Design, Analysis and Optimization of Turning Fixture for Steering Knuckle

Samant Lal Deo[1], P.A. Dixit[2], Krishnan Mahadevan[3]
[1] P.G. Student, Department of Mechanical Engineering, Bharati Vidyapeeth Deemed University, College of Engineering, Pune
sachindeo.91@gmail.com
[2] Asst. Professor, Department of Mechanical Engineering, Bharati Vidyapeeth Deemed University, College of Engineering, Pune
[3]Director Seinumero Nirman Pvt. Ltd.

Abstract: Turning Fixtures for Steering Knuckle is used to mount the work-piece to perform turning, milling or machining operations. Turning Fixture designs play a very important role to achieve the best finish while performing all the operation at minimum operating cost and less rate of rejection. Many Industries are facing an issue with the turning operation as accuracy of the turning is not achieving as per the standard due to the instability in rotation. This unstable rotation is caused due to may reason like improper design, presence/absence of bob weight, Improper mounting, wearing of fixture etc. The purpose of this research is to make a new design of turning fixture for steering knuckle and optimize it. Work piece of Steering knuckle mounted on the fixture will transfer the static and dynamic load on the fixture by the different (we have considered only turning) operation on the work piece. Due to the application of loads stresses are developed. These stresses in the fixture is analyzed using the finite element method, further the design Optimization is done in such a way that the performance of the fixture improve, weight and cost is reduced. Purpose of this design and analysis is to come out with an optimum design to ensure desired performance at minimum cost.

Keywords: *Turning Fixture, Steering Knuckle, FEA, Design Optimization, Hyperworks*

*****

1. INTRODUCTION

In automotive suspension, a **steering knuckle** is a part which contains the wheel hub or spindle, and attaches to the suspension components. It is variously called a steering knuckle, spindle, upright or hub, as well. In the manufacturing of steering knuckle various machining operations are involve and each operation require a Fixture to hold the work piece.

Research in fixtures design is done considering the work-piece and the fixture elements is rigid for the design and kinematic analysis. In this thesis, fixture is design based on the input, it is virtually simulated and further optimization using FEA software Hyperwroks.

During any operation which are performed on work-piece should be properly clamped and positioned o the fixtures, then only guaranteed outcome from the work-piece such as machining with accurate tolerance, turning can be assured [1]. In addition to the machining or turning operation, fixtures are also used for the operation like welding, assembly or inspection [2], [3] and [4]. Fixture affect the cost of manufacturing process around 5-15 % is estimated in manufacturing cycle. Hence to reduce the lead time and improve the manufacturing outcome, fixture design need to improve which indirectly save the cost [5].

In the past, little analysis work was devoted to the design of fixtures. With the recent development of new techniques, software, and numerical solution and theories, changes can be expended beyond design and synthesis. Past research in optimization in fixtures could not handle supports not necessarily on a single plane. Use of faster and better optimization techniques and a comparative study of original and modified design were not employed in fixturing analysis. In this thesis, finite element analysis is used for evaluating the deformation, secondly, optimization procedures is adopted

Turning Fixture complete assembly is generated in CAD software (CATIA). Detail of fixture is shown in Figure 1.

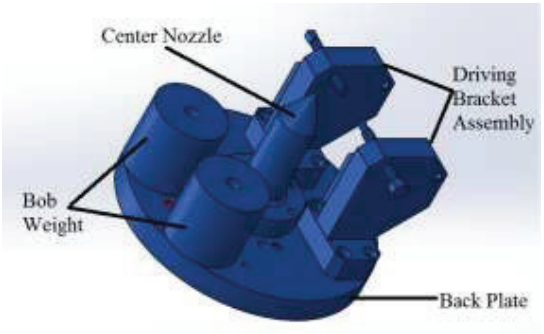

Figure 1: Turning Fixture – 3D view

SCOPE OF WORK

In this thesis designing of the fixture is done that can be used on lathe machine for execution of turning operation taking into consideration the input from steering knuckle and further the design is optimized. This thesis also focuse on the method of analyzing and optimizing a fixture design

 ISSN: 2321-8169
36 - 38

such that the weight of the fixture reduces with improvement in dynamic characteristic. With the nature of turning load and the complications on the geometry, both FEA (Finite Element) and optimization of fixture The modified fixture has been designed to reduce the weight the of the fixture.

