Design and Analysis of Intelligent Robotic Arm

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1. Abstract:

Many robots have been built for manufacturing or for different applications for lifting the heavy loads with accurate displacement, orientation and to perform the same work repeatedly. The idea behind this work is to reduce the utilization of human energy for hazardous applications. This work involves in development of pneumatic controlled pick and place arm. To achieve this goal we intend to incorporate a simple linkage actuation mechanism. An AC motor is used along with spur gears and a threaded shaft arrangement. The gripper can perform the basic function of picking, holding and grasping of objects by means of a DC motor and it forms the mechanism. This work gives details about how to design and assemble the pneumatic pick and place robotic arm and analyze the design for better material properties to bare the maximum load conditions. The gripper can easily accessible for any design of components without slipping.

Key words: Intelligent robot, pick and place, arm

2. Introduction

When mentioning robots, many people will think about machines with hands and feet. However, this kind of machines often appears in scientific movies, entertainment, exhibitions and toy stores. They are very different from industrial robots. Industrial robots are abbreviated as IR. Most of them are simple apparatus. Sometimes they are called robotic arms. Robotic arms are used in performing simple up-and-down motion, to take and pick out components from machines. However, a lot of machines can be entirely controlled by programs to do different types of jobs, such as, searching, transportation, targeting, assembly and inspection.

In 1979, the American Robots Association has defined robots as '**a multi-functional operator which can be controlled by programs. It moves the materials, components, tools and other special apparatus through control programs to finish a series of work**'. Although many industrial machines do not possess human shapes, they satisfy the criteria and can be called robots.

Robots are being used widely in industries. It is estimated that a lot of industrial robots will be in service in near future. At present, scientists are designing robots with visions so that robots can accomplish more complicated tasks

Robot classification:

Types of robots by applications:

- Industrial Robots
- Domestic or household robots
- Surgical robots
- Service robots
- Military robots
- Entertainment robots
- Space robots
- Hobby and competition robots

Types of robot arms

- Articulated
- Cartesian
- Cylindrical
- Polar
- SCARA
- Delta

Applications of industrial robots

- Welding
- Handlingmaterials
- Load and unload of cutting tools
- Assembling components
- Cast treatment
- Painting
- Robot Gripper & End Effectors

Dynamics of system:

Dynamic system is needed for movement in the working area. The most important of which is the robotic arm. According to the designs of the robots, the main axis will move linearly or rotationally. The number of axes represents the number of directions that a robot can move individually. It can be called 'the degree of freedom'. If the volumes of robots are the same, the robot with 3 rotating axes or the highest degree of freedom has the larger working area. A robot usually has 2 to 10 axes, most of the robots have 5 to 6 degrees of freedom.

Usually, the drive of the robot maintains the function to change the supplied power to the grippers into usable kinetic energy for moving the robot and its positioning. The different types of drives are:-

(1) Electrical,
(2) Hydraulic and
(3) Pneumatic.

Electrical drive:
Electromechanical drive systems are found in about 20 percent of robots in today‘s world. These systems are of different types including servo stepper pulse motors. Electrical energy is converted into mechanical energy in these motors to power the robot for various applications, unlike hydraulic or pneumatic driving system that needs a lot of accessories. The advantages of an electrical system is that it is simple, clean and silent, but it cannot lift or move heavy object. It is commonly used in middle sized or small sized robots.

Hydraulic drive:
The most known form of the drive systems which are used widely is the hydraulic system as hydraulic cylinders and hydraulic motors are generally very sizeable and transfer high force and power, most importantly with accurate control. A hydraulic actuator works by changing forces obtained from high pressure hydraulic fluid into usable mechanical energy which is used for different linear motions and rotation of shafts. The Hydraulic fluid power is generally cost effective for factors such as short stroke and straight-line positioning where high forces are required. This drive system packs enormous power into a small package but is very safe and resistant to harsh environments.

Pneumatic drive:
A pneumatic driving system has similar advantages to that of the hydraulic driving system. Pneumatic systems are approximately found in about 30 percent of robots in today's world. Pneumatic drives use compressed air to propel the robots for various applications. The pneumatically driven robot is very popular these days for most of the machine shops have compressed air lines in their working areas. Actually, for difficulty in control of either speed or position or both which are the essential ingredients for any successful robot, this system is used selectively.

Materials used for robotics:
There is plenty of choice when it comes to picking the building materials for your robot. However not every material is a good choice.
There are three groups of materials. Each of these three groups have their own characteristics, possibilities and difficulties.
Note: There is a fourth group of materials called ceramics. However this group is only marginally useful for robotics.
Wood, Metals (Aluminum, Steel, Bronze, Brass, Copper), Synthetic Materials (PVC, Plexiglas), Composite materials, Foam core, Cardboard

3. Components to be designed:

- Base bottom plate
- Base side plate
- Base top/Intermediate plate
- Arm side plate
- Arm top/Bottom plate
- Forearm side plate
- Forearm top/bottom plate
- Wrist side plate
- Wrist bottom plate
- Gripper jaws
- Spacer
- Actuating gear spacer
- Gripper base
- Actuating gear
- Gripper rotation gear
- Gear case
- Gripper worm gear
- Gripper actuating gear
- Gripper rotation bearing
- Gripper link

4. DESIGNING OF ROBOTIC ARM

4.1 Base bottom plate:
The base bottom plate is the base part for whole robot arm. This plate can be fixed to the mobile robot base.

