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# Design and Analysis of Component of Hydraulic Gripper

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***Abstract: The objective of this study is to design a hydraulic arm with a gripper that can be used for the purpose of material handling in various fields and be economical, flexible and easy to operate. Grippers are devices used with pick-and-place robotic systems to pick up or place an object on an assembly line, conveyor system, or other automated system. Hydraulic grippers are most often used in conjunction with a piece of equipment that only has a hydraulic power source for actuators. The main objectives of the project are: To select a suitable configuration of links for the equipment. To design and analyze the links based on load considerations. Make the system mobile so that work volume can be increased. Reduce power consumption.***
***Index Terms: Hydraulic Gripper, Conveyor System, Automated System, Actuators.***

## I. INTRODUCTION

Grippers are devices used with pick-and-place robotic systems to pick up or place an object on an assembly line, conveyor system, or other automated system. Fingered tooling—or jaws—is attached to the grippers to grip or hold the object. They come in a variety of styles and powered designs. Three common types are parallel, three-finger, and angled designs. The most common are parallel designs, with two fingers that close on a workpiece to grip it or open it out by creating pressure on the inside. Three-finger designs hold the workpiece in the center, and have three fingers offset by 120°. Finally, angled designs feature jaws that work at a variety of different angle openings (for example, 30°, 40°, etc.). In addition, three choices of power are available; the most common being pneumatic grippers; electromechanical grippers are second most common; and the least common being hydraulic grippers. Hydraulic grippers are most often used in conjunction with a piece of equipment that only has a hydraulic power source for actuators. Most hydraulic grippers are designed for a hydraulic system where the cylinder diameter is made with less surface area, meaning that a hydraulic gripper would have the same force at 60 bars as a pneumatic gripper of the same size at 6 bars. In general, hydraulic and pneumatic grippers have the same basic actuation principle. They include direct acting piston designs as well as piston wedge designs. The direct acting piston design is used when a hydraulic force acts directly on a piston that is directly connected to the jaw or finger that is touching or gripping the part. The piston wedge design features a hydraulic force acting on a piston while the piston itself is acting on a wedge. The wedge translates this force to the jaws or fingers, providing the grip force to grip the part. The wedge can give a mechanical advantage as it can increase grip force while keeping the piston diameter and pressure to the piston the same. This allows more grip force in a smaller package compared to the directing piston. Unlike electromechanical grippers, which have motors on each actuator, one single motor powers the hydraulic fluid that supplies energy to multiple devices throughout a plant.

## II. HISTORY

In this paper by Ikuo Yamano, Development of A Two-Fingered and A Four-Fingered Robotic Gripper is done. 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 workpiece 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 grippers are designed as a multipurpose gripper. 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 possesses the ability to confirm the 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 raju, 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 fulfil 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 modelling has been designed using Pro-E Wildfire5.0 software and a three-finger gripper is fabricated by aluminium 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.

## III. PROBLEM STATEMENT

A gripper is something that grips things or makes it easier to grip things. But the Major issue is what if someone wants to grip a high temperature object in a different situation. What if someone wants to grip something from a particular distance. For this, there is no hydraulic gripper. Like the people who are working in sewage pipes, they have to go in deep for cleaning of the sewerage material. This is the daily life problem and it is very harmful for the people who are working in severages.so if they will use the gripper it will their hands will be safe and also free from virus and bacteria. Gripper will allow much more load thereby increasing their capacity of loading in a simple and easy manner. The other problems such as for old and weak people hydraulic grippers will act as a useful tool. As they are old and unable to carry heavy weight and face problems in daily life. Also, in housing they sometimes need to shift some heavy items from one place to another and they face difficulties and problems.so hydraulic grippers can be used as an emerging tool for them.Another problem is like if lower manufacturing industries the workers are facing problem when they transfer heated metal for quenching or annealing for which they use tonge and it is risky as it can sometimes slips and fall and also dangerous and risky to work.so they need some devices which has more gripping power. During this covid-19 pandemic we all have to follow social distancing and it is a big problem in local shops to follow. We can see the local general, medical, stationary, food and other stores are giving hand to hand items to the customer which can increase the risk of covid-19. So, we need some items which can be used to deliver items easily and conveniently from one place to another and also for some distance.

