International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Modeling and Model Analysis of an Industrial Robot Arm for Pick and Drop Circular Motion Using Different Materials

P Ravi Chander, Y Madhu M. Reddy, Shaik Sajeed Ahmed

Abstract: ***In the present day, scenario Robots play a significant role all told the activities in human life as well as industrial wants.In fashionable industrial producing method c onsists of precise and quickest proceedings. Human operations are required to perform a spread of tasks in an exceedingly robotic system like set-up, programming, troubleshooting, maintenance and error handling activities. System styleers and technology managers are needed to think about the constraints of the operator sensory activity method in design and layout of the robotic system. The final word objective is to avoid wasting human lives additionally to increasing productivity and quality of technology work environments. The employment of business robots is increasing in areas like food, commodity, wood, plastics, and physics, however continues to be largely focused within the automotive trade. A tangle is that workstations in littler and medium-sized corporations that turn out small batches of merchandise don't get productive enough by having a good placed industrial golem. An answer may well be a light-weight golem that's adaptable to the merchandise would like. It'd have a lower moving mass that may cut back the ability would like and lead to sensible and optimum artificial-intelligence. The aim of this paper has been to develop a concept of a lightweight robot using lightweight material with a servo actuator prototype. In this paper we are designing and analyzing the industrial robot by using SOLIDWORKS and ANSYS workbench and firstly we are making 3D geometry of industrial robot as per the dimensions after those applying boundary conditions like weight of robot force applied on its body in order to check the total deformations stress, strains, and natural frequency of the model.***

Index Terms: 3D Geometry, Ansys, Human lives, Industrial Robot, Servo Actuator

I. INTRODUCTION

The modern definition of a mechanism will be associate in Nursing electro mechanical device that follows a collection of directions to hold out sure jobs, however virtually mechanism means that a 'slave'. Robots realize wide application in industries and so are referred to as there as industrial robots and additionally as humanoids. Once we suppose artificial intelligence very first thing that come back to our mind is automation. Robots are famous to perform tasks mechanically while not a lot of human intervention, aside from initial programming and instruction set being provided to them. It performs the required sequence of operations repeatedly with constant accuracy. A Robot is a mechatronic device which also includes resourcefulness or autonomy. A device with autonomy does its thing "on its own" without a human directly guiding it moment-by-moment.

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

P Ravi Chander*, Asst. Professor in Mechanical Engineering Department, Methodist College of Engineering & Technology, Abids, Hyd

Y Madhu M. Reddy, Asst. Professor in Mechanical Engineering Department, Methodist College of Engineering & Technology, Abids, Hyd

Shaik Sajeed Ahmed, ME (CAD/CAM) from Methodist College of Engineering & Technology, Abids, Hyd.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

II. LITERATURE SURVEY

A. H. Soni, studied analyzed the surgery instruments. Firstly, they collected the design data of surgical instruments after that they study on the applications of the instrument to collect data describing the vertical alignment of a scoliotic spine in three dimensions, before & after surgical correction. Lastly, they compare the relative efficiency by using various surgical techniques involving Harrington rod, Lugun rod & Dwyer apparatus etc [1].

S. G. Solanke and **A. S. Bharule**, the inspiration driving this paper is an Investigation on Stress Distribution for Optimization of Yoke in Universal Joint under Variable Torque Condition. Weight is separating under torque stack from controlling bar watching issue Stress obsession region, hot district perhaps passing on stack, expansion to improve part by adjusting thickness to support district of hot region with diminishing in dead region [2].

Anup A. Bijagare, **P.G. Mehar** and **V.N. Mujbaile**, in this examination the fantastic carbon, epoxy composite drive shaft has been arrange to supplant conventional steel drive shaft of a vehicle. A one-piece composite drive shaft for raise wheel drive automobiles has been design in a perfect world by using Genetic Calculation for excellent carbonepoxy composites with the objective of minimization of weight of shaft and researched using ANSYS for better torque transmission point of confinement and winding vibration qualities [3].