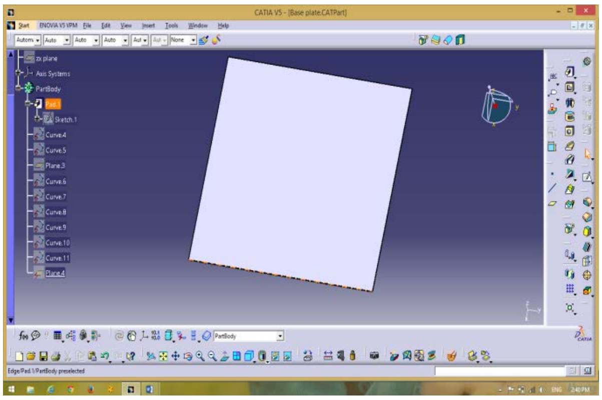

Fig 1: Base bottom plate

4.3 Base side plate:
Base side plate is connected to the base plate and it supports to the robot arm linkage.

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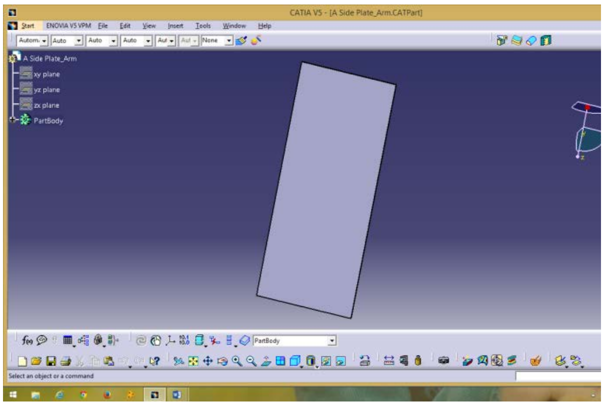

Fig 2: Base side plate

4.4 Base top/Intermediate plate:

Top and Intermediate plates are connected between the two base side plates. The middle arm link is connected to this part. Base top/Intermediate is joined to the side plates by welding joint.

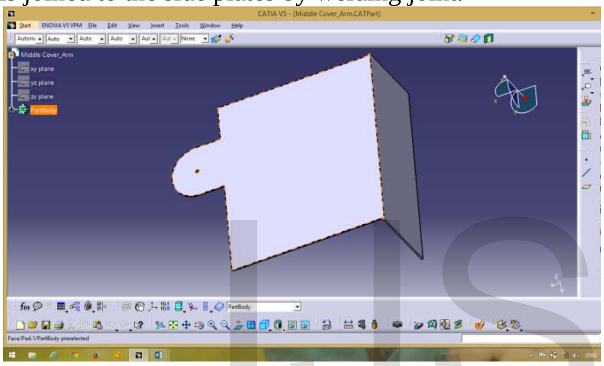

Fig 3: Base top/intermediate plate

4.5 Arm side plate:

Arm is the middle part of the robot arm. Which consist of two degree of freedom that is right and left motion to the robot. The arm consist of gears and motor to actuate the motion. The total parts in this arm is fixed to this side plate.

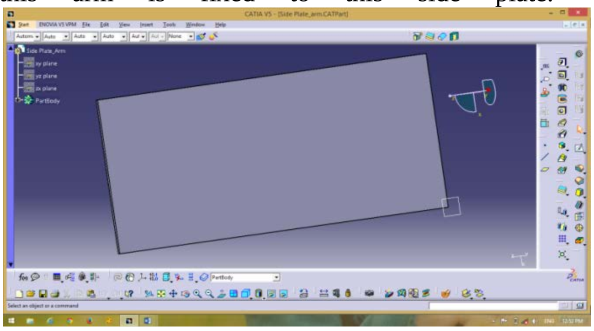

Fig 4: Arm side plate

4.6Arm Top/Bottom plate:

Arm top/bottom plate is to close the arm side plates and this part is connected to gear to give the motion to the arm.

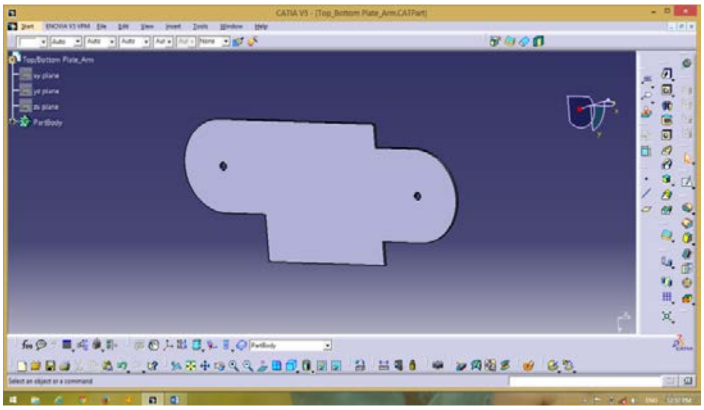

Fig 5: Arm top/bottom plate

4.7 Forearm side plate:

Forearm is connected to the arm. That is also giving right and left motion the arm. In this plate also the actuating gear is connected to this plate.

