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Analysis of Turning and Drilling Fixture for HSU Housing Component using FEM

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Abstract- **In this paper an attempt has been made to design a turning and drilling fixtures for HSU component and an analysis has been carried out under different loading conditions, that it will be subjected during the cutting process. During the turning and drilling process an axial loads is acted on the workpiece. Due to this continuous axial load acting, a stress is developed in the fixture. Two loading conditions were considered viz. cutting force and the clamping force during the operation. An investigation has been carried out for stress induced in both the fixtures through Ansys workbench. Three softwares were used during the course of this project namely. AutoCAD, CATIA and ANSYS. AutoCAD was used for 2D drawings, CATIA for modeling and ANSYS workbench for meshing and analysis. Firstly 2D diagrams were drawn with dimensions in AutoCAD to develop the picture of both the fixtures and 3D models has been done in CATIA. The individual parts were assembled to give a clear 3D figure of the turning and drilling fixture. The maximum cutting force and the clamping forces were considered and the maximum stress and deformation were calculated. These results were compared with the material yield strength value. The Ansys results indicated that, maximum stress obtained is less than the material yield strength. This is inferred that the obtained results of the analysis can be trusted. Comparing these results with material strength, it is summerised that the turning and drilling fixtures were safe under all the loading conditions.**

Keywords- Fınıte Element Method (FEM), Modeling , Meshing, Hydrostatic Steering Unit(HSU).

I. INTRODUCTION

Fixture design is a field of tool engineering which is one of the main field in the manufacturing processes. It is difficult to manufacture a new product without proper tool and also it is not an easy job to do it with these tools. The tool should have a definite design and specifications with required quality. Basically in designing a fixture, the geometrical constraints are the main factors in the sequence of machining operations, namely supporting constraints, locating constraints and clamping constraints. Fixture design is not an easy task to develop or to design. Many analysis should be carried out to develop a new fixture. The study of workpiece component and also selection of cutting tool is very important in all the machining process. Machining process is the process of cutting away the unwanted material and to obtain the final finished part. Fixture design plays a vital role to hold the workpiece firmly, before designing a fixture preliminary analysis should be done by selecting the proper material. Before designing a fixture some of the steps should be carried by taking the data of the machining information and design requirements.

In this paper, the fixtures required for performing several machining operations on HSU component has been designed and analyzed. The paper is organized as follows, section 1 gives the introduction, section 2 describes the HSU component, section 3 gives the boundary condition, section 4 describes the load experienced by the fixture, and section 5 gives the discussion of results followed by the conclusion in section 6.

II. HSU COMPONENT

The housing is basically used as a directional control valve when assembled with the sleeve and the spool. The housing has 4-ports at the top, two for the entry and two for the exit. They are called as right-line, left-Line, and transfer-line cylinder accordingly. The HSU is basically connected to a hydraulic power house which is the liquid reservoir from where the liquid is supplied to the HSU as required. When the steering wheel is rotated the spool rotates with the sleeve and opens the port. The hydraulic fluid from the reservoir enters into the HSU through the R-line. If the steering wheel is rotated in the right direction the R-line ports will open and the fluid enters into the right side of the cylinder causing the vehicle to turn in the right direction. If the steering wheel is rotated in the left direction, then the L-line Ports will open causing the hydraulic fluid to enter into the left side of the cylinder and pushing back fluid from the right side of the cylinder. This will cause the vehicle to turn the left direction. The fluid which is pushed back from the other side is sent back to the reservoir through the T-line. This is the brief working of the Hydro-Static Unit (HSU). Figure 2.1 shows model of HSU component.

