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Material and Cost Analysis of Five Fingered Robot Gripper

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Abstract: *In this paper, a five fingered robot gripper is designed and modeled in 3D modeling software Solid works. Material analysis is performed on the gripper by applying the chemical composition and properties of given materials. Cost analysis is developing and analyzing cost data from separate business and estimating incremental and total resources indeed to support current and future business strategies. A robot griper 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. Cost analysis is performed on the robot arm by applying cost of 265 cost/kg and 312 cost/kg and density of 7850 kg/m^3 and 4540 kg/m^{3}using two different materials Alloy Steel and Titanium. Material analysis is performed to Test and evaluation capabilities include metallographic, material properties testing, microscopy, environmental testing, non-destructive evaluation, and analytical chemistry.*

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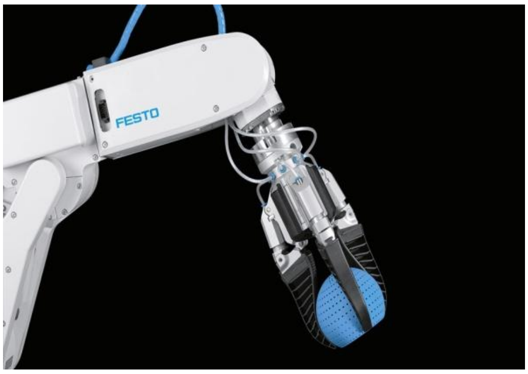
I. Introduction

Grippers are sometimes called as a hand grippers, and primarily used for testing and increasing the strength of the hands this specific form of grip strength has been called crushing grip, which has been defined as meaning the prime movers are the four fingers, rather than the thumb. There are differences from brand to brand, but the common features of standard grippers are that they use a torsion spring fitted with two handles. The exact dimensions of these elements vary, as well as the materials used to make them. The springs are made from various types of steel, and the handles are generally made from wood, plastic, steel or aluminum.

A robot gripper 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. There are four types of robotic grippers. That is vacuum grippers, pneumatic grippers, hydraulic grippers and servo-electric grippers.



The pneumatic gripper is connected to a compressed air supply network. When air pressure is applied on the pistons, the gripper closes. When the pressure is released the gripper opens. The only way to manage the force in the gripper is to manage the air pressure in the air intake.

Electric servo grippers offer a different set of functionality than pneumatic grippers. They trade speed and force for flexibility. In fact having specifications such as programmable; stroke, force and speed can make your applications a lot easier.

- For assembly tasks an electric gripper can be really useful. In fact, most assembly tasks are done at a single spot in the production line. This means the gripper that is positioned there must be flexible and be able to grasp different parts. There is absolutely no time for tool changing and this is why a flexible electric gripper should be used.

- An electric gripper in machine tending applications is that some grippers can handle a lot of different shapes. In fact often the shape of the part will change from before and after the machining operation. This is why you should have a gripper that can grasp both the raw part and the finished part. Otherwise you might be stuck using a tool changer and this can be complicated as well as time consuming.
- Some grippers are specifically clean room rated and are designed to be installed in these kinds of rooms. A good alternative to the pneumatic gripper might be an electric on-off gripper.
- Pneumatic grippers always have to be fed by their air lines which make it pretty hard to drive around with a hose as a tether. Electric grippers can run on batteries. Even if the electric grippers are more useful than a pneumatic gripper with certain kinds of applications, the Adaptive Grippers are even more efficient.

For the applications require more freedom, additional degrees can be obtained from the wrist, which gives the end effect or its flexibility. The three degrees of freedom in the wrist have aeronautical names: pitch, yaw. The pitch, or bend, is the up-and-down movement of the wrist. The yaw is the side-to-side movement, and the roll, or swivel, involves rotation. The track-mounted robot has a total of seven degrees of freedom. This addition also increases the robot's reach. Although the robot's freedom of motion is limited in comparison with that of a human, the range of movement in each of its joints is considerably greater. For example, the human hand has a bending range of only about 165 degrees. The six major degrees of freedom by comparing those of a robot to a person using a spray gun.

