3D MODELING AND FINITE ELEMENT ANALYSIS OF FIVE FINGER ROBOT

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ABSTRACT- A robot gripper is the physical realization of an electromechanical system to perform physical handling tasks automatically. A robot gripper is an essential element of the robotic system and it is designed to suit industrial application to typically grasp, carry, manipulate and assemble the components. The design of a gripper finger is a difficult task with many considerations such as task requirements, geometry of gripper and the complexity of mechanism.

In this thesis, a five fingered robot gripper is designed and modeled in 3D modeling software creo2.0 Motion analysis is performed on the gripper by applying angular displacement to the rotary motors determine angular velocity, angular momentum and motor torque. Static analysis is performed on the robot arm by applying forces of 441.299N and 882.59N and torque of 17.64 N-m and 35.28 N-m using two different materials Alloy Steel and Titanium. Motion analysis is performed in solid works and Finite Element analysis is performed in ansys.

Cost analysis is performed in estimating the cost of five finger robot gripper. Material analysis is performed to explore further alternate material options for weight reduction and also design integrity and sustainability.

I. INTRODUCTION

1.1 GRIPPER

A gripper is a device which enables the holding of an object to be manipulated. The easier way to describe a gripper is to think of the human hand. Just like a hand, a gripper enables holding, tightening, handling and releasing of an object.

1.2 ROBOT GRIPPER

A robot gripper (Fig 1.1) is a type of end of arm tooling (EOAT) that is used to pick up items and can be customized for your application. Grippers come in a variety of styles including magnetic, claw, bag, and suction. Magnetic grippers are often used to handle heavy, rigid metal objects such as steel sheets or tables.

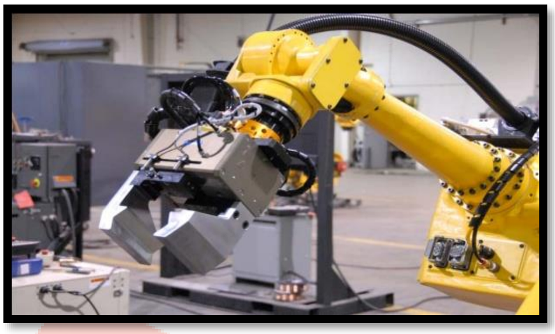


Fig 1.1 Robot gripper

WORKING PRINCIPLE

Choosing a robot gripper will generally be confusing. As there are wide decisions of various grippers out there, you actually wish to create the correct alternative for your applications. Some gripper makers are promoting the performance or dependability of their grippers while not even considering your desires. This text can discuss just one variety of industrial robot finish effectors: the parallel gripper.

In many industrial applications such as welding, positioning an object, heating a product or material at very high temperatures, etc., industrial robots such as line following robots, fire fighting robots are used. Especially, the robotic arm of a pick-and-place robot is used for holding an object in industrial applications.

Working principle of Hydraulic gripper:

In general, hydraulic and pneumatic grippers have identical basic effort principle. They embrace direct acting piston styles similarly as piston wedge styles. The direct acting piston style is employed once a hydraulic force acts directly on a piston that's directly connected to the jaw or finger that's touching or absorbing the half.

The piston wedge style options hydraulic force working on a piston whereas the piston itself is working on a wedge. The wedge interprets this force to the jaws or fingers, providing the grip force to grip the half. The wedge will provide a ratio because it will increase grip force whereas keeping the piston diameter and pressure to the piston identical. This enables a lot of grip force in a very smaller package compared to the guiding piston.

APPLICATIONS OF GRIPPERS

A. Grippers for Assembly

For assembly tasks an electrical gripper will be extremely helpful. In fact, most assembly tasks are done at one spot within the line. This implies the gripper that's positioned there should be versatile and be ready to grasp totally different elements. There's completely no time for tool dynamical and this is often why a versatile electrical gripper ought to be used.