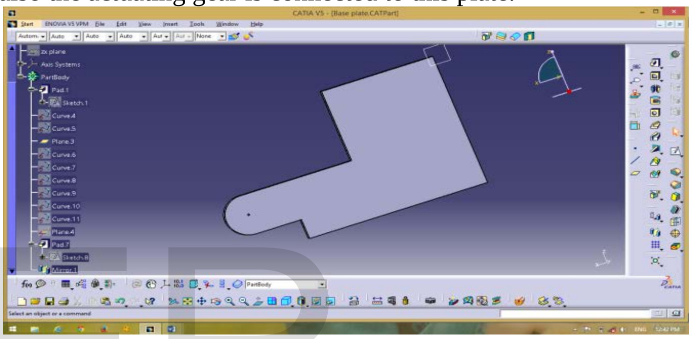

Fig 6: Forearm side plate

4.8 Forearm Top/bottom plate:

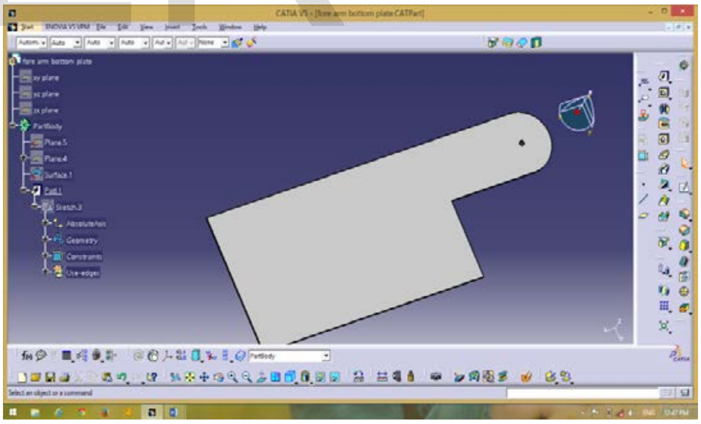

Fig 7: Forearm top/bottom plate

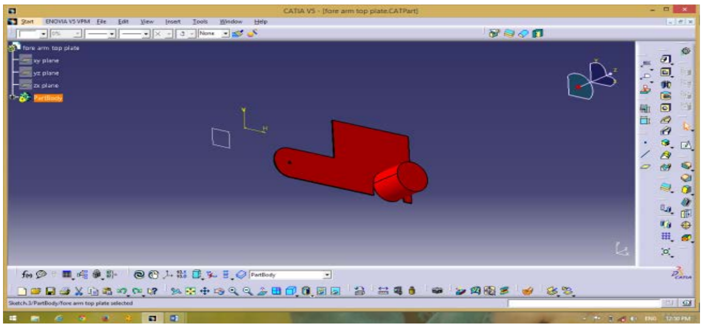

Fig 8: Forearm top/bottom plate

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4.9 Wrist side plate:

Wrist is the main part of the robot arm because all actuating motions to the gripper part is supplied from this wrist. The motions are the gripper actuating and the gripper opening and closing motion through worm gear.

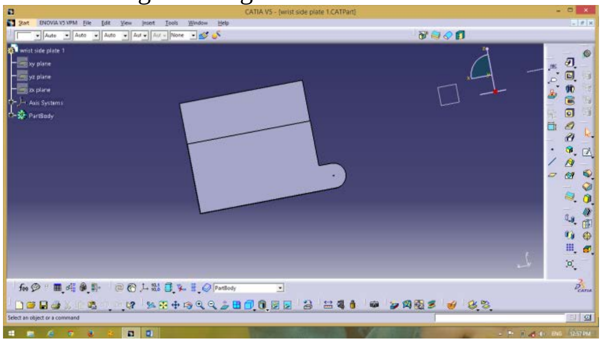

Fig 9: Wrist side plate

4.10 Gripper jaws:

Gripper jaw is the one of the part in the gripper. This gripper jaws are help to hold the objects. This gripper jaws can get the motion from the worm gear followed by the gripper actuating gear.

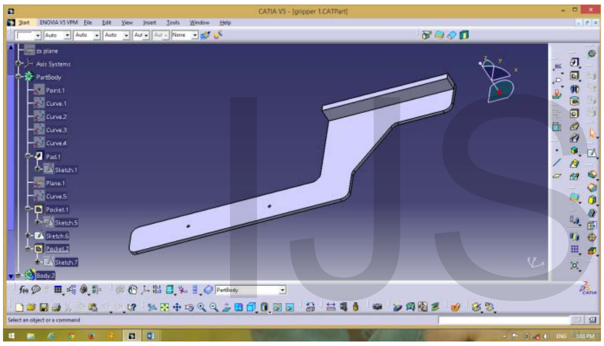

Fig 10: Gripper jaw

4.11 Spacer:

Spacer used in between the connection of gear and arm side plates

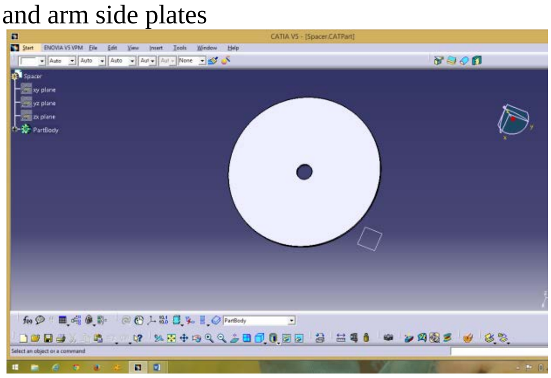

Fig 11: Spacer

4.12 Actuating gear spacer:

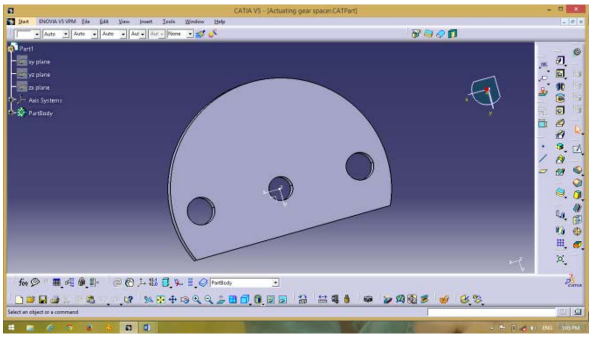

Fig 12: Actuating gear spacer

4.13 Gripper base:

Gripper base is the base for the gripper to hold he all parts of the gripper and the gripper rotation gear also connected to this base to rotate the whole gripper.

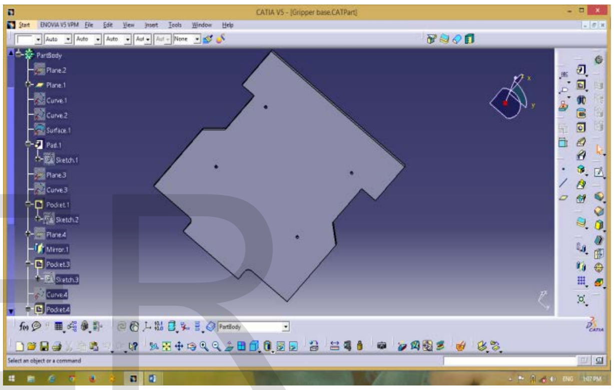

Fig 13: Gripper base

4.14 Gripper Actuating gear:

Gripper Actuate gear actuate gripper jaws to move and hold the object

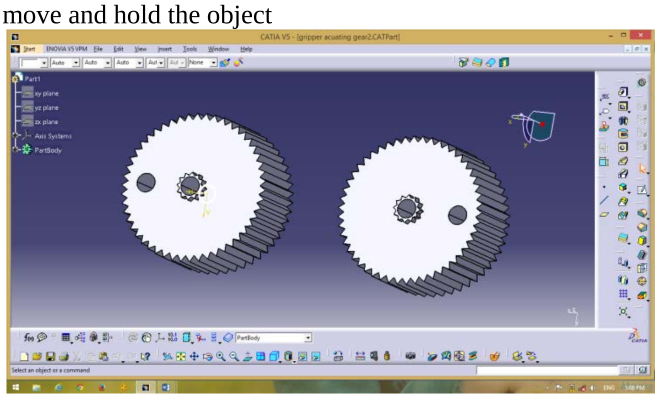

Fig 14: Gripper actuating gear

4.15 Gripper rotation gear:

Gripper rotation gear can rotate the whole gripper. This gripper rotation gear is fixed to the gripper base.

