DESIGN AND OPTIMIZATION OF FIXTURES TO MINIMIZING MANUFACTURING FAILURES OF TURBINE BLADE: A FINITE ELEMENT APPROACH

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ABSTRACT:

Many of the parts require sophisticated fixture in order to be machined. A variety of CNC machine brands all of which have differently designed tables. They needed a way of sharing the clamping systems with all of the machines. After reviewing the fixtures and machines, we designed, and tested a clamping system to minimise the manufacturing defects obtained in turbine blade machining. Gas turbine rotor blade of stage 3 taken in to consideration for machining mistakes to develop an alternative fixture. The fixture design based on the practical considerations taken from the manufacturing industry to show the solution of minimising optimal values of the blade formation as per the requirement. The design carried out by using Uni-Graphics NX8.0 software. The assembly of the fixture taken to finite element approach to get the comparison of present using fixture to modified fixture. Ansys 15.0 workbench used to simulate fixture load conditions and the material boundary conditions taken from the practical loads applied.

Keyword: *M/c design applicability on fixtures, turbine blades, fixture design, manufacturing techniques, FE approach.*

INTRODUCTION

Fixtures: Being used in machine shop, are strong and rigid mechanical devices which enable easy, quick and consistently accurate locating, supporting and clamping, blanks against cutting tool(s) and result faster and accurate machining with consistent quality, functional ability and interchange ability.

Jig: is a fixture with an additional feature of tool guidance.

Purpose of Using Fixtures and Jigs: The fixture is a special tool for holding a work piece in proper position during manufacturing operation. For supporting and clamping the work piece, device is provided. Frequent checking, positioning, individual marking and non-uniform quality in manufacturing process is eliminated by fixture. This increase productivity and reduce operation time. Fixture is widely used in the Industry practical production because of feature and advantages.

Problem statement for present project: To initiate the fixture-design process, clearly state the problem to be solved or needs to be met. State these requirements as broadly as possible, but specifically enough to define the scope of the design project.

Important considerations while designing fixtures: Designing of jigs and fixtures depends upon so many factors. These factors are analyzed to get design inputs for jigs and fixtures. The list of such factors is mentioned below:

a. Study of work piece and finished component size and geometry.

b. Type and capacity of the machine, its extent of automation.
c. Provision of locating devices in the machine.
d. Available clamping arrangements in the machine.
e. Available indexing devices, their accuracy.
f. Evaluation of variability in the performance results of the machine.
g. Rigidity and of the machine tool under consideration.
h. Study of ejecting devices, safety devices, etc.
i. Required level of the accuracy in the work and quality to be produced.

Introduction to design of fixtures: While designing for clamping the following factors essentially need to be considered:

1. Clamping need to be strong and rigid enough to hold the blank firmly during machining.
2. Clamping should be easy, quick and consistently adequate
3. Clamping should be such that it is not affected by vibration, chatter or heavy pressure
4. The way of clamping and unclamping should not hinder loading and unloading the blank in the jig or fixture.
5. The clamp and clamping force must not damage or deform the work piece.
6. Clamping operation should be very simple and quick acting when the jig or fixture is to be used more frequently and for large volume of work.
7. Clamps, which move by slide or slip or tend to do so during applying clamping forces, should be avoided.
8. Clamping system should comprise of less number of parts for ease of design, operation and maintenance.
9. The wearing parts should be hard or hardened and also be easily replaceable.
10. Clamping force should act on heavy part(s) and against supporting and locating surfaces.
11. Clamping force should be away from the machining thrust forces.
12. Clamping method should be fool proof and safe.
13. Clamping must be reliable but also inexpensive.

OBJECTIVES:

(1) Turbine blades manufacturing defects.
(2) Clamping system for Fourth axis Rotary.
(3) Blade fixing system.
(4) Fourth axis clamping system.
(5) Special purpose fixture for blade machining operations.
(6) Study of market requirements for the present application.
(7) Comparative study on both clamping system with motion analysis

Specifications for present project:

(1) The indexing chuck to chuck distance =450mm
(2) Bed length in CNC VMC bmv45 =600 -850mm
(3) Indexing chuck Diameter (ID - 150mm)
(4) In case of flat Fixture the Side plates dimensions =80x80

(5) No of Tap holes 16 no's of M12 Tap –on both plates
(6) These side plates size is less than the job so that it can clamp rigidly.
(7) side plates Thickness = 30mm
(8) Overall chuck dia in O.D=350mm

