Design, Development and Kinematic Analysis of Robotic Arm Manipulators

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ABSTRACT: Robot is a machine that collects the information about the milieu using some sensors and makes a decision robotically. People prefer it to use different field, such as industry, some dangerous jobs including radioactive effects. In this point, robots are regarded as a server. They can be managed easily and provides many advantages. Robot kinematics is the study of the motion (kinematics) of robots. In a kinematic analysis the position, velocity and acceleration of all the links are calculated without taking into consideration the forces that cause this motion. The correlation between motion, and the associated forces and torques is studied in robot dynamics. In this Paper, a robotic arm with 3 freedom degrees is designed and modeled using Solidworks. Kinematic analysis will be performed on the robotic arm manipulator to calculate position velocity and acceleration without considering the forces. Static analysis will also be performed to calculate the stresses by considering the forces.

Keywords: Kinematic analysis, robot dynamics

1. INTRODUCTION

A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm the arm may be the sum total of the mechanism or may be part of a more multifarious robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement [1]. The links of the manipulator can be considered to form a kinematic chain. The boundary of the kinematic chain of the manipulator is called the end effectors' and it is analogous to the human hand. The common industrial manipulator is often referred to as a robot arm, with links and joints described in similar terms. Manipulators which emulate the characteristics of a human arm are called articulated arms. All their joints are rotary (or revolute). Representative articulated manipulators are the ASEA robot. The motion of articulated robot arms differs from the motion of the human arm. While robot joints have fewer degrees of freedom, they can move through greater angles. For example, the elbow of an articulated robot can bend up or down whereas a person can only bend their elbow in one direction with respect to the straight arm position

2.0 LITERATURE REVIEW

Mehmet et.al studied the kinematics of manipulators is a central problem in the automatic control of robot manipulators. Theoretical background for the analysis of the 5 Dof Lynx-6 educational Robot Arm kinematics is presented in this paper. The kinematics problem is defined as the transformation from the Cartesian space to the joint space and vice versa. **Anurag verma et.al** concluded the kinematic analysis of a SCORBOT-ER Vplus robot arm which is used for doing successful robotic manipulation task in its workspace. The SCORBOT-ER Vplus is a 5-dof vertical articulated robot and all the joints are revolute. The kinematics problem is defined as the transformation from the Cartesian space to the joint space and vice versa. The Denavit-Harbenterg (D-H) model of representation is used to model robot links and joints in this study along with 4x4 homogeneous matrixes. SCORBOT-ER Vplus is a dependable and safe robotic system designed for laboratory and training applications. This versatile system allows students to gain theoretical and practical experience in robotics, automation and control systems[2]. The MATLAB 8.0 is used to solve this mathematical model for a set of joint parameter.