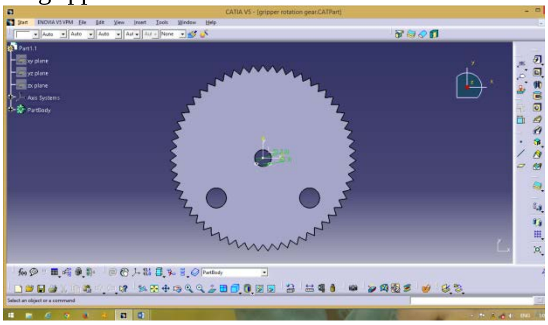

Fig 15: Gripper rotation gear

4.16 Gear case:

Gear case consist of all gears that is motion changing gears and the motor is fixed to this gear case.

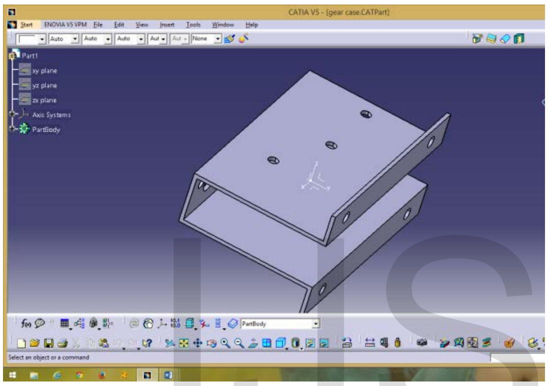

Fig 16: Gear case

4.17 Gripper worm gear:

Gripper worm gear is giving motion to the gripper actuating gear and get the motion from the wrist.

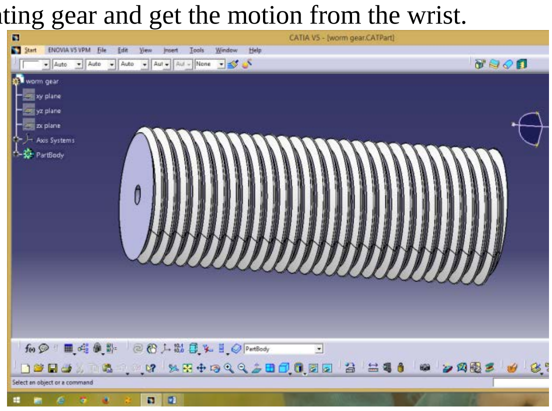

Fig 17: Gripper worm gear

4.18Final Assembly of Robot Arm:

Final Product of the robot arm is designed to hold and lift 25kg object op to 2 meters of height.

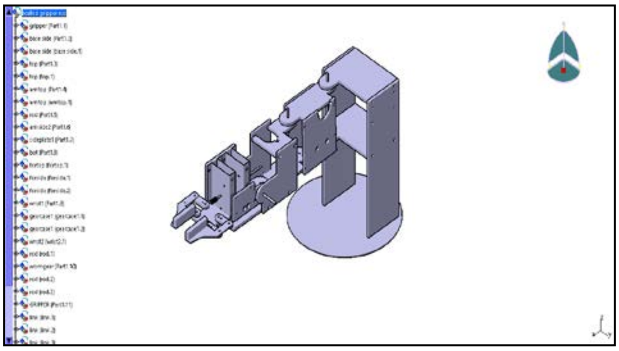

Fig 18:Assembly design of Robotic arm

5. ANALYSIS OF ROBOTIC ARM

ANALYSIS for the robot is done using a software CATIA that shows the working ability of the robot as possible as for the implementation results before manufacturing. This shows all the properties of the materials that study the working capability of the robot.

The analysis depends on the type of material used and different types of loads applied in certain directions.Here the analysis is done on two materials, iron and mild steel. Observations has done on iron and mild steel and this is shown below correspondingly.

ALUMINUM:

Aluminum (or aluminum, both are correct) is commonly available in extruded forms in different shapes. It's pretty cheap, light, strong, resistant to corrosion and easy to work with. However welding aluminum isn't practical as it needs special welding equipment (MIG/MAG or TIG welding) and the bond isn't very strong. While soldering is possible, it doesn't make a strong bond.The linear and parabolic meshing properties of the element is calculated and various types of observations acquired are

- Deformation
- Displacement
- Von-mises stress
- Principal stress
- Precision

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5.1 Worm gear Measure Inertia of Aluminum:

Volume - 0.004m^3
Area - 0.283m^2
Mass -10.074kg
Density -2710kg_m^3

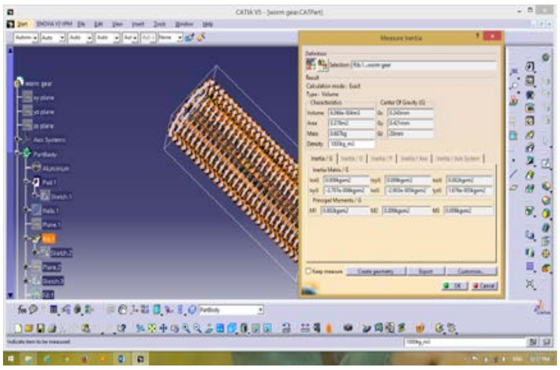

Fig 19: Worm gear Measure Inertia of Aluminum

5.2 Gripper Measure Inertia of Aluminum:

Area - 0.135m^2
Mass -1.351kg
Surfacic mass -10kg_m^2

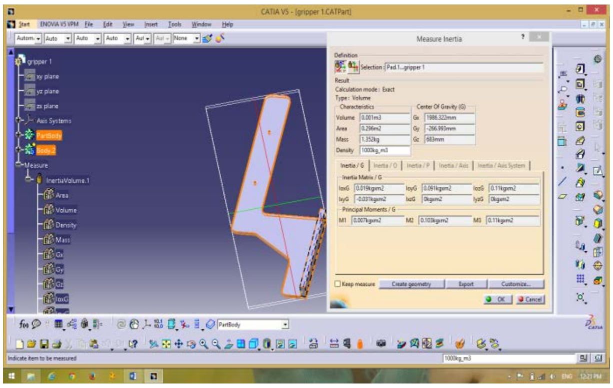

Fig 20: Gripper Measure Inertia of Aluminum

5.3 Parabolic deformation of Worm gear and Gripper Jaw:

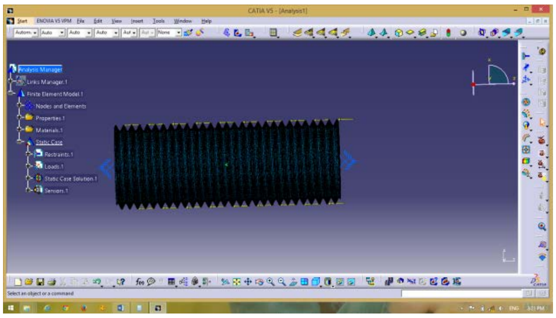

Fig 21: Parabolic deformation of Worm gear

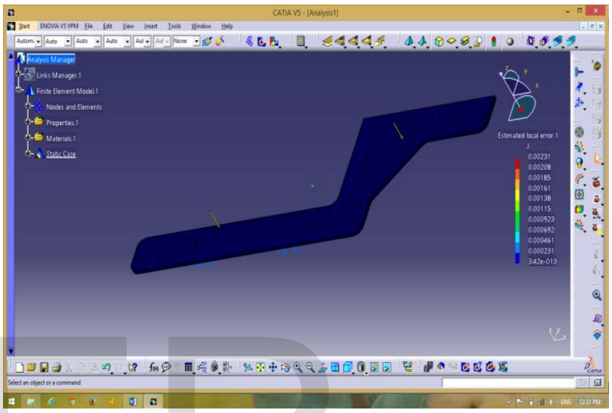

Fig 22: Parabolic deformation of Gripper jaw

5.4 Parabolic displacement of Worm gear and Gripper Jaw:

Translational displacement is 0.000228mm

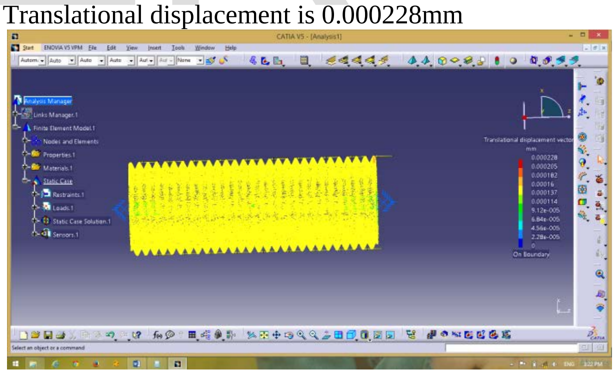

Fig 23: Parabolic displacement of Worm

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Translational displacement is 8.82mm

