DESIGN AND KINEMATIC ANALYSIS OF INDUSTRIAL WELDING ROBOT

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ABSTRACT

This project describes the design and kinematic analysis of a 6-link, 5-DOF welding robot. The current work is undertaken taking into account the commercially available smokie arm robot and with geometrical similarity a model is designed and static structural analysis is don for stress, deformations and weight analysis with different materials and the results are plotted accordingly. The new design is implemented for better flexibility and portability with better working condition.

The models are designed in CATIA and further the end effector calculations are done using MATLAB, static structural analysis is done in Ansys and Kinematic analysis in Adams. Kinematic analysis includes comparisons of velocity acceleration and angular displacement with respect to time. The results are plotted as graphs i.e., V-T, A-T, θ-T graphs.

Finally results obtained are compared in reference to the Smokie robot and also stresses and weight comparisons are made using 2 different materials i.e., steel and epoxy glass.

Key words: Smokie Robot, Steel, Epoxy glass, kinematic analysis ,CATIA, ANSYS, ADAMS, MATLAB

1. INTRODUCTION

Industrial robots are not completely androids that mimic human, but are more anthropomorphic in nature, in the sense that they are designed with resemblance to a human hand and are also incapable of self-movement.

The requirement graph for these industrial robots has always been an upward one. Faster robots with multiple functions to increase production and reduce manufacturing cost are the necessity of the day. Factors such as: better precision, accuracy and repeatability; maximum load carrying capacity and work space and versatile operating environments are being given utmost importance during the development of any industrial robot.

D-H matrix is used to find out the end effectors position and the calculation is done using the MATLAB code where the geometrical values of the robot are given as an input which gives the end effectors position as output. The change in end effectors position for every angular change of each arm is found out with the help of MATLAB.

Design of the robotic arm is done based on the lengths and angles in CATIA and then analysis of the smokie robot is performed for stress, weight and deformations respectively by changing the materials like aluminium and composites and the results are evaluated in each case and the material is selected based on the analysis in ANSYS and then keeping the same geometrical similarity a model is designed in CATIA by reducing the weight and a more flexible design. Similarly as smokie robot the new robot is tested for stress deformations weights and selecting the best material with the help of ANSYS and then the results are compared with that of original design and a more flexible and portable design is being designed.

2. PROBLEM DEFNITION

New model is designed with geometrical similarities as that of smokie robot with 5 dof. Weight reduction is being done increasing its flexibility and portability. Testing is being done with various materials like aluminium with structural steel as the base material to increase the strength and also with composites and the best combination is being chosen depending upon the stresses and deformations on the members on the links and the results are compared with the original smokie robot design.

3. DESIGN CONSIDERATIONS AND PROCEDURE

3.1 MATERIAL PROPERTIES:

Properties	**Epoxy glass**	**Structural steel**	**Aluminium**
Density	2000 kg/m³	7850 kg/m³	2270 kg/m³
Youngs modulus	45 Gpa	200 Gpa	71 Gpa
Poissons ratio	0.3	0.3	0.33
Tensile strength	1100 Mpa	550 Mpa	310 Mpa

3.2 SPECIFICATIONS OF EXISTING SMOKIE ROBOT:

Figure1: Original smokie robot.

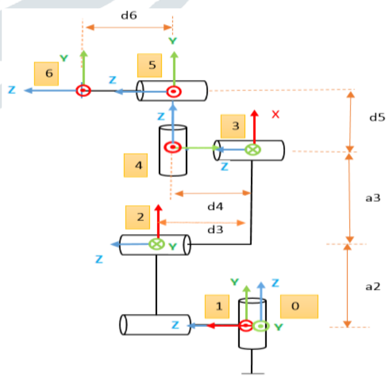


Figure2: Revolute joints.

3.2.1 Links and Joint Identification

Our Smokie robot consists of 6 links and 6 revolute joints. Each joint connects two consecutive links to each other. All the 6 revolute joints have −180°~180° rotation capability. The links, Joints and Dimensions are shown in figure 2.

3.3 DESIGN PROCEDURE FOR INDUSTRIAL WELDING ROBOT

Initially, CATIA name is an abbreviation for Computer Aided Three-dimensional Interactive Application the French Dasault Systems is the parent company and IBM participates in the softwares and marketing, and CATIA is invades broad industrial sectors, and has been explained in the previous post position of CATIA between 3d modelling software programs.

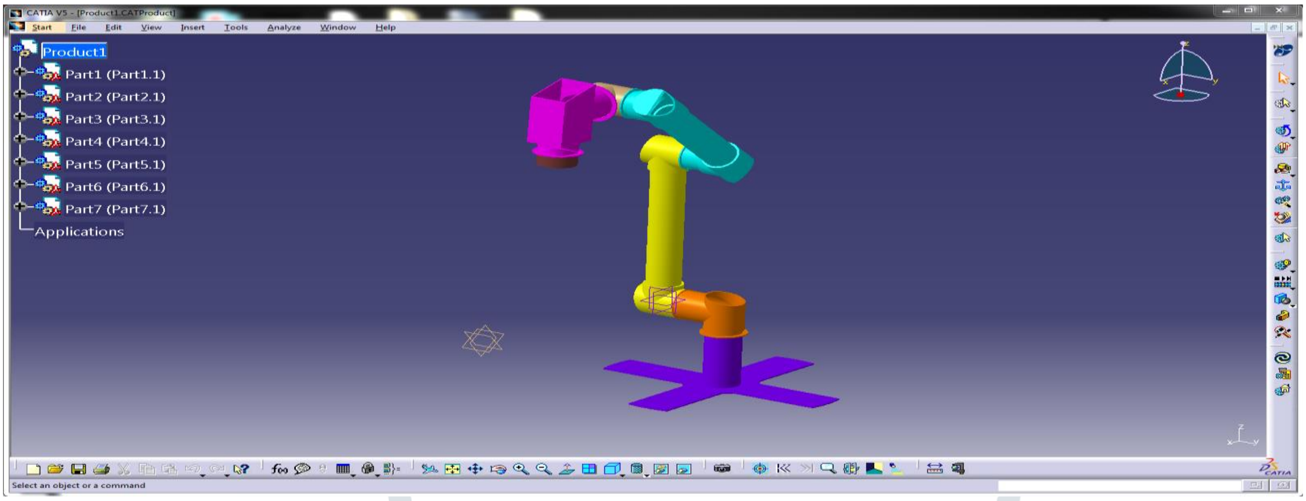


Figure 3: Assembly model created in Catia

4. ANALYSIS OF MODIFIED ROBOT

4.1 INTRODUCTION TO ANSYS

The ANSYS program is self contained general purpose finite element program developed and maintained by Swason Analysis Systems Inc. The program contain many routines, all inter related, and all for main purpose of achieving a solution to an engineering problem by finite element method. I.G.E.S. models are imported into ansys here the model is having 12256 elements and 21593 nodes.

4.2 STATIC STRUCTURAL ANALYSIS: Bottom portion of robot is fixed and dead load is considered. here analysis is performed when the robot at the maximum height position.In the present work two types of materials are considered . These two materials are using in automobile industries in present days. Here aluminium and E glass composite materials are taken to find out the suitable materials for robot structure and these stresses and deformation should be in allowable limit.