2. Methodology

2.1. Material properties

The material for the Design is specified by Company (Seinumero Nirman Pvt. Ltd.) The material for the design are listed below

Table 1: List of Part and Material

Sr. no.	Part Name	Material
1	Back Plate	Mild Steel
2	Bob weight	Mild Steel
3	Clamping bolt and stopper bolt	EN8
4	Center	OHNS
5	Back plate clamping pin	EN8
6	Driving Bracket Assembly	Mild Steel

2.2. Design & Analysis

Each part of the fixture is design as per the input from the organization and assembled. (Refer Figure1.)
Original weight of the model according to materials specified by the company is 35.89kg
Further the analysis of the model is done using Hyperwork software.

Industrial Inputs:

Loads acting on center in X direction: 10,000N, 12,000N, 14,000N, and 15,000N
Loads acting on driving bracket in Z direction: 1000N
Maximum speed of operation: 1500rpm
Constrains: Lock all DOF except rotational X for all back plate clamping pin

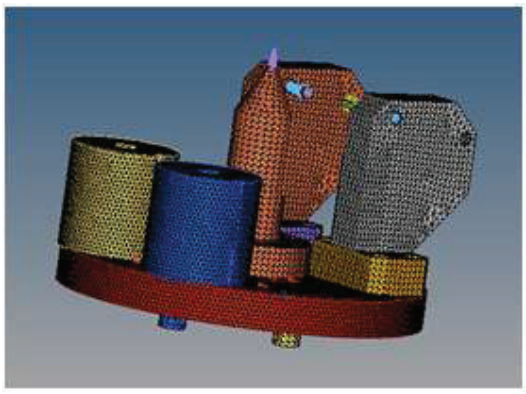

Figure 2: Meshed Fixture in Hypermesh – 3 D View Fixture is meshed with solid tetra elements.

The global size of elements is 5mm. Fixture is meshed to reduce the infinite degree of freedom to finite degree of freedom and solve it to get desired output.

3. RESULT AND DISCUSSION

Below analysis were done using Hyperworks Software - Hypermesh for meshing and Optistruc for solving

Load Applied	Max. Displacement	Max. Stresses
10,000N	0.029 mm	133.37 N/mm^2
12,000N,	0.034mm	160.048N/mm^2
14,000N	0.04mm	186.72 N/mm^2
15,000N	0.043 mm	200.061 N/mm^2