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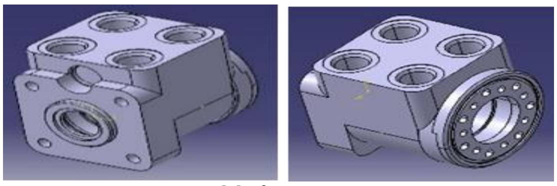

Fig 2.1: 3D Catia Model of HSU Housing Component

The HSU-housing is the most important part of the hydro-static unit. All the other components of the HSU are fitted into the housing such as Cardon-Shaft, stator and rotor etc. The housing has four large ports through which the hydraulic fluid enters and exits. These large ports open into small ports which again open into the bore of the housing at different locations. There is a pressure relief valve which helps to obtain required amount of pressure to achieve the effective steering of the vehicle.

A. Modeling

The following materials were used for building up the fixtures namely 1) clamping stud, clamping support stud and clamping strap which were made up of medium carbon steel C45 2) rest button, conical washer and liner bush which were made up of Carburizing steel 17Mn1Cr95 3) rest pad and jig bush which were made up of bearing steel 103Cr1 and 4) Fixture bracket was made up of MS Weldment.
All the dimensions of the fixture are developed by analyzing the HSU component (workpiece) dimensions and by measuring available area at the work station. Figure 2.2 shows the structure of hydraulic steering system.

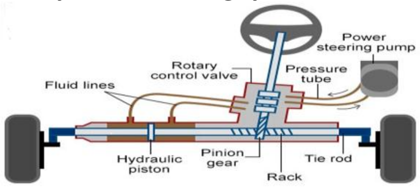

Fig 2.2 Hydraulic Steering System

The following below figures from 2.3 to 2.10 shows the 3 D Catia models of all the parts of fixtures as per required dimensions.

- Fixture Bracket and V Block: The fixture bracket is used as base plate as well as supporting structure and v block is located on the fixture bracket which act as support for HSU workpiece.

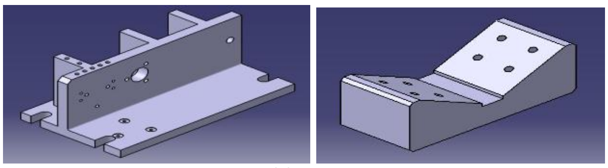

Fig 2.3: 3-D model of fixture bracket and V block

- Clamping Support Stud and Clamp Stud: These studs act as supporting structure for clamping strap.

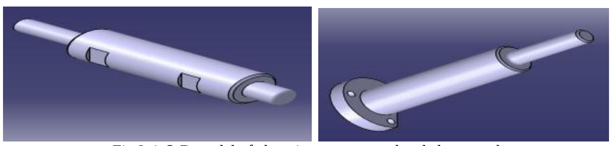

Fig 2.4: 3-D model of clamping support stud and clamp stud

- Jig Plate and Liner Bush: The jig plate act as guidance for drilling and liner bush is placed inside the jig plate.

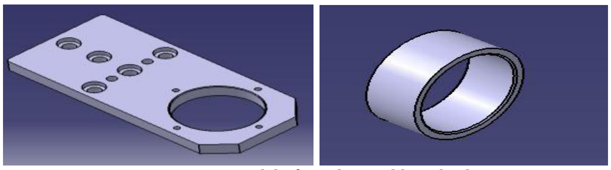

Fig 2.5: 3-D model of jig plate and liner bush

- Clamping Strap and Conical Washer: The clamping strap is used as clamping element for HSU workpiece and conical washer is placed inside the strap in conical space.

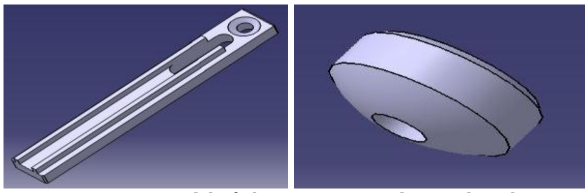

Fig 2.6: 3-D model of clamping strap and conical washer

- Rest Button and Rest Pad: The rest button is used as resting material for HSU workpiece and rest pad is placed in v block which act as support for HSU workpiece at cylindrical surface.

