Design, Analysis and Optimization of Turning Fixture for Steering Knuckle: A Review

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ABSTRACT

This project is about the design and analysis of fixture which is used in the manufacturing of steering knuckle. By performing analysis on fixtures we find out stress acting on fixtures. The fixtures are the economical ways to produce a component in mass. So fixtures is used and serve as one of the most important facility of mass production system.. The main purpose of a fixture is to locate and in the cases hold a work piece during an operation. The main objective of this project is analysis and optimization of turning fixture for steering knckle. CATIA has been used for drawing the 3D CAD model which act as an input for the FEM software Hypermesh and optimization. Structural optimization has been chosen for optimizing the turning fixture.

Key Words— Creo, Fixture, Linear Static, Optistruct, Steering Knuckle, Optimization.

I. INTRODUCTION

Afixture is a work-holding or support device used in the manufacturing industry. Fixtures are used to securely locate (position in a specific location or orientation) and support the work, ensuring that all parts produced using the fixture will maintain conformity and interchangeability. Using a fixture improves the economy of production by allowing smooth operation and quick transition from part to part, reducing the requirement for skilled labor by simplifying how workpieces are mounted, and increasing conformity across a production run.[1]

Fig. 1 A common type of fixture, used in materials tensile testing

A fixture is a work holding device and position the work; but doesn't guide 'locate or position the cutting tool' the setting of the tool is done by machine adjustment and a setting blocker using slip gauges. A fixture is hold or clamp-ed to the machine table. It is usually heavy in construction. Jigs are used on drilling , reaming , tapping and couter boring operations , while fixtures are used in connection with turning, milling , grinding , shaping , planning and boring operations.

Uses of Jigs and Fixtures:

Jigs and fixtures are used to reduce the cost of production as there use elimination being out work and setting up of tools.[2]

- To increase the production.
- To assure the high accuracy of the parts.
- To provide for interchangeability.
- To enables heavy and complex shaped parts to be machined by holding rigidly to a machine.

- To control quality control expenses.
- Less skilled labor.
- Saving labor.
- There use partially automates the machine tool.
- Improve the safety at work, thereby lowering the rate of accidents.

II. OBJECTIVES

Objective of this investigation is reduction of mass of the fixture of steering knuckle of a vehicle including certain additional required parameters. Whereas methodology remains same for other geometries with some minor changes in design. This research focuses on Structural and shape optimization. Finite element analysis has been used to implement optimization and maintaining stress and deformation levels and achieving high stiffness which will reduce the cost with respect to the mass production process.

a) Modeling of turning fixture for steering knuckle.
b) To draw 3D CAD model of the driving bracket , base plate, holding fixture etc
c) F.E.A analysis of the turning fixture for steering knuckle by using hypermesh.
d) Optimization of turning fixture.
e) Manufacturing of the fixture in tool room.
f) Verification/ trial of the design parameter on the machine uses the fixture to produce the component

III. LITERATURE REVIEW

A fixture should be securely fastened to the table of the machine upon which the work is to be done. Though largely used on milling machines, fixtures are also designed to hold the work for various operations on most of the standard machine tools. Fixtures vary in design based on the use of relatively simple tools to expensive or complicated devices. Fixture helps to simplify metalworking operations performed on special equipments.

Nachiket Kulkarni and Vitthal Lakkannavar in “Optimization and Fine-tuning of a Vibration Fixture Design for DesiredDynamic Response” presented in this work is a case, wherein a fixture design is optimized and fine-tuned to meet the desired frequency and weight requirements. The initial optimization of the fixture is carried out through modal analysis. Mass of the fixture is minimized with design constraints on minimum fundamental frequency, mount locations of the lamp on to the fixture and attachment points available on the shaker table. Further design fine-tuning is achieved through frequency response analysis. The results thus obtained were verified against physical test results and were found to be in a good correlation. The finite element model used in this case was generated, executed and post-processed through Altair HyperWorks software packages- HyperMesh, Optistruct and HyperView respectively.[3] The final model of the fixture generated through CAE based optimization is better in design compared to the base design in terms of all the major parameters like better performance, lower cost, lower weight and ease of manufacturability. Altair Optistruct together with HyperMesh and HyperView provides a powerful platform for design optimization. With the help of these tools even the turnaround time required to produce the optimized design is quite less, thereby giving a comprehensive monetary edge.

SD.Ruksar Begum, T.Sita Ram Babu and M.JagadeeswaraRao in “ Finite Element Analysis and Optimization of Machine Fixture” this research work, the machining fixture layout, clamping forces and number of fixturing elements optimization problems are considered with an objective of minimizing the work piece elastic deformation caused during machining. In this machining fixture layout optimization problem, the work piece is treated as elastic model and fixture elements are treated as rigid to predict the work piece elastic deformation, which influences the dimensional and form errors of the work piece. In this research work, Finite element solver ANSYS has been used to determine the work piece elastic deformation caused due to machining and clamping forces. [4] Fixture layout is optimized with an objective of minimizing the overall elastic deformation of the work piece, which influences the dimensional and form errors. The number of fixturing elements is also optimized for minimum work piece deformation.