## IV. OBJECTIVES

The objective is to create a Hydraulic Gripper which can withstand different capacity of items without any errors. Also, the purpose of designing a hydraulic gripper is to make it mobile so that it can be used in any way and in multi-dimensional. When selecting a hydraulic gripper, it is important to consider the following: 1. Part weight and size to be lifted 2. Part material 3. Clearance issues around the part that could interfere with the gripping part 4. The environment the gripper will be used in (corrosive, food or beverage, etc.) 5. The motion path of the robot or linear device that is moving the gripper 6. The power supply that will be available and the pressure ratings available. The main objective is to create a design of hydraulic gripper which can overcome all the above pointed issues by having capacity of handling different weight parts, can grip different material, having a solid grip and mobile motion.

## V. METHEDOLOGY

### *A. Conceptual Design*

The basic concept used behind the operation is PASCAL's LAW. This law states that when a pressure is applied at one point of a fluid contained in a constrained volume, then the pressure due to that force is equally transmitted to all the points of the fluid, which are acted upon by the same pressure. Using the same principle, we applied pressure to fluid in the master cylinder which is transmitted to the other end of the tube which is connected to another cylinder. This motion of the cylinder is used to move the lin. or parts of the mechanism which are attached to respective ram bars.

### *B. Methodology*

All the dimensions of the parts including their weights, their required job, are decided effectively to obtain overall dimensions of the mechanism and allow the required degree of freedom and to obtain required motion and do the required task.

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## VI. COMPONENTS

### A. Hydraulic Cylinder

A Hydraulic cylinder (also called a linear hydraulic motor) is a mechanical actuator that is issued to give a unidirectional force through a unidirectional stroke. It has many applications, notably in engineering vehicles. Hydraulic Fluids Petroleum Based Synthetic fire-resistant water based fire-resistant. The three most common cylinder configurations are tie-rod, welded and ram styles. Tie-rod cylinders use high-strength threaded steel tie-rods, typically on the outside of the cylinder housing, to provide additional stability. Welded cylinders feature a heavy-duty welded cylinder housing with a barrel welded directly to the end caps, and require no tie rods. Ram cylinders are just what they sound like—the cylinder pushes straight ahead using very high pressure. Ram cylinders are used in heavy-duty applications and almost always push loads rather than pull.

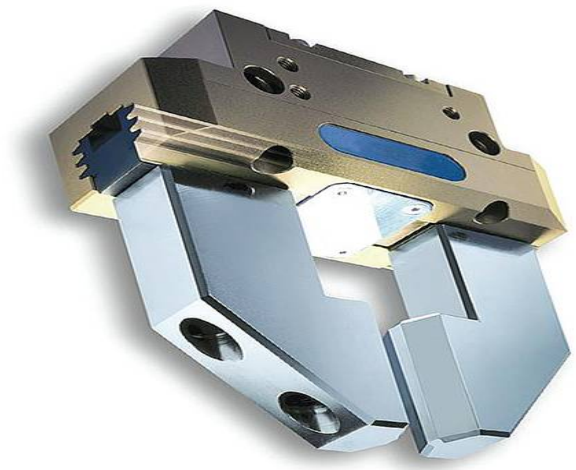

Figure 1. Hydraulic Gripper *(Source: https://www.mobilehydraulictips.com/wp-content/uploads/2013/09/hydraulic-gripper.jpg)*

