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A STUDY OF FLEXIBLE FIXTURE USING COMPUTER AIDED FIXTURE DESIGN NEED AND APPLICATION OF RECONFIGURABLE FIXTURE DESIGN

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Abstract: Jigs and fixtures are the special production tools which make the standard machine tool, more versatile to work as specialized machine tools. They are normally used in large scale production by semi-skilled operators; however they are also used in small scale production by when interchangeability is important. Various areas related to design of fixture are already been very well described by various renowned authors, but there is a need to couple and apply all these research works to an industrial application. The paper includes the study on finished part drawing, fixture drawing 3D assembled view of fixture using Catia and Ansys will be used CAD modeling and Analysis respectively.

Keywords: Jigs, Fixture, Functional Requirement, Flexible fixture controlsystem

I. INTRODUCTION

There is an increasing need for improved methods of determining the reliability and predicting the lifetime of machines and production systems more accurately. The paper presents review on: Fixture design for engine and designing fixture for TATA motors model number BMV60 VMC. The important details of the part and fixture are included in each fixture design section for clarifying doubts in addition to component drawing & fixture drawing. The research work includes the CATIA used for CAD modeling and ANSYS used for Analysis. The present research work deals with the study of literature of various authors and finally concluded that hydraulic mixture will be good and efficient for manufacturing of engine for model number BMV60 of TATA motors.

II. LITERATURE SURVEY

The fixture designing and manufacturing is considered as complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes. The specifications & limitations of the machine limit the ideas of designing. To design a fixture and collet, a designer must know manufacturing procedures. He must be able to visualize exactly how the work-piece is to be made. He should be competent to judge the merits of different methods. He must have knowledge of standards and procedures. He must be inventive and original. He must be able to incorporate his ideas in design layouts. He must understand how tools perform their function. He needs a good background in mechanics and mathematics. He should also know how the physical properties of materials used in making tools. A mastery of drafting techniques is an essential to the tool designer as ability to read and write.

While designing this work, a good number of literature and titles written on the subject by renowned authors are referred. All findings and conclusions obtained from the literature review and the interaction with fixture designers are used as guide to design the present research work. The design of machining fixtures and collet relies on designer experience and his/her implicit knowledge to achieve a good design. In order to facilitate its application, the explicit definition of the collet design process and the knowledge involved is a prior and a fundamental task to undertake.

Additionally, a fundamental and well-known engineering principle should be considered: the functional requirements and their associated constraints should be the first input to any design process. A relevant issue when considering requirements, taking this as a general concept, is to make explicit the meaning of two main terms: Functional Requirement (FR) and Constraint (C). Functional Requirement (FR), as it stated by different authors, represents what the product has to or must do independently of any possible solution'. Constraint (C) can be defined as 'a restriction that in general affects some kind of requirement, and it limits the range of possible solutions while satisfying the requirements' [1]. Various areas related to design of fixture like machining fixture knowledge, optimizing work-piece setups, modeling of forces, improving work-piece location and high efficiency tools [2-6] are already been very well described by various renowned authors.

Rigid-body methods have been reported that can be used to analyze problems of work-piece location, loading/unloading, stability, and total constraint [7–9]. Fixture layout and clamping force optimization schemes have also been developed using these methods [9–12]. Although computationally efficient, the rigid body approach is unable to solve for fixture work-piece contact forces/moments uniquely since it typically results in a statically indeterminate problem.

In general, this limitation may be overcome by accounting for elastic deformation of the fixture–work-piece system [13]. Hockenberger and DeMeter [14] used empirically derived contact force–deformation relationships to simultaneously solve the static equilibrium equations for rigid-body displacements and rotations of the work-piece owing to clamping and machining forces. DeMeter also used the rigid-body model to formulate a min–max optimization problem for computing the minimum clamping force [3]. However, these works did not address analysis of fixtures with large contact areas. Gui et al. [9] reported an elastic contact model for improving work-piece location accuracy through optimization of the clamping force. However, they did not address the problem of large-area contact fixtures, and methods for computing the contact stiffness were not discussed. Li et al. [10] used contact mechanics based models to determine the reaction forces and contact region deformation. They, too, do not consider the large-area contact problem.
The fixture designing and manufacturing is considered as complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes. Due to the complexity of the fixture design process, the fixture design cannot be considered as an independent process with respect to the manufacturing process. In this sense, the information of the manufacturing process is directly present in the fixture design process. In a similar way, the resources involved in the manufacturing process have a narrow relationship with the fixture resources, in terms of machine tools and commercial elements of fixture [16].

III. FIXTURE CLASSIFICATION

Classification is done by technological and constructive fixture characteristics. In the process, the necessary information is gained by linking certain codes or code combinations to certain fixture parameters. The features considered for classification are the following:

- Qualitative—machining type, location scheme, clamping scheme, etc.,
- Quantitative— work-piece dimensions, number of simultaneously machined work-pieces, clamping force intensity, etc.