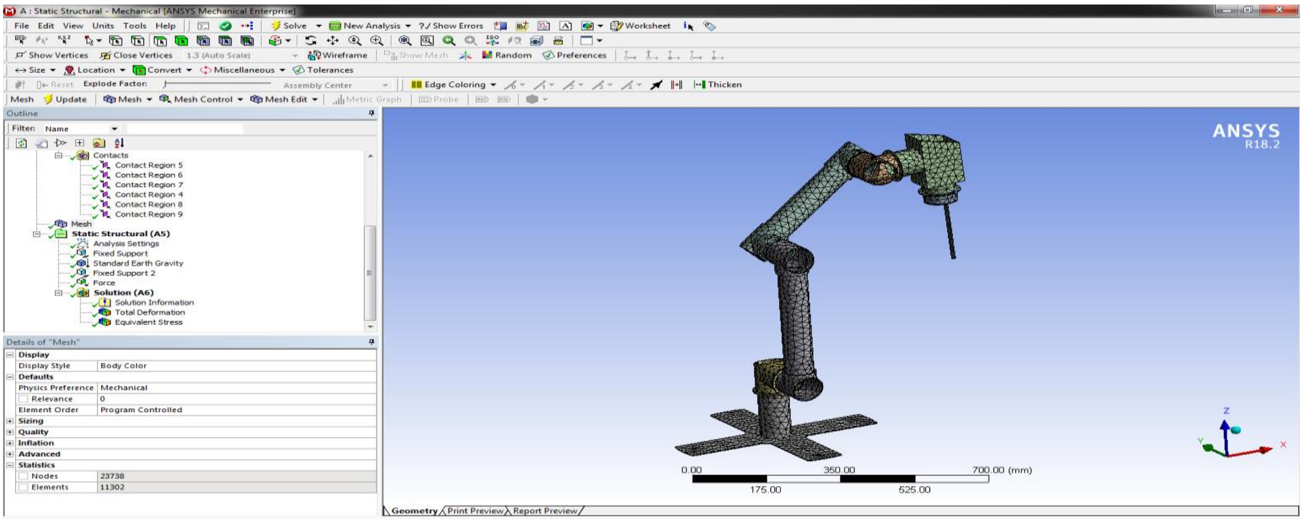


Figure4: Triogonal meshing of Smokie Robot.

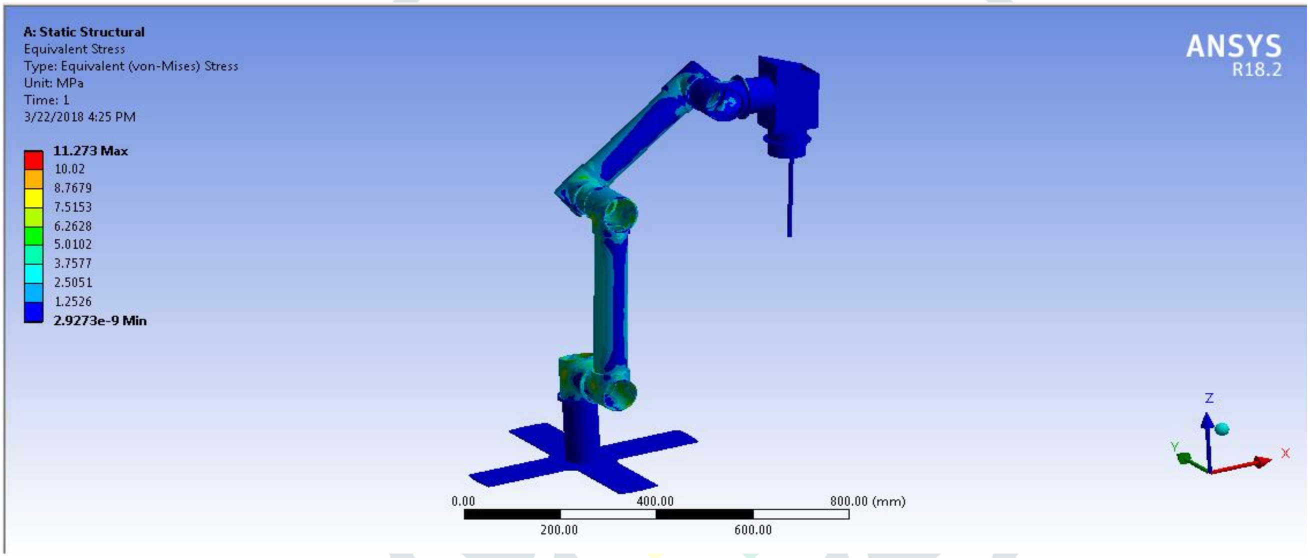


Figure5:vonmises stress of smokie arm robot with steel as base & aluminium as material for all links.

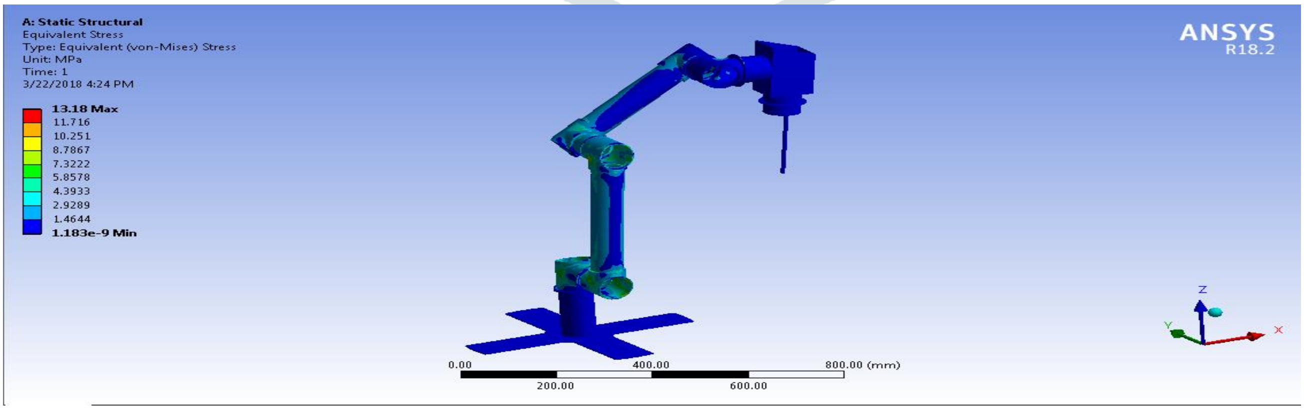


Figure6:vonmises stress of smokie arm robot with steel as base & epoxy glass as material for all links.