Failure considerations in manufacturing of blade

1. Machining paths adjustment in cam programming

2. Tool safety considerations while machining.

3. Tool marks and blade finishing.

4. Quality check of blade profiles at different sections.

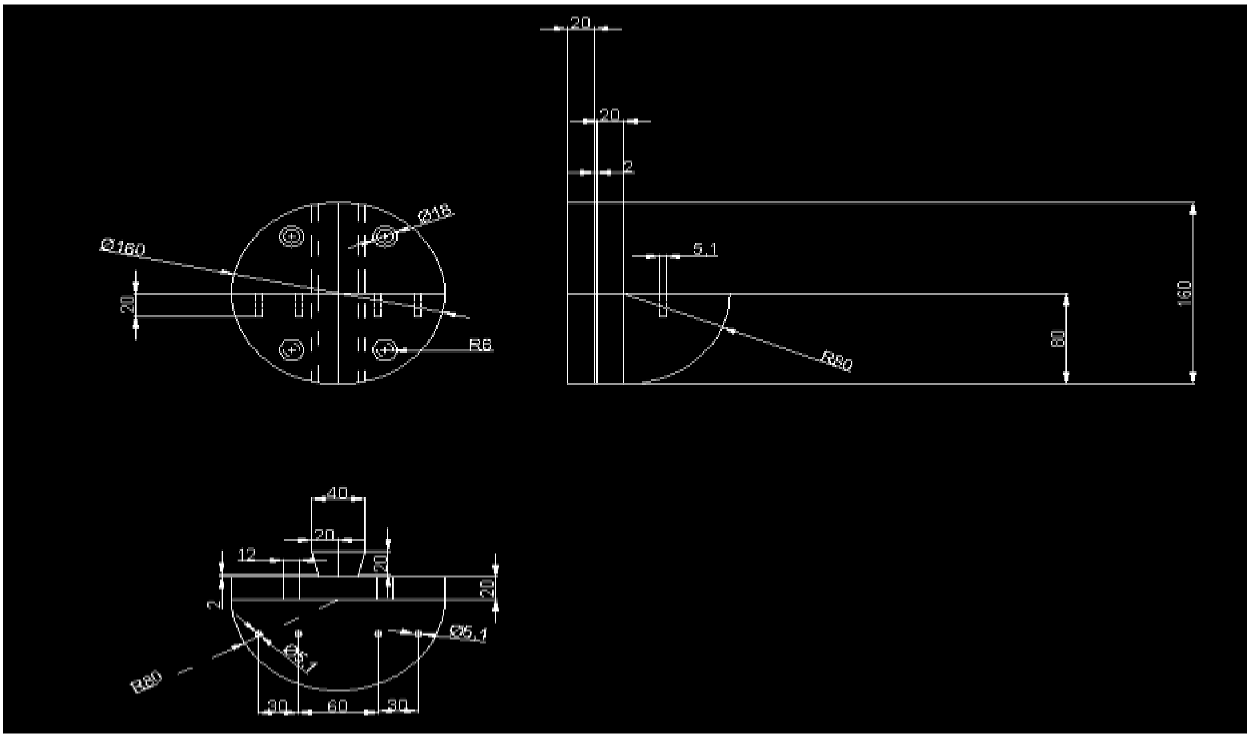
5. Blade accuracy levels after machining.

