

# Design Of Special Purpose Manipulator For Handling Component

**Jayant Arbune**

Rajarambapu Institute of Technology,  
Rajaramnagar, Sakharale, Maharashtra, India

**Mr. I. N. Mulla**

Company Guide

**Prof. M. M. Mirza**

Guide

*Abstract: Robotics is an advance technology, which is widely used across all over the world. In this paper we discuss how the problems in the company, its solution, design and analysis of the manipulator. The problem is, to pick up the component from the conveyor and to place it on the bed of the CNC machine. Worker use the overhanging crane and to hold the component they use V-belt. It is wrong way to handling of component and not safe to worker. At this location in company the automation is required. The solution is hydraulic manipulator. In this paper we discuss designed parameters of manipulator, static structural analysis of manipulator components and analysis of assemblies.*

*Keywords: Robotics, Hydraulic manipulator, Manipulator Design, Hydraulic calculations, static structural analysis, analysis of manipulator.*

## I. INTRODUCTION

Manual handling of heavy components is not a solution in company. For that they required special workers. It leads to increase in cost of the components and investment. Robotics gives a proper solution for that, advance technology in robotics makes it easier and cost effective. Also the design required being safe, for that the analysis of the manipulator is required. Static structural analysis is the method to analyses the manipulator. Total deformation, normal stresses, equivalent elastic strain can be evaluated by using the analysis software. The analysis of simulation and results regarding the impact of the manipulability improves the life of manipulator, manipulator performance.

## II. OBJECTIVES

- ✓ Design of hydraulic manipulator for handling castings
- ✓ To carry out the handling of component with worker safety
- ✓ To reduce handling time and increasing accuracy of work
- ✓ To analyses the manipulator to improve its performance

## III. PROBLEM

In company, they produce different types of castings and done many operations on casting to get finished final product. During performing the operations the company has to face many problems. Handling of components is one of them. For finishing of the castings they have CNC machines. To perform the operations on CNC machine the job or casting require to place on bed of machine in specified orientation.

The weight castings are above 70kg and pick up them from conveyer and to place on the bed of the machine is not easy manually. So for that purpose they need special purpose mechanism. Conventionally worker use overhanging cranes with V-belt for handling and moving of casting to bed of machine. This is not a safe technique to handle above 70kg casting. That will create some problems like accident, damage to worker or casting. So, that's why there is need of automation.



Figure 1: Manual handling in Company

#### IV. SIGHT MEASUREMENT

At the initial stage different measurements at sight are required to taken. These measurements reflect the initial and final position of the component. Also these measurements are reference to the height, length and size of the manipulator. These are as follow,

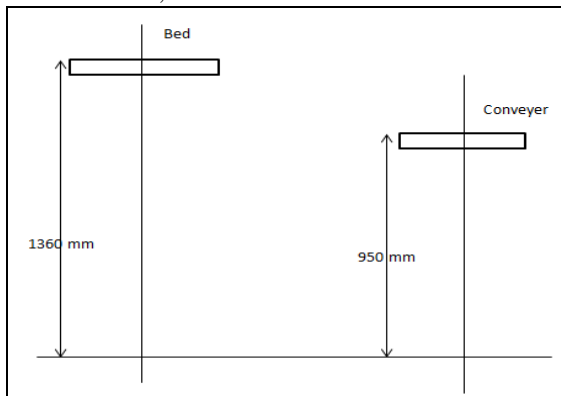


Figure 2: Front View

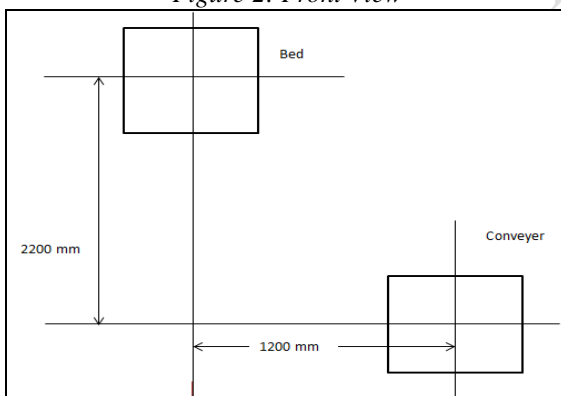


Figure 3: Top view

Then by referring the above measurements of the sight, it's clear from which position the component is picking up and to which position the component is place. Also by using top view measurements calculate the distance required to travel by the arm to place the component. It's difficult to travel 1000mm distance by arm with the component, so there is requirement to minimize the distance and the optimized position to where the manipulator is placed is in figure no. 4. Now the distance require to travel by the arm to place the component is 200mm only.