### B. Parts of a Hydraulic Cylinder

A hydraulic cylinder consists of the following parts: –

1) *Cylinder Barrel:* The cylinder barrel is mostly a seamless thick-walled forged pipe that must be machined internally. The cylinder barrel is ground and/or honed internally Cylinder base or cap: In most hydraulic cylinders, the barrel and the bottom portion are welded together. This can damage the inside of the barrel if done poorly. Therefore, some cylinder designs have a screwed or flanged connection from the cylinder end cap to the barrel. (See "Tie rod cylinder", below) In this type the barrel can be disassembled and repaired.
2) *Cylinder Head:* The cylinder head is sometimes connected to the barrel with a sort of a simple lock (for simple cylinders). In general, however, the connection is screwed or flanged. Flange connections are the best, but also the most expensive. A flange has to be welded to the pipe before machining. The advantage is that the connection is bolted and always simple to remove. For larger cylinder sizes, the disconnection of a screw with a diameter of 300 to 600 mm is a huge problem as well as the alignment during mounting. Piston: The piston is a short, cylindrical metal component that separates the two parts of the cylinder barrel internally. The piston is usually machined with grooves to fit elastomeric or metal seals. These seals are often O-rings, U-cups or cast-iron rings. They prevent the pressurized hydraulic oil from passing by the piston to the chamber on the opposite side. This difference in pressure between the two sides of the piston causes the cylinder to extend and retract. Piston seals vary in design and material according to the pressure and temperature requirements that the cylinder will see in service. Generally speaking, elastomeric seals made from nitrile rubber or other materials are best in lower temperature environments, while seals made of Viton are better for higher temperatures. The best seals for high temperature are cast iron piston rings.
3) *Piston Rod:* The piston rod is typically a hard chrome-plated piece of cold-rolled steel which attaches to the piston and extends from the cylinder through the rod-end head. In double rod-end cylinders, the actuator has a rod extending from both sides of the piston and out both ends of the barrel. The piston rod connects the hydraulic actuator to the machine component doing the work. This connection can be in the form of a machine thread or a mounting attachment, such as a rod-clevis or rod-eye. These mounting attachments can be threaded or welded to the piston rod or, in some cases, they are a machined part of the rod-end.

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4) Rod Gland: The cylinder head is fitted with seals to prevent the pressurized oil from leaking past the interface between the rod and the head. This area is called the rod gland. It often has another seal called a rod wiper which prevents contaminants from entering the cylinder when the extended rod retracts back into the cylinder. The rod gland also has a rod wear ring. This wear ring acts as a linear bearing to support the weight of the piston rod and guides it as it passes back and forth through the rod gland. In some cases, especially in small hydraulic cylinders, the rod gland and the rod wear ring are made from a single integral machined part. Other parts are: -
5) Cylinder base connection
6) Seals
7) Cushions

### *C. Fluid Lines And Fittings*

The control and application of fluid power would be impossible without suitable means of transferring the fluid between the reservoir, the power source, and the points of application. Fluid lines are used to transfer the fluid, and fittings are used to connect the lines to the power source and the points of application.

● TYPES OF LINES

Three types of lines is used in this system are pipe (rigid), tubing (semi rigid) and hose(flexible).

● PIPES AND TUBINGS

There are three important dimensions of any tubular product - outside diameter (OD), inside diameter (ID), and wall thickness. Sizes of pipe are listed by the nominal (or approximate) ID and the wall thickness. Sizes of tubing are listed by the actual OD and the wall thickness.

### *D. Lever*

A lever is a machine consisting of a beam or rigid rod pivoted at a fixed hinge, or fulcrum. A lever is a rigid body capable of rotating on a point on itself. On the basis of the location of fulcrum, load and effort, the lever is divided into three types. ft is one of the six simple machines identified by Renaissance scientists. A lever amplifies an input force to provide a greater output force, which is said to prode leverage. The ratio of the output force to the input force is the mechanical advantage of the lever. A lever works by reducing the amount of force needed to move an object or lift a load. A lever does this by increasing the distance through which the force acts. You will see that levers neither increase nor decrease the amount of total effort necessary.

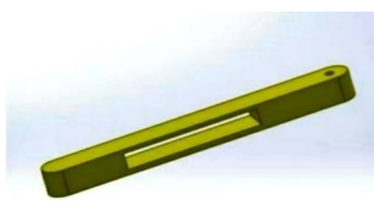

Figure 2. A Lever

### *E. Arms*

Arms is the vital part of this vehicle one is the base arm in which the whole structure of the arms are steady and second is the vertical arm in which the gripper and all small arms are fixed.

• It is the base arm in which the whole structure is attached or fixed and by this arm the whole structure are stable.

• It is the vertical arm or the gripper joining arm in this arm the gripper is joint by the screw and in for this arm the gripper is steady and the load carrying capacity is defined by this arm.

### *F. Grippers*

Grippers are used to grasp and hold objects. The objects are generally work parts that are to be moved by the hydraulic arm. These part handling applications include machine loading and unloading picking parts from a conveyor, and arranging parts into a pallet. Depending on the mechanism used for the purpose of gripping they can be classified as:

1) Mechanical Grippers.
2) Adhesive Grippers.
3) Hooks, Scoops etc.
4) Vacuum Cups.
5) Magnetic Grippers.