DESIGN ANALYSIS

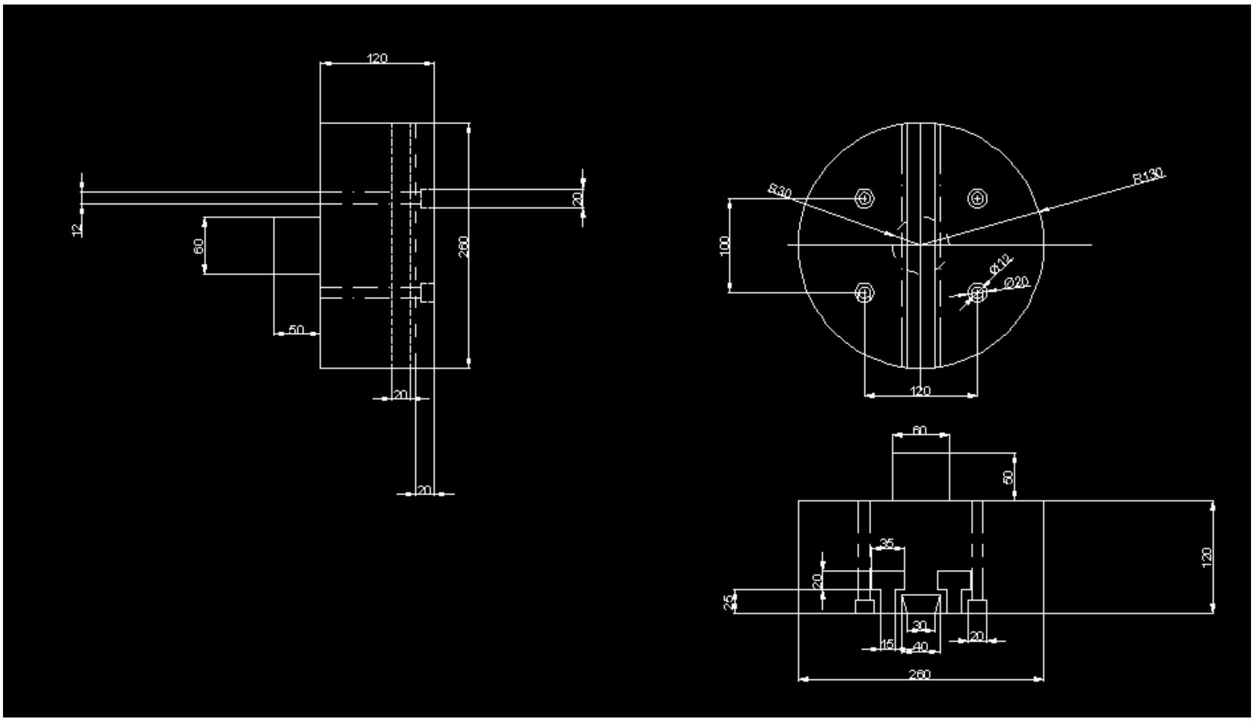
Introduction to CAD

Computer-aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

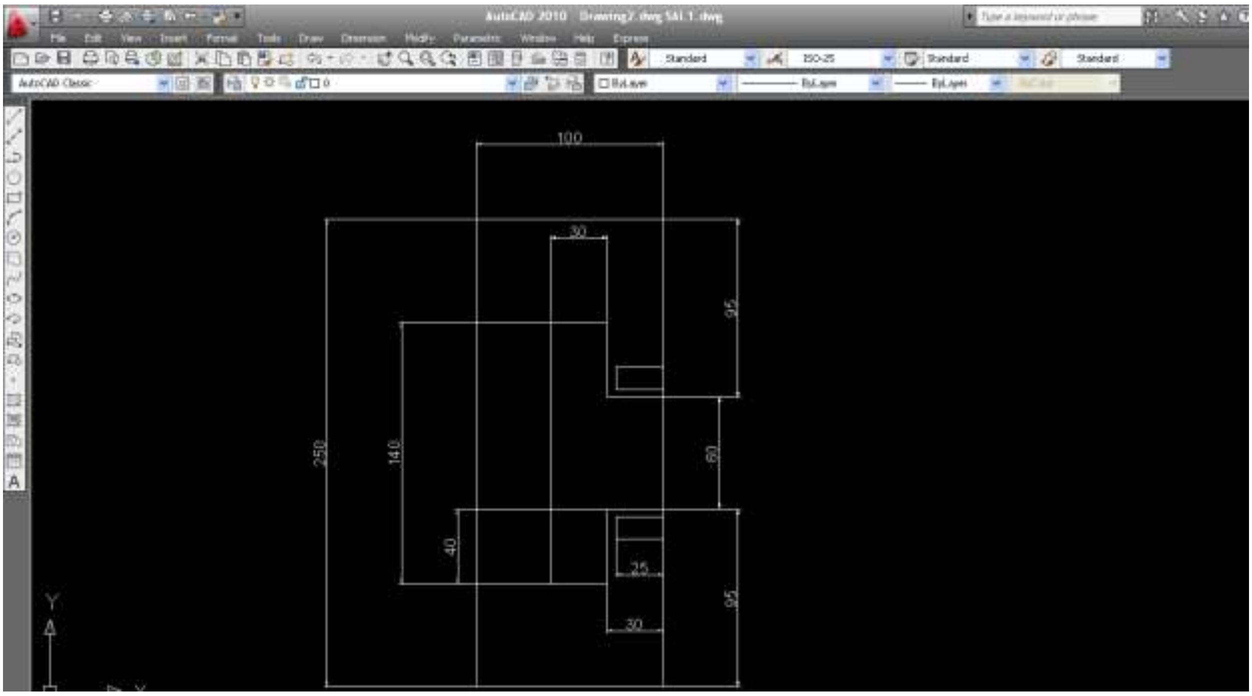
Auto CAD design Layouts



Insert preparation in AutoCAD for 2nd side modified fixture



Fixing insert f second side modified



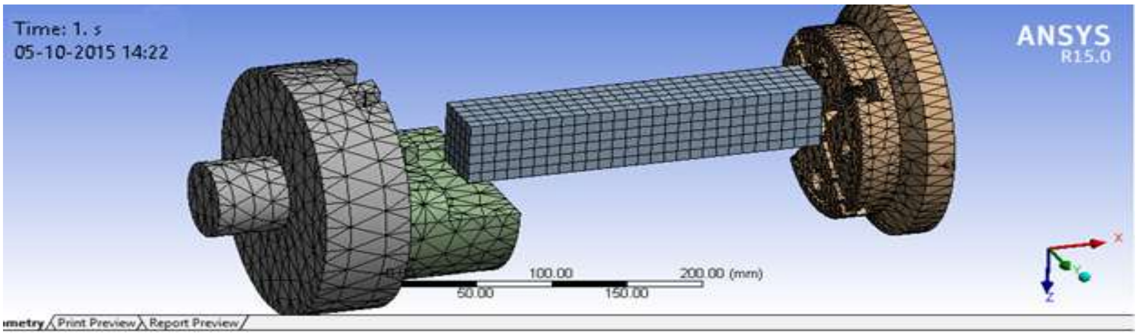
Fixture base on second side modified

FINITE ELEMENT ANALYSIS

In finite element analysis of fixture stiffness, the main task is to describe the fixture unit stiffness by using a numerical method. In this chapter, a finite element model of fixture unit stiffness is developed. A contact element is utilized to solve the contact problems encountered in the study of fixture unit stiffness analysis. Due to the contact conditions, the status of contact elements may change, and contact stiffness is not constant in the analysis of process. In the FEA model, the contact and friction conditions will be represented mathematically and discussed in detail. The finite element model and the analysis procedure are validated by case study.