3 MODELLING APPROACH

a. Introduction to Computer Aided Design

Computer Aided Design is an interactive process, where the exchange of information between the designer and the computer is made as simple and effective as possible. Computer aided design   encompasses a wide variety of computer based methodologies and tools for a spectrum of engineering activities planning, analysis, detailing, drafting, construction, manufacturing, monitoring, management, process control and maintenance. CAD is more concerned with the use of computer-based tools to support the entire life cycle of engineering system.
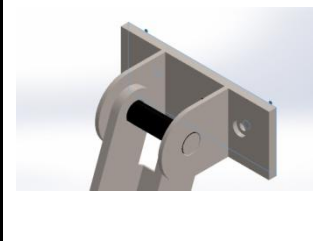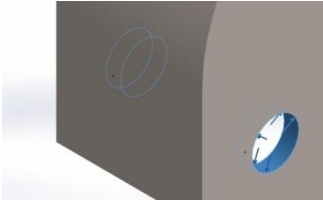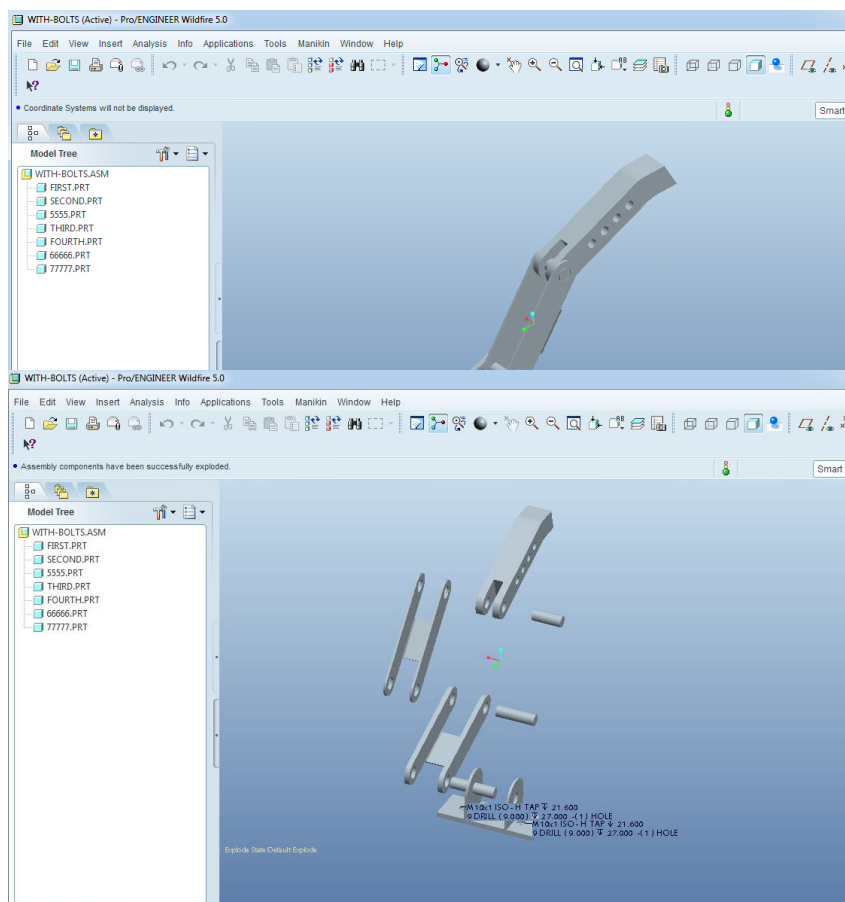
4.0 STATIC ANALYSIS OF ROBOTIC ARM

A stress analysis needs to be performed to ensure the robotic arm is able to withstand the specified load limit. Eventhough the designer has performed the analysis in the design stage; it has been found that some modifications are required after the robot has been reanalyzed once the assembly process is completed. The analysis of robotic arm includes a certain safety factor. The requirements are important to be met since the robot is designed to handle the radioactive products and failure during handling will present a danger to personnel and environment.
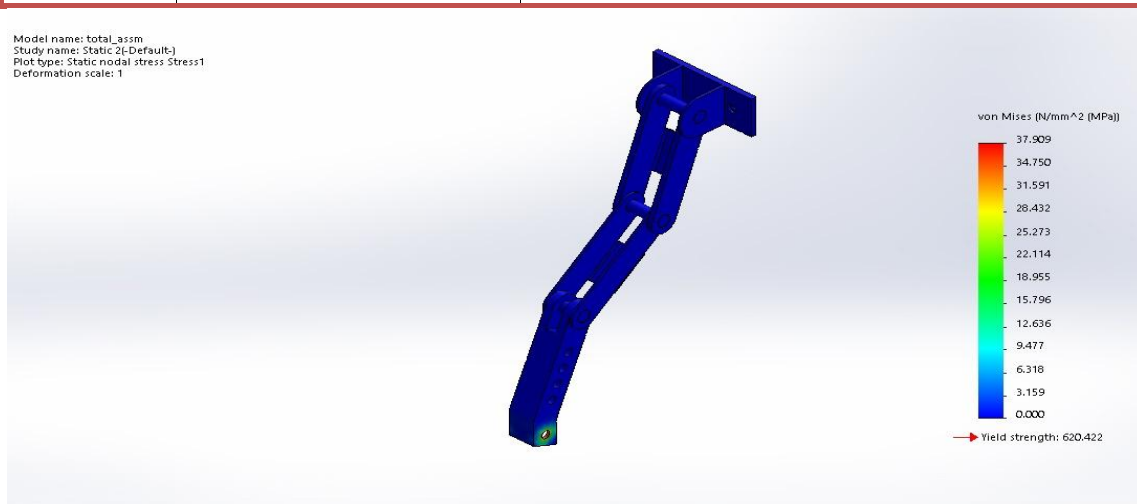
MATERIAL – ALUMINUM ALLOY

