

DESIGN AND ANALYSIS OF CIRCULAR AND SQUARE ARM ROBOT

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ABSTRACT

An articulated robot is a robot with rotary joints (e.g. a legged robot or an industrial robot). Articulated robots can range from simple two-jointed structures to systems with 10 or more interacting joints. They are powered by a variety of means, including motors. Some types of robots, such as robotic arms, can be articulated or non-articulated; an articulated robot is a robot which is fitted with rotary joints. Rotary joints allow a full range of motion, as they rotate through multiple planes (x, y, z directions) and rotary motions also.

In this project by using CAD-tool (creo-2) we created 2 different robots. One is circular arm robot and another is square shape arm robot models and analysed with real time boundary conditions with 3 different materials (steel, al-356, ARAMID epoxy). And calculated results of deformation and stress, and shear stress and strain values for both models. From all these results here we are going to conclude which material has less weight and which material has fewer amounts of stress values. From all these results we can get an idea which robot with which material we should use for different conditions like less weight or less stress producing robots.

Tools were used:

Cad tool: creo-2

Cae tool: Ansys work bench

INTRODUCTION

An articulated robot is a robot with rotary joints (e.g. a legged robot or an industrial robot). Articulated robots can range from simple two-jointed structures to systems with 10 or more interacting joints. They are powered by a variety of means, including motors. Some types of robots, such as robotic arms, can be articulated or non-articulated



A six-axis articulated welding robot reaching into a fixture to weld.

An articulated robot is a robot which is fitted with rotary joints. Rotary joints allow a full range of motion, as they rotate through multiple planes, and they increase the capabilities of the robot considerably. An articulated robot can have one or more rotary joints, and other types of joints may be used as well, depending on the design of the robot and its intended function. With rotary joints, a robot can engage in very precise movements. Articulated robots commonly show up on

manufacturing lines, where they utilize their flexibility to bend in a variety of directions. Multiple arms can be used for greater control or to conduct multiple tasks at once, for example, and rotary joints allow robots to do things like turning back and forth between different work areas. These robots can also be seen at work in labs and in numerous other settings. Researchers developing robots often work with articulated robots when they want to engage in activities like teaching robots to walk and developing robotic arms. The joints in the robot can be programmed to interact with each other in addition to activating independently, allowing the robot to have an even higher degree of control. Many next generation robots are articulated because this allows for a high level of functionality. At present, the main interest is to protect nuclear workers in highly contaminated areas or hostile environments, robots can be used in nuclear power plants to reduce human exposure not only to radiation, but also to hot, humid and oxygen-deficient atmosphere researchers in the field of robotics are proposing a great variety of robots configurations and functional capabilities to be used in nuclear power plants. Wheeled robots and tracked vehicles are the common configurations for mobile robots. The robotic system is made up of three main sub-systems: sensory head; teleoperation and control panel; and mobile robot, vision, sound and temperature cover 90% of all inspections tasks required in BWR nuclear power plants pan-tilt mechanism. So it can be easily plugged into different mechanical robots. Video camera used inspection purpose, stereo vision equipment, produced by stereo Graphics, has been integrated in the tele-operation panel. This

stereo system is of great use in guiding the mechanical robot through cloistered areas.

LITERATURE REVIEW

Early research efforts in legged locomotion focused on statically stable gaits in which robot's centre of gravity is always kept over the polygon formed by the supporting feet [1]. Raibert, around 1985, set the stage with his ground-breaking work on dynamic legged locomotion [2], which resulted in one of the most advanced quadrupeds, Boston Dynamics' BigDog that can control its forward speed, and although it moves with static stable gaits, it can achieve a dynamically balanced trot gait when moving at human walking speeds [3]. Boston Dynamics' statically stable LittleDog, is a quadruped walking robot with 12 degrees of freedom, used as an algorithm test bed. A different design and control approach is followed in Scout II [4] and in the NTUA Quadruped Robot [5, 6], which use only one actuator and a spring per leg to realise dynamically stable running with speed control. While the Scout requires a time-consuming trial-and-error controller parameter determination to achieve a given speed, the NTUA quadruped control algorithm does not need empirical gain tuning. Quadruped robots like Kotetsu [7] that employ Central Pattern Generator (CPG) based controllers and KOLT [8] that uses a fuzzy controller are different approaches towards achieving dynamic stable gaits. Recent research efforts by the Autonomous System Lab at ETH [9] and the Advanced Robotics Department at IIT [10] are aiming at making a step forward from LittleDog and BigDog respectively. Generally, the tendency for the new robotic quadrupeds is to aim for very fast, rapidly accelerated, able to make tight turns robots with