S. K. Chandole, M. D. Shende, M. K. Bhavsar,in this paper restricted segment examination of the part is done to find the uneasiness and movement of the last thing. For showing of the part, CATIA V5 R17 writing computer programs is used.

Preprocessing work like grid and examination work is finished in HYPERWORKS programming. Using FEA examination, we can recognize the nature and traits of stresses following up on the weight and besides evaluate the effect of the loads, mass, geometry, constrain conditions over the weight [4].

Farzad Vesali, Mohammad Ali Rezvani and **Mohammad Kashfi** , It is the explanation behind this investigation to consider the components of the comprehensive joints and to propose some judicious strategies for improving their execution. The errand is performed by at first deducing the development conditions identified with the general joints. That is trailed by explaining the oscillatory lead in the rotational speed and the torque that transmits through the middle person shaft. The forces in the joint heading are found out by using an analytic system that is in like manner maintained by the numerical illustrating. Such models are additionally used as a piece of demand to figure the musicality and the measure of the plenitude stacks on the joint [5].

S.K. Chandole, M.K. Bhavsar, S.S. Sarode, G.R. Jadhav, In this paper essential headway of the coordinating weight is finished. For showing of the portion, CATIA V5 R17 writing computer programs is used. Before all else time of thought age, topology streamlining should be used to develop a beneficial structure from the soonest beginning stage. At this level an automatized assortment of headway parameters was exhibited useful to and the best down to earth design. In the later stage, shape and size change should be used to change the structure made sense of it [6].

X. Liao, in this project work they are work on the base of the welding robot. By using ANSYS-10.0,they are find out the natural frequencies, mode shapes of base of welding robot & dynamic analysis of robot. There results from model analysis are , the upper edge & tail edge of the base have a larger vibration which are susceptible to be fatigued & damaged. They found maximum amplitude at the 7th natural frequency was 39.249 Hz. By using ANSYS -10.0 software the results are quick & reliable [7].

G. Chung, this work is based on design of heavy duty industrial robot. After that they tested or find out the static & dynamic analysis for heavy duty applications i.e. at 600kgweight.Finally, they compare the experimental as well as FEM results. They are analyzed that the elastic rigid body dynamics to estimate the robustness of the robot's parts during working motion of robot. The results are found that frequency of reaction forces from multi body analysis is 6.67Hz & Natural Frequency was 18 Hz [8].

A. Problem definition: -

The Robot-Concept is to a great degree direct.Each Joint is moveable in two ways. This is a simple approach to give a XY pivot development.

The industrial robot arm before made up of cylinderical rod which where connected with the joints. This would drastically increase the weight of the robot arm and the mechanical motor which would drive the moment of arm would ware out very soon.

In this work, the fundamental piece of mechanical robot i.e., outline and investigation of a widespread joint is taken in to thought and making of examination utilizing diverse materials to it keeping in mind the end goal to get the best material which withstand the applied load and is even light in weight, and the mechanical motor is replaced with the servo motor. This whole work is completed utilizing plan and FEA based examination programming in particular solidworks and ansys workbench.

B. Methodology

- Literature review and investigation of problem has been done through
- Synthesis from similar articles and case studies.
- Design and structure are defined such that to obtain optimal values of stress, strain and deformation.
- Results are then compared to select the best material for the robot arm.

C. Objectives:

In the wake of planning the Problem Statement, the accompanying targets are laid keeping in mind the end goal to accomplish the most ideal arrangements.

- Creation of parametric structure: Making of parametric structure. To have the ability to separate quick way, remarkable geometries of a comparative model, it is vital to have the ability to change its estimation. Thus, there is a prerequisite for a parametric blueprint. Not with standing, the mass properties of this model should resemble the honest to goodness show remembering the ultimate objective to get tantamount results when playing out an essential examination.
- To carry out the static and modal analysis on the model with different materials and finalizing the best material which fulfill all the requirements of our project.