I. TABLE 1: LOADS AND FIXTURES FIGURE3 VON-MISSES STRESSES

Fixture name	Fixture Image	Fixture Details	
Fixed-1		Entities:	**1 face(s)**
		Type:	**Fixed Geometry**

Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	**9.59901e-6**	**1.03191e-6**	**0.000165**	**0.000166**
Reaction Moment(N.m)	**0**	**0**	**0**	**0**

Load name	Load Image	Load Details	
Pressure-1		Entities:	**2 face(s)**
		Type:	**Normal to selected face**
		Value:	**19.5**
		Units:	**N/mm^2 (MPa)**
		Phase Angle:	**0**
		Units:	**deg**

Model name: total_assm
Study name: Static 2(-Default-)
Plot type: Static nodal stress Stress1
Deformation scale: 1

von Mises (N/mm^2 (MPa))
37.909
34.750
31.591
28.432
25.273
22.114
18.955
15.796
12.636
9.477
6.318
3.159
0.000
→ Yield strength: 620.422

5.0 SIMULATION AND MOTION STUDIES

Motion studies are graphical simulations of motion for assembly models. You can incorporate visual properties such as lighting and camera perspective into a motion study. Motion studies do not change an assembly model or its properties. They simulate and animate the motion you prescribe for a model.
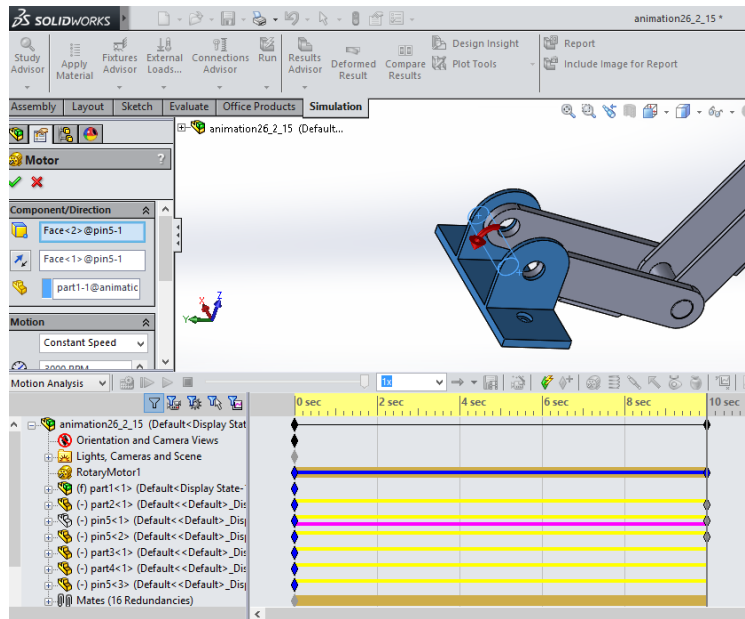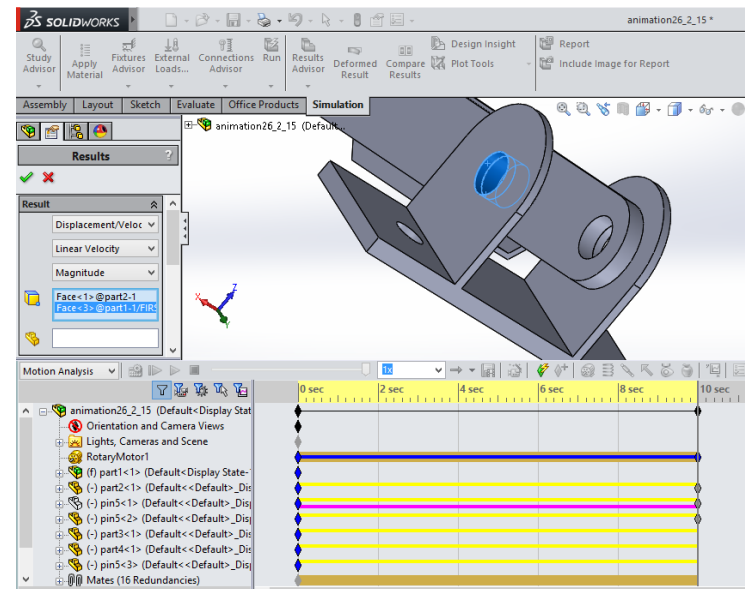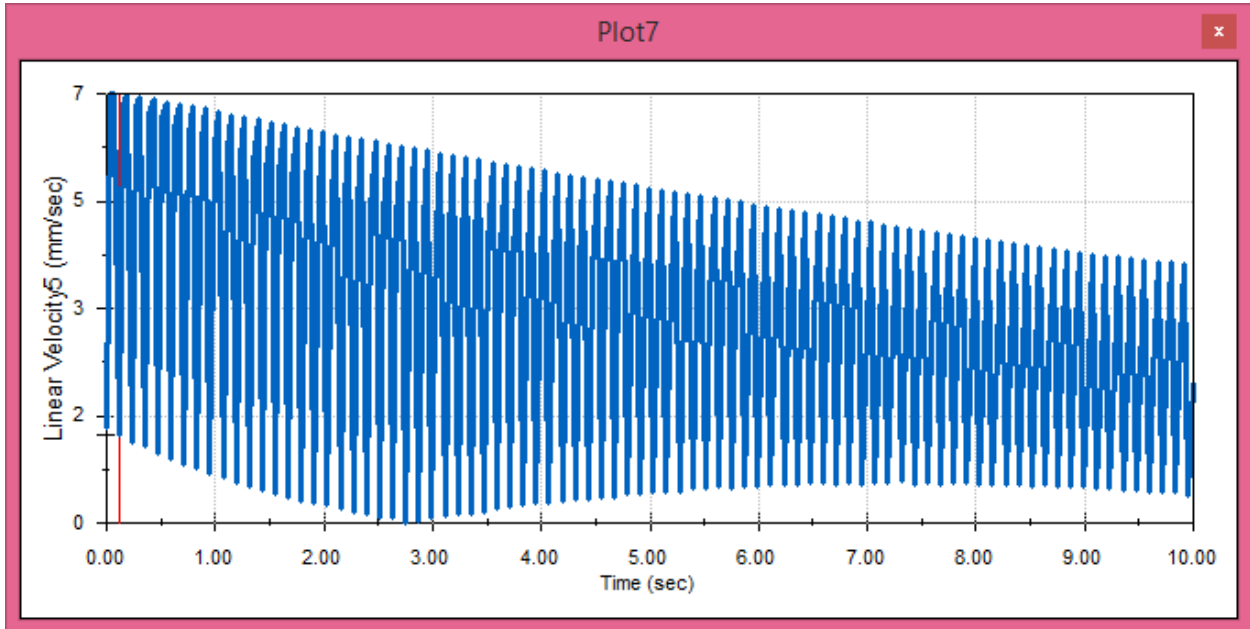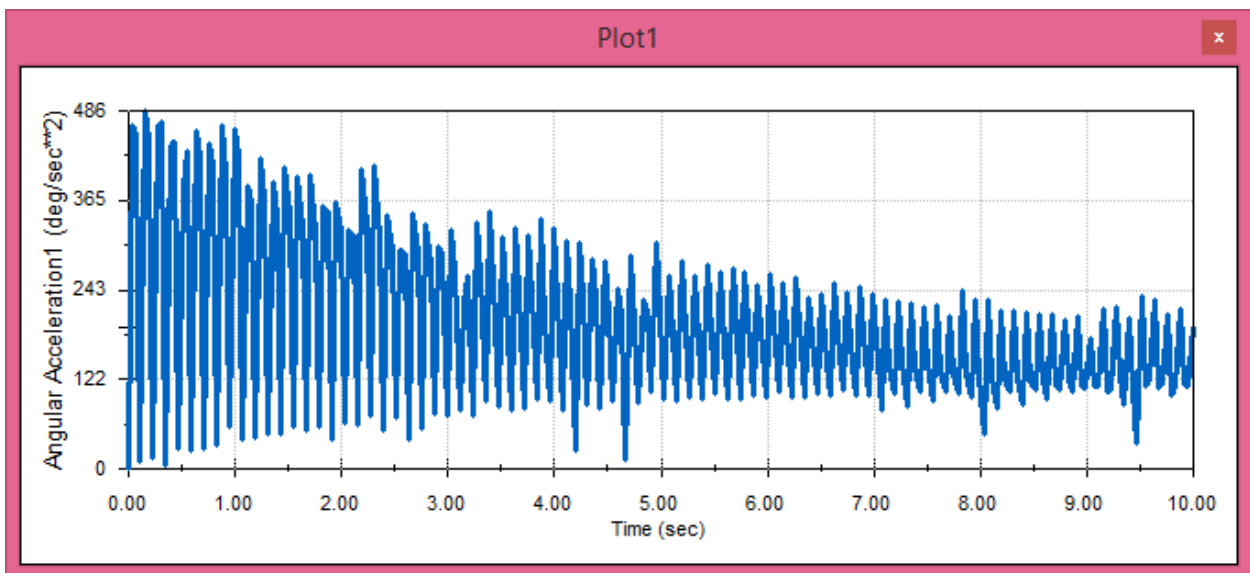
Figure 4 Simulation in solid works