II. Literature Survey

In this paper by Ikuo Yamano [1], Development of A Two-Fingered And A Four-Fingered Robotic Gripper**.** In this thesis study, a two-fingered gripper and a four-fingered multipurpose gripper are developed and manufactured. In addition to development of robotic hands, computer control hardware and software are also developed for computer control of both hands. The two-fingered gripper is designed for a specially defined pick and place operation. Its task is to pick a cylindrical work piece and place it in the appropriate position in a flexible manufacturing cell. Pneumatic actuator is used for power generation and mechanical links are used for power transmission. Four fingered gripper is designed as a multipurpose gripper. The task is not predefined for this gripper, so, human hand and previous dexterous hands are taken as model during design. It consists of 3 fingers and a thumb. It has 1 degree of freedom for every finger and thumb. Pneumatic actuators are also used for this gripper. Rope and pulley system is used for the power transmission mechanism. Structures of both hands are manufactured from 5083 series aluminum. Gripping force can be controlled by the pressure regulator of the pneumatic system for both hands.

. In this paper by Deepak Dhole [2], Comparison: 4 & 5 Finger Based Humanlik Robotic Hand. In this paper basically we try to compare Four Fingered Robotic Hands (FFRH) with five-finger anthropomorphic robotic arm. The aim of this work was to find out a robot hand which is effectively used at workplaces for the ease or for immobile patients for their help keeping in mind that the robot hand should be cost efficient and have a good holding capability. The design of the FFRH system is simple and easy to control having 14 independent commands for all kind of movements of robot hand like pick and place. The robot hand is based on double revolute joint system mechanisms with a wireless feedback due to which it possess the ability to confirm to topology of objects. On the other side five fingered anthropomorphic robotic arm is a low cost robotic arm designed for object picking tasks for immobile patients with nine degrees of freedom. The robotic arm is made up of shoulder, elbow, wrist and five-finger gripper and it can perform various gripping actions. Here a high torque DC motor is used with gear assembly with five cables acting as tendons which lead to perform various gripping action. Finally, the results of the experimental work for pick and place applications for both of the robot hands are compared.

In this paper by Krishna rajuA [3], Design of Three Fingered Robot-Gripper Mechanism. The aim of this paper is to study the challenges and to design a three fingered robot mechanism which has the potential to fulfill various demand in industry and factories. So far there are so many mechanisms available for robot gripper in three fingered robot gripper mechanism is a type of mechanism which is used in industrial robots for moving object, which has higher gripper ratio. The kinematic system has been designed for one degree of freedom and the kinematic design of robot structure is developed using SAM mechanism software. The gripper modeling has been designed using Pro-E Wildfire5.0 software and a three finger gripper is fabricated by aluminum material for 5 kg payload. The gripper mechanism has three fingers which are used to hold the object in a balanced way to meet the challenges faced on the industrial life. The fingers are also provided with senses to identify the type of object

In this paper by Pramod Kumar Parida [5], Kinematic Design and Compliant Grasp Analysis of a 5-Fingered Robotic Hand Handling of objects with irregular shapes and that of flexible/soft objects by ordinary robot grippers is difficult. It is required that various objects with different shapes or sizes could be grasped and manipulated by one robot hand mechanism for the sake of factory automation and labour saving. Dexterous grippers will be the appropriate solution to such problems. Corresponding to such needs, the present work is towards the design and development of an articulated mechanical hand with five fingers and twenty five degrees-of-freedom having an improved grasp capability. Since the designed hand is capable of enveloping and grasping an object mechanically, it can be conveniently used in manufacturing automation as well as for medical rehabilitation purpose