III. DESIGN AND ANALYSIS

CAD (Computer motor-assisted Design) is that the use of pc package to style and document a product's design method. Engineering drawing entails the utilization of graphical symbols like points, lines, curves, planes and shapes. Primarily it provides careful description regarding any during a graphical type.CAD is employed to accomplish preliminary style and layouts, style details and calculations, making 3-D models, making and cathartic draw ings, still as interfacing with analysis, marketing, producing, and end-user personnel.

A. Modules used in solid works

Some of the workbenches used in this process

- Sketcher, Features, Assembly, Drafting, Photo rendering

B. Parts to be design of industrial robot arm

- Device platform, Front arm, Rotation servo, Joint coupler, Rear arm, Joint servo

C. Robot arm

The Design and Shape of the Arm can be changed, to improve the acoustic test results. There is also an option to add a second Arm for a Reference Mic.

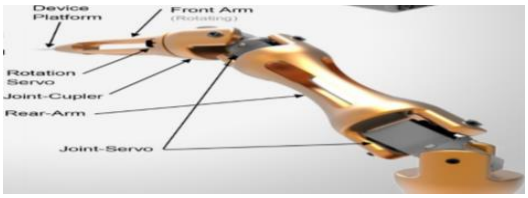

Fig: 3.1 Different Parts of Industrial Robot Arm

D. Design of parts of industrial robot arm

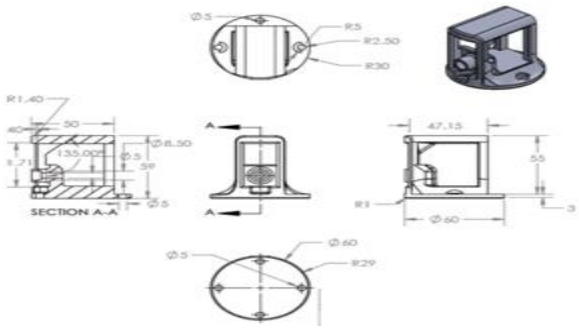

Fig: 3.2 Drafting Of Shell Box

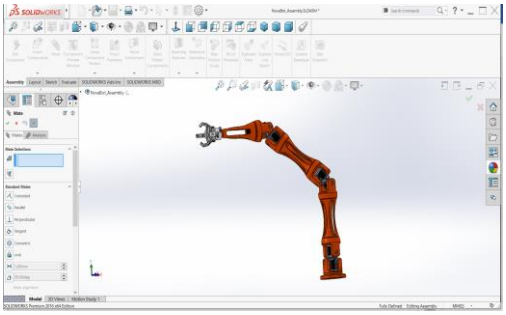

Fig: 3.3 drafting of arm

E.

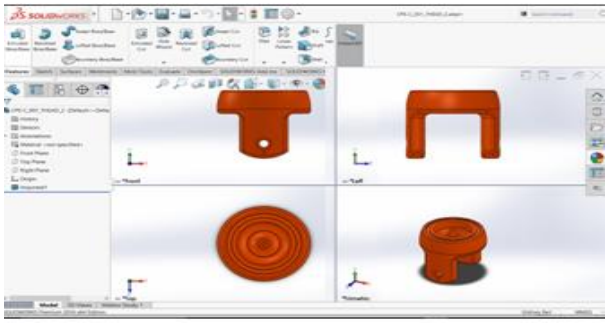

Fig: 3.4 Rotation Servo

2D drafting of the rare arm with dimension.