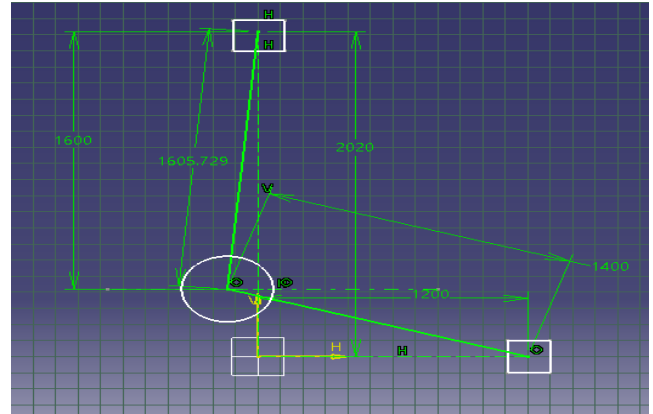


Figure 4: Optimized view

#### V. DESIGN OF MANIPULATOR

The design of manipulator requires many factors to taken in consideration. By considering these factors, sight measurements, some calculations the design of manipulator is completed. The sequence of manipulator design is as follow. At the initial stage the basic design of the manipulator is selected from the different ideas.

#### VI. BASIC DESIGN

This is the basic 2D design of the manipulator is selected from the different ideas. This is the simple idea, which has following advantages:

- ✓ Easy to use
- ✓ Less cost
- ✓ Highly flexible
- ✓ Less cycle time
- ✓ Safe to worker

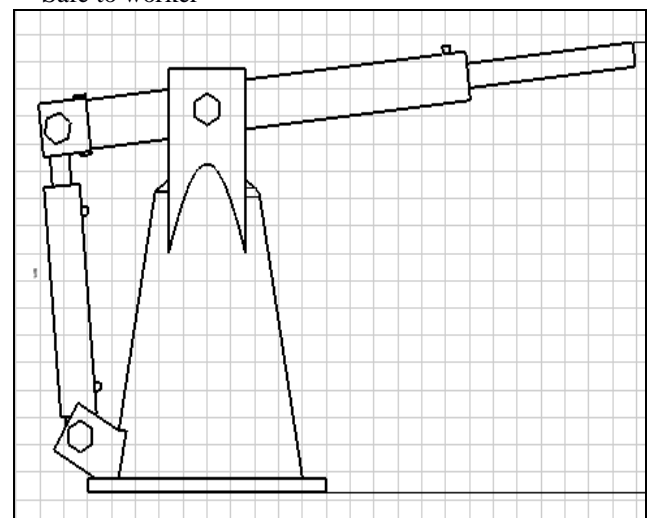


Figure 5: Basic 2D design

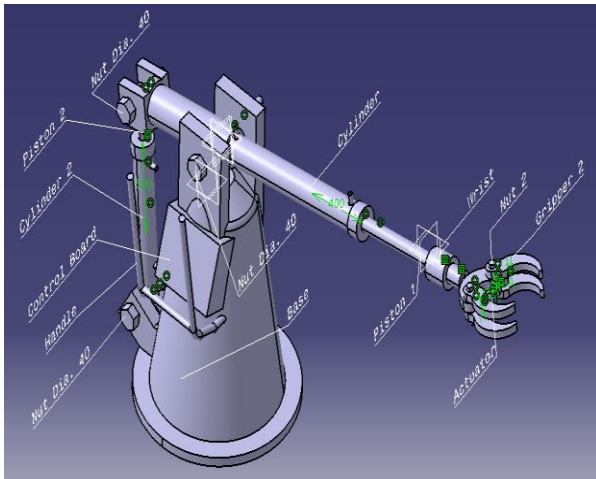


Figure 6: 3D Design

### VII. ANALYSIS OF MANIPULATOR

The designed hydraulic manipulator is the assembly of many components like cylinders, pistons, piston rods, bearings and many more. The assembly is completed, but it is necessary to check the manipulator will suitable for the environment under it will work. Now here environment means the load applied on manipulator, load to lift, different forces applied on it. So all these factors we have to take in account and if then the manipulator work its desired function only then it will be accepted. For that we calculate the total deformation, equivalent stress, and normal stress of the parts of the manipulator. Some of the analysis of the parts is as follows.