FEA Formulation Consider a general fixture unit with two components I and J. For multi-component fixture units, the model can be expanded. The fixture unit is discretized into finite element models using a standard procedure, except for the contact surfaces, where each nodes on the finite element mesh for the contact surface is modeled by a pair of nodes at the same location belonging to components I and J, respectively, which are connected by a set of contact elements. The basic assumptions include that material is homogenous and linearly elastic, displacements and strains are small in both components I and J, and the frictional force acting on the contact surface follows the Coulomb law of friction.

MESHING OF PRESENT PROJECT:

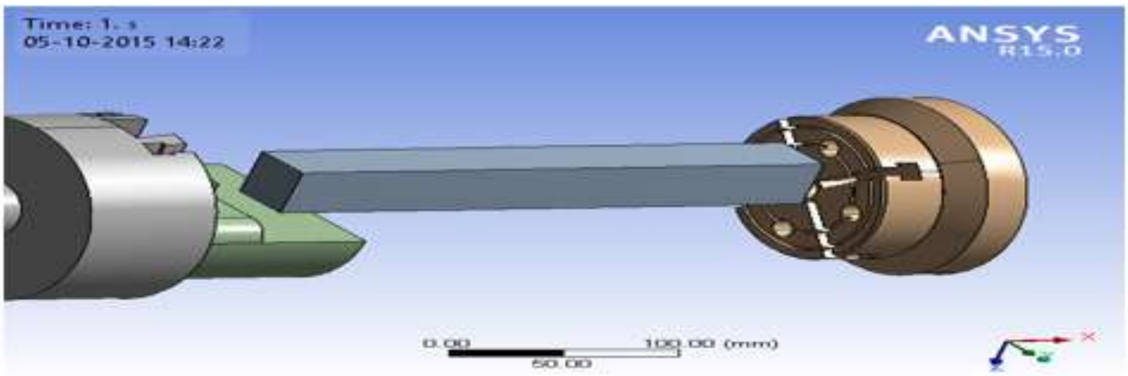


Material Data - Structural Steel

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

RESULTS & DISCUSSIONS

Static Structural



Frictionless Support2

TABLE: Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

TABLE : Structural Steel > Compressive Ultimate Strength

Compressive Ultimate Strength MPa
0

TABLE: Structural Steel > Compressive Yield Strength

Compressive Yield Strength MPa
250

TABLE: Structural Steel > Tensile Yield Strength

Tensile Yield Strength MPa
250

TABLE : Structural Steel > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
460