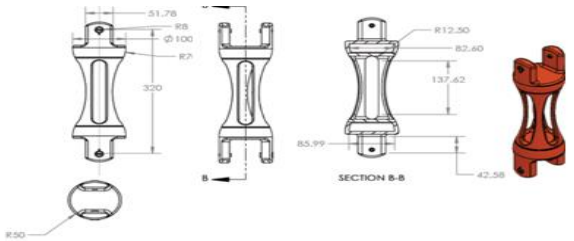

Fig: 3.5

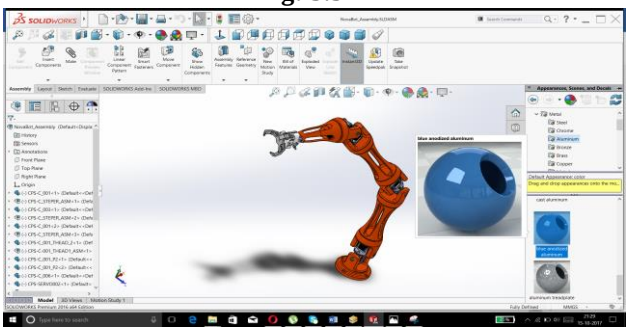

Fig: 3.6 Material applied model

F. Design of rotation servo:

It's a one of the important part in this robot. To make this part it can be made with revolve and extrude boss and to remove material use extrude cut and revolve cut.

G. Assembly of industrial robot arm

H. Fem analysis on industrial robotic arm

Analysis was disbursed on associate in nursing early part employing a customary atomic number 13 material and then checking with the opposite materials like steel, carbon fiber, optical fiber and 3D printable materials polymer half-dozen nylon 6. The Associate in Nursingalysis was to look at the however well the part would react once it had been exposed to an external force, deformations, stress and strain. By closing this Associate in Nursingalysis we tend to may get an understanding whether or not the development would last once subjected with a load and additionally If i used to be on the correct track. the burden applied is half-dozen metric weight unit, that was then increased by a pair of to induce a rough estimation of Associate in Nursing accelerated load, which supplies twelve metric weight unit or a force of regarding a hundred and twenty Newton.

ANALYSIS OF ROBOTIC ARM *WITH ALLUMINUM, STRUCTURAL STEEL, CARBON FIBER E GLASS FIBER AND 3D PRINTABLE MATERIALS Polyamide 6 - Nylon 6.*

I. FEM static structural and modal analysis using structural steel

Table 3.1: Properties of structural steel

S.No	Property	value
1	Mass Density	7850 kg / m^3
2	Modulus of Elasticity	2E+11 Pa
3	Poisson's ratio	0.3
4	Bulk modulus	1.6667E+11 Pa
5	Modulus of Rigidity	7.6923E+10 Pa

Assigning the material to the model **-structural steel**

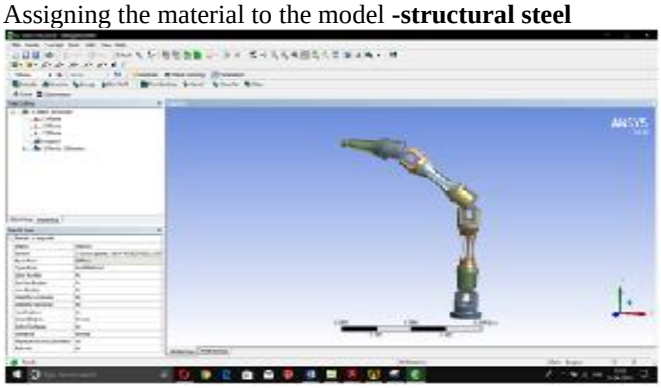

Fig: 3.7 Material applied

After the meshing we get the following number of nodes and elements Nodes: 51547 Elements: 26031

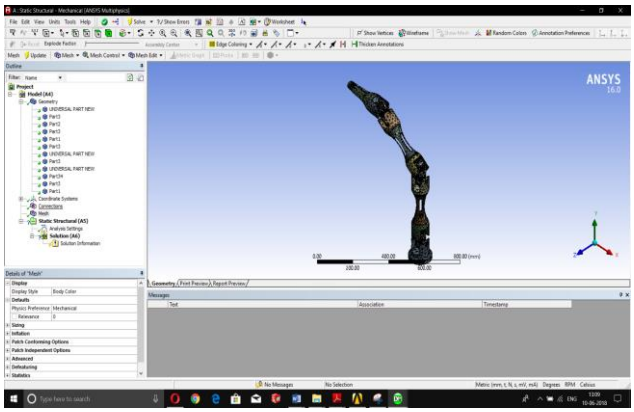

Fig: 3.8 Meshing of Model

Here the model is fixed at its base by fixed support. A frictionless support is applied to the middle arm of the robot and a force of 120N is applied on front arm.