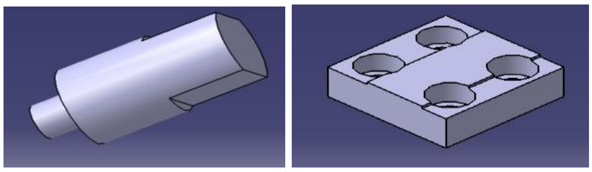

Fig 2.7: 3-D model of rest button and rest pad

- Jig Bush and Nut: The jig bush is used as guidance for drilling which is placed inside the jig plate and nut is used to tight the clamping strap.

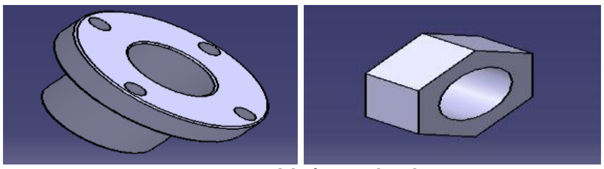

Fig 2.8: 3-D model of Jig Bush and Nut

- Center Locator and Housing Locator: The center locator is used as locking material from where tailstock load is applied on it and housing locator is used as locating part in spindle.

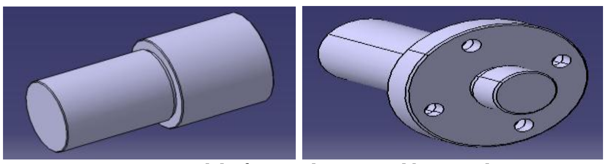

Fig 2.9: 3-D model of center locator and housing locator

- Spindle Flange and Fixture Flange: The spindle flange is fixed to chuck and fixture flange is located to spindle flange at on one side other side housing locator is placed.

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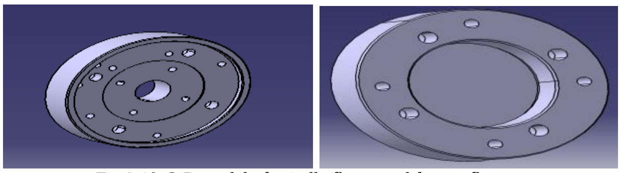
Fig 2.10: 3-D model of spindle flange and fixture flange

The below figure 2.11 and 2.12 shows the 3D Catia model of turning and drilling fixture for HSU housing component.

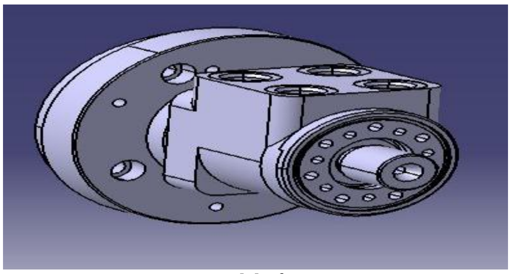
Fig 2.11: 3-D model of Turning Fixture

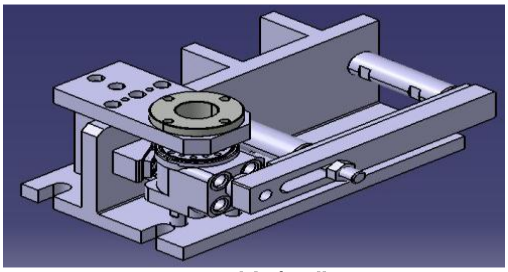
Fig 2.12: 3-D model of Drilling Fixture

B. *Meshing*

Meshing has been carried out in workbench itself, figure 2.13 shows the meshed model of turning and drilling fixture. Meshing is the one of the preprocessor steps in FEM, used to divide the continuum into smaller regions called ‘elements’ before carrying out the analysis. For the given physical problem, the accuracy of the numerical solution depends largely on the quality of the mesh.