Also, grippers like our 3-Finger adaptative Gripper that have a programmable stroke will scale back the cycle time of the automaton significantly. Particularly since if you'll be able to set the stroke. The gripper ought not to run through its whole stroke before closing back on the item. The gripper will be set to a small degree wider than the half and this will scale back the cycle time of the automaton by reducing the gripper's motion

II. LITERATURE REVIEW

In this paper by Krishna raju A [1], design of 3 fingered Robot-Gripper Mechanism. The aim of this paper is to review the challenges and to design a 3 fingered robot mechanism that has the potential to satisfy varied demand in industry and factories. Up to now there are such a lot of mechanisms accessible for mechanism gripper in 3 fingered mechanism gripper mechanism may be a kind of mechanism that is employed in industrial robots for moving object that has higher gripper magnitude relation. The kinematic system has been designed for one degree of freedom and also the kinematic design of mechanism structure is developed exploitation guided missile mechanism package. The gripper modeling has been designed victimization Pro-E Wildfire5.0 software package and a 3 finger gripper is made-up by aluminum material for five kilo payload. The gripper mechanism has 3 fingers that area unit accustomed hold the item during a balanced thanks to meet the challenges round-faced on the commercial life. The fingers are supplied with senses to spot the sort of object.

In this paper by E. Simo-Serra[2], Kinematic Synthesis of Multi-fingered Robotic Hands for Finite and minute Tasks. During this paper we tend to gift a completely unique methodology of coming up with multi-fingered robotic hands mistreatment tasks composed of each finite and minute motion. The strategy is predicated on representing the robotic hands as a kinematic chain with a tree topology. we tend to represent finite motion mistreatment Clifford algebra and small motion mistreatment Lie algebra to perform finite dimensional kinematic synthesis of the multi fingered mechanism. This permits tasks to be outlined not solely by displacements, however additionally by the rate and acceleration at totally different positions for the planning of robotic hands. The extra info allows an increased native approximation of the task at crucial positions, in addition as contact and curvature specifications. An example task is provided employing an experimental motion capture system and that we present the planning of a robotic hand for the task exploitation a hybrid Genetic Algorithm/Levenberg-Marquadt problem solver.

In this paper by SafeenYassenQassab [3], Modal analysis of pneumatic 2 Finger Robotic hand by Finite element Analysis and Experimental Testing. the target of the current work was finding out the technique of modal analysis exploitation theoretical, numerical and experimental strategies .Two axis modal finger of pneumatic robotic hand was designed and designed. The theoretical modeling was done by derivation equations of stress and deflection looking on the free body diagram of robotic clamp, finite element analysis was performed exploitation Cosmo l Multi physics three.5a software system program. The modal testing was done by dial and pressure gauges. For every methodology dynamic stress and deflection were found, and also the results from all 3 analyses were compared and tried that the rated deflection and stresses that calculated from the theoretical calculation create a good agreement with the results obtained from the finite part analysis and experimental testing. The appropriate most holding weight of designed hand was found to be 400g.

In this paper by Pramod Kumar Parida [4], Kinematic design and Compliant Grasp Analysis of a 5-Fingered Robotic Hand handling of objects with irregular shapes which of flexible/soft objects by normal mechanism grippers is troublesome. it's needed that numerous objects with totally different shapes or sizes may well be grasped and manipulated by one mechanism hand mechanism for the sake of manufacturing plant automation and labor saving. Deft grippers are going to be the suitable answer to such issues. Equivalent to such desires, this work is towards the look associated development of associate articulated mechanical hand with 5 fingers and twenty 5 degrees-of-freedom having an improved grasp capability. Since the designed hand is capable of close associated grasping an object automatically, it is handily employed in producing automation also as for medical rehabilitation purpose. This work presents the kinematic style and therefore the grasping analysis of such a hand.

III. INTRODUCTION TO CAD

Computer Aided Design (CAD) is a technique in which man and machine are blended in to problem solving team, intimately coupling the best characteristics of each. The result of this combination works better than either man or machine would work alone , and by using a multi discipline approach, it offers the Advantages of integrated team work.

The advances in Computer Science and Technology resulted in the emergence of very powerful hardware and software tool. It offers scope for use in the entire design process resulting in improvement in the quality of design. The emergency of CAD as a field of specialization will help the engineer to acquire the knowledge and skills needed in the use of these tools in an efficient and effective way on the design process.

Computer aided design is AN interactive method, wherever the exchange of data between the designer and therefore the pc is formed as easy and effective as potential. pc aided design encompasses a good kind of computer primarily based methodologies and tools for a spectrum of engineering activities coming up with, analysis, detailing, drafting, construction, producing, monitoring, management, method management and maintenance. CAD is additional involved with the utilization of computer-based tools to support the complete life cycle of engineering system.

Results of Finite Element Analysis

FEA has become an answer to the task of predicting failure attributable to unknown stresses by showing drawback areas in a very material and permitting designers to check all of the theoretical stresses inside. This technique of product style and testing is way superior to the producing prices which might accrue if every sample was truly designed and tested.