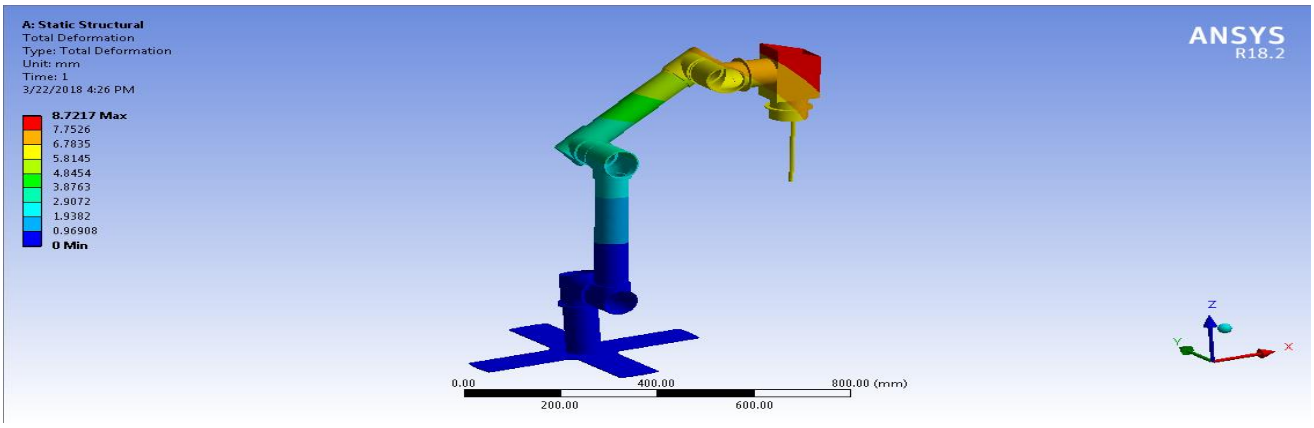


Figure7:Deformation of smokie arm robot using steel as base and aluminium for all links.

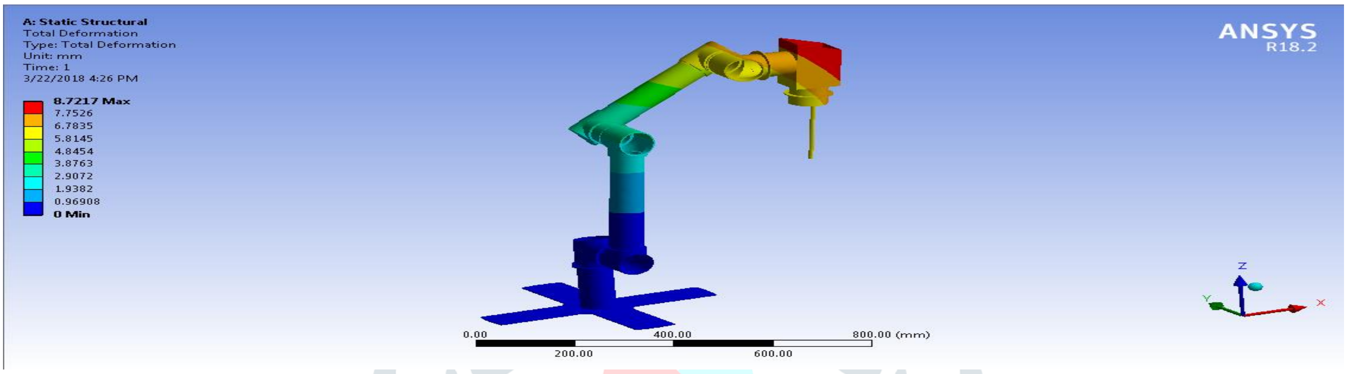


Figure7:Deformation of smokie arm robot using steel as base and epoxy glass for all links.

5. MODIFIED DESIGN:

5.1 FIRST ANGLE PROJECTION:

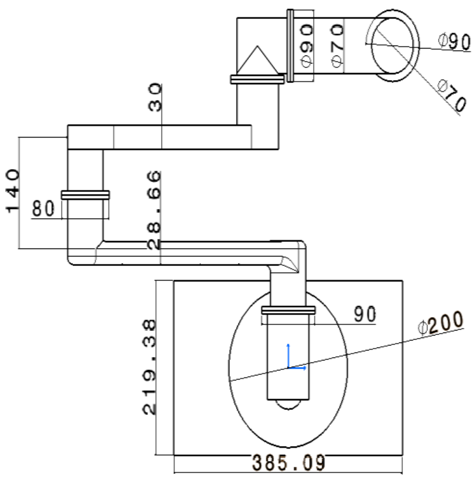


Fig 8: Top view of modified robot structure

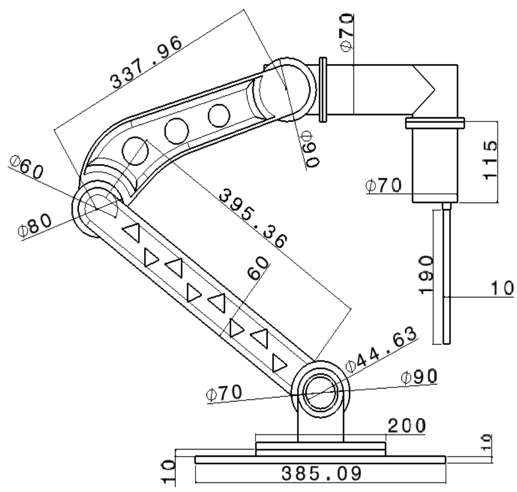


Fig 9: Front view of modified robot structure

5.4 Modified Robot Design made by using Catia:

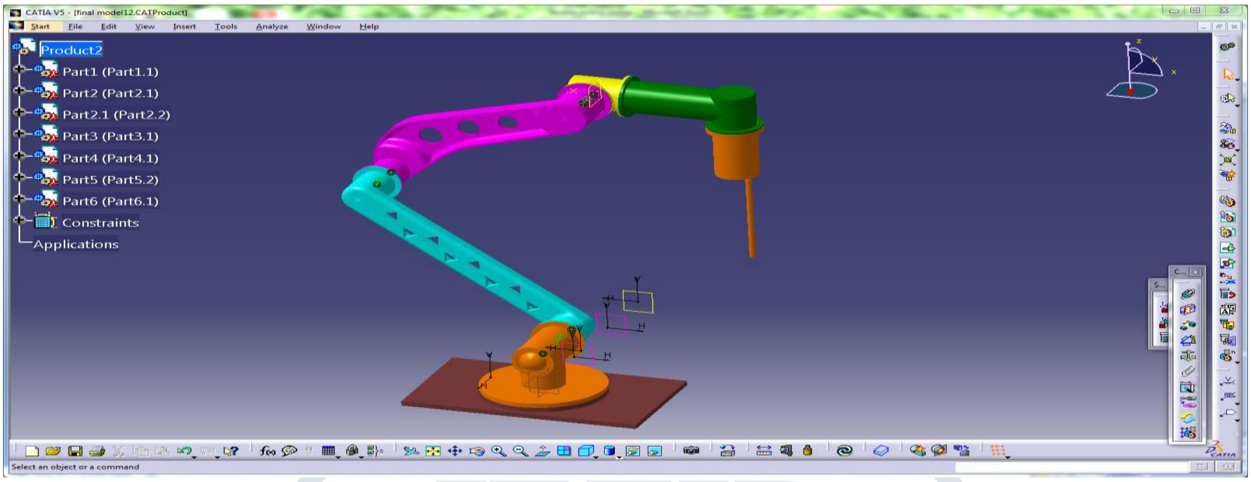


Figure 8: Isometric view of modified robot.