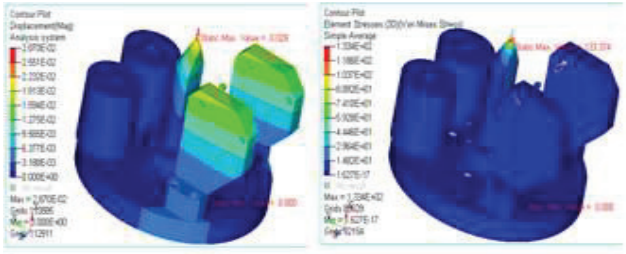

Figure 3: Load applied 10,000N, Displacement and Stress

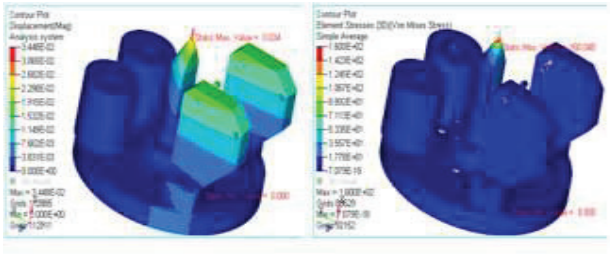

Figure 4: Load applied 12,000N, Displacement and Stress

 ISSN: 2321-8169
36 - 38

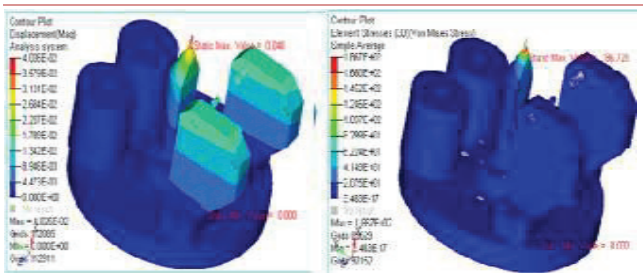

Figure 5: Load applied 14,000N, Displacement and Stress

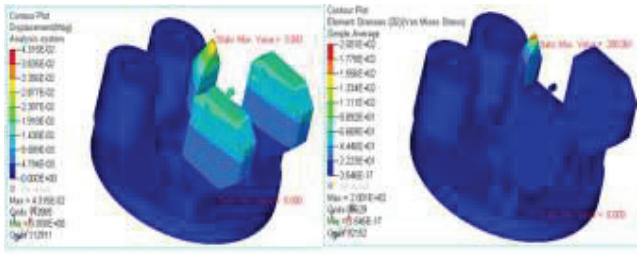

Figure 6: Load applied 15,000N, Displacement and Stress

Topology Optimization

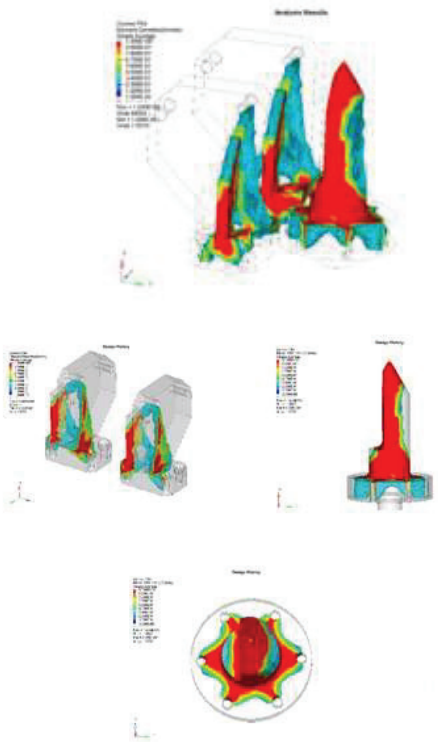

Figure 7: Topological Optimization

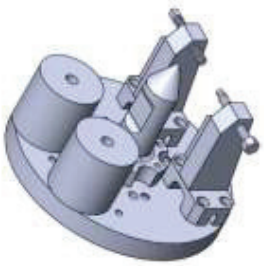

Figure 8: Topological Optimization CAD Model

Weight of the model after optimization is 31.73 i.e. weight of fixture was reduced by 4.16 kg. This will positively affect the efficiency and performance of the fixture.

4. CONCLUSION

Turning fixture is design taking into consideration the input/boundary condition given by company. Design and modeling is done in CAD-Catia Software. Original weight of the model according to materials specified by the company was 35.89kg. The design was analyzed using Hyperwork software (Hypermesh for meshing and Optistruc for Solving) taking 10000N, 12000N, 14000N, 15000N load condition. Displacement varied from 0.029 mm to 0.043 mm and Stresses developed were
133.37 MPa to 200.061 MPa.
Topological Optimization of the design fixture was done and weight was reduced by 4.16 kg that will have positively affect the efficiency and performance of the fixture and also on the operation cost.

REFERENCES

[1] Simunovic, G; Balic, J; Saric, T (2010), comparison of various technological time prediction models, vol 52, No. 2, 137-145.

[2] Fratini, L, Micari F, Buffa G; (2010). A new fixture for FSW process of titanium alloys, CIRP Annals – Manufacturing technology, Vol 59, No. 1, 271-274, doi:10.1016/j.cirp.2010.03.003.

[3] Iacob R, Popescu, D.; Mitrouchev, P. (2012). Assembly/disaasembly analysis of modelling techniques; Journal of Mechanical engineering, Vol 58, No.11, 653-664, doi:10.5545/sv-jme.2011.183

[4] Acko. B.; Mc Carthy, M.;Haertig, F.; Buchmester, B. (2012). Standard for testing free form measurement capability of optical and tactile coordinate system, Measurement science and technology, Vol23, No 9,13p.

[5] Bi, Z.M.; Zhang, W. J. (2001). Flexible fixture design and automation: Review, issues and future directions, International Journal of Production Research, Vol. 39, No. 13, 2867-2894, doi:10.1080/00207540110054579

[6] K.M.Viramgama, R.D.Makwana (2014) A Study on Design Of Fixture For Valve Body For CNC Machine, International Journal of Advance Engineering and Research Development, Volume 1,Issue 12

[7] Nachiket Kulkarni, (2015) Optimization and Fine-tuning of a Vibration Fixture Design for Desired Dynamic Response, Altair Technology.