In apply; a finite part analysis sometimes consists of 3 principal steps:

Preprocessing: The user constructs a model of the half to be analyzed within which the geometry is split into variety of separate sub regions, or components," connected at separate points known as nodes." sure of those nodes can have mounted displacements, et al. can have prescribed hundreds. These models may be very time overwhelming to arrange, and industrial codes compete with each other to own the foremost easy graphical "preprocessor" to help during this rather tedious task. a number of these preprocessors will overlay a mesh on a preceding CAD file, in order that finite component analysis may be done handily as a part of the computerized drafting-and-design method.

INTRODUCTION TO COSMOS WORKS

Cosmos works is beneficial package for design analysis in engineering. That's associate introduction for you who would love to find out additional regarding COSMOS Works. COSMOS Works could be a design analysis automation application totally integrated with Solid Works. This package uses the Finite part technique (FEM) to simulate the operating conditions of your designs and predict their behavior. FEM needs the answer of huge systems of equations. Powered by quick solvers, COSMOS Works makes it potential for designers to quickly check the integrity of their designs and hunt for the optimum resolution.

VI. MOTION AND STRUCTURAL ANALYSIS OF FIVE FINGERED ROBOT GRIPPER ARM

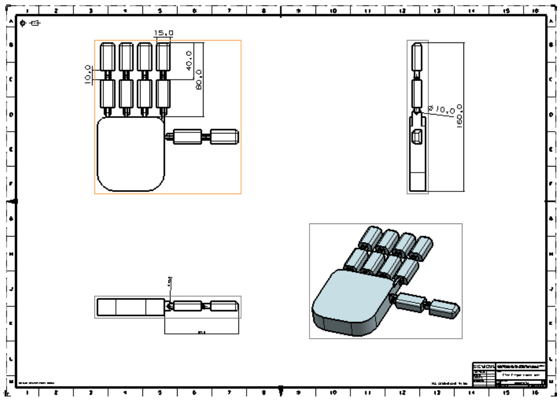


Fig. drafting image of five finger gripper robot

3D MODEL OF FIVE FINGERED ROBOT GRIPPER ARM

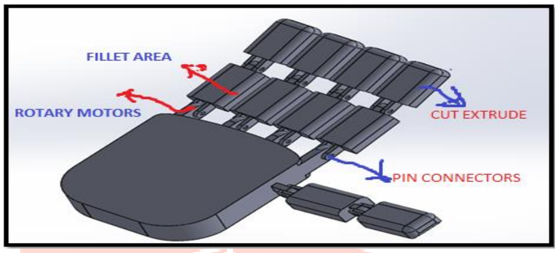


Fig. Von Mises stress of helicopter rotor blade

STUDY OF ANGULAR DISPLACEMENT OF FIVE FINGER ROBOT USING SOLID WORKS

The motion analysis is conducted by applying the angular motion to the fingers.

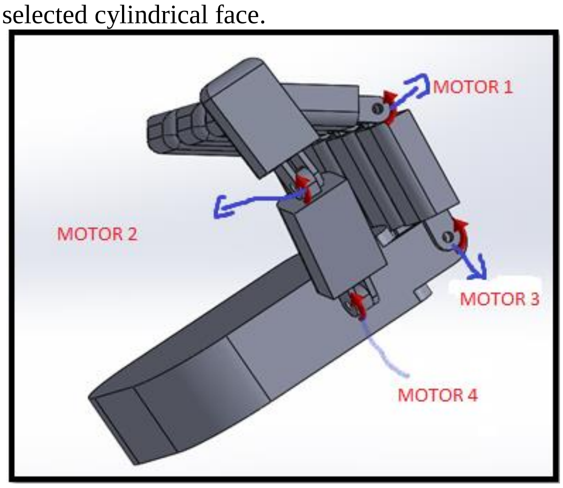
Fixed and Moving Components

Fixed and moving components in Solid Works Motion are determined by their Fix/Float status in the Solid Works model. In our case, Bottom component is fixed while the five fingers are moving.