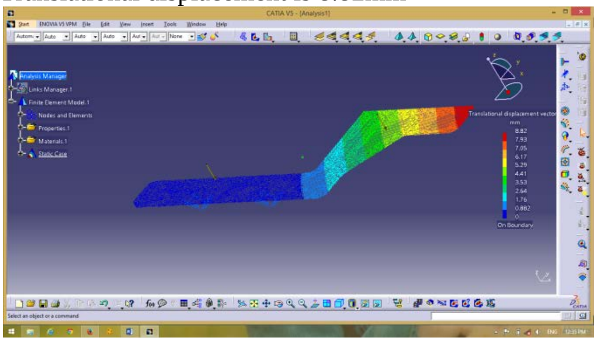

Fig 24: Parabolic displacement of Gripper jaw

5.5 Parabolic von mises stress of Worm gear and Gripper Jaw:

Stresses in Worm gear is 34.5 N_m^2

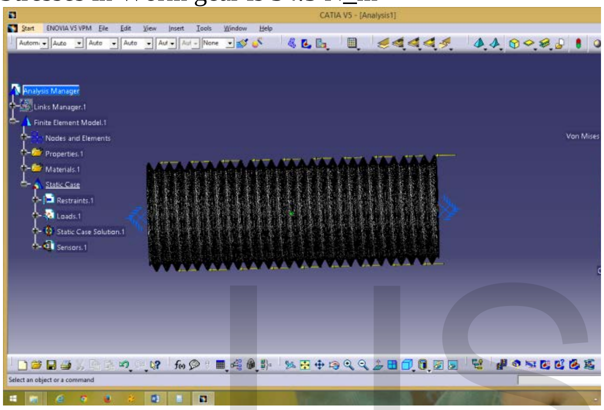

Fig 25: Parabolic von mises stress of Worm

Stresses in Gripper jaw is 36.6 N_m^2

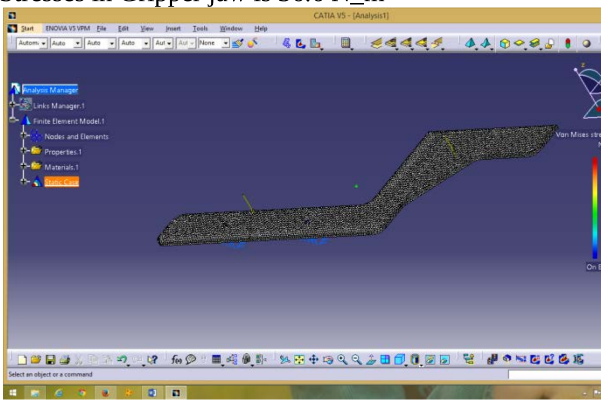

Fig 26: Parabolic von mises stress of jaw

5.6 Parabolic principal stress of Worm gear and Gripper Jaw:

Stress principal in Worm gear is 48.8 N_m^2

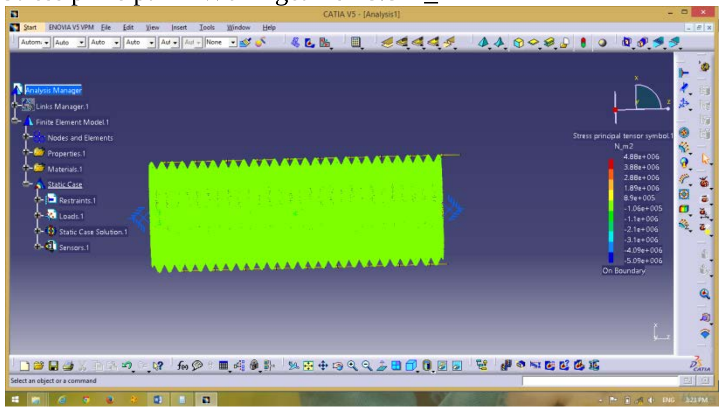

Fig 27: Parabolic Principal stress of Worm

Principal Stresses in Gripper Jaw is 34.1 N_m^2

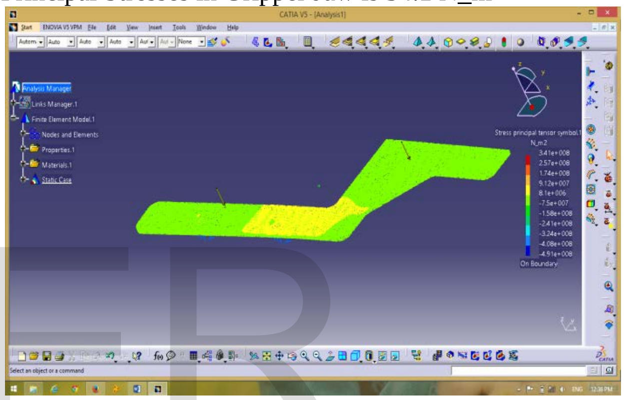

Fig 28: Parabolic Principal stress of Gripper jaw

5.7 Parabolic precision of Worm gear and Gripper Jaw:

Parabolic precision of Worm gear is 43.3J

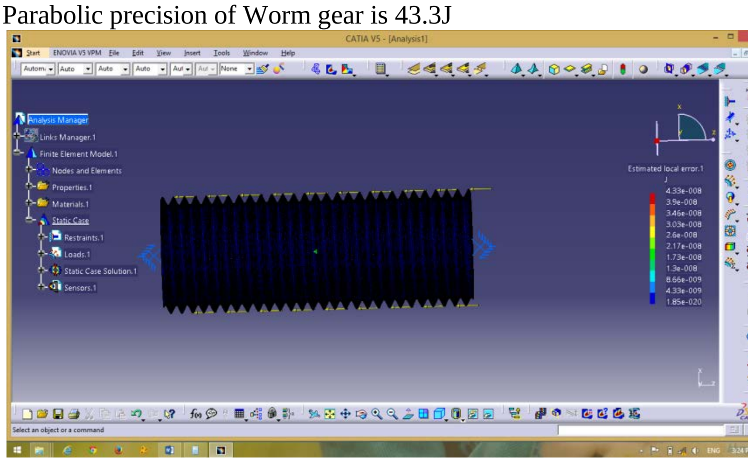

Fig 29: Parabolic precision of Worm gear

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Parabolic precision of Gripper jaw is 0.00124

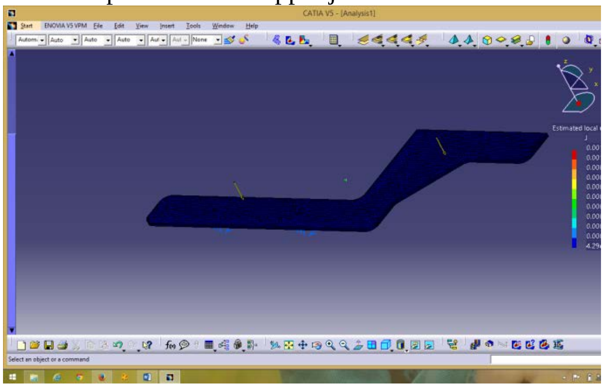

Fig 60: Parabolic precision of Gripper jaw

Mild Steel material:

Steel is commonly used in the construction of the chassis and body panels of trucks and automobiles. The reason for steel's use in the automotive sector is steel's unique set of characteristics as a construction material.