flexible spine, articulated legs, possibly including head and tail, such as the Boston Dynamics' Cheetah concept. Lygorouas et al. [11] developed a computer-controlled lightweight mechanical arm. This mechanical arm was a self-contained, autonomous system capable of executing high-level commands from a supervisory computer. The actuators of the joints were permanent magnet type dc motors driven by servoamplifiers via Pulse Width Modulation. Aung [12] designed and implemented a controller circuit based on PIC microcontroller and H bridge circuit to control the motion of a Wheeled Mobile Robot (WMR). He used MATLAB software for the modeling of the total system. Silva [13] applied fuzzy logic at several hierarchical levels of a typical robotic control system. For controlling robotic manipulators, Moosavian [14] used transpose jacobian (TJ) control. Arciniegas et al. [15] developed neural network based adaptive control system to control the flexible robotic arm. Tseng [16] developed a DSP based instantaneous torque controller to control the manipulator. Rogers [17] designed a microcontroller circuit for interfacing joint sensor to control robotic arm. A simple structured linked model of the articulated limb was developed where the model is manipulated in simulation to 'pull' the end of the limb towards the desired destination position and orientation [18]. Hisham [19] developed a PIC 16F877 microcontroller based system where an articulated robot arm having six degrees of freedom was controlled [19]. In this present work, an ATmega32L microcontroller based controller circuit has been designed to control the three degrees of freedom of an articulated robot arm. The robot arm is actuated by the three DC servomotors. A seven segment display and set of LEDs are

used for indication purpose. Push buttons are set to give the necessary input commands. Programming language C is used to program the microcontroller which is written in AVR STUDIO 4 software.

Introduction to CREO

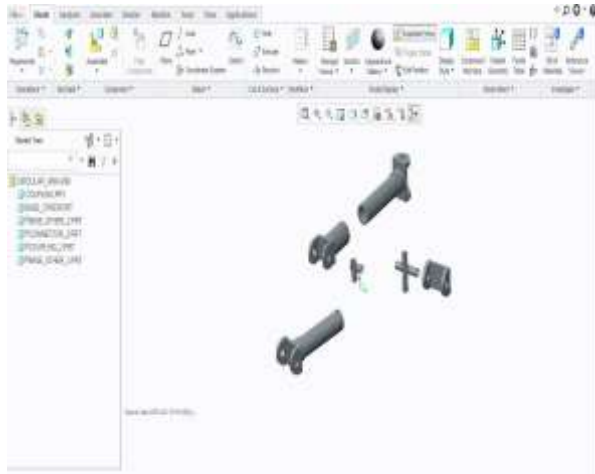
CREO is a suite of programs that are used in the design, analysis, and manufacturing of a virtually unlimited range of product.

CREO is a parametric, feature-based solid modeling system, "**Feature based**" means that you can create part and assembly by defining feature like pad, rib, slots, holes, rounds, and so on, instead of specifying low-level geometry like lines, arcs, and circle & features are specifying by setting values and attributes of element such as reference planes or surfaces direction of creation, pattern parameters, shape, dimensions and others.

"**Parametric**" means that the physical shape of the part or assembly is driven by the values assigned to the attributes (primarily dimensions) of its features. Parametric may define or modify a feature's dimensions or other attributes at any time.

For example, if your design intent is such that a hole is centered on a block, you can relate the dimensional location of the hole to the block dimensions using a numerical formula; if the block dimensions change, the centered hole position will be recomputed automatically.

"**Solid Modeling**" means that the computer model to create it able to contain all the information that a real solid object would have. The most useful thing about the solid modeling is that it is impossible to create a computer model that is ambiguous or physically non-realizable.



Explode view

The above figure is complete exploding view of the object, and in this figure here we can see all parts of the circular arm robot.

SQUARE ARM ROBOT:

Here we are creating another articulated robot with square shape with same dimensions which we were used for circular arm robot.



Square arm final assembly model

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Topp established a broader definition of numerical analysis. The paper centered on

the "stiffness and deflection of complex structures".