### VIII. MANIPULATOR PISTON ROD WITH PISTON

This part is the main part of assembly to which the end effector is attached. Now for the analysis we consider the extreme position of the rod, at that position the rod is act as a cantilever beam. So by applying all the boundary conditions we got following results.

#### BOUNDARY CONDITIONS

- ✓ At piston end: Fixed
- ✓ At rod end : 10,000N in Z-direction

#### RESULTS

- ✓ Total Maximum deformation : 15.545mm
- ✓ Maximum equivalent stress : 318.85MPa
- ✓ Maximum Normal stress : 117.64MPa

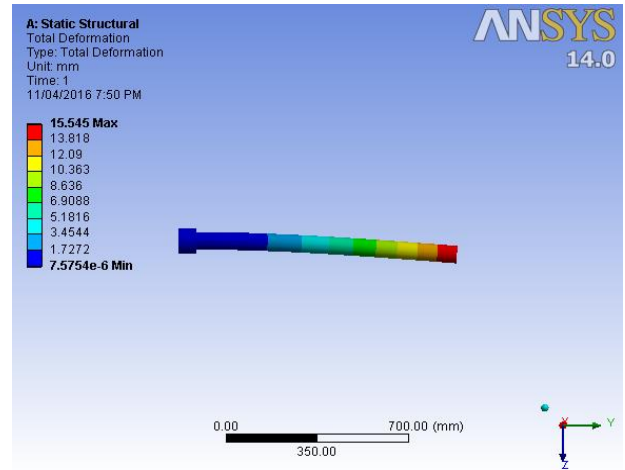


Figure 6: Total Deformation

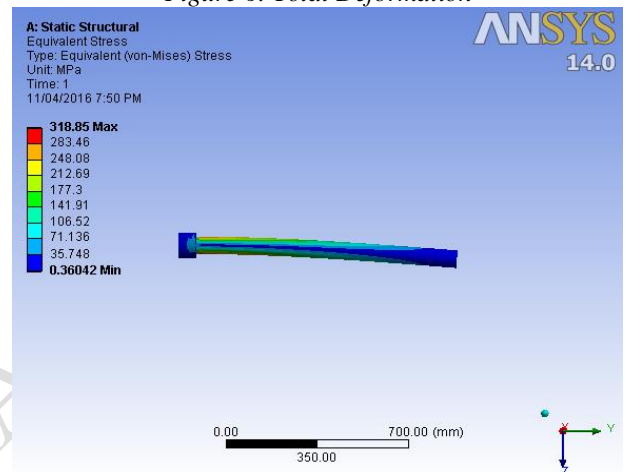


Figure 7: Equivalent Stress

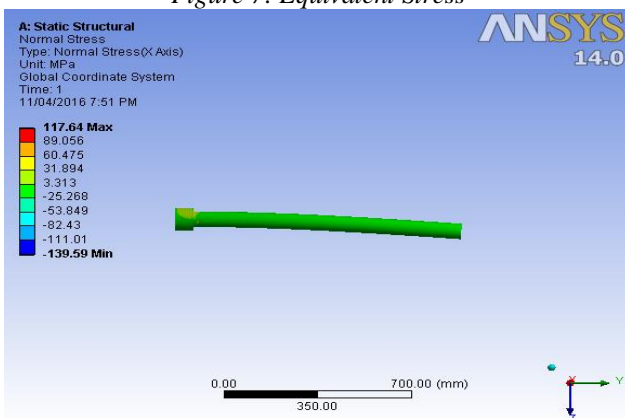


Figure 8: Normal Stress

Object Name	Total Deformation	Equivalent Stress	Normal Stress
State	Solved		
<b>Scope</b>			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
<b>Definition</b>			
Type	Total Deformation	Equivalent (von-Mises) Stress	Normal Stress
By	Time		
Display Time	Last		

Calculate Time History	Yes		
Suppressed	No		
Orientation			X Axis
Coordinate System			Global Coordinate System
Results			
Minimum	7.5754e-006 mm	0.36042 MPa	-139.59 MPa
Maximum	15.545 mm	318.85 MPa	117.64 MPa
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option	Averaged		

Table 1: Results of piston rod analysis

IX. BASE

The base gives support to the all of the components of the manipulator. Different types of loads and forces are applied on the base. The base can be rotate manually with minimum force. So because of all these forces different stresses are generated on the base. By analysis all these stresses and deformation can be calculated. All the results are in the permissible limit so the design is safe. The results are as follows.