III. Iii. Modeling And Analysis Of Five Fingered Robot Arm 3d Model Of Five Fingered Robot Arm

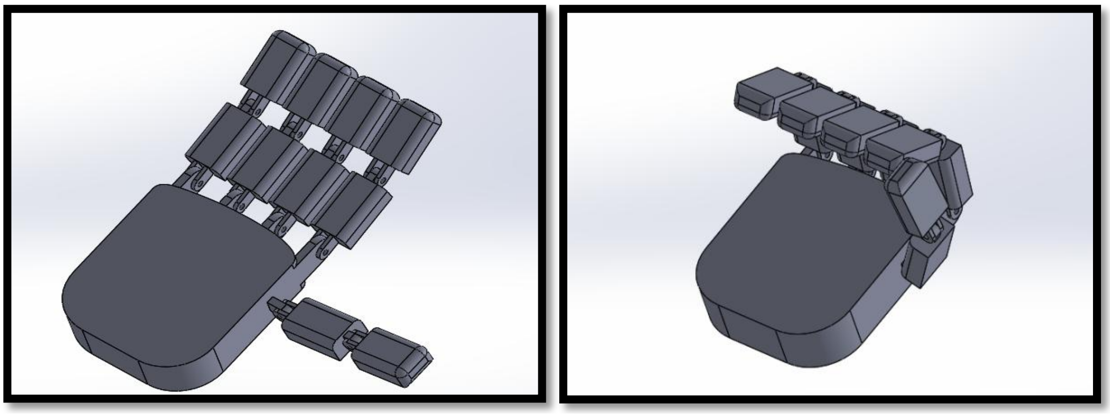


Fig: 3d model of five fingered robot arm

Motion studies are graphical simulations of motion for assembly models.
Animation (available in core Solid Works). You can use Animation to animate the motion of assemblies:

- Add motors to drive the motion of one or more parts of an assembly.
- Prescribe the positions of assembly components at various times using set key points. Animation uses interpolation to define the motion of assembly components between key points.
- The effects of motors, springs, contact, and gravity on assemblies. Basic Motion takes mass into account in calculating motion. Basic Motion computation is relatively fast, so you can use this for creating presentation-worthy animations using physics-based simulations.
- The effects of motion elements (including forces, springs, dampers, and friction) on an assembly. Motion Analysis uses computationally strong kinematic solvers, and accounts for material properties as well as mass and inertia in the computations. You can also use Motion Analysis to plot simulation results for further analysis

A. MATERIAL ANALYSIS

The material analysis is carried out by its chemical composition, properties, applications etc.

1. ALLOY STEEL:

It is steel that is alloyed with a variety of elements in total amounts between 1% and 50% by weight to improve its mechanical properties. Alloy steels mainly classified into two groups: they are low alloy steels and high alloy steels. Alloy steel is the standard term referring to steels with other alloying elements in addition to the carbon.
Ex: Iron (Fe) alloyed with carbon (0.1-1%)

Chemical composition:
Generally, steel is the main product of ferrous metallurgy, with roughly 90% manufactured as carbon steel and 10% as alloy steel.
The chemical composition is as follows

- Carbon-0.06 to 1.7%
- Manganese-0.3 to 1%
- Silicon-0.05 to 0.32%
- Sulphur-0.05 %(max)
- Phosphorus-0.05 %(max)

When carbon steel is alloyed with other elements besides carbon, it is called as alloy steel. The alloying elements commonly used are chromium, nickel, tungsten, cobalt, vanadium, molybdenum.

Properties:
The following are the improved properties in alloy steel.

- Strength,
- Hardness,
- Toughness
- Wear Resistance
- Corrosion Resistance
- Hardenability etc.

To achieve these improved properties the metal requires heat treatment.

Applications:

- Nuclear reactors
- Space crafts
- Turbine blades of jet engines
- Electromotor
- Transformers
- Robot Accessories etc.

2. TITANIUM:
The physical qualities of titanium make it a preferable material
Chemical composition:

- Aluminium-6.2% (5.5-6.75%)
- Vanidium-4.3% (3.5-4.5%)
- Iron-0.25%(max)
- Oxygen-0.2%(max)

Properties:

- High strength
- High Toughness
- Durability
- Low density
- Ability to with stand high and low temperature

Applications:

- Air crafts
- Naval ships
- Missiles
- Space crafts
- Robot accessories etc.