5.9 Worm gear Measure Inertia of Steel:

Volume - 0.004m^3
Area - 0.283m^2
Mass -29.21kg
Density -7860kg_m^3

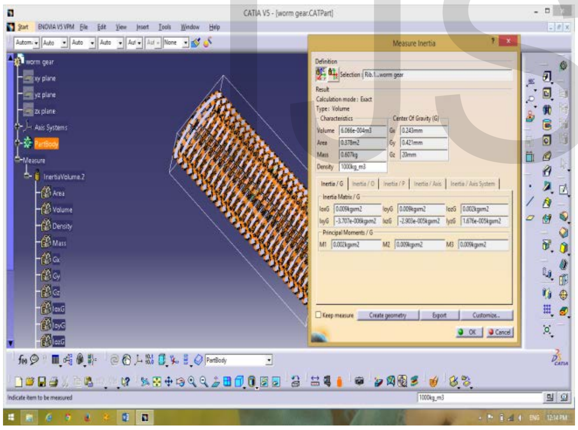

Fig 61: Worm gear Measure Inertia of Steel

Area - 0135m^2
Mass - 1.351kg
Surfacic mass-10kg_

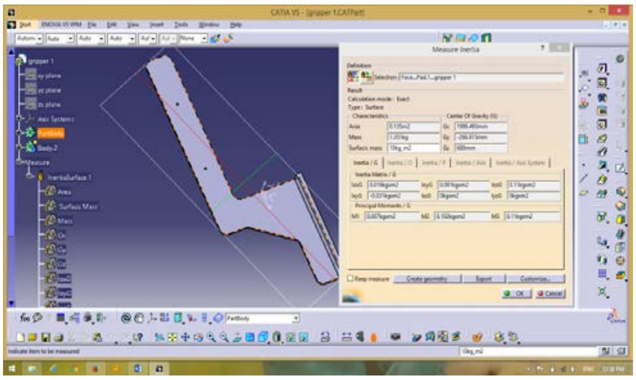

Fig 62: Gripper Measure Inertia of steel

5.10 Parabolic deformation of Worm gear and Gripper Jaw:

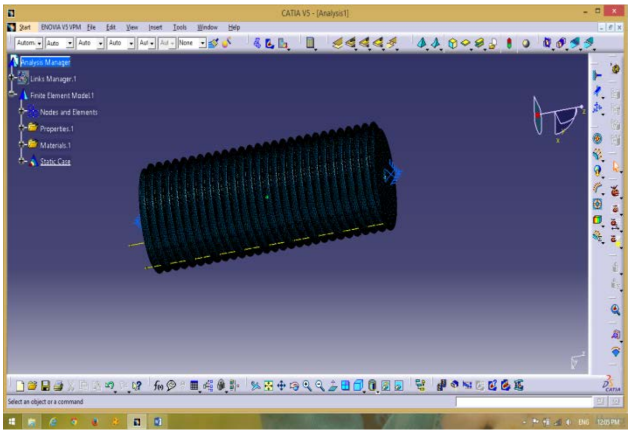

Fig 63: Parabolic deformation of Worm gear

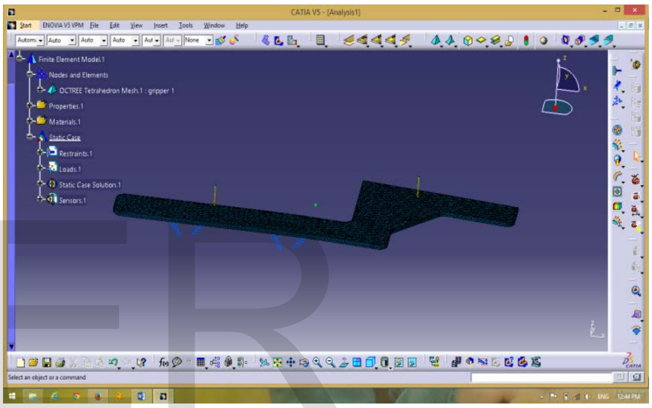

Fig 64: Parabolic deformation of Gripper jaw

5.11 Parabolic displacement of Worm gear and Gripper Jaw:

Parabolic displacement of Worm is 83.7

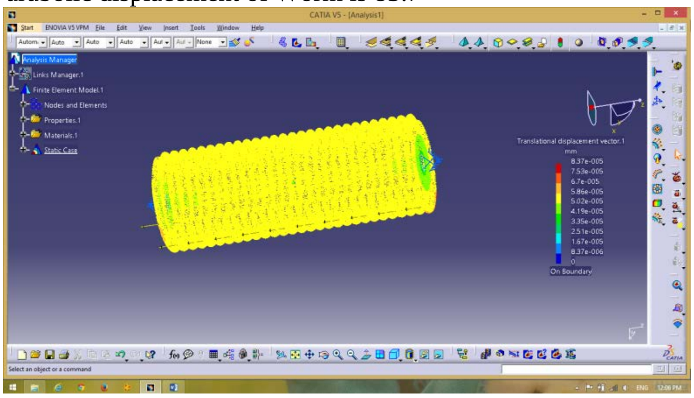

Fig 65: Parabolic displacement of Worm

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Parabolic displacement of Gripper base 3.08mm