Fig:3.9 Boundary Condition Applied to model

Table 3.2 The Static analysis results with structural steel

	Deformation(mm)	Stress(Mpa)	Strain (mm/mm)
Minimum	0	2.3794e-006 MPa	3.5648e-011
Maximum	0.43883	98.896 MPa	5.24e-004

Model Analysis with 6 mode shapes

A roughly 6 mode shapes are examined by seeing the specific pattern of vibration of the structure to the specific frequency. The following are the 6 modes of total deformation.

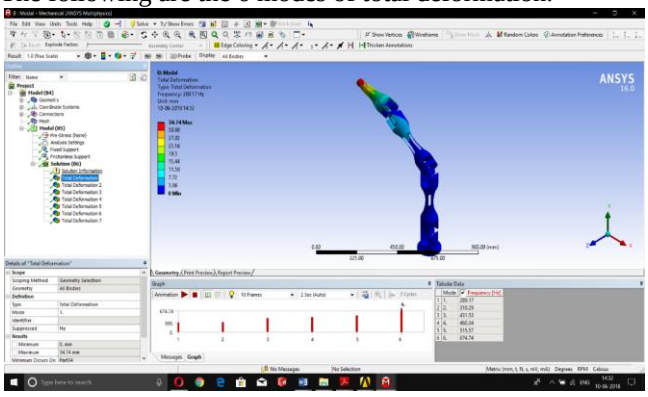

Fig: 3.10 Modal Analysis

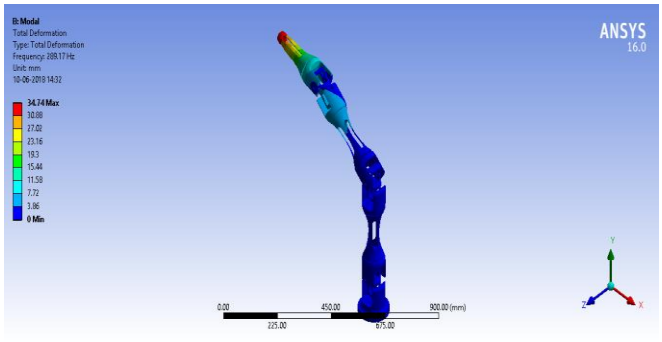

Fig: 3.11 1st mode shape @289.17 Hz

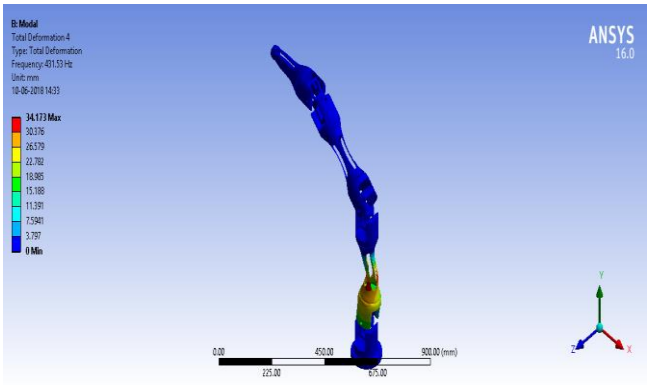

Fig: 3.12 2st mode shape @310.29 Hz

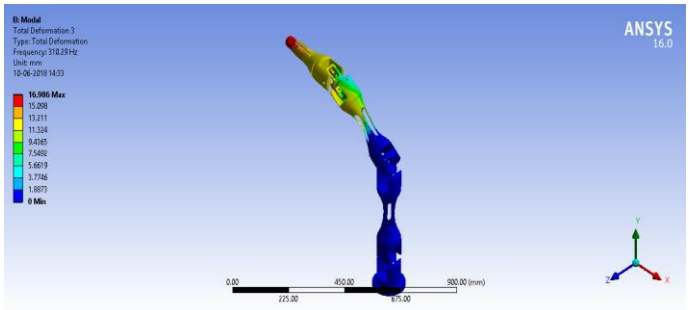

Fig: 3.13. 3rd mode shape @431.53 Hz

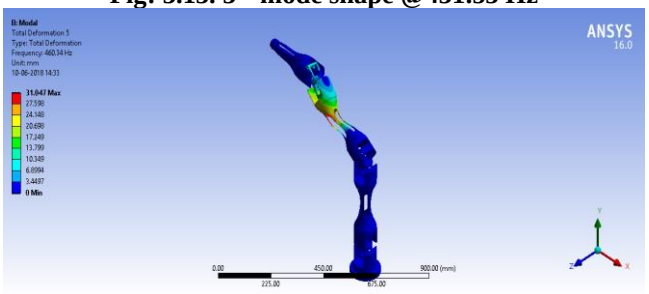

Fig: 3.14: 4th mode shape @460.34 Hz

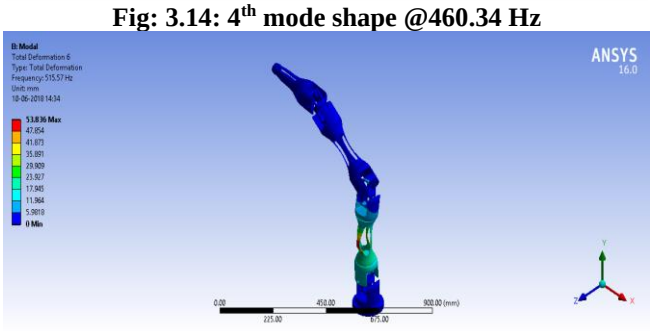

Fig: 3.15 5th mode shape @515.57 Hz