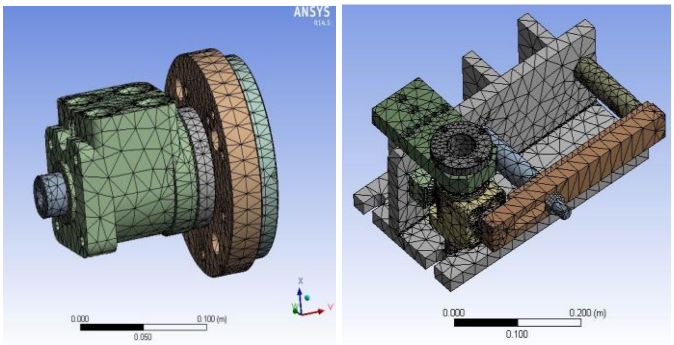

Fig 2.13 Meshed model of turning fixture and drilling fixture

In a uniform mesh, the discretization error reduces as number of elements increases. Analysis of turning and drilling fixture were analyzed the stress concentration in the fixture.

III. Boundary Conditions

The work piece must be placed correctly in the fixture with the correct orientation by providing a good support, locating and clamping materials. Any solid body may have maximum twelve degrees of freedom. So that maximum number of degrees of freedom were constrained and the work piece would be firmly fixed. The figures 3.1 and 3.2 shows the locating and clamping points of workpiece in fixtures.

A. *Supporting and Locating Design Principle*

The following supporting and locating design principles were adopted: 1) Proper alignment is ensured corresponding to locating points for mating parts. 2) 3-2-1 principle location was used, with 3 to largest surface. 3) Locating points were made visible so that operator can see to clean up and to replace it when needed. 4) Provided clamps that are quick acting, easy to use and economical. 5) Complicated clamping arrangements were avoided to minimize the wear out or malfunction. 6) Clamps were located opposite to locators to avoid deflection during machining and spring back. 7) Thrusting forces were considered on locators and not on clamps. 8) Selection of fixture materials were made carefully which are easily available and economical.

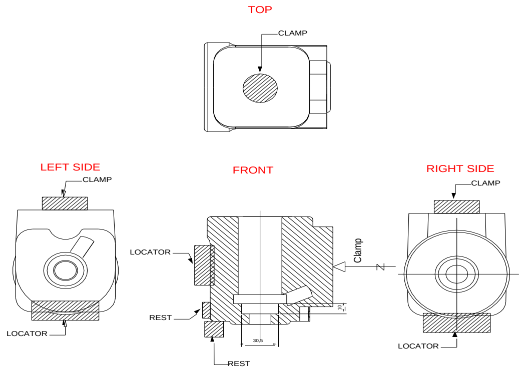

Fig 3.1: Locating and Clamping Points for Drilling Fixture

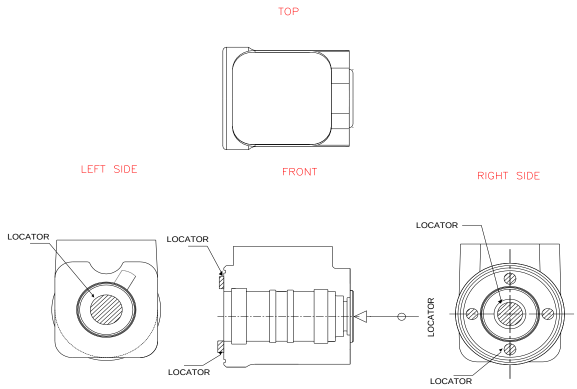

Fig 3.2: Locating and Clamping Points for Turning Fixture

IV. Imposition Of Loads And Constraints

The stress induced in any member depends on the loads and the constraints provided to prevent the rigid body motion. Here drilling process has been carried and amount of torque and thrusts were calculated.
Details of the drilling force calculation are as given below:

A. *Calculation in Drilling:*

1) Diameter of the drill (D) = 30.5mm
2) Rpm = 450 (n)
3) Cutting speed (v) = $(\pi D n)/1000$

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$= (30.5 \times 450 \times \pi)/1000$

$$\boxed{v = 43.118 m/min}$$

4) Feed / rev (s) = 0.22 mm/rev

5) Material factor (K) = 1.5 From CMTI Hand Book

6) Power at the spindle (N)