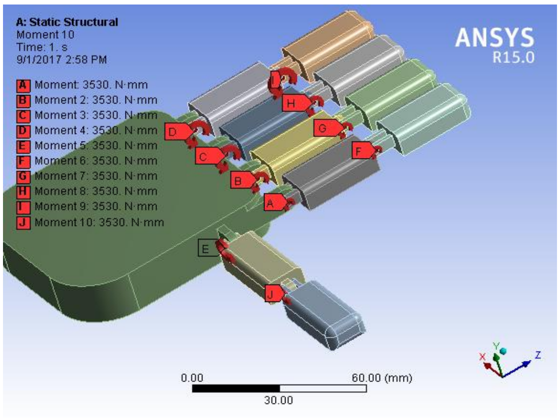
Click on the Motor icon to open the Motor dialog.

Under Motor Type select Rotary Motor.

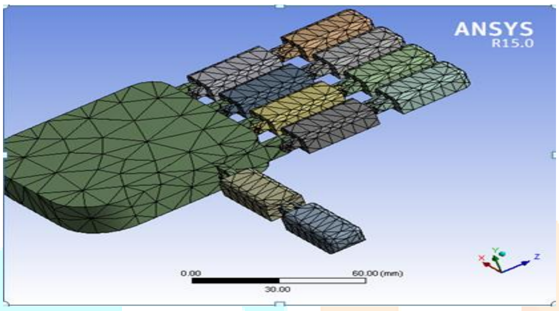
Under Component/Direction, select the cylindrical face of finger pinned to the Bottom (see the figure) for both the Motor Direction and Motor Location fields. The motor will be located at the center of the selected cylindrical face.



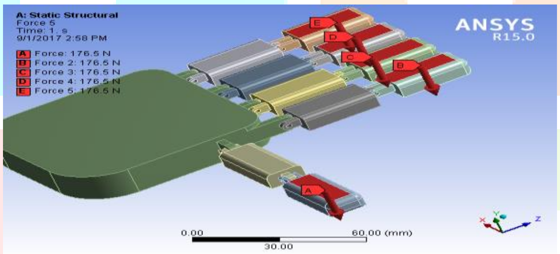
STATIC ANALYSIS



Static structural momentum about 10 motors



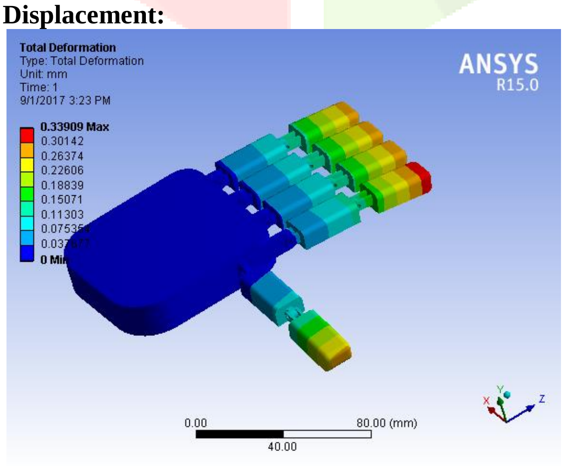
FORCES APPLIED



Shows meshing fixed geometry & forces applied

<u>OBTAINED RESULTS FOR 45kgf (441.299N) ON ALLOY STEEL</u>

Displacement:

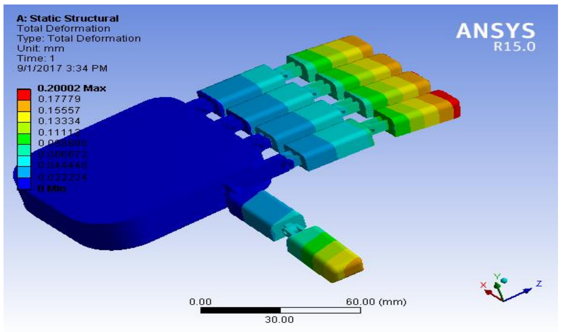


Shows maximum displacement (0.339)

<u>RESULTS OBTAINED WITH FORCE AND TORQUE</u>

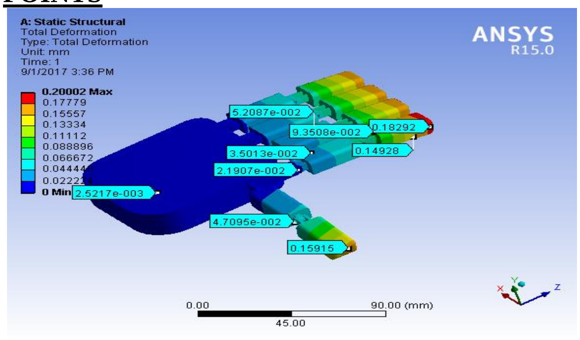
TORQUE 17.640 N/m & FORCE 45kgf (441.299N)