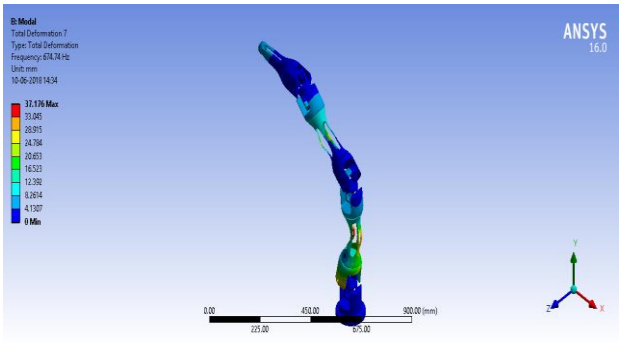

Fig: 3.16 6th mode shape @674.74 Hz

Below are the 6 different natural frequency and mode shapes of the robot arm using structural steel

Table 3.3 Natural Frequency And Mode Shapes

Mode	Frequency [Hz]
1.	289.17
2.	310.29
3.	431.53
4.	460.34
5.	515.57
6.	674.74

J. FEM static structural and modal analysis using aluminum alloy.

Table 3.4: Properties of aluminum alloy

s.no	Property	value
1	Mass Density	2770 kg / m^3
2	Modulus of Elasticity	7.1E+10 Pa
3	Poisson's ratio	0.33
4	Bulk modulus	6.9608E+10 Pa
5	Modulus of Rigidity	2.6692E+10 Pa

Assuming the material to the model- aluminum alloy

Table 3.5: Static analysis results with Aluminum alloy

	Deformation(mm)	Stress(Mpa)	Strain (mm/mm)
Minimum	0	3.072e-006	1.1723e-010
Maximum	4.6777	99.79	1.4855e-003

Below are the 6 different natural frequency and mode shapes of the robot arm using aluminum alloy material.