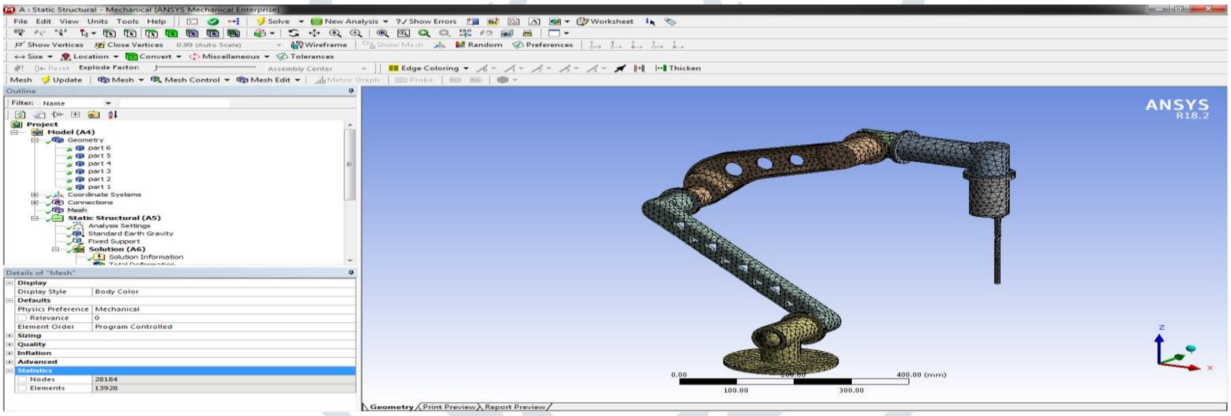


Figure9: Meshing of modified robot structure.

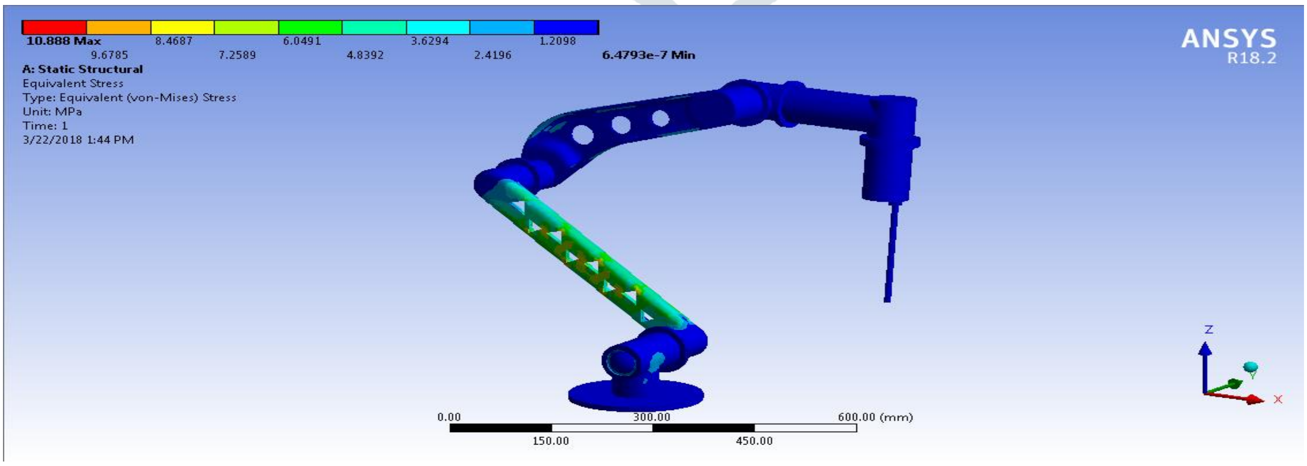


Figure10: vonmises stress of modified robot with steel as base & aluminium as material for all links.

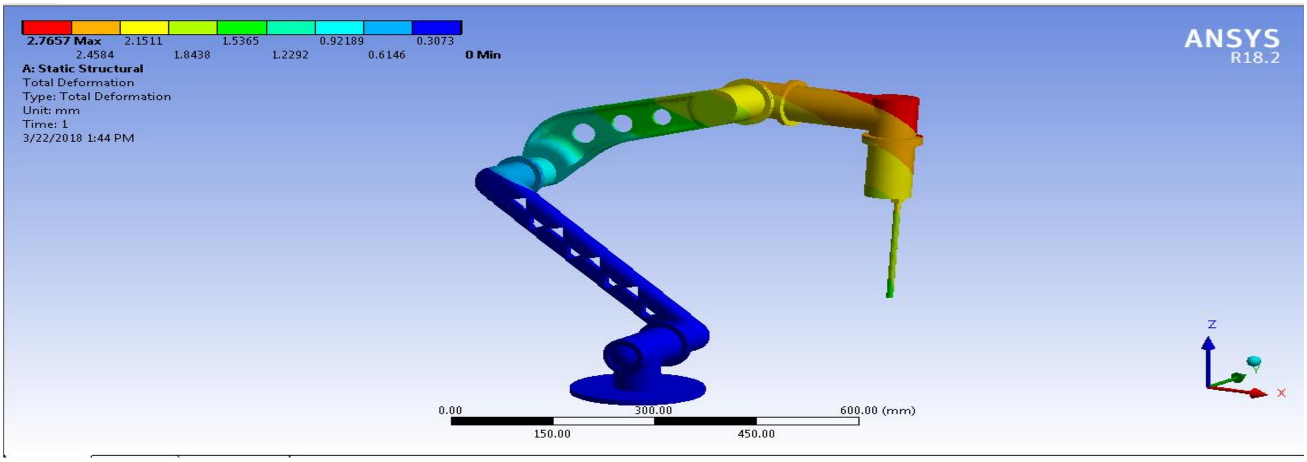


Figure11:Deformation of modified robot using steel as base and aluminium for all links.

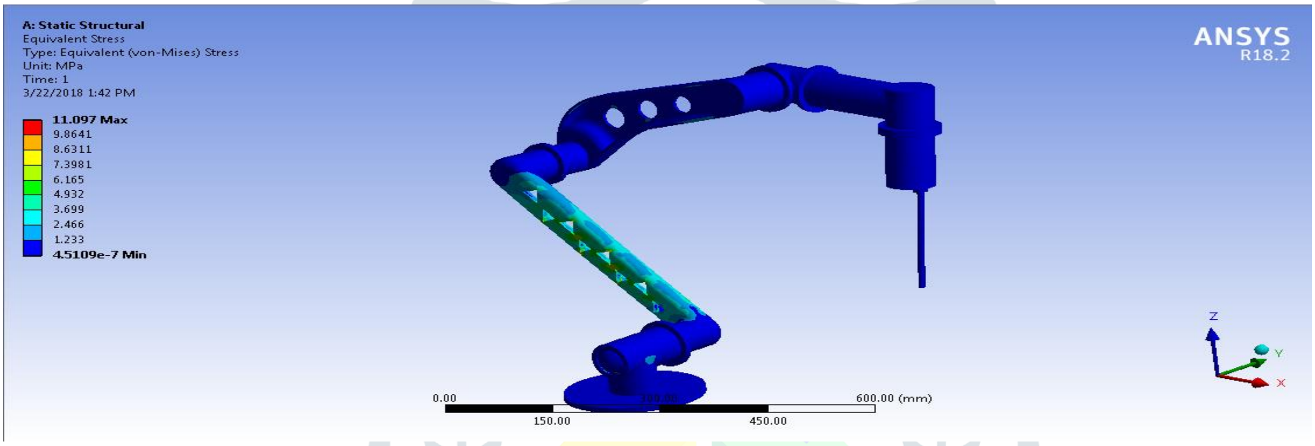


Figure12: vonmises stress of modified robot with steel as base & epoxy glass as material for all links.