$N = 1.25D^2.K.n\ (0.056 + 1.5S)/10^5$

$= 1.25\ (30.5)^2 \times 1.5 \times 450x\ (0.056+1.5(0.22))/10^5$

$$\boxed{N = 3.029\ Kw}$$

7) Efficiency (E) = 85% = 0.85

8) Power of the motor (N_{el}) = N/E =3.029/0.85

$$\boxed{N_{el} = 3.56\ KW}$$

9) Torque (T_s)

$T_s = 975\ N/n$

$= 975\ (3.029/450)$

$$\boxed{T_s = 6.56\ kgf.m}$$

10) Thrust (T_h)

$T_h = 1.16\ KD\ (100S)^{0.85}$

$= 1.16\ (1.5)\ (30.5)\ (100(0.22))^{0.85}$

$$\boxed{T_h = 734.35\ kgf}$$

11) Force applied by the body at length 'L'is given by,

$(P) = 2M_t/d_p.\tan(\beta+\rho)$

Where, $M_t = FxL = 20x0.25x9.81 = 49.05N\text{-}m$

$\beta = \tan^{-1}(lead/\pi x d_p) = (2.5/\pi x17.5) = 2.6036$

$\rho = \tan^{-1}(\mu) = \tan^{-1}(0.72) = 35.75$

$P = (2x50x1000)/\ (17.5\tan(2.6036+35.75))$

$$\boxed{P = 7219N}$$

V. Results And Discussions

To study the performance of various elements and its results, the analysis have been carried out using Ansys software. This analysis is performed on individual parts and assembled fixture. The stress concentration and the yield strength of the material have been calculated. The following materials like clamping stud, clamping support stud and clamping strap were made up of medium carbon steel C45 and Fixture bracket was made up of MS Weldment.

5.1 Comparison of elements chosen

The results of an elements have compared for the suitability of chosen elements in the turning and drilling fixture.
The details of the calculations are as shown below.

5.1.1 Analysis of clamping support stud: Load on neck surface

In this case, a compression force about 7219N has been applied on the neck surface of the clamping support stud.

5.1.2 Analysis results of clamping support stud:

The analysis results shown in figures are noted as below
Maximum deformation observed: 0.0083 mm
Maximum stress: 41.985 MPa

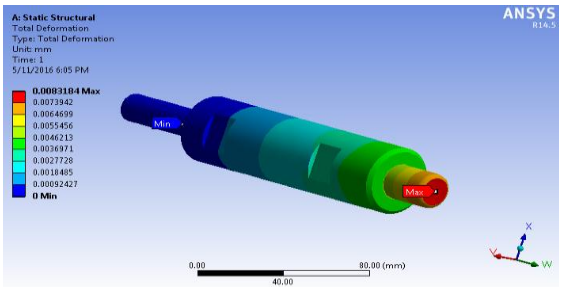

Fig 5.1 Deformation of clamping support stud loaded on the neck surface.

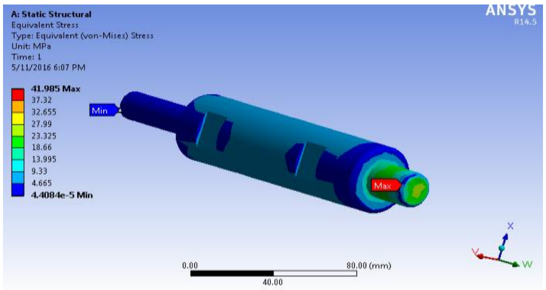

Fig 5.2 Stress of clamping support stud loaded on the neck surface.

5.1.3 Analysis of clamping stud: Load on neck surface

In this case, a clamping force of 7219N has been applied on the surface of the clamping stud. The applied torque for M20 thread is of 49.5 N-m with force of 25kg at a distance of 250mm with wench.