3. COMPARISION BETWEEN ALLOY STEEL AND TITANIUM:

- Titanium is a non-poisonous and biologically inert metal
- Alloy steel is stronger, but has a more fatigue life than Titanium
- Alloy steel can shatter, whereas titanium can with stand high and low temperatures.
- Steel is a magnetic and corrosive, whereas titanium is nonmagnetic and non-corrosive.
- Steel preferred when the strength is needed in a hard material, and titanium is preferred where a light weight and strong material is required.

- The cost of the titanium is higher than steel.
- The density of Steel is greater than titanium.
- The durability of titanium is higher than steel.

B. COST ANALYSIS

The process of developing and analyzing cost data from separate business and estimating incremental and total resources indeed to support current and future business strategies. The raw material cost for a particular component may be 20 times the cost if made from one material compared to another on a weight to weight basis. However the life time cost may be very similar if all of the other factors taken into consideration.

The material cost of a mass produced cast investment casting item may be 80% of the final cost. The material cost of a single complicated machined item may be less than 10% of final cost. It is not possible to provide the cost comparison between different materials to any level of accuracy each metal is varying in price on a day to day basis and different alloys of the same material can have significantly different cost. Comparing cost should only be based on final installed cost.

Ex: for a domestic industrial piping system a screwed steel system would cost about 40% more than a copper piping systems.

COMPARISION IN COST OF AN ALLOY STEEL AND TITANIUM:

As Per June 2017 Market Values

S.No	Material	Cost/Kg	Density(kg/m^3)
1.	Alloy steel	265	7850
2.	Titanium	312	4540

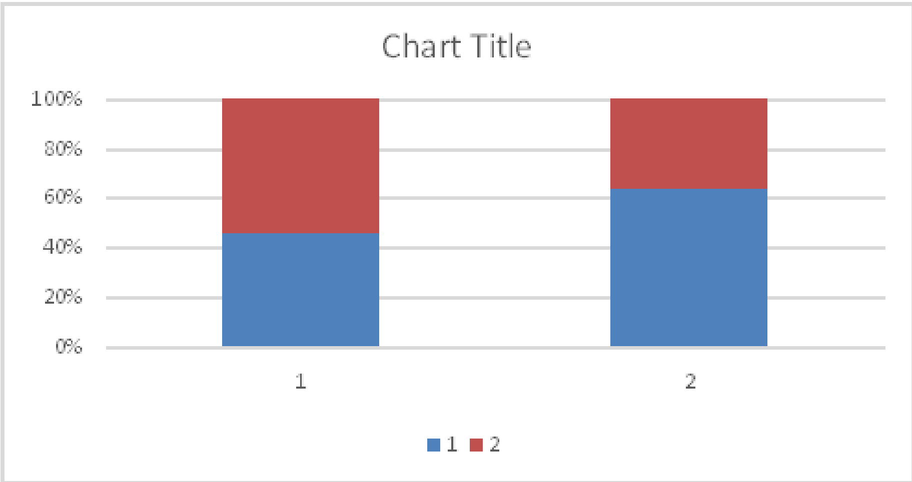


Fig: Graph between alloy steel and titanium for a cost and dens.

IV. Conclusion

Material analysis is performed on the gripper by applying chemical composition, properties, applications etc. Cost analysis is performed on the robot arm by applying cost of 265 cost/kg and 312 cost/kg and density of 7850 kg/m^3 and 4540 kg/m^3 using two different materials Alloy Steel and Titanium. By observing the cost analysis results, from this study we can conclude that the project cost management is a very essential in the research and day to day laboratory practices. By observing the material analysis results, steel preferred when the strength is needed in a hard material, and titanium is preferred where a light weight and strong material is required. The durability of titanium is higher than steel.

The five fingered robotic grip seems sensible, given that it's the solution discovered by the multi-billion year optimization process we call evaluation. Robotic fingers generally require a centralized control system to handle data streams from touch and visual sensors. In the recent years we have got simple grippers. It consist of an air tight rubber bag filled with grains, these simple devices are performing the operations very easily. As we all know that the grippers made of alloy steel are corrosive and cannot withstand higher temperatures like titanium. Titanium material grippers have high durability than steel grippers we might have an advantage of increasing the productivity. In future this five-fingered robot gripper has a more important as it can perform many operations with ease.

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