A mechanical gripper is used as an end effector in a robot for grasping the objects with its mechanically operated fingers. In industries, two fingers are enough for holding purposes. As most of the fingers are of replaceable type, it can be easily removed and replaced.

Electromagnetic grippers are easier to control, but require a source of dc power and an appropriate controller unit. As with any other robotic gripping device, the part must be released at the end of the handling cycle.

This is easier to accomplish with an electromagnet than with a permanent magnet. When the part is to be released, the controller unit reverses the polarity at a reduced power leave before switching off the electromagnet. This procedure acts to cancel the residual magnetism in the work piece and ensure a positive release of the part.

The advantages of magnetic grippers in material handling applications are:
· Pickup times are faster
· They have the ability to handle metal parts with holes (not possible with vacuum grippers.)
· They require only one surface for gripping.

A disadvantage of magnetic grippers is the problem of picking up only one sheet from a stack. The magnetic attraction tends to penetrate beyond the top sheet in the stack resulting in the possibility that more than a single sheet will be lifted by the magnet. This problem can be confronted in several ways:

- The magnetic grippers can be designed to limit the effective penetration to the desired depth, which would correspond to the thickness of the top sheet.
- The stacking device used to hold the sheets can be designed to separate the sheets for pickup by the robot. One such type of stacking device is called a “fanner”. It makes use of a magnetic field to induce a charge in the ferrous sheets in the stack.

### G. Ram Plate

This is the base or a chassis for which the two arms and whole body are fixed in this base. The base is made of steel and the lower hole the motor is fixed and in the motor shaft the wheels are fixed for this reason the vehicle or the hydraulic arm are moved in anywhere and the motor is operated by manually so in anywhere we used this. Powder coated Metal chassis for robots. Easy to mount the motors in place by using a normal motor mount nut. It can be used in skid steel configuration or differential configuration (2rear wheels + 1 front castor wheel). The body contains perforated holes for easy mounting of various size circuit boards and other mechanical components.