5.1.4 Analysis results of clamping stud:

The analysis results shown in figures are noted as below
Maximum deformation observed: 0.014 mm
Maximum stress: 40.596 MPa

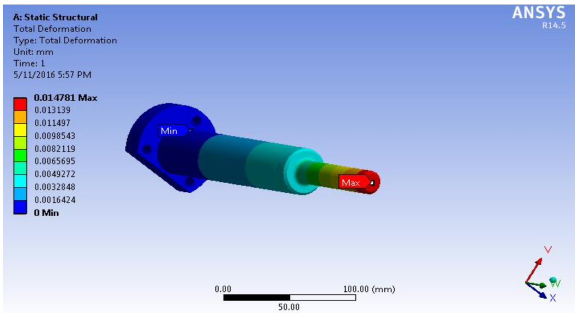

Fig 5.3 Deformation of clamping stud loaded on the neck surface.

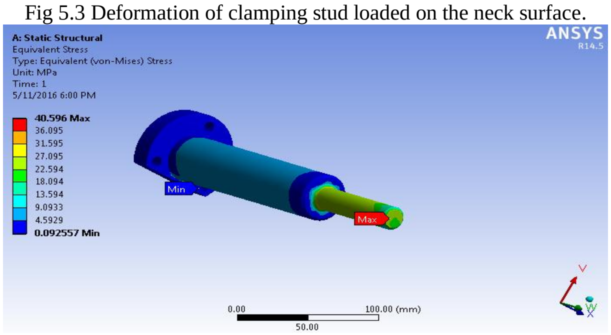

Fig 5.4 Stress of clamping stud loaded on the neck surface.

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5.1.5 Analysis of fixture bracket: Load on fixture bracket
In this case, a force have been applied at locating surface at supporting stud of 7210N and some of location have been fixed.
5.1.6 Analysis results of fixture bracket:
The analysis results shown in figures are noted as below
Maximum deformation observed: 0.0161 mm
Maximum stress: 92.861 MPa

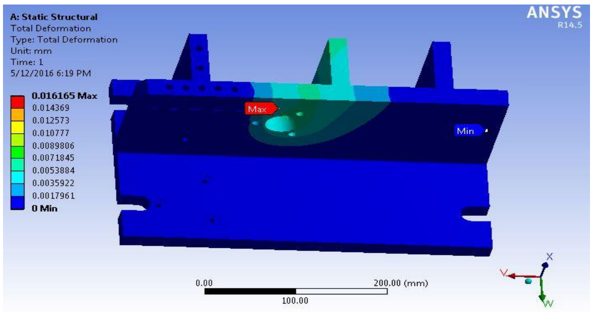

Fig 5.5 Deformation of fixture bracket loaded on the clamping stud surface.

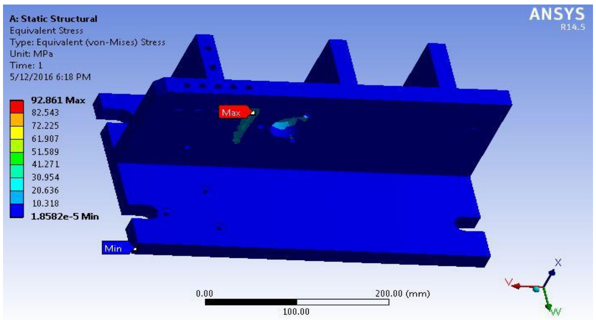

Fig 5.6 Stress of fixture bracket loaded on the clamping stud surface.

5.1.7 Analysis of V Block: Load on workpiece locating surface
In this case, a clamping force of 7210N have been applied on the surface of the workpiece locating surface of the v block.
5.1.8 Analysis results V block:
The analysis results shown in figures are noted as below
Maximum deformation observed: 0.0011 mm
Maximum stress: 11.136 MPa

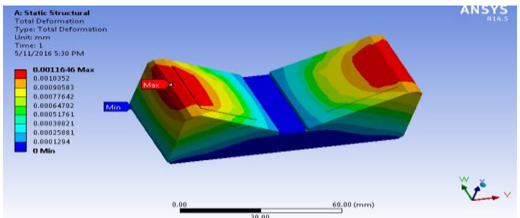

Fig 5.7 Deformation of v block loaded on the workpiece locating surface.