Table 3.6: Mode and frequency

Mode	Frequency [Hz]
1.	292.37
2.	311.2
3.	432.02
4.	460.68
5.	518.27
6.	675.24

K. FEM static structural and modal analysis using e-glass carbon fiber

Material property of e-glass carbon fiber

Table 3.7: Properties of e-glass carbon fiber

s.no	Property	value
1	Mass Density	2E-09 kg / m^3
2	Modulus of Elasticity	45000MPa
3	Poisson's ratio	0.3
5	Modulus of Rigidity	5000MPa

Table 3.8:Static analysis results with e-glass carbon fiber

	deformation	stress	strain
Minimum	0. mm	2.0416e-006 MPa	3.8833e-010 mm/mm
Maximum	4.9568 mm	101.46 MPa	5.5311e-003 mm/mm

Below are the 6 different natural frequency and mode shapes of the robot arm using e-glass carbon fiber material.

Table 3.8: Mode and frequency

Mode	Frequency [Hz]
1.	162.15
2.	167.66
3.	206.23
4.	242.78
5.	243.2
6.	311.2

L. FEM Static structural and modal analysis with Polyamide 6 – Nylon 6 – PA 6

Table 3.9: Static analysis results - Polyamide 6 – Nylon 6 – PA 6

	Deformation(mm)	Stress(Mpa)	Strain (mm/mm)
Minimum	0	2.0416e-006	4.8833e-010
Maximum	5.1568	102.46	6.5311e-003

Table3.10: Material properties - Polyamide 6-Nylon 6–PA 6

s.no	Property	value
1	Mass Density	1.14gcm^-3
2	Modulus of Elasticity	2.4E+06 Psi
3	Poisson's ratio	0.39
4	Bulk modulus	2.5072E+10 Pa
5	Modulus of Rigidity	5.9523E+09 Pa

Below are the 6 different natural frequency and mode shapes of the robot arm using Polyamide 6 - Nylon 6 - PA 6 material.

Table 3.11: Mode and Frequency

Mode	Frequency [Hz]
1.	225.47
2.	235.32
3.	324.43
4.	345.85
5.	393.19
6.	506.46

IV. RESULT AND DISCUSSION

Overall results using Structural Steel, Aluminum Alloy, e-glass carbon fiber and Polyamide 6 - Nylon 6 - PA 6.

Analysis was carried out on an early component using a standard aluminum material and then checking with the other materials like structural steel, e-glass carbon fiber and Polyamide 6 - Nylon 6 - PA 6. The use of the analysis was to observe the how well the component would react when it was exposed to an external force, deformations, stress, and strain.

The weight applied is 6 kg, which was then multiplied by 2 to get a rough estimation of an accelerated load, which gives 12 kg or a force of about 120 Newton. When comparing with the results, the best material to make the model or a structure is aluminum alloy, though it has more deformation then other materials but the weight and cost to be considered it has a weight of 31 kgs which lesser than the structural steel.

Table 3.12: Static analysis results for all Materials

S.NO	MATERIAL	Deformation (mm)	Stress(M pa)	Strain (mm/mm)
1	Structural steel	0 0.43883	2.3794e-006 98.896	3.5648e-011 5.24e-004
2	Aluminum alloy	0 4.6777	3.072e-006 99.79	1.1723e-010 1.4855e-003
3	e-glass carbon fiber	0 4.9568	2.0416e-006 101.46	3.8833e-010 5.5311e-003
4	Polyamide 6 - Nylon 6	0 5.1568	2.0416e-006 102.46	4.8833e-010 6.5311e-003

Table 3.13: Natural frequency -mode shapes data

MATERIAL / MODE SHAPES	Structural steel	Aluminum alloy	e-glass carbon fiber	Polyamide 6 - Nylon 6 - PA 6
1	289.17	292.37	162.18	225.47
2	310.29	311.2	167.66	235.32
3	431.53	432.02	206.23	324.43
4	460.34	460.68	242.78	345.85
5	515.57	518.27	243.2	393.19
6	674.74	675.24	321.17	506.46