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress

usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

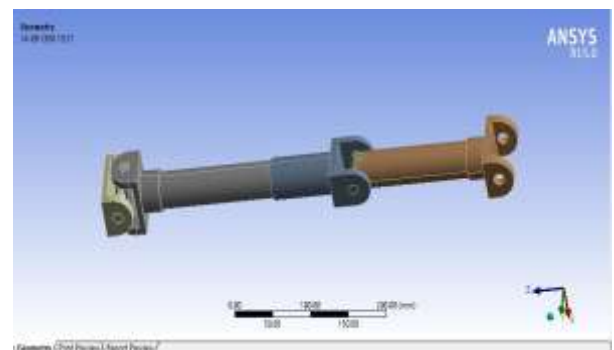
With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective

designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc

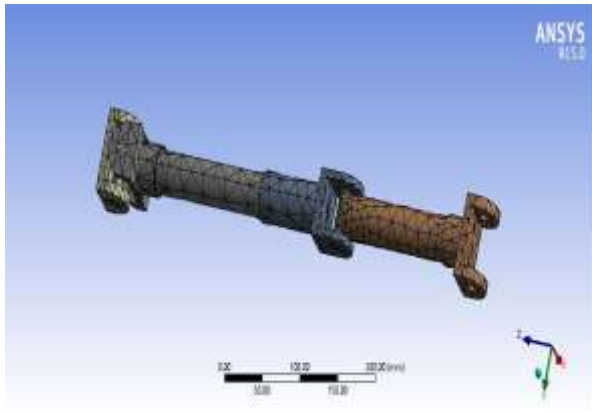
Modal Analysis

A modal analysis is typically used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It can also serve as a starting point for another, more detailed, dynamic analysis, such as a harmonic response or full transient dynamic analysis. Modal analyses, while being one of the most basic dynamic analysis types available in ANSYS, can also be more computationally time consuming than a typical static analysis. A reduced solver, utilizing automatically or manually selected master degrees of freedom is used to drastically reduce the problem size and solution time.

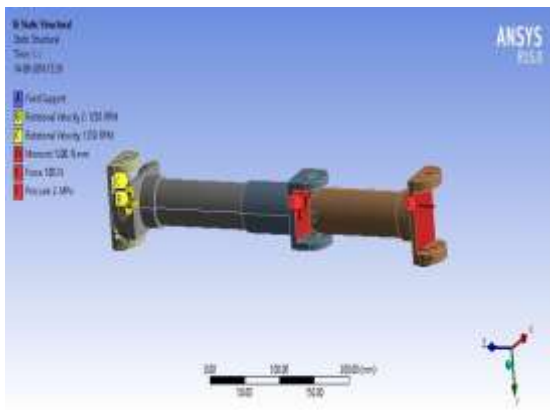
Model imported from pro-e tool in IGES format.



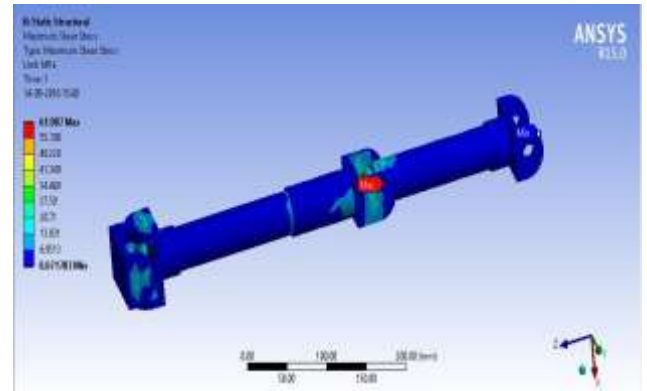
Meshing: - Volume Mesh - Tetmesh.



Tet Volume Mesh.