Figure 5 Simulation in inner view

6.0 KINEMATIC ANALYSIS RESULTS

Table (2).motor speed - 1000rpm
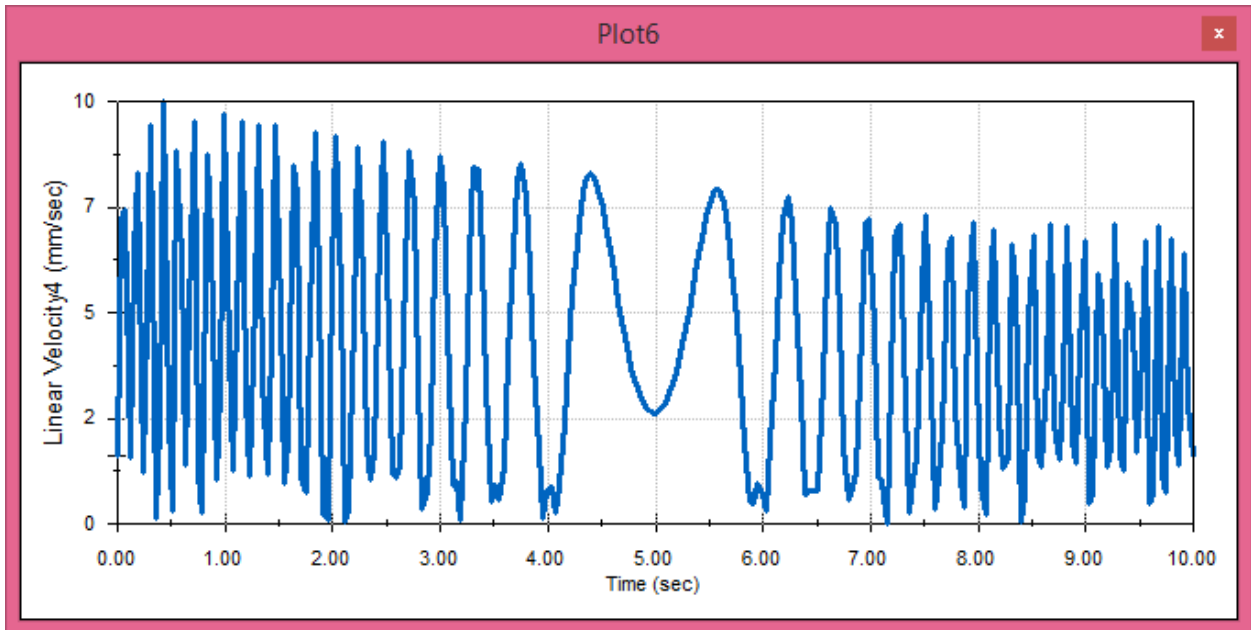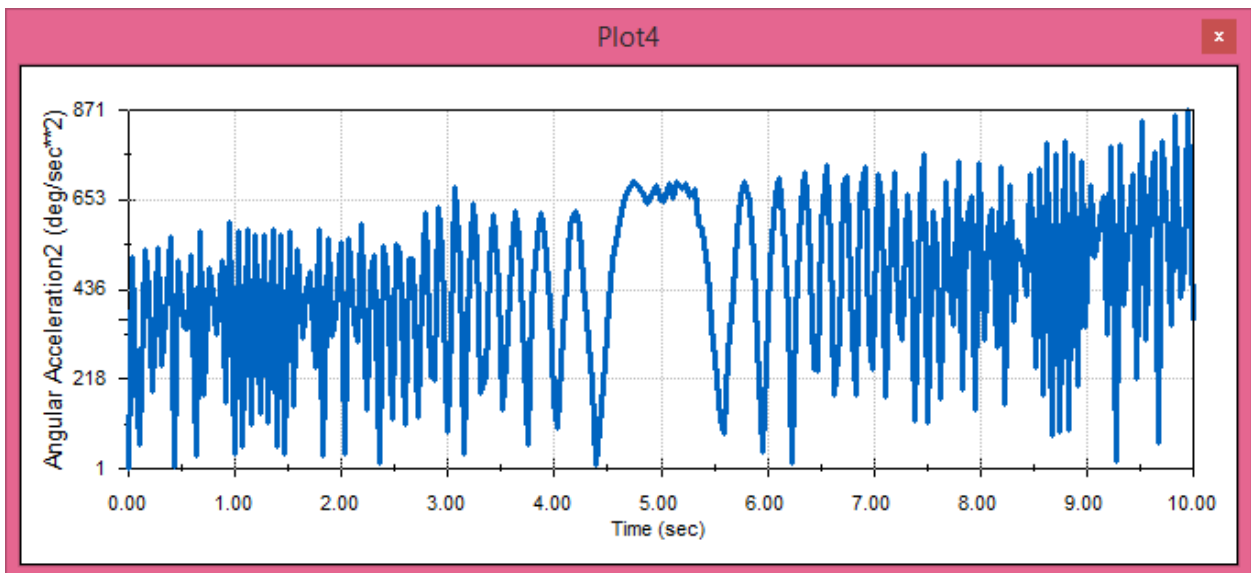**Linear velocity Vs time**