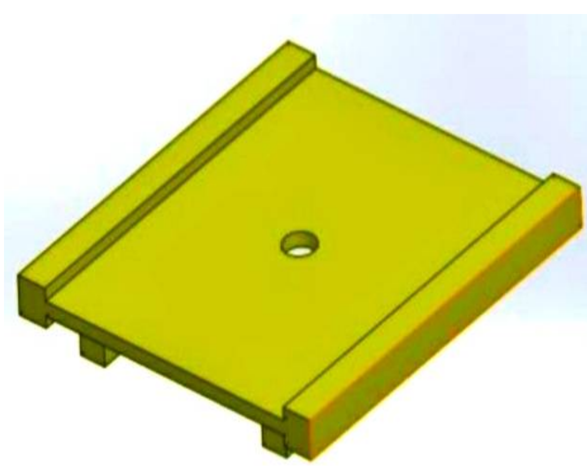

Figure 3. Ram Plate

### *H. Vector Model*

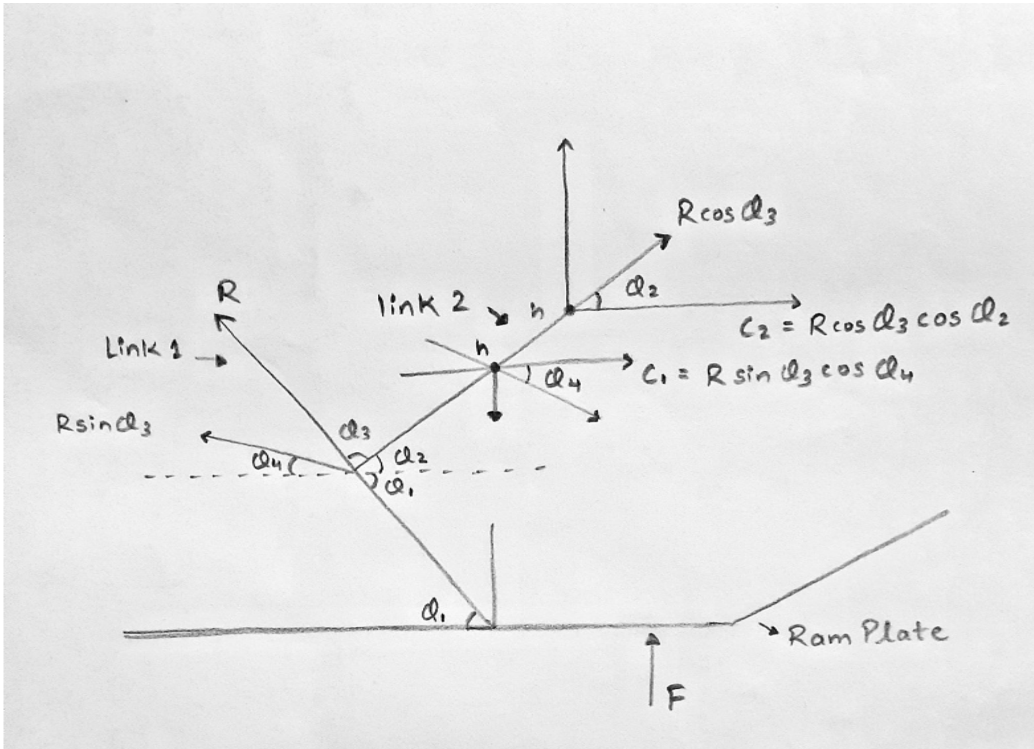


Figure 4. The Line Diagram of the Action of Forces acting

For the mechanical analysis of the project, it has been considered that a Force F acts on Ram plate in the vertical direction.

- Link 1 makes an angle $\theta_2$ with the ram plate, in this direction the reaction considered is R.
- This reaction R makes angle $\theta_3$ with link 2, hence its vertical and horizontal component will be $R\sin\theta_3$ and $R\cos\theta_3$.
- A hinge point h is considered on the link 2 where the actual horizontal and vertical components of $R\cos\theta_3$ are resolved.
- Hence the horizontal component will be $R\cos\theta_3 * \cos\theta_2$ this will be our $C_2$ which will be one of the actual forces which will be used to lift the object.
- On the other hand the moment of $R\sin\theta_3$ can be considered in the just opposite direction on the point h and it makes an angle $\theta_4$ with the horizontal.
- Hence again the horizontal and vertical components of $R\sin\theta_3$ are resolved. The horizontal component comes out to be $R\sin\theta_3 * \cos\theta_4$, this will be the second force $C_1$ which will be responsible for gripping the object.
- Hence the forces $C_1$ and $C_2$ are our output forces which will be responsible to grip the object.
- Our device is identical with the vertical axis hence the same force $C_1+C_2$ will act on the object to grip and hold the object.

## VII. COMPONENT DESIGN PREPARED

Figure 5. Ram Plate

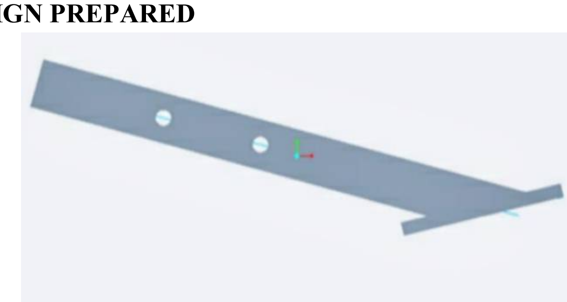

Figure 5. Link

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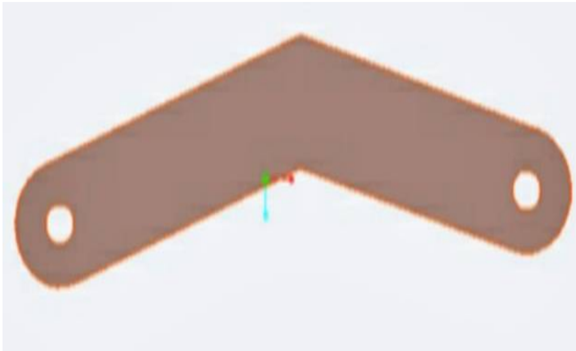

Figure 6. Arm

Figure 7. Ram Rod

## VIII. ANALYSIS

Analysis is done to get values of stress under dynamic condition and to ensure greater reliability of equipment. A static structural analysis is done under following criteria.