Fixture homology

Fixture homology presents a complex set of measures for rational reduction of construction types and dimensions. Type construction is a constructional fixture scheme made on the basis of basic construction and containing primarily principal type elements for locating and clamping work-pieces of certain types. Type fixture constructions have process characteristics, clamping scheme, locating scheme, and geometric characteristics similar to work-pieces for which they can be used.
Working fixture construction presents a set of principal or type constructions and a group of alternative and/or adjustable elements in coordination with concrete machining operation. Working construction is the final fixture construction applied at the work place during machining process. [17]

Design of the flexible fixture control system

Flexibility of flexible fixture system is mainly reflected in high reconstruction and high adaptability of system, as far as possible to improve tooling control system can be scalability. The key of tooling motion control is design as far as possible to improve the scalability, stability and reliability of tooling control system. There are three ways to achieve multi axis motion control. 1. The servo motion is control is based on CNC system. 2. The servo motion control is based on PC and motion control card; 3. The servo motion control is based on PLC pulse generating module.CNC servo system mainly used for CNC machine tools, has high control precision and can realize multi axis synchronization and linkage, as well as acceleration and deceleration functions.[18]

Problem statement and Methodology

The main objective of work is to Design, Development and Analysis of engine fixture for Differential case or case of differential component in automobile engine assembly. In this required work, modelling is carried out in CATIA and analysed using Ansys to determine the safe working condition of the fixture.

Hydraulic Fixture

Hydraulic Fixture is a clamping system which utilises liquids of high pressure for power clamps and holding of work piece in place. Hydraulically clamped fixtures have an edge over manually clamped fixtures.

a) The major advantage of hydraulic work holding is time saving in clamping & de-clamping the component(s). It reduces cycle time paving way for increase in manufacturing capacity & cost reduction.
b) In hydraulic fixture, forces in clamping are constant resulting in precision positioning & clamping. This ensures sequential processing procedures & assured quality.
c) Parts are clamped with the same clamping force for every cycle & in the same location eliminating the part deflection variability from clamping forces and improving process stability.

d) More parts shall fit within machine envelope due to the high clamp forces generated with small hydraulic components .Thus paving way for more productivity.
e) Eliminates human error due to assurance that every clamp will be actuated with every cycle, eliminating human error and missed steps. Also allows operators to be consistently more productive with less effort hence increase ergonomic efficiency.[19]

IV. COMPUTER AIDED FIXTURE DESIGNS

The clamping forces applied are caused to deform the work-piece, so therefore it is important to minimize such effects by using optimal design of the hydraulic fixture layout. In machining, work holding is a main aspect, and hydraulic fixture is the element responsible to satisfy this important goal. Locating, orientating, centering, supporting, and clamping can be considered as basic functional requirements of fixtures.
For this Engine cylinder block there are two types of hydraulic fixtures are designed in CATIA V5 software by considering all locating and clamping principles and from that two designs one best fixture design having less work-piece deformation and stresses is selected for development.
The 1st type Fixture is having two locating pins for component location, four resting pads, and two vertical hydraulic clamps shown in Fig 4.1.

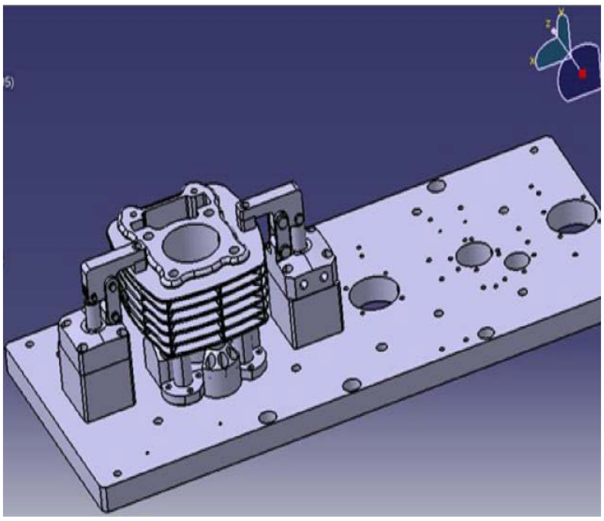

Fig 4.1. 1st type Fixture assembly with and Cylinder block

The 2nd type Fixture is having one locating pin for cylinder block location, four resting pads, and three vertical hydraulic clamps shown in Fig 4.2. [20]