TABLE : Structural Steel > Isotropic Secant Coefficient of Thermal Expansion

Reference Temperature C
22

TABLE : Structural Steel > Alternating Stress Mean Stress

Alternating Stress MPa	Cycles	Mean Stress MPa
3999	10	0
2827	20	0
1896	50	0
1413	100	0
1069	200	0
441	2000	0
262	10000	0
214	20000	0
138	1.e+005	0
114	2.e+005	0
86.2	1.e+006	0

TABLE : Structural Steel > Strain-Life Parameters

Strength Coefficient MPa	Strength Exponent	Ductility Coefficient	Ductility Exponent	Cyclic Strength Coefficient MPa	Cyclic Strain Hardening Exponent
920	-0.106	0.213	-0.47	1000	0.2

TABLE : Structural Steel > Isotropic Elasticity

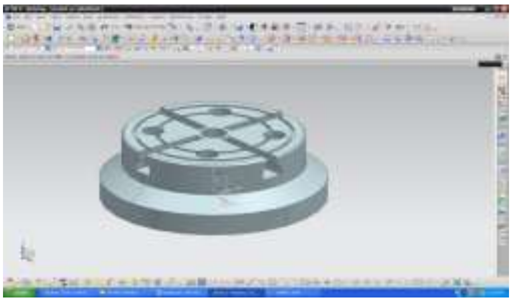
Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	2.e+005	0.3	1.6667e+005	76923

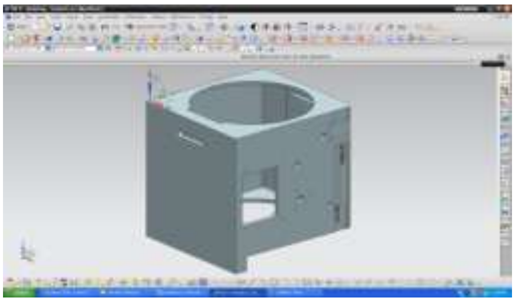
TABLE : Structural Steel > Isotropic Relative Permeability

Relative Permeability
10000

DESIGN CONSIDERATIONS OF BEARING HOUSING:
Housing fixing bore-100mm, bearing size-60mm dia (I.D), supported wall thickness-12mm, Bottom wall thickness-10mm