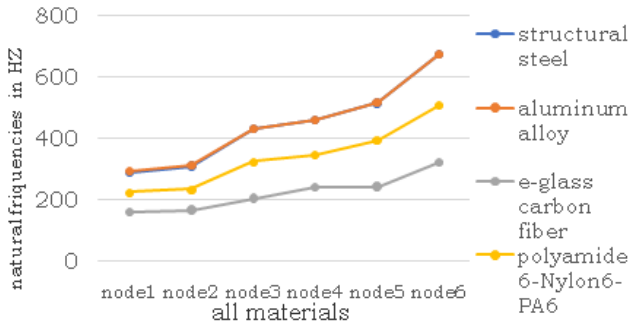

Fig: 3.17 comparison of natural frequencies of different materials

V. CONCLUSION

The current paper aimed to cut back the load of the structure and minimizing its structural deformations to enhance the stiffness, on the idea of the load forces applied during a static study.Some variants are also chosen from higher form, weight, stiffness, static and dynamic behavior. The results obtained from the finite part analysis with mesh size of zero.01 are significantly sensible where ever investigation on most deformation, most stress and maximum strain is well done. With this static and modal analysis, the robotic arm which is designed with different material and subjected to a load of 120N, shows that the structural steel has a good strength with its maximum stress intensity of 98.896MPa when comparing with other materials but weight in point of view I suggest to use to aluminum alloy since if the weight is more the load will be applied on servo motors it causes problem for the servo motors. Finally, we can also see in the condition of pick and drop positions with aluminum alloy material there are considerably low maximum stress and strains formed.

REFERENCES

1. A.H.Soni and M.H.F. Dado, Dynamic response analysis of 2-R robotwith flexible joints. IEEE Conf. on Robotic and Automation (1987).
2. Application of passive robot in spine surgery, Soni, A.H. OklahomaState university, Stillwater, OK. Gudavalli, M. Herndon, W; Sullivan, J. Robotics and Automation. Proceedings. 1987 IEEE International Conference (Volume:4).
3. Structural Design Optimization and Comparative Analysis of a New High-Performance Robot Arm via Finite Element Analysis-Jaydeep Roy, Louis L. Whitcomb; proceedings of the 1997 IEEE,International Conference on Robotics and Automation Albuquerque, New Mexico - April 1997.
4. Comparative Structural Analysis of 2-DOF Semi-Direct-Drive Linkages for Robot ArmsJaydeep Roy, Louis L. Whitcomb; IEEE/ASME Transactions On Mechatronics, Vol. 4, No. 1, March 1999.
5. Application of passive robot in spine surgery, Soni, A.H. Oklahoma State university, Stillwater, OK. Gudavalli, M. Herndon, W; Sullivan, J. Robotics and Automation. Proceedings. 1987 IEEE International Conference.
6. Åstrand, B.; Baerveldt, A., J (2002). An agricultural mobile robot with vision-based.
7. perception for mechanical weed control. Autonomus Robots, 13, 1, (July 2002) 21-35.
8. Bak, T.; Jakobsen, H. (2004). Agricultural robotic platform with four wheel steering.
9. Structural Design, Analysis, and Performance Evaluation of a New Semi-Direct //DriveRobot Arm: Theory and Experiment- Jaydeep Roy, Member, IEEE, Randal P. Goldberg, and Louis L. Whitcomb, Senior Member, IEEE IEEE/ASME Transactions On Mechatronics, Vol. 9, No. 1, March 2004.

AUTHORS PROFILE

Dr. P. Ravi chander, did Ph.D from JNTUH, Currently working as Asst. Professor in Mechanical Engineering Department, Methodist College of Engineering & Technology, Abids, Hyd. Areas of intrest are Thermal Engineering.

Y Madhu Maheswara Reddy did ME (Turbo Machinery) from Osmania University. Currently working as Asst. Professor in Mechanical Engineering Department, Methodist College of Engineering & Technology, Abids, Hyd. Areas of intrest are Thermal Engineering.

Mr. Shaik Sajeed Ahmed, student did ME (CAD/CAM) from Methodist College of Engineering & Technology, Abids, Hyd.