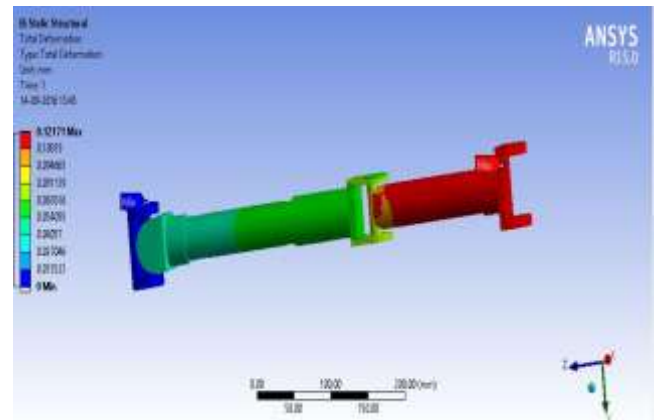


Select geometry assign material properties



Material: al-356

Deformation

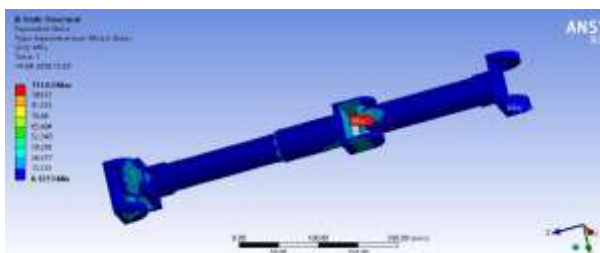


Stress

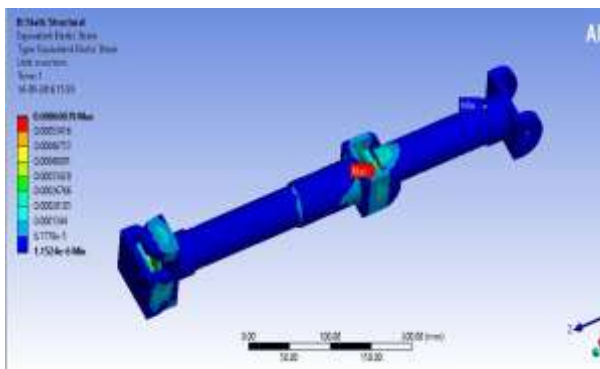
CIRCULAR ARTICULATED ROBOT ARM RESULTS

material:Steel

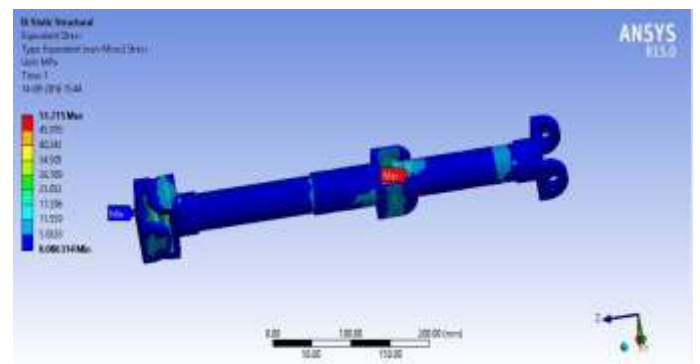
Stress



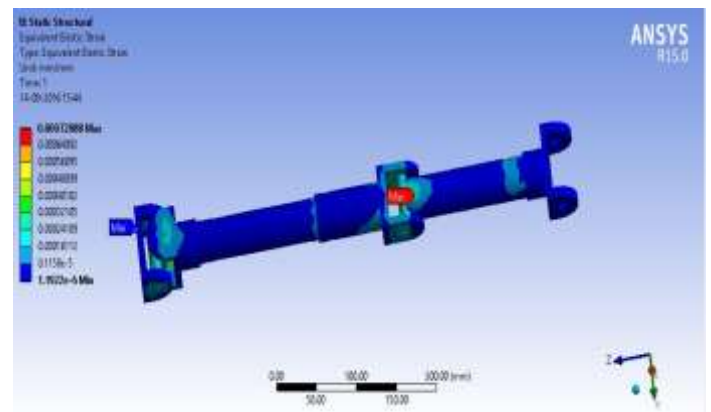