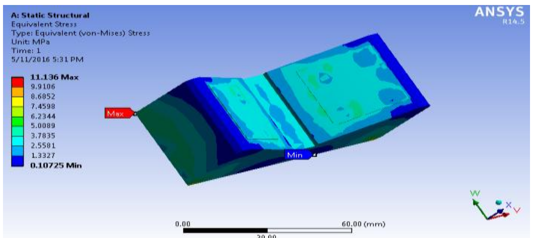

Fig 5.8 Stress of v block loaded on the workpiece locating surface.

5.1.9 Analysis of Clamping Strap: Load on strap surface
In this case, a clamping force of 7210N has been applied on the surface of the clamping strap and some location have been fixed.
5.1.10 Analysis results of Clamping Strap:
The analysis results shown in figures are noted as below
Maximum deformation observed: 0.046 mm
Maximum stress: 141.7 MPa

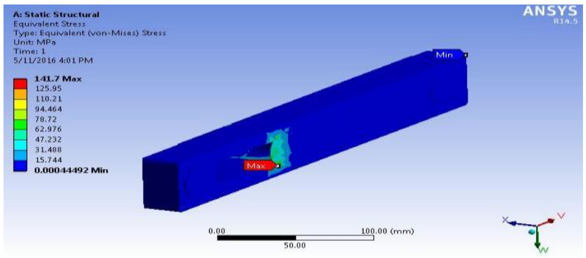

Fig 5.9 Stress of clamping strap loaded on the clamping surface.

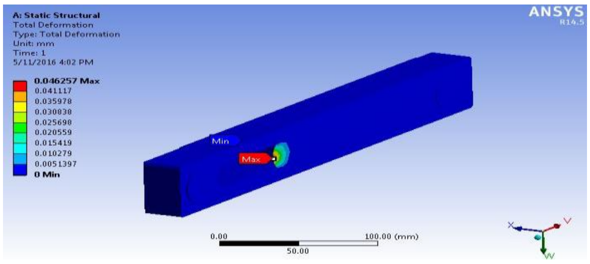

Fig 5.10 Deformation of clamping strap loaded on the clamping surface.

5.1.11 Analysis of Drilling Fixture: Load on clamping surface
In this case, a clamping force of 7210N has been applied on the surface of the clamping strap. The applied torque is of 49.5 N-m with force of 25kg at a distance of 250m and Tangential force of 5402.98N workpiece clamping surface.

5.1.12 Analysis results of drilling fixture:
The analysis results shown in figures are noted as below
Maximum deformation observed: 0.0240 mm
Maximum stress: 99.237 MPa

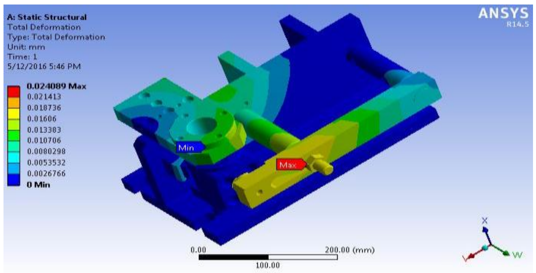

Fig 5.11 Deformation of drilling fixture loaded on the clamping surface.

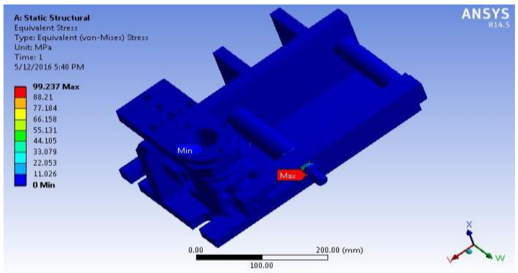

Fig 5.12 Stress of drilling fixture loaded on the clamping surface.