Displacement:



Shows deformation max (0.20002)

<u>DEFORMATION VALUES AT INDIVIDUAL POINTS</u>

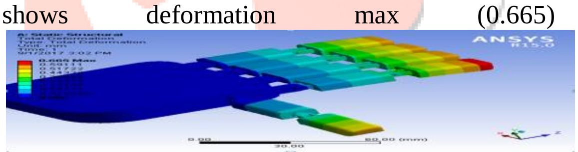


Shows deformation values

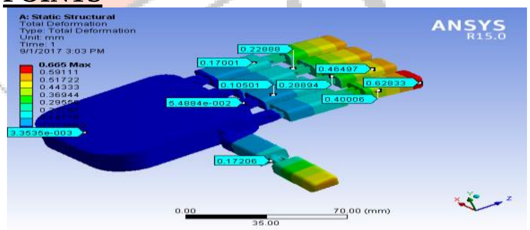
<u>ALLOY STEEL WITH FORCE 90kgf(882.598N)</u>

Displacement:

shows deformation max (0.665)



<u>DEFORMATION VALUES AT INDIVIDUAL POINTS</u>

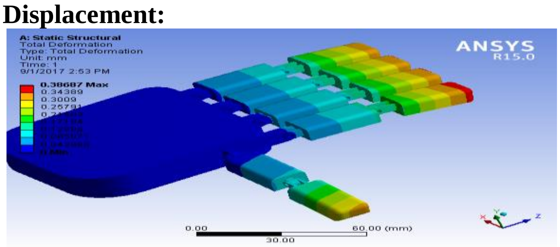


shows deformation values

<u>RESULTS OBTAINED WITH FORCE AND TORQUE</u>

TORQUE 35.280 N/m &FORCE 90 kgf (882.598N)

Displacement:



shows deformation max (0.38687)

MATERIAL - TITANIUM

Material Name: - Commercially Pure CP-Ti UNS R50400

Material Properties:

Property	Value	Units
Elastic Modulus	105000	N/mm^2
Poisson's Ratio	0.37	N/A
Shear Modulus	45000	N/mm^2
Mass Density	4510	kg/m^3
Tensile Strength	344	N/mm^2
Compressive Strength		N/mm^2
Yield Strength	370	N/mm^2
Thermal Expansion Coefficient	9e-006	/K
Thermal Conductivity	16.4	W/(m·K)

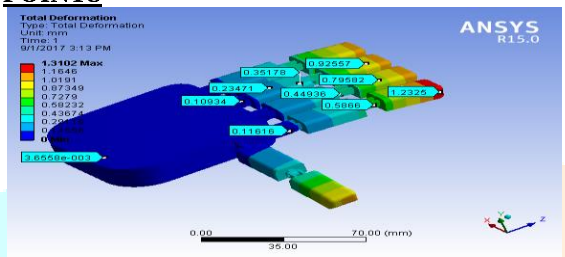
Material Properties of titanium

STRESS:

STRESS VALUES AT INDIVIDUAL POINTS

Shows strain values

DEFORMATION VALUES AT INDIVIDUAL POINTS



Shows deformation values.

CHAPTER -5

CONCLUSION

Motion analysis is performed on the gripper by applying angular displacement 45 deg to the rotary motors determine angular velocity, angular momentum and motor torque. By observing the results, the maximum angular velocity is obtained at 2.5sec with max value of 18deg/sec, the maximum angular momentum is obtained at 2.5sec with max value of 1176 N mm sec, the max torque of the motor is obtained at 0 secs with value of 0.06 N.mm, the max angular displacement of rotary motor 1 is 140 deg at 5secs, the max angular displacement of rotary motor 2 is 90 deg at 5secs, the max angular displacement of rotary motor 3 is 80 deg at 5secs and the max angular displacement of rotary motor 4 is 60 deg at 5secs.

Static analysis is performed on the robot arm by applying forces of 45Kgf and 90Kgf and torque of 17640Nmm and 35280Nmm using two different materials Alloy Steel and Titanium. By observing the static analysis results, the stress values for both the materials are less than their respective yield stress values. The stress values are slightly less for alloy steel than Titanium alloy. And the weight of the robot arm will be less when Titanium is used since its density is less than that of Alloy Steel but the stress values are more compare to alloy steel. So using alloy steel for robot arm is better.

REFERENCES

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