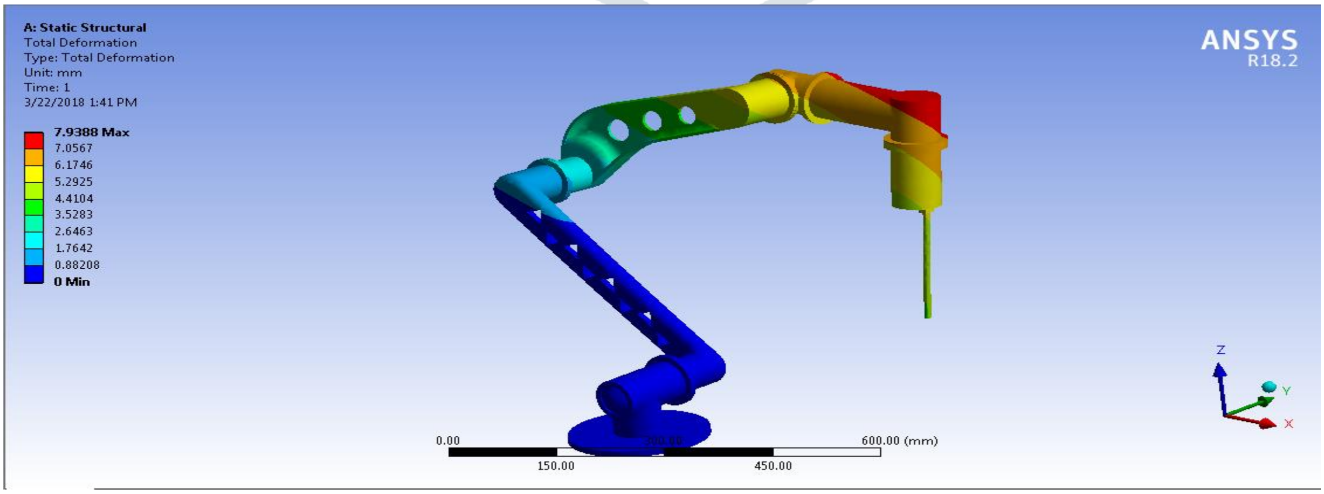
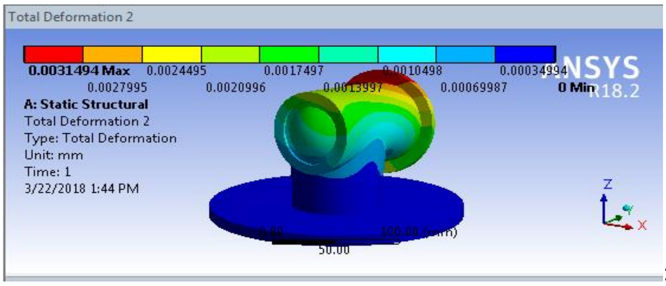
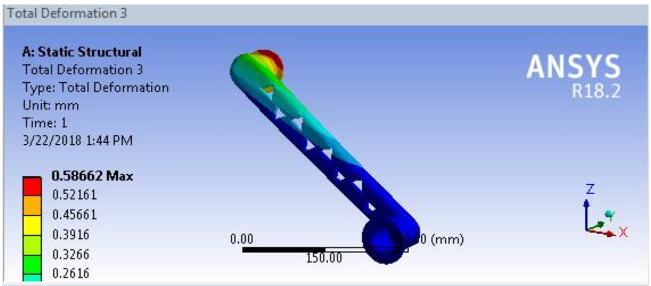
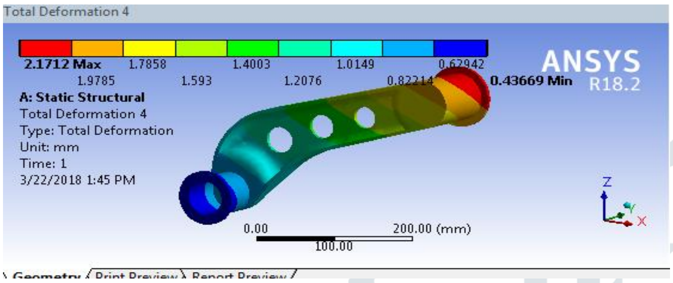


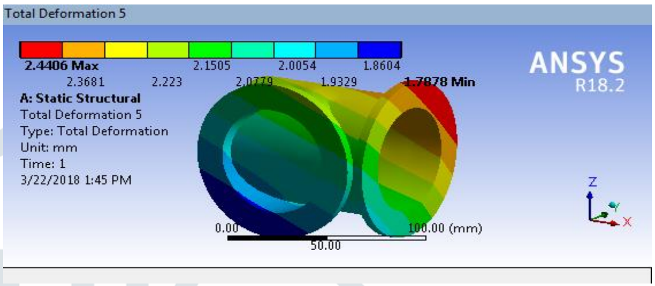
Figure13: Deformation of modified robot using steel as base and epoxy glass for all links.

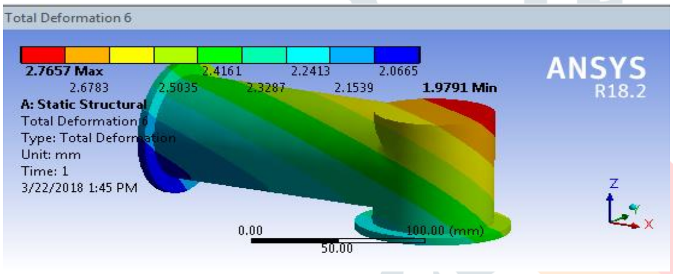
5.5 DEFORMATIONS AND STRESES OF MODIFIED LINKS OF ROBOT USING STEEL AS BASE AND ALLUMINIUM FOR ALL LINKS:

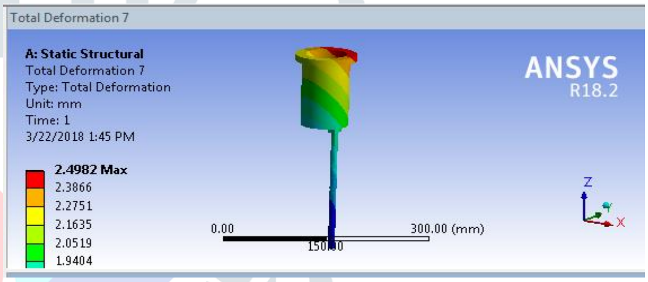


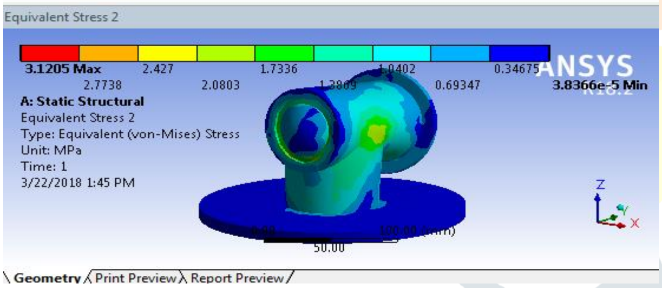


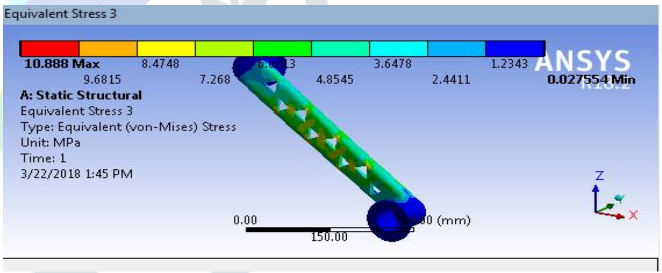


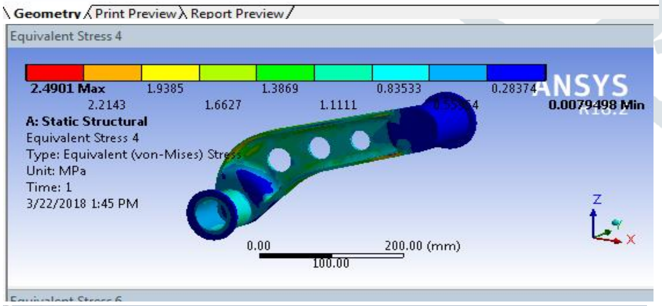


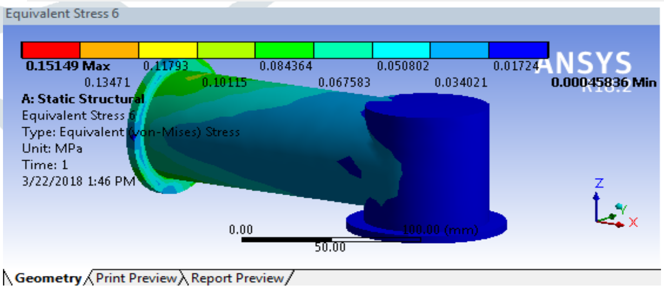


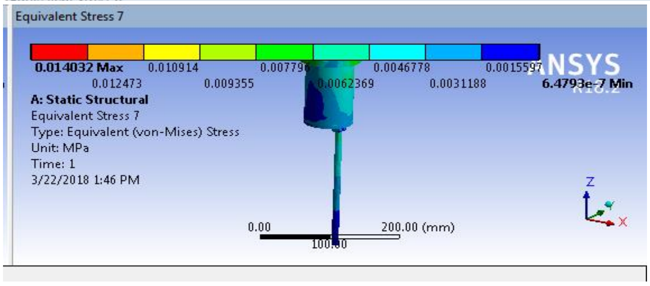




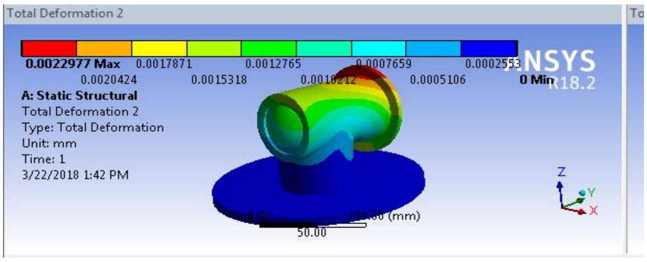


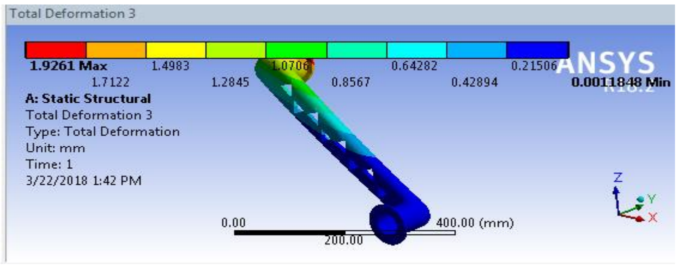


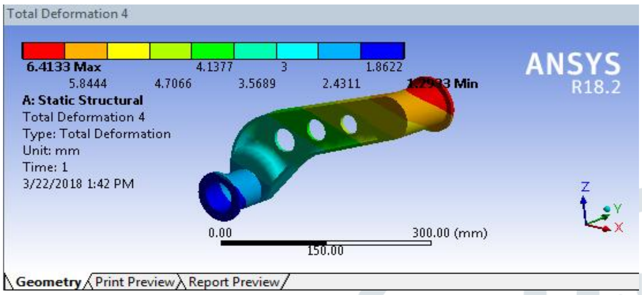


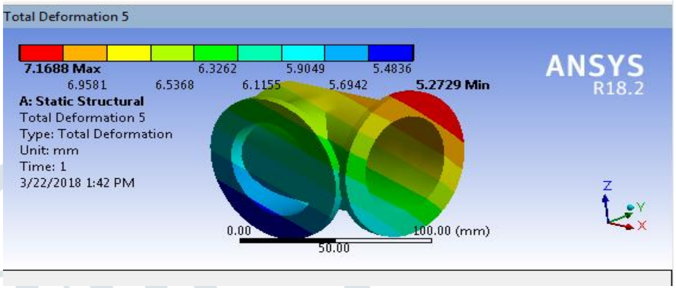


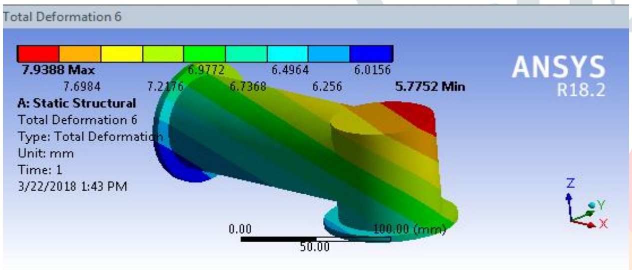
5.6 DEFORMATIONS AND STRESSE OF MODIFIED LINKS OF ROBOT USING STEEL AS BASE AND EPOXY GLASS FOR ALL LINKS:

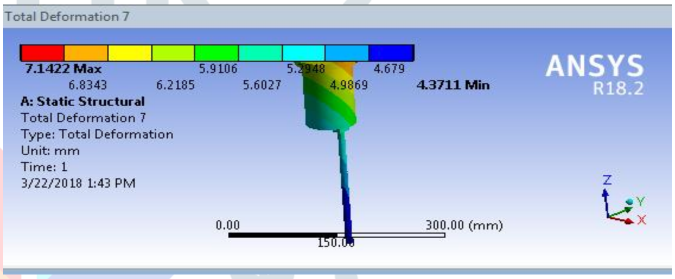


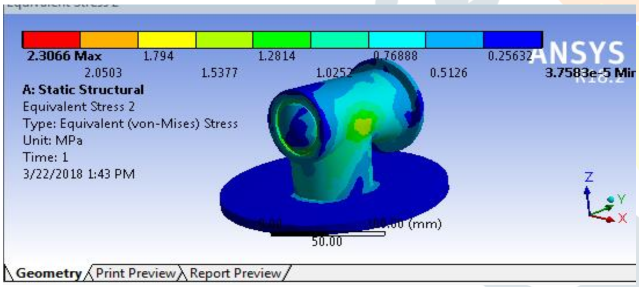


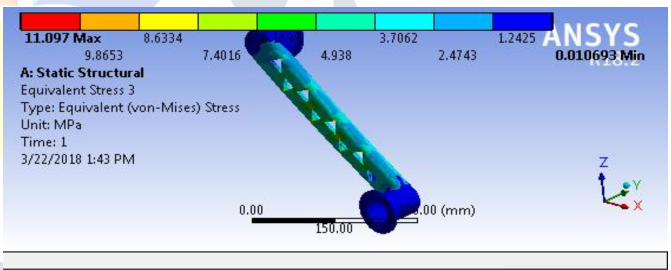


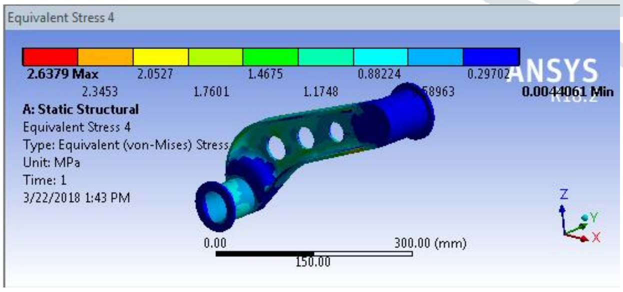


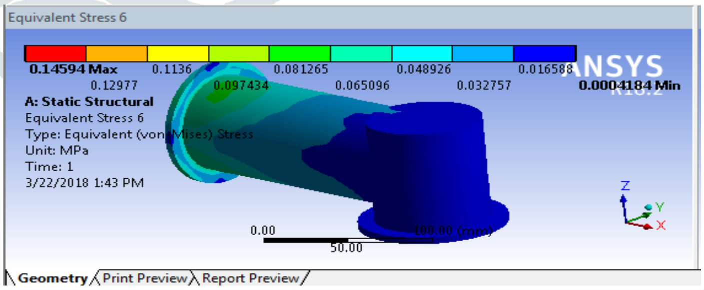


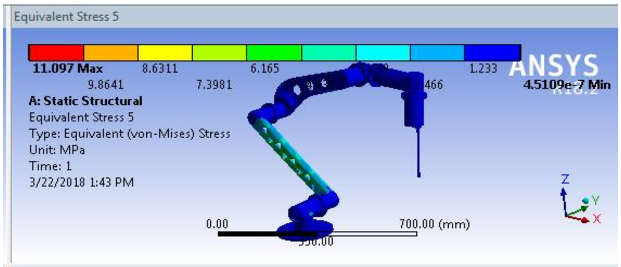


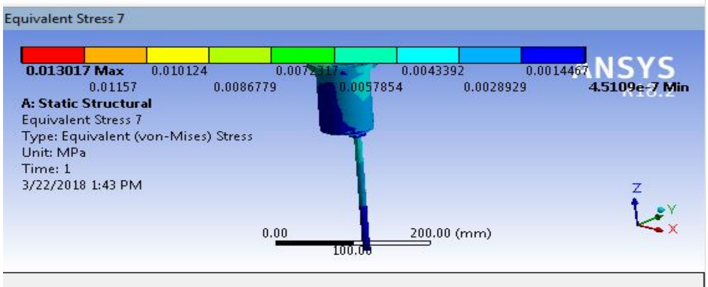




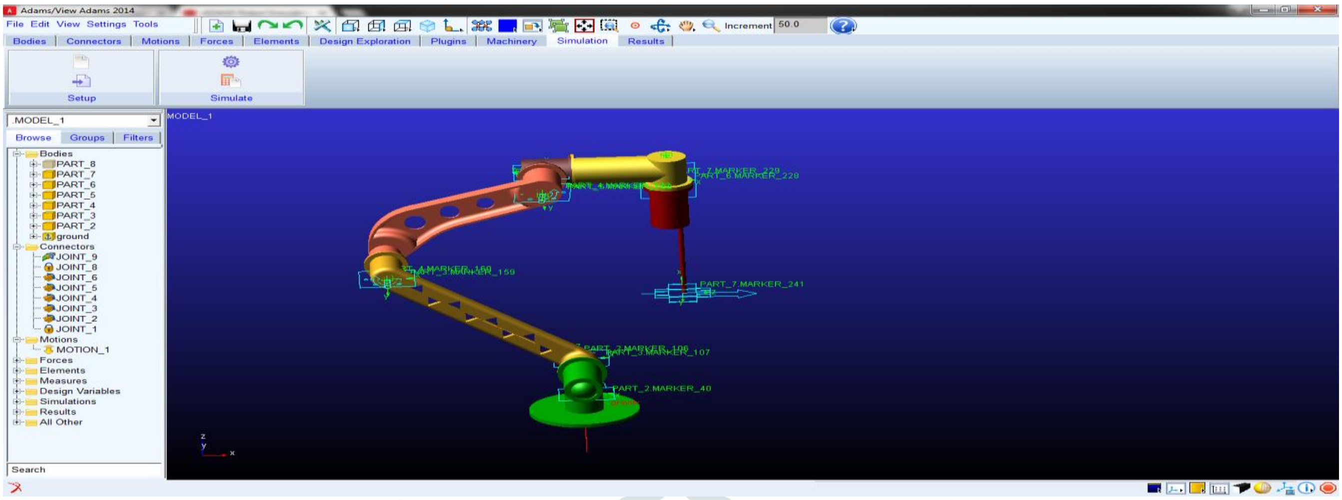






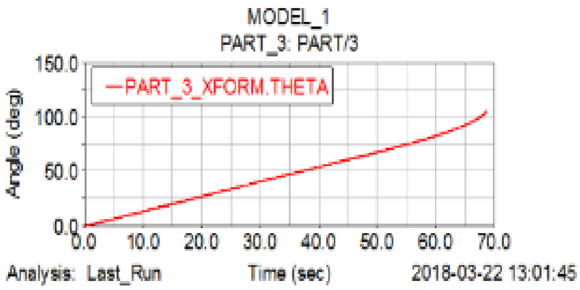


5.4 ADAMS SOFTWARE:

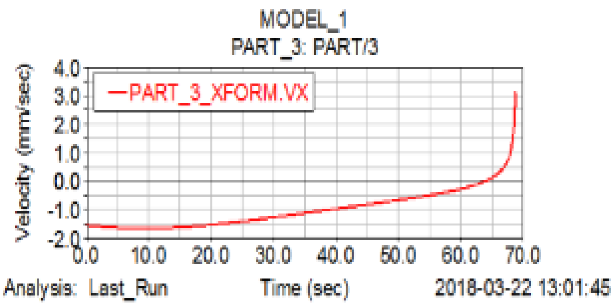


ADAMS (**acronym of Automated Dynamic Analysis Mechanical Systems) is** a multimode dynamics simulation software equipped with FORTRAN and C++ numerical solvers. ADAMS was originally developed by Mechanical Dynamics incorporation.