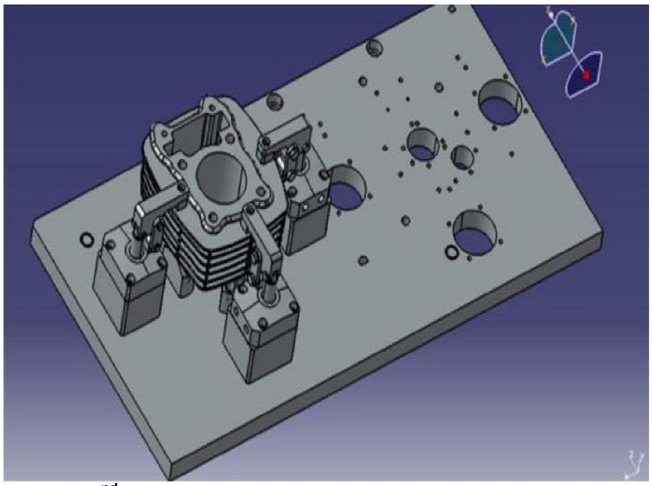

Fig 4.2. 2nd type Fixture assembly with Cylinder block Analysis

The critical and weak part in this fixture is Link which we are using for clamping the component. The cylinder force depends upon lever length, two types of lever length are using in this fixture. Therefore the analysis of each link for stress and deformation carried out in Simulation Xpress.

Stress Plot for Link

The Link is applying the force on the component to hold the component on its proper position. Link is applying the force of 2000N. The below Fig 4.3 shows the Static Stress Plot for Link.

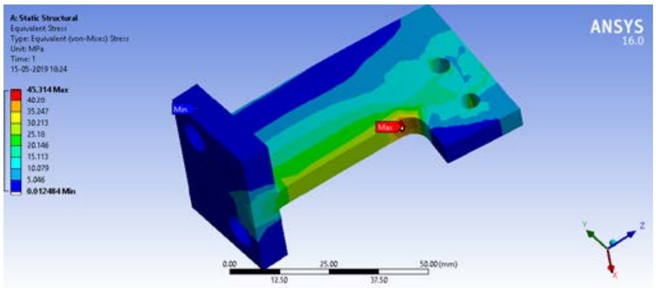

Fig 4.3. Static Stress Plot for Link 1

Material 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 Result
Maximum Stress: $6.009x10^6$
Deformation Scale: 263.201
Result and Discussions

From above analysis it is clear that the maximum Stress occurred at Link and maximum deflection occurred at Link end are within the limit. Hence Link can apply the force of 2000N.

Stress Plot for Link 2

Link length is 97 mm. Link is applying the force of 2N. The below Fig 4.4 shows the Static Stress Plot for Link.

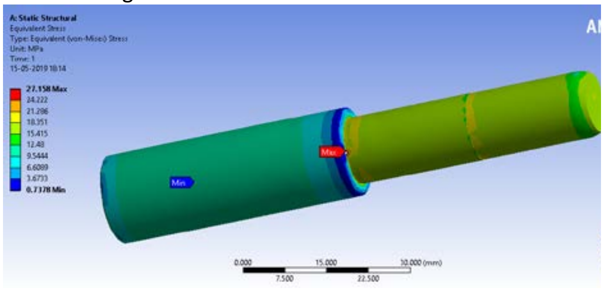

Fig. Static Stress Plot for Link2

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
Maximum Stress: $9.5207x10^7$
Deformation Scale: 312.9
Displacement Plot for Link 2

Link length is 97 mm. Link is applying the force of 3000N. The below Fig 4.5 shows the Static Stress Plot for Link.

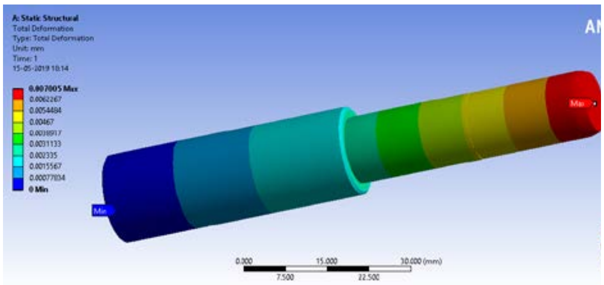

Fig. Static Displacement Plot for Link2

V. CONCLUSION

The following are the results obtained while designing and from tryout of the fixture.

- The unique feature of fixture is that, it can be used for two different component.
- The change in fixture design will enhance the production ability & the same time cost of production and time is reduced.
- Rigid clamping and proper loading sequence has achieved the total assembly accuracy within prescribed limit without any deformation in the part.
- As this Fixture is used for two component, it results in the saving of the money for manufacturing the fixture, this is the most advantageous and profitable aspects for the company. Cost of One Fixture is around Rs 12 to Rs14 lacs. So modifying The previous fixture as per suitable to the new component, around Rs 8 to Rs 10 lacs saved by the company
- Production rate increased by 650 units /hr to 700 units /hr.
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