Thati Govindaiah Dr.V.Krishna Reddy in “Design and Optimization of Fixture for Mirror Holder to Get High Surface Finish and Reduce Machining Time”, The main objective of this paper is to design and optimize the fixture

for mirror holder, which reduces the unit cost of the component and at the same time provides good surface finish. A Mirror Holder is a device that holds a mirror. In optics research, these can be quite sophisticated devices, due to the need to be able to tip and tilt the mirror by controlled amounts, while still holding it in a precise position when it is not being adjusted. Precision mirror mounts can be quite expensive, and a notable amount of engineering goes into their design. Such sophisticated mounts are often required for lasers, interferometers, and optical delay lines.[5]

Modeling of mirror holder is done using unigraphics software. Fixture is designed to arrest the degree of freedom of mirror holder to allow high cutting speeds and to increase production rate. Proper tools are specified which will support for machining typical components like mirror holders. Graphical representation of Product cost reduction, Reduction of setup times & Optimization of cycle times is shown in results. Manufacturing process sequence of mirror holders is shown in the document. Graphical representation of Product cost reduction rate of mirror holders shows reduction of time as well as cost of component when manufactured by using designed fixture which will arrest total degree of freedom and allows high cutting speed and increases production rate and reduces machining time, labour cost.

Kiran Valandi, M.Vijaykumar, Kishore Kumar S "Development, Fabrication and Analysis of Fixture" This dissertation work aims at designing a fixture used for performing machining operations at certain angle (102.5 degree) on the Crank case used in commercial vehicles. The design is proposed so that the required operations are performed properly with the conventional CNC machines to obtain required dimension which includes Design & Structural analysis of fixture is carried out using known and proven methods, i.e., CATIA Elements/Direct modelling 17.0 Software

IV. METHODOLOGY

This research project investigated optimization opportunities that a fixture for steering knuckle can offer. In this investigation, first a literature review on several aspects of fixture for steering knuckle in the areas of load and stress analysis, durability, manufacturing, economic and cost analysis, and optimization was carried out. First, the fixture for steering knuckle was digitized. Load analysis was performed based on the input. A linear static FEA at that point performed utilizing the results from load analysis to gain insight on the structural behavior of the fixture for steering knuckle and to determine the design loads for optimization.

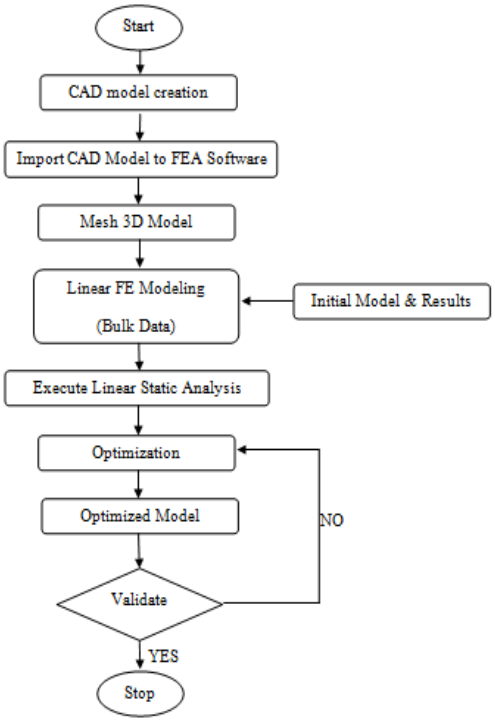

Fig. 2 Methodology

V. MODELLING OF TURNING FIXTURE

The turning fixture taken for the study is used to hold the steering knuckle for various machining operations. The turning fixture is an assembly of various parts whose bill of material is shown below with dimensions for preparing 3D CAD model. CATIA V5 R21 is used to draw the model of turning fixture for steering knuckle.

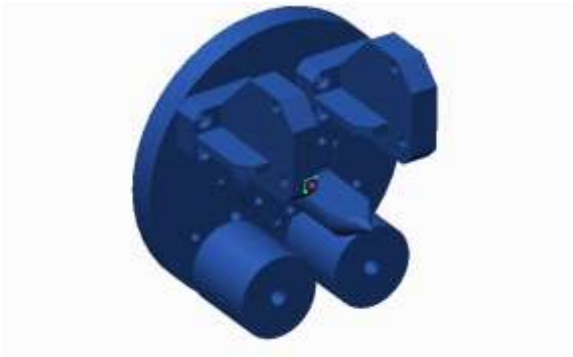

Fig. 3 Assembly of Turning Fixture for Steering Knuckle

VI. CONCLUSION

The following conclusions can be drawn from this investigation:

a) The steering knuckle produced cannot be used directly. It has to undergo various machining operations which requires fixture.
b) A fixture is a workpiece holding device whose primary purpose is to hold the steering knuckle for various machining operations.
c) The design of the project involved making use of most of the important features of CATIA which is a versatile and comprehensive software for three-dimensional solid modeling.
d) Pad and pocket are used as main feature to develop the components. The components are drawn very using CATIA
e) The importance of using finite element analysis as a way of minimizing cost and time required for designing frame concept.
f) Analysis can also be used to redesign highly stressed areas of the component, in which the stress distribution is more balanced.
g) Finite Element Method is one of the perfect ways to reduce the valuable time of real time testing of the components in the real world.

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