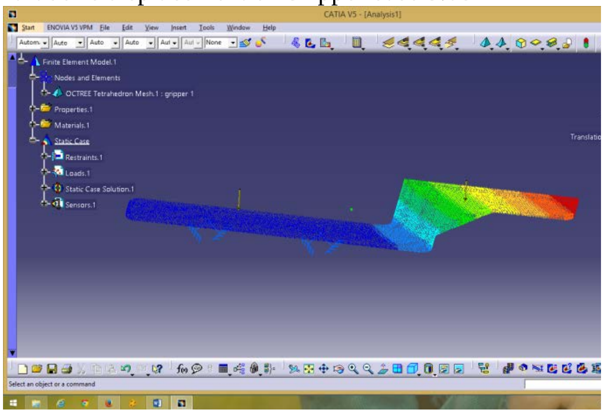

Fig 30: Parabolic displacement of Gripper jaw

5.12 Parabolic von mises stress of Worm gear and Gripper Jaw:

Parabolic von mises stress is 37.8N_m^2

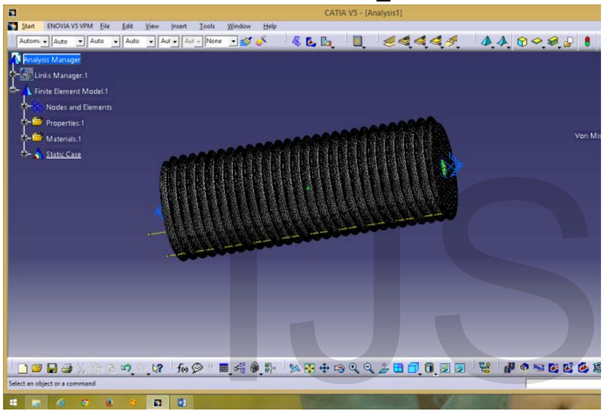

Fig 31: Parabolic von mises stress of Worm

Parabolic von mises stress in Gripper base is 38.2N_m^2

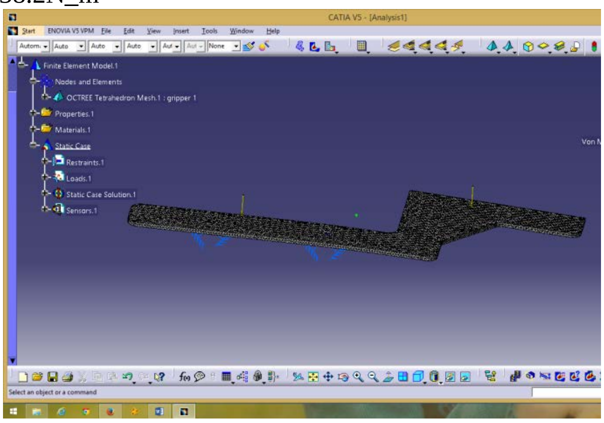

Fig 32: Parabolic von mises stress of jaw

5.13 Parabolic principal stress of Worm gear and Gripper Jaw:

Parabolic principal stress of Worm gear is 47.8 N_m^2

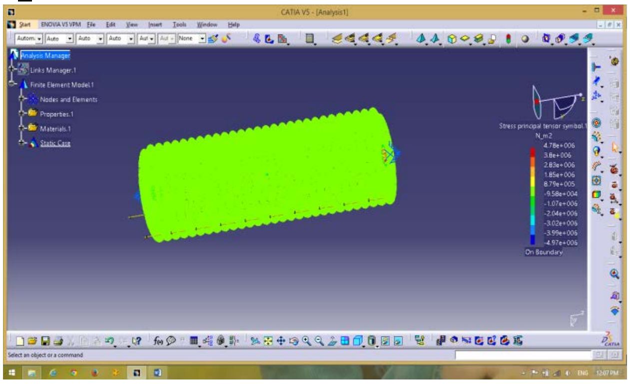

Fig 33: Parabolic Principal stress of Worm

Parabolic principal stress of Gripper base is 32.5N_m^2

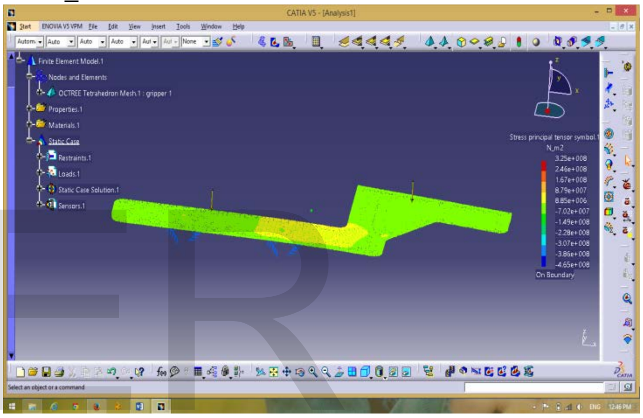

Fig 34: Parabolic Principal stress of Gripper jaw

5.14 Parabolic precision of Worm gear and Gripper Jaw:

Parabolic precision of Worm 16.7J

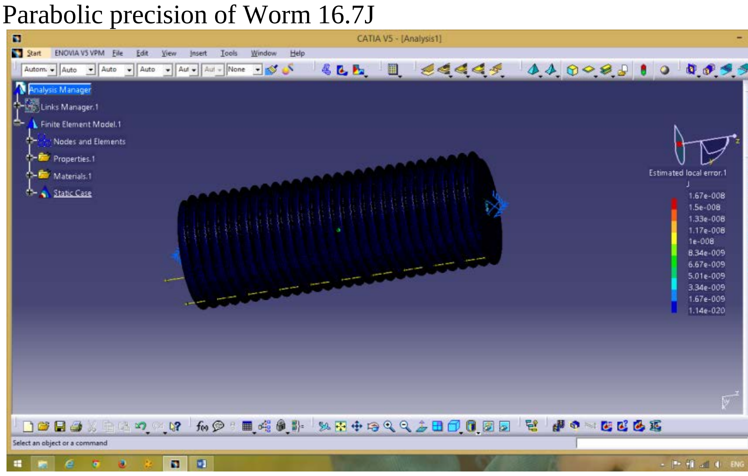

Fig 35:Parabolic precision of Worm gear

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Parabolic precision of Gripper base is 0.000437

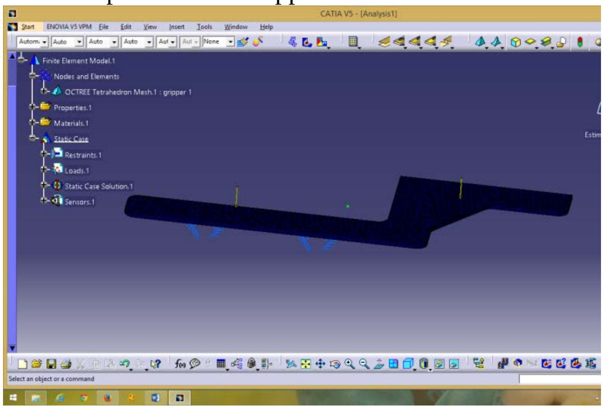

Fig 36: Parabolic precision of Gripper jaw

6. Result:

The Worm gear and is analyzed using the materials Mild steel and Aluminum. After analyzing the Worm gear the values of component weight, Stress in component, Deflections in component are show in below table

MATERIAL USED	WEIGHT OF COMPONENT (Kg)	STRESSES IN COMPONENT (N_m^2)	DEFLECTION IN COMPONENT (mm)
Mild steel	**29.218**	**78.2**	**0.00122**
Aluminum	**10.07**	**68.4**	**0.000119**

From above all values Aluminum is less weight compared to mild steel and less amount of stresses are developed in material used as Aluminum.

7. CONCLUSION:

Today we find most robots working for people in industries, factories, warehouses, and laboratories. Robots are useful in many ways. For instance, it boosts economy because businesses need to be efficient to keep up with the industry competition. Therefore, having robots helps business owners to be competitive, because robots can do jobs better and faster than humans can, e.g. robot can built, assemble a car. Yet robots cannot perform every job; today robots roles include assisting research and industry. Finally, as the technology improves, there will be new ways to use robots which will bring new hopes and new potentials.

Hence all the requirements needed are satisfied by Robot arm. So, it is perfectly implemented to resolve several problems for the upcoming technologies. The applications of Robot arm involves many operations such as in airports, warehouses, production plants,industry, military and security environments, construction fields etc.., for carrying different types of loads. It can be used pick and place easily with carrying a load.

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