BOUNDARY CONDITIONS

- ✓ At base plate : frictionless support
- ✓ At 'A' : Force 25363.04N in -Z-direction
- ✓ At 'B' : Force 20000N in -Z-direction
- ✓ At 'C' : Force 300N in Y-direction

RESULTS

- ✓ Total Maximum deformation : 4.7771mm
- ✓ Maximum equivalent stress : 17.686MPa
- ✓ Maximum Normal stress : 7.0483MPa

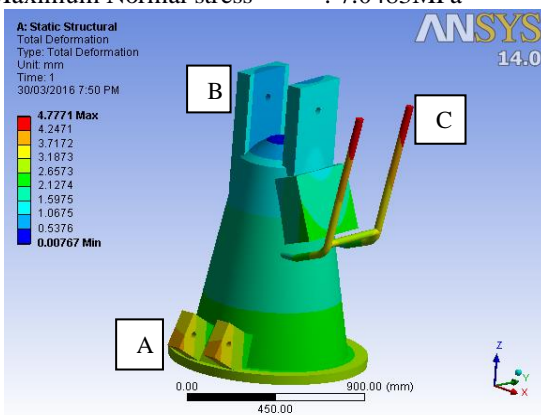


Figure 9: Total Deformation (Base)

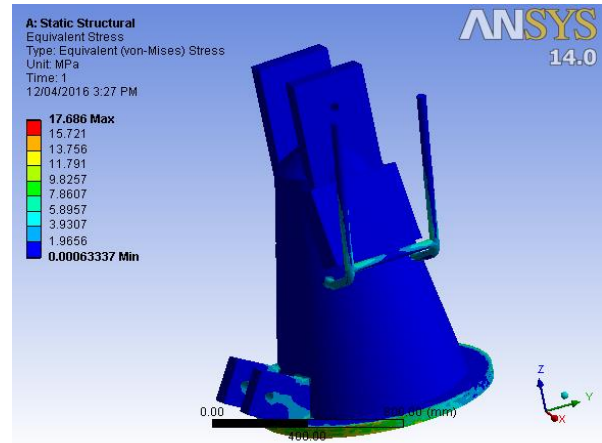


Figure 10: Equivalent Stress

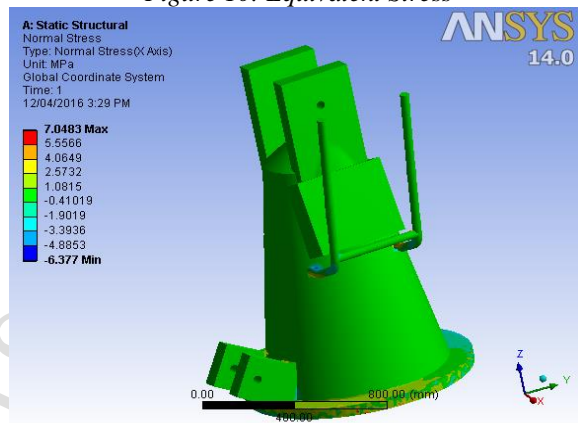


Figure 11: Normal Stress (Base)

Object Name	Total Deformation	Equivalent Elastic Strain	Normal Elastic Strain
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Total Deformation	Equivalent Elastic Strain	Normal Elastic Strain
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Suppressed	No		
Orientation			X Axis
Coordinate System			Global Coordinate System
Results			
Minimum	7.67e-003 mm	6.0075e-009 mm/mm	-7.1258e-005 mm/mm
Maximum	4.7771 mm	1.6645e-004 mm/mm	8.0228e-005 mm/mm
Information			
Time	1. s		
Load Step	1		

Substep	1	
Iteration Number	1	
<b>Integration Point Results</b>		
Display Option		Averaged

Table 2: Results of base analysis

X. PISTON AND ROD ANALYSIS OF REAR CYLINDER

This is the piston and rod of the cylinder attached at the rear side of the base which pull the main cylinder. Now we considering the extreme position of the manipulator to calculate highest values of the stresses, so at that position the boundary condition and the results are as follows.