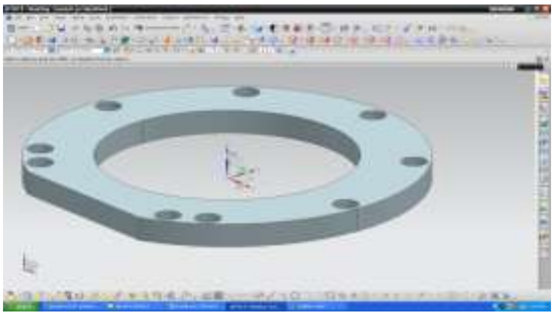
DRAWING OF PROPOSED PROJECT

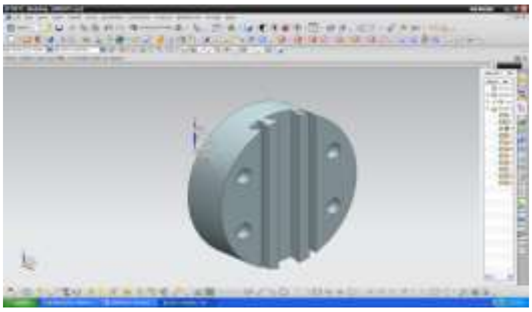




Chuck

Housing





Chuck support ring

fixture plate

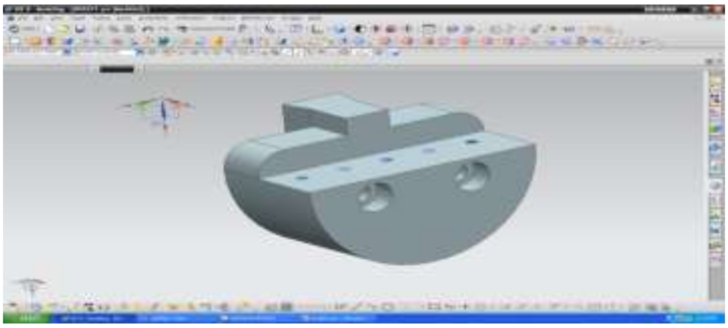
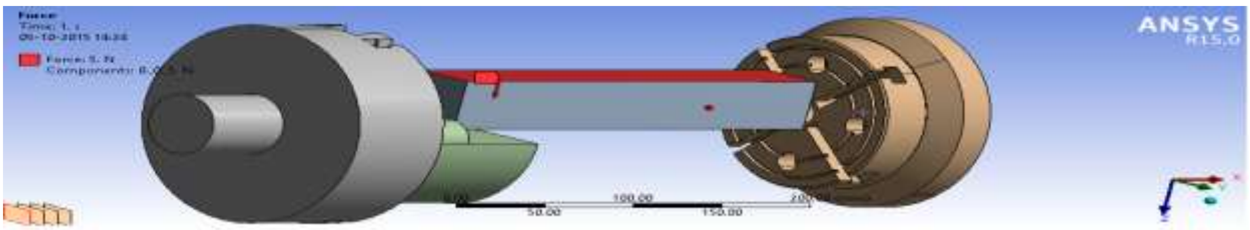
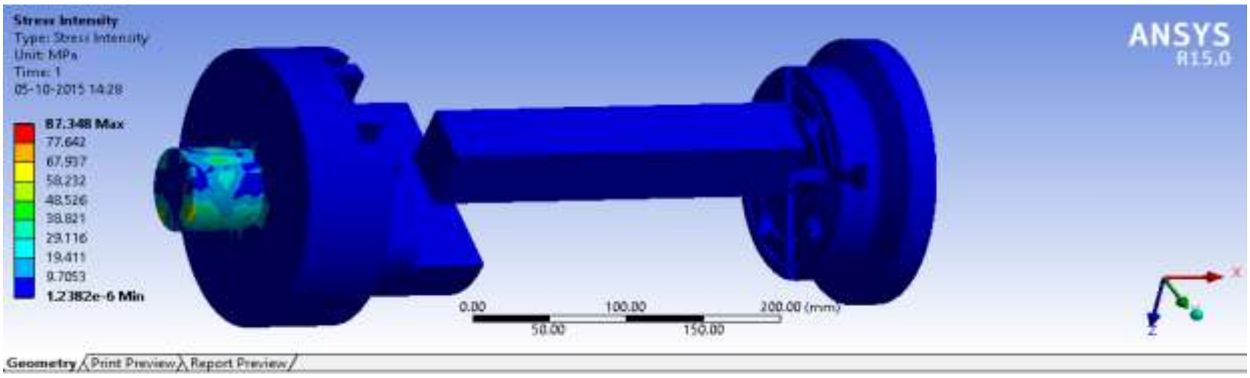