Strain



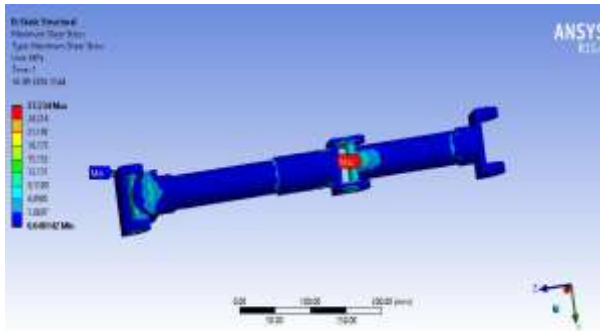
Shear stress



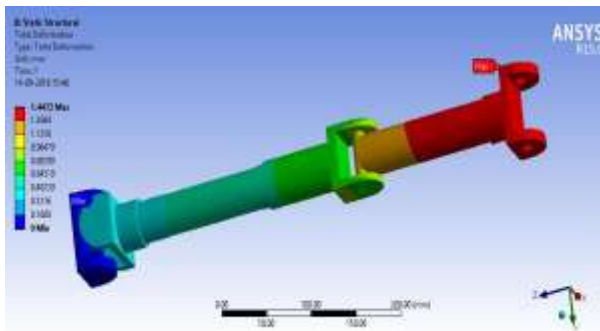
Strain



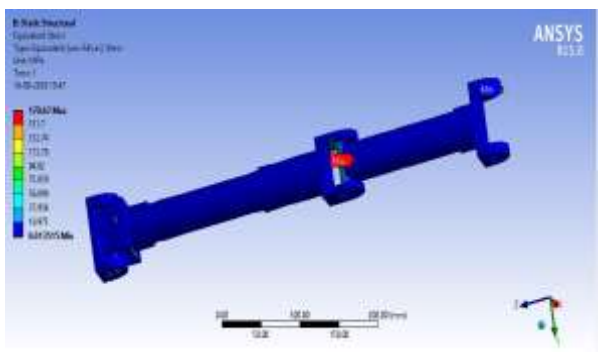
Shear stress



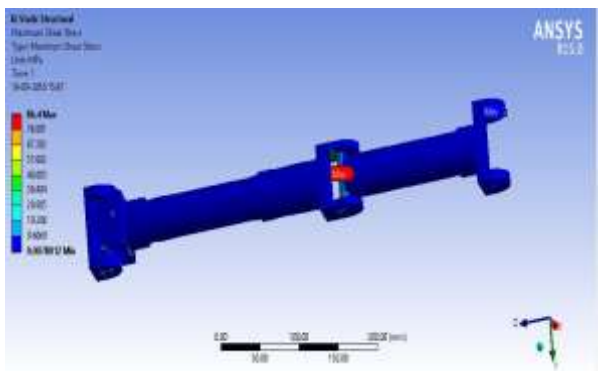
Material: ARAMID EPOXY
Deformation



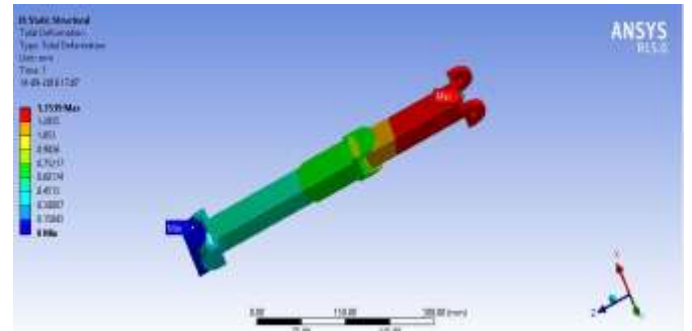
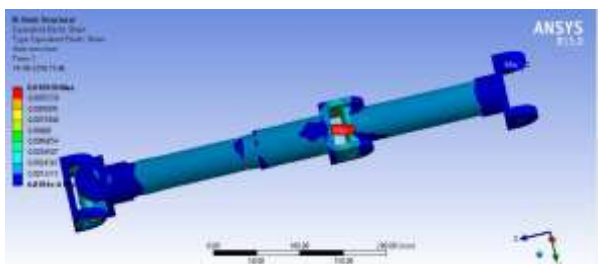
Stress