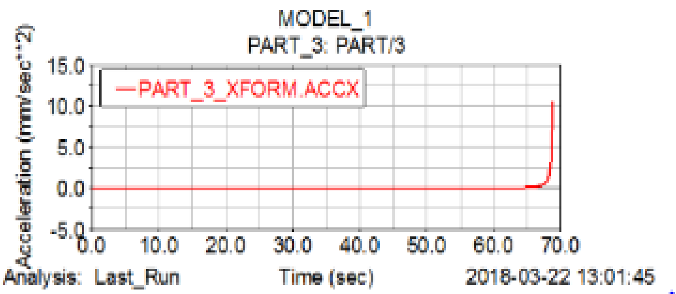
5.4.1 KINEMATIC ANALYSIS (V-T, A-T, θ-T GRAPHS): PART-3:



Graph1: angle turns with respect to time



Graph2: velocity with respect to time



Graph3: Acceleration with respect to time.

This graph1 shows a linear line between the Angular displacement of part 3 with respect to time.

This graph2 shows a simple curved path between the Velocity of part 3 with Respect to time.

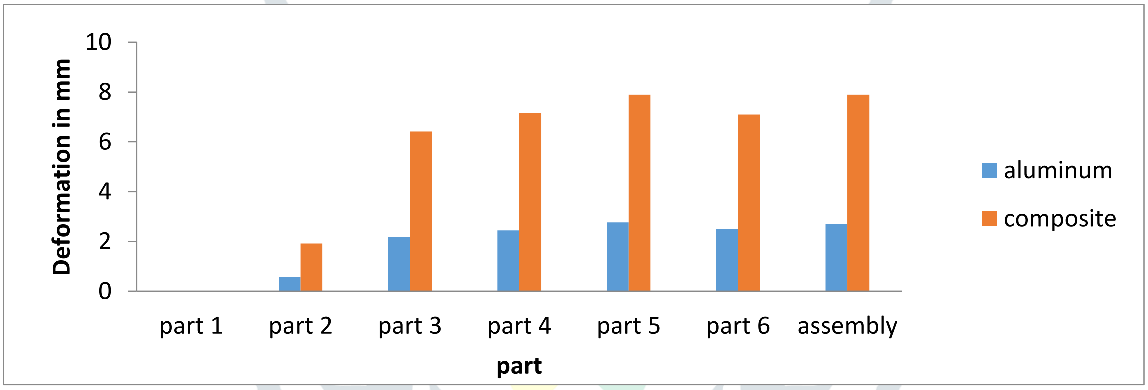
This graphs3 shows the Acceleration of part3with respect to time like linear path and turns into a curve at the end

Similarly this kinematic analysis is done for a the modified parts and the graphs are plotted.

6.RESULTS AND DISCUSSIONS:

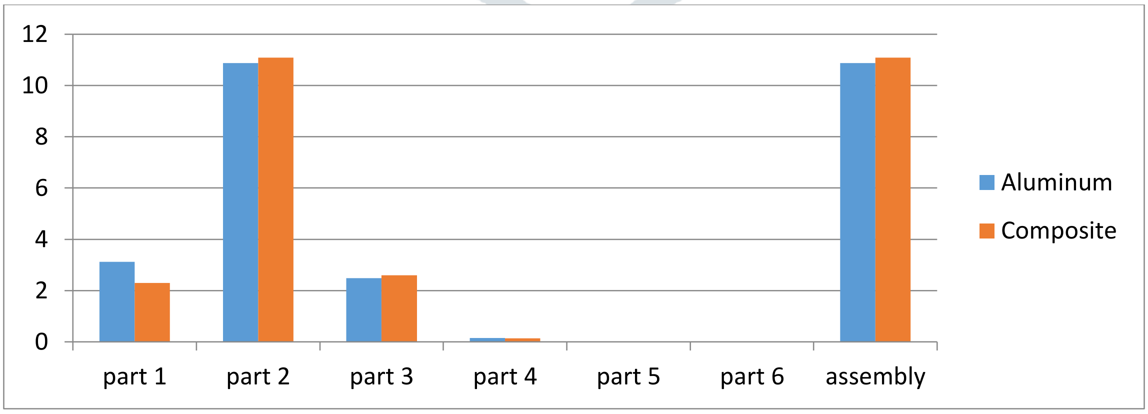
Table1: Vonmises Stress and deformations of modified robot.

part number	Aluminium		Composite (Epoxy glass)	
	deformation in mm	stresses in Mpa	deformation in mm	stresses in Mpa
part 1	0.0031	3.12	0.002	2.3
part 2	0.58	10.88	1.92	11.09
part 3	2.17	2.49	6.41	2.6
part 4	2.44	0.154	7.16	0.14
part 5	2.76	0.015	7.9	0.015
part 6	2.49	0.014	7.1	0.013
Assembly	2.7	10.88	7.9	11.09



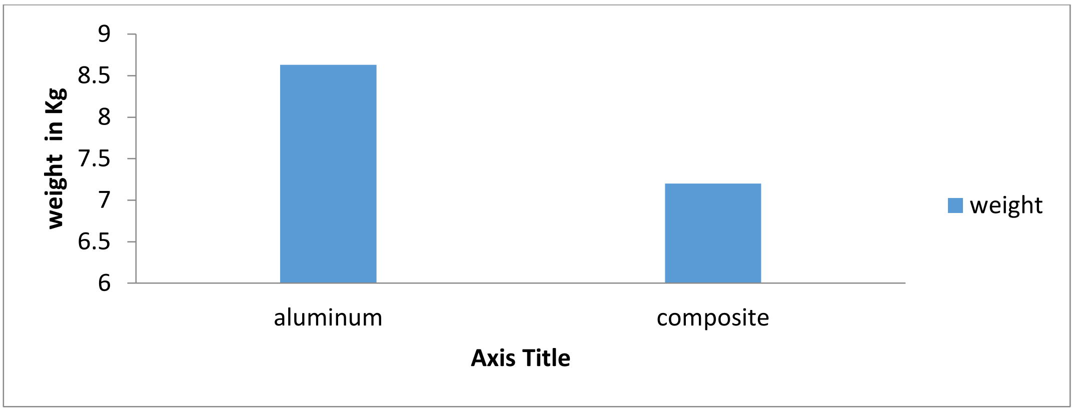
Graph 4 : Variation of deformation between aluminium & composite material.

- The graph depicts that the deformation is high when composite material is used than that in aluminium case.



Graph 5: stress variation between aluminium & composite material.

The graph depicts the stress variation when two different materials are used and it is evident that stress variation is very minute.



Graph 3: Weight comparison between aluminium & composite material.

- The graph depicts the weight difference in the robot when two different materials are used weight drastically drops in case of composite on par with aluminium.

CONCLUSIONS:

From the above analysis the weight of our designed robot with same geometrical similarities as that of original SMOKIE is less than the original robot which is achieved by decreasing width and thickness of links and the maximum stresses and deformations of our robot is less than that of original robot, hence the modified robot is considered to be better design on par with the existing.

Further analysis with composite material called epoxy glass and steel base with rest of the aluminium links is carried out and it is evident that weight of composite is 7.2704 kg which is less than that of steel base with aluminium material whose weight is 8.6346kg which makes it more portable but the maximum stresses and deformations in epoxy glass is greater than that in aluminium material and hence to ensure safety, material with steel base and other links as aluminium is taken as the material for the design of the robot. If we increase the thickness of composite materials of each link we can improve the bending strength and maintain the less weight as compared to aluminium materials.

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