BOUNDARY CONDITION

- ✓ At rod end : Frictionless support
- ✓ At piston end: Force 25363.04N in Y-direction

RESULTS

- ✓ Total Maximum deformation : 0.06196mm
- ✓ Maximum equivalent stress : 19.309MPa
- ✓ Maximum Normal stress : 10.531MPa

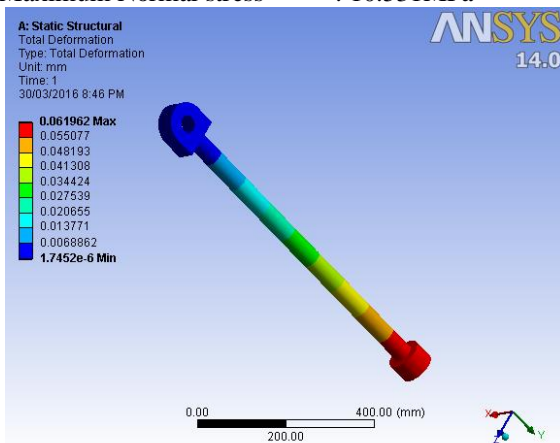


Figure 12: Total deformation (Piston and rod)

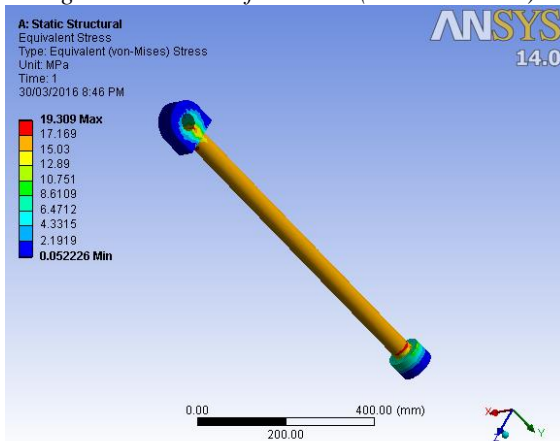


Figure 13: Equivalent Stress (Piston and rod)

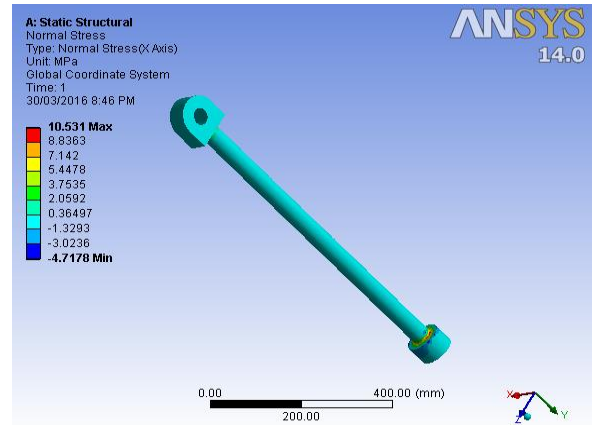


Figure14: Normal stress (Piston and rod)

Object Name	Total Deformation	Equivalent Stress	Normal Stress
State	Solved		
<b>Scope</b>			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
<b>Definition</b>			
Type	Total Deformation	Equivalent (von-Mises) Stress	Normal Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Orientation			X Axis
Coordinate System	Global Coordinate System		
<b>Results</b>			
Minimum	1.7452e-006 mm	5.2226e-002 MPa	-4.7178 MPa
Maximum	6.1962e-002 mm	19.309 MPa	10.531 MPa
<b>Information</b>			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
<b>Integration Point Results</b>			
Display Option		Averaged	

Table 3: Results of piston and rod analysis of rear cylinder

XI. END EFFECTOR ANALYSIS

This is the end effector of the manipulator, which is directly contact with the casting parts. It holds the castings and place on desired place. There are two holding hand type parts as shown in figure. There is a cylinder which moves the hands and they hold the castings. These two hands are connected to the cylinder rod by specially designed component. The boundary conditions and results are as follows.