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5.1.11 Analysis of Drilling Fixture: Load on clamping surface

In this case, an applied force of 5000N has been applied on center locator which is located inside the housing locator.

5.1.12 Analysis results of turning fixture:

The analysis results shown in figures are noted as below

Maximum deformation observed: 0.0036 mm

Maximum stress: 150.02 MPa

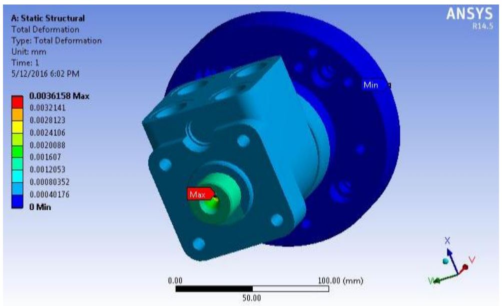

Fig 5.13 Deformation of turning fixture loaded on center locator surface.

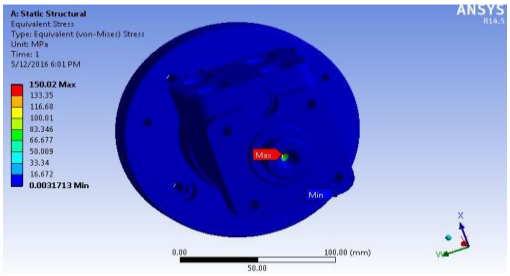

Fig 5.14 Stress of turning fixture loaded on the center locator surface.

VI. DISCUSSION OF RESULTS

After the analysis of each individual parts, it's observed that the stress concentration is maximum near the curved surfaces, neck and holes. All the results of each of parts were found to be within limits. The maximum stress in drilling fixture is being observed at the surface of the clamping location in clamping strap material. Maximum stress of 99.237mpa is noted and Maximum deflection is found to be 0.0240mm, which occurs at hole surface. This maximum stress, is much less as compared to the yield strength of the carbon steel material.

VII. CONCLUSION

The following points have been drawn from the present investigation:

- The 2D and 3D of the individual parts of turning and drilling fixtures were drawn as per the required dimensions using AutoCAD and Catia respectively
- Ansys workbench software is used in analysis of the part drawing and assembly drawing.
- The maximum stress of 99.237mpa and Maximum deflection of 0.0240 mm, was observed at the clamping strap hole surface in drilling fixture.
- The maximum stress of 150.02mpa and Maximum deflection of 0.0036 mm, was observed at the surface of center locator in turning fixture.
- The maximum stress indicated is less than the yield stress of medium carbon steel material i.e. 340 to 400mpa, thus the turning and drilling fixtures are under safe condition. The maximum stress value is very much lower than the yield stress, which suggests that, the material is under-utilized.
- In total the design of drilling and turning is found to be safe and satisfactory.

REFERENCES

[1] ANSYS 14.5 (Help Menu and Tutorial Manuals)

[2] Edwards, L. and Endean, M., Manufacturing with materials, 1990, Butterworth Heinemann, ISBN 0-7506-2754-9.

[3] Colvin, fred H: Haas, Lucian l(1938), jigs and fixtures ,reference book,mcgraw-hilll

[4] Shailesh S.Pachbhai1, Laukik P.Raut2, A Review on Design of Fixtures, International Journal of Engineering Research and General Science Volume 2, Issue 2, Feb-Mar 2014 ISSN 2091-2730

[5] Charles Chikwendu Okpala, Ezeanyim Okechukwu C., Science Research 2015; 3(4): 213-219 published online July 25, 2015 (http://www.sciencepublishinggroup.com/j/sr)doi:10.11648/j.sr.20150304.19 ISSN: 2329-0935 (Print); ISSN: 2329-0927 (Online).

[6] X. Dong, W. R. DeVries (2). M. J. Wozny, Rensselaer Polytechnic institute, Troy, New York USA Received on January 16, 1991, Annals of the CIRP, Vol. 40/1/1991