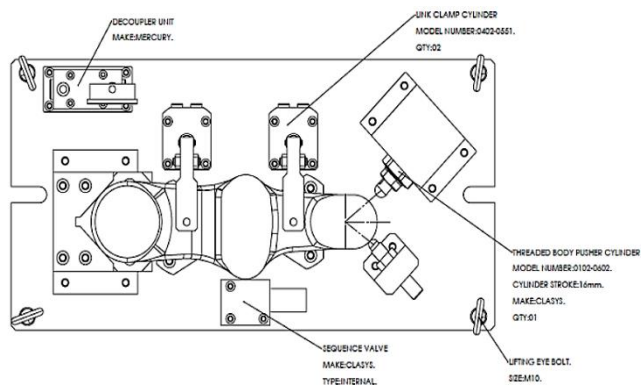


Fig 3. 3D Fixture assembly model

5 CONCLUSION

Design of Hydraulic fixture for face milling operation on Pitman Arm has been done with the available dimensions of work component and machine parameters. The cutting forces and clamping forces are analyzed. The detailed specification of machine & various force analysis is considered and design of fixture is done based on the requirements.

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