**BOUNDARY CONDITIONS**

- ✓ At end 'A' : Frictionless support
- ✓ At curved surface : Force 5000N in -X-direction

**RESULTS**

- ✓ Total Maximum deformation : 0.17091mm
- ✓ Maximum equivalent stress : 62.979MPa
- ✓ Maximum Normal stress : 51.326MPa

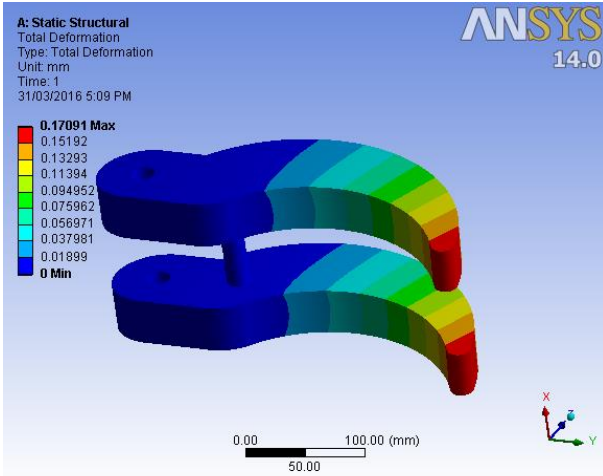


Figure 15: Total deformation (End effector)

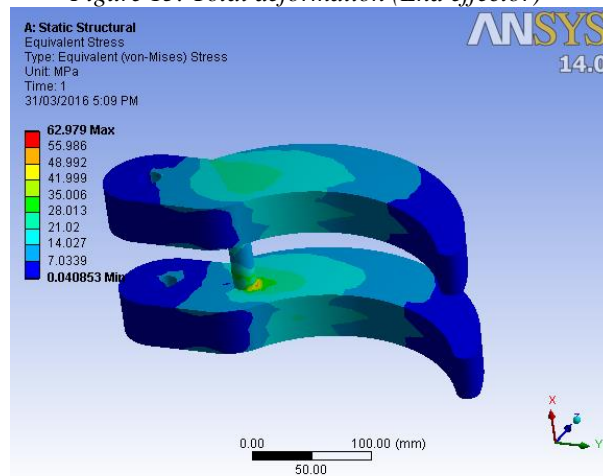


Figure 16: Equivalent Stress (End effector)

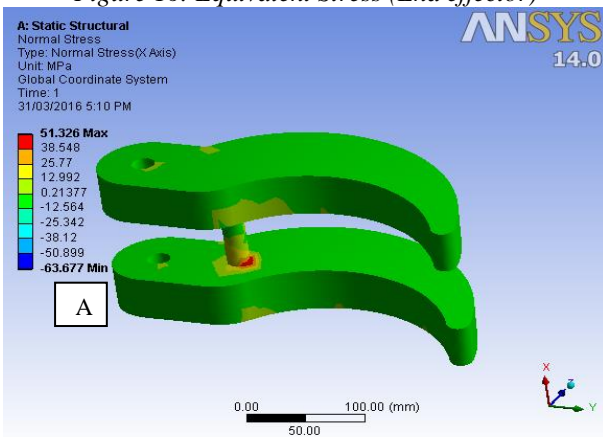


Figure 17: Normal stress (End effector)

Object Name	Total Deformation	Equivalent Stress	Normal Stress
State	Solved		
<b>Scope</b>			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
<b>Definition</b>			
Type	Total Deformation	Equivalent (von-Mises) Stress	Normal Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Orientation			X Axis
Coordinate System			Global Coordinate System
<b>Results</b>			
Minimum	0. mm	4.0853e-002 MPa	-63.677 MPa
Maximum	0.17091 mm	62.979 MPa	51.326 MPa
<b>Information</b>			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
<b>Integration Point Results</b>			
Display Option	Averaged		

Table 4: Results of End effector analysis

**XII. CONCLUSION**

Hydraulic system is selected for automation because of having great advantages over other systems. With the introduction of hydraulic system for casting handling, productivity, production rate and safety of the worker will be improved. As there is less interaction between worker and castings, there will be no effect on workers health. With the advantage of partial automation there will be decrease in the requirement of the workers.

Design of the manipulator is completed but it is essential to check its feasibility, strength and effect of working environment on the parts and the assembly. From the above analysis it is clear that the manipulator is safe and applicable on desirable place and environment. All the analysis results are in the acceptable limit. All the part designs are safe and work as required in desirable environment.

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