Plate section view

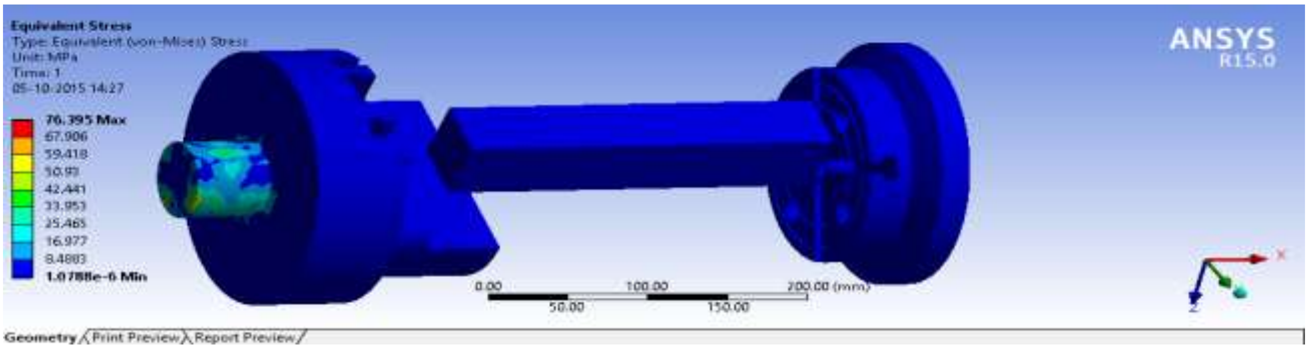
RESULTS & DISCUSSIONS



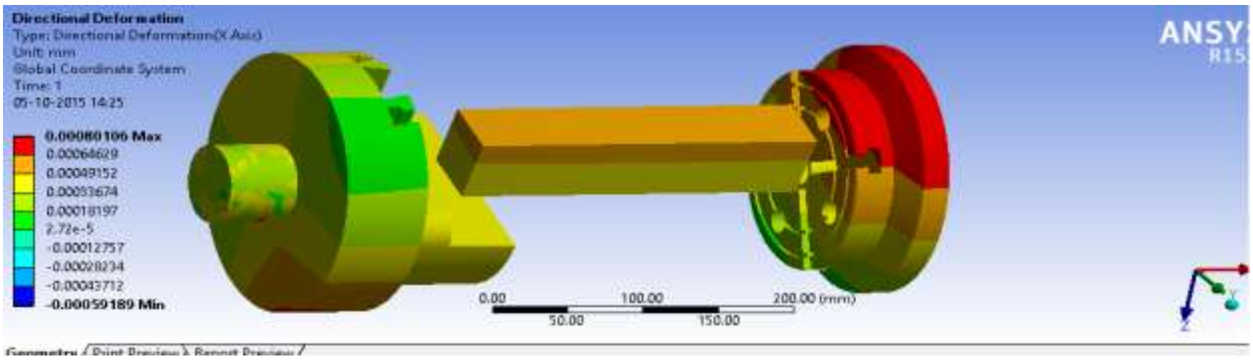
Force



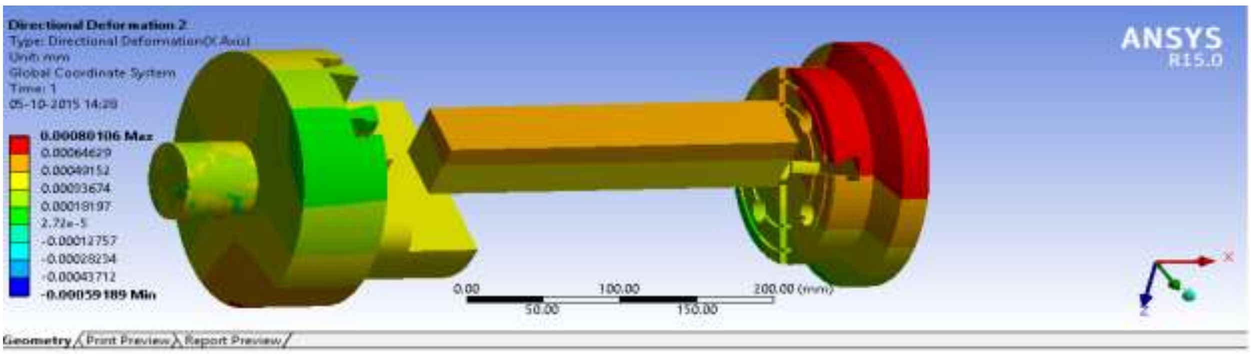
Equivalent Stress



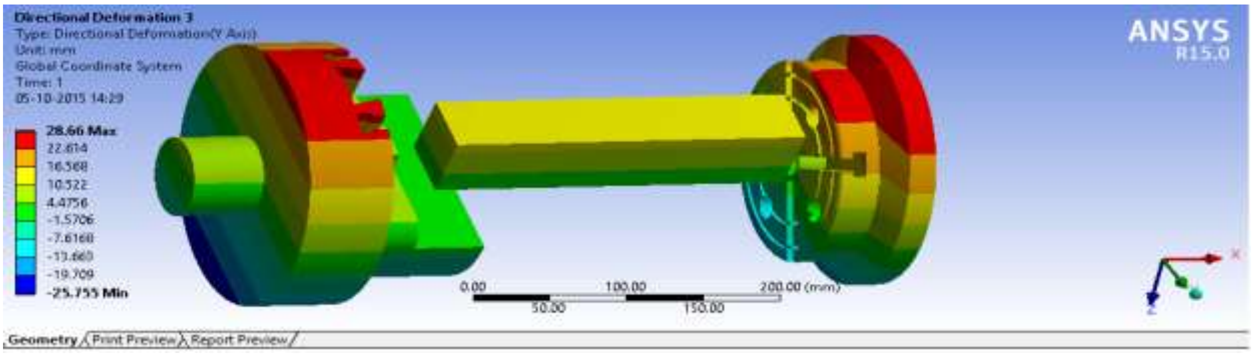
Stress Intensity



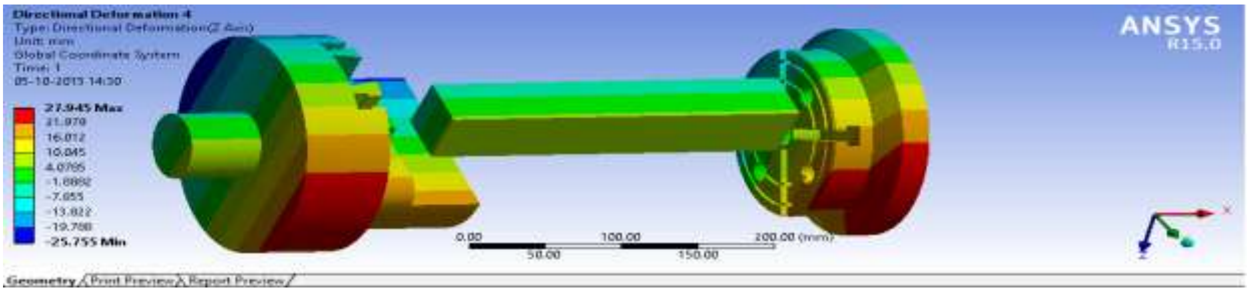
Directional Deformation



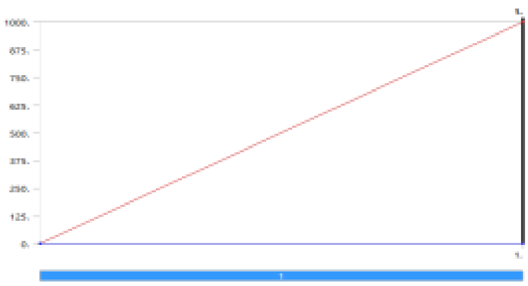
Directional Deformation2

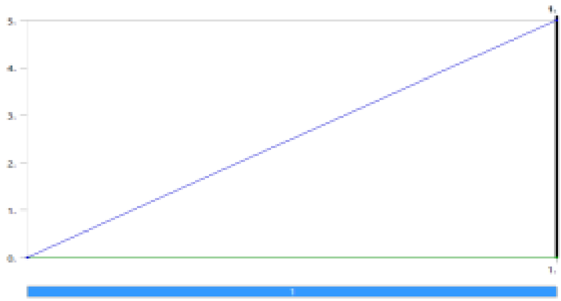


Directional Deformation 3



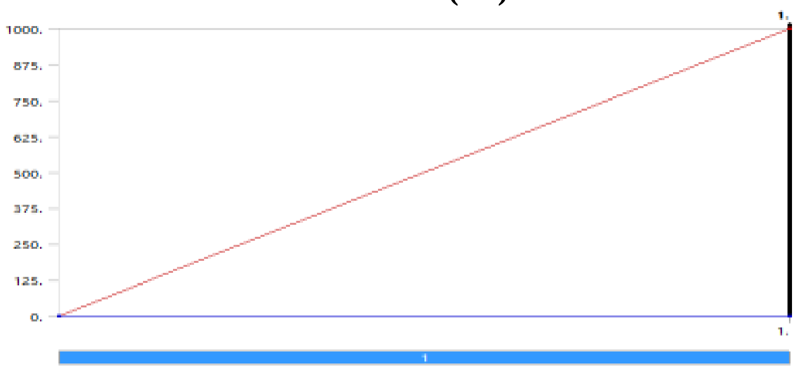
Directional Deformation 4





Static Structural > Moment **Static Structural (A5) > Force**

Static Structural (A5) > Moment 2



CONCLUSIONS:

The efficiency and reliability of the fixture design has enhanced by the system and the result of the fixture design has made more reasonable. To reduce cycle time required for loading and unloading of part, this approach is useful. If modern CAE, CAD are used in designing the systems then significant improvement can be assured. To fulfil the multifunctional and high performance fixturing requirements optimum design approach can be used to provide comprehensive analyses and determine an overall optimal design. Fixture layout and dynamic clamping forces optimization method based on optimal fixture layout could minimize the deformation and uniform the deformation most effectively .The proposed fixture will fulfilled researcher production target and enhanced the efficiency, Hydraulic fixture reduces operation time and increases productivity, high quality of operation, reduce accidents. From the study of simulations on fixture there is not so much deflection occurring on the fixture when compared to single stated inserted fixture. The multipurpose use of the present fixture not showing any rotational deflection but with load and forces taken into account it shows a slight deflection comparably negligible as considered for practical approach. This project shows an edge of multipurpose job work can be done without changing number of inserts for each job.

Limitations & Future scope

1. Theoretical simulations only observed in the present project with material and work piece and loads are taken from practical values of work place.
2. Rotational forces can be studied by applying practical rpm of components can be studied.
3. Practical study may given a direct solution to the extension of this work.
4. Limitation of present study can be extended to a materialized practical work and comparison in industry.

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