Acceleration Vs time

Liner velocity & acceleration velocity respect to time at 1000 rpm

Table (3) . Motor speed - 2000rpm
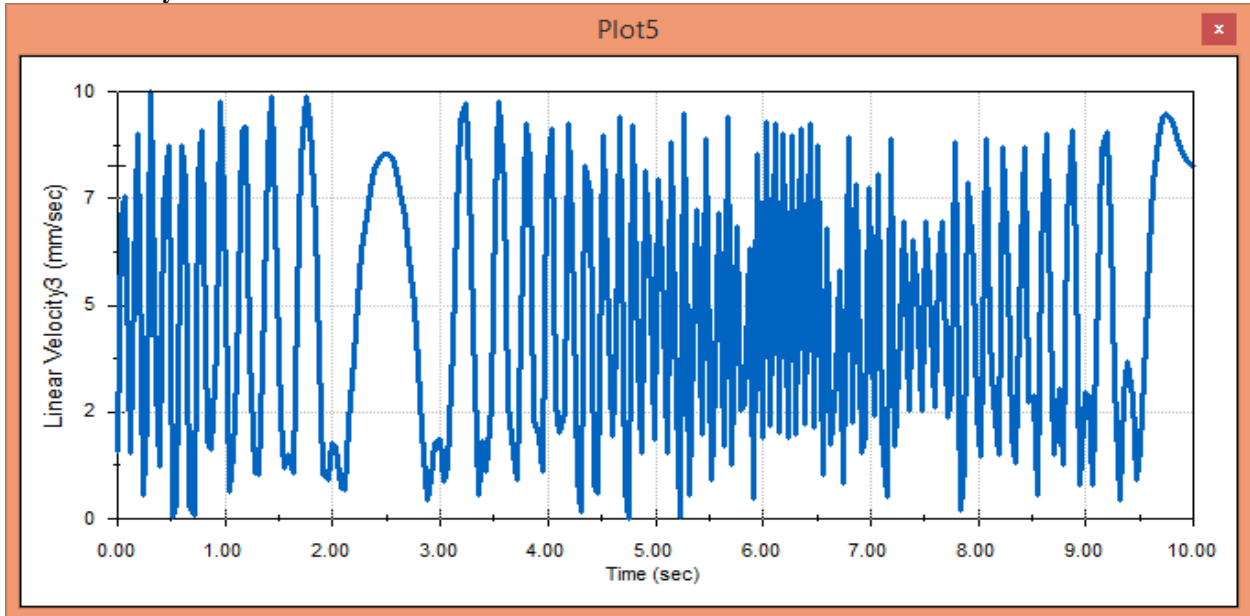**linear velocity Vs time**
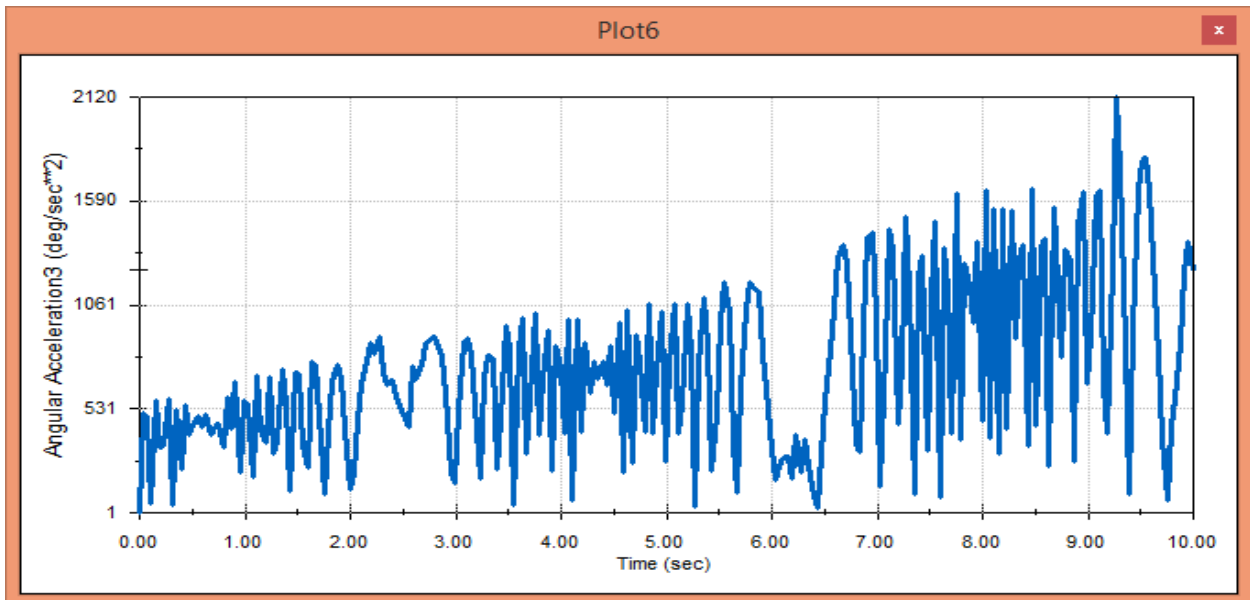

Acceleration Vs time

liner velocity & acceleration velocity respect to time at 2000 rpm

Table (4) . Motor speed - 3000RPM
Linear velocity Vs time

Acceleration Vs time

Liner velocity & acceleration velocity respect to time at 3000 rpm

7.0 CONCLUSION

In this paper, a robotic arm with 3 freedom degrees is designed and modeled using Solid works. Static analysis is performed to calculate the stresses by considering the forces. The materials used are Steel and Aluminum alloy.
By observing the results, the stress values are less than the strength of both the materials by applying load of 2000Kgs on the arm.
 Kinematic analysis is performed on the robotic arm manipulator to calculate position velocity and acceleration without considering the forces. The analysis is performed at motor speed of 1000rpm, 2000rpm and 3000rpm.
By observing the kinematic analysis results, by increasing the motor rpm linear velocity and acceleration is increased with respect to time.
The kinematic analysis results for tow materials alloy steel and alloy aluminum, we obtained the results

FOR ALLOY STEEL
Von miss stress = 37.9092 N/mm^2
Resultant displacement = 0.00170663mm
equivalent strain = 0.000130404

 FOR ALLOY ALUMINUM
Von miss stress = 38.0743 N/mm^2
Resultant displacement = 0.00530118mm
Equivalent strain = 0.00041295

From the above calculations for these metals to see which materials best in terms of safety factor, that the metal steel alloy is better than of metal aluminum alloy based on the safety factor for each metal
It was found that the metal first highest factor of the second metal equivalent to 11 times in
terms of stress tolerance

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