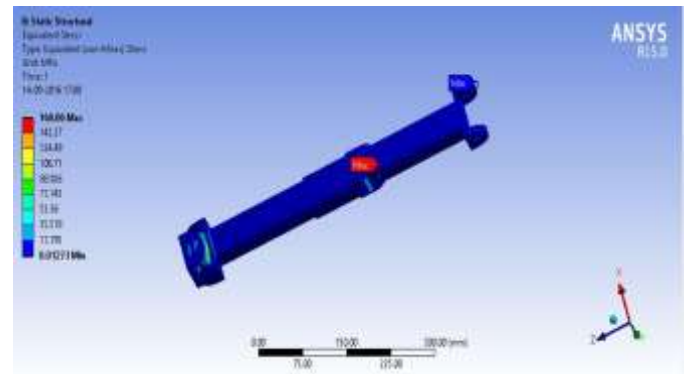
Shear stress



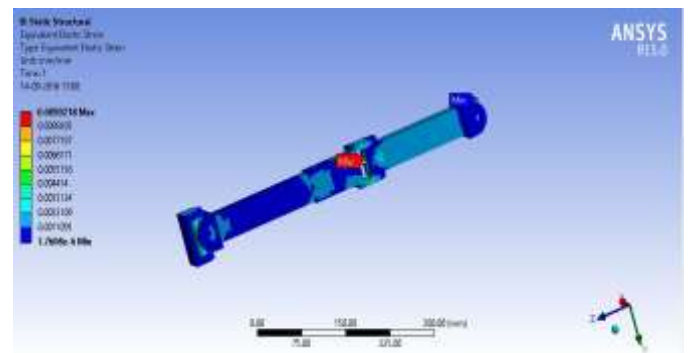
Strain



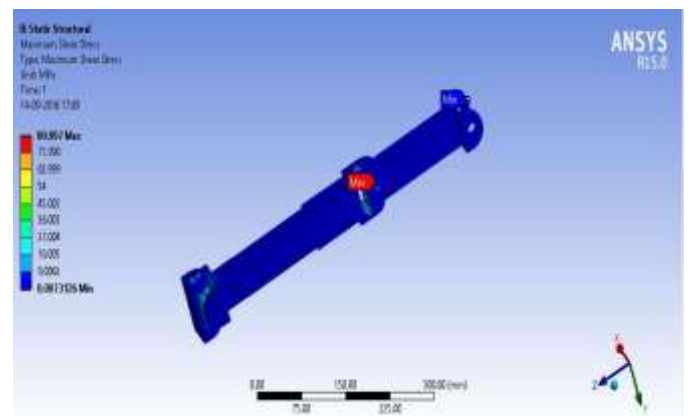
Stress



Strain



Shear stress



RESULTS & DISCUSSION

Circular arm robot

	STEEL	AL-356	ARAMID EPOXY
Deformation(mm)	0.099402	0.12171	1.4472
Stress(Mpa)	117.63	51.715	170.67
Strain	0.00060079	0.00072088	0.010939
Shear stress(Mpa)	61.987	27.234	86.4

Square arm robot

	STEEL	AL-356	ARAMID EPOXY
Deformation(mm)	0.08673	0.12102	1.3539
Stress(Mpa)	98.649	50.117	160.06
Strain	0.00056627	0.00078903	0.0099218
Shear stress(Mpa)	52.071	26.498	80.997

From the above results if we compare both robots by materials we can say that steel square arm robot will reduce overall stress by 16% compare with circular arm robot with steel material. But in al-356 material we reducing only 2% of stress compare

with circular arm. And in ARAMID epoxy produces much more stress compare with other 2 materials. And we know that composite materials generally high strength materials and also expensive.

Weight estimation table:

	Circular arm robot	Square arm robot
STEEL	4.0945	4.1982
Al-356	1.3927	1.4279
ARAMID EPOXY	0.80	0.8236

By comparing both circular and square arm robots here we observe that square shape arms have more weight compare to circular arm robots. And from all materials ARAMID epoxy has very less amount of weight compare to other but it is expensive and we can use these robots when cost doesn't matter only weight is matter (for example: Airplane usage) . And among all steel has more weight and al-356 has less

weight and also it has very less stress values.

CONCLUSION

In this project by using CAD-tool (creo-2) we created 2 different robots. One is circular arm robot and another is square shape arm robot models and analysed with real time boundary conditions with 3 different materials (steel, al-356, ARAMID epoxy). And calculated results

of deformation and stress, and shear stress and strain values for both models

While analysing models with different materials we got different weights and different stress and different strain values. From all these results we can say, if we compare both robots by materials we can say that steel square arm robot will reduce overall stress by 16% compare with circular arm robot with steel material. But in al-356 material we reducing only 2% of stress compare with circular arm. And in ARAMID epoxy produces much more stress compare with other 2 materials. And we know that composite materials generally high strength materials and also expensive. By comparing both circular and square arm robots here we observe that square shape arms have more weight compare to circular arm robots. And from all materials ARAMID epoxy has very less amount of weight compare to other but it is expensive and we can use these robots when cost doesn't matter only weight is matter (for example: Airplane usage) . And among all steel has more weight and al-356 has less weight and also it has very less stress values.

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