| | |
|---|---|
| Software | Hypermesh |
| Material | AISI 1018 |
| Mesh Size | 2mm |
| Mesh Dimensions | 3D (Tetrahydral) |
| Failure Theory | Theory of failure |
| Factor Of Safety | 2-2. |

### A. *Boundary Conditions*

Boundary conditions are specified by how much load we are applying and where we are applying Some Critical Components boundary conditions and their analysis under them are

| Component | Load Value | Fix Position |
|---|---|---|
| Ram Plate | 1200N (generated by master cylinder | Center position of plate |
| Arm | 750N | Where to link are connected |
| Link | 950N | Parallel and perpendicular to link |
| Ram Rod | 600N | Perpendicular to axis |

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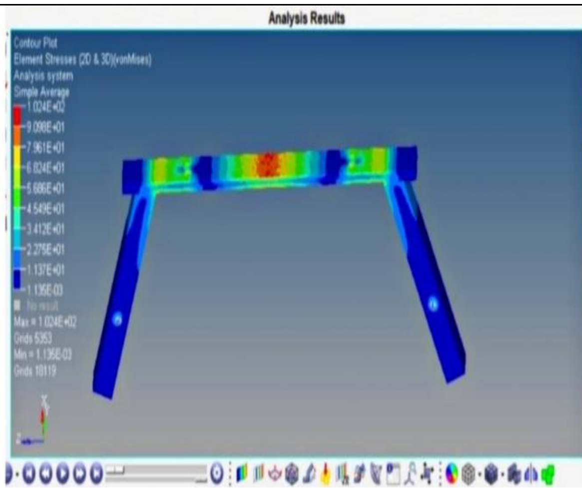


Figure 5. Analysis on Ram Plate

Material: MS Plate
Dimensions: 380*40*10mm
Yield Stress: 440MPa
Induced Stress: 109MPa

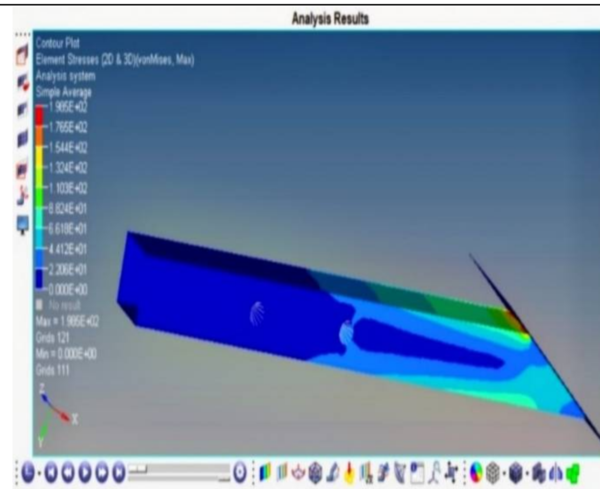


Figure 5. Analysis on Link

Material: MS Square Tube
Dimensions: 25.4*2mm
Yield Stress: 440MPa
Induced Stress: 196MPa

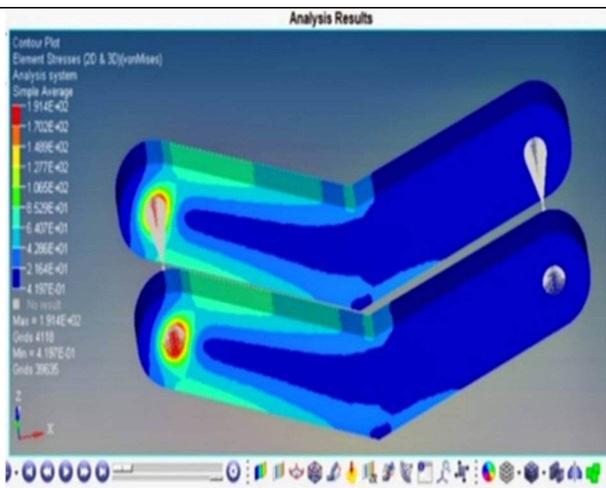


Figure 6. Analysis on Arm

Material: MS Plate
Dimensions: 10mm Thick
Yield Stress: 440MPa
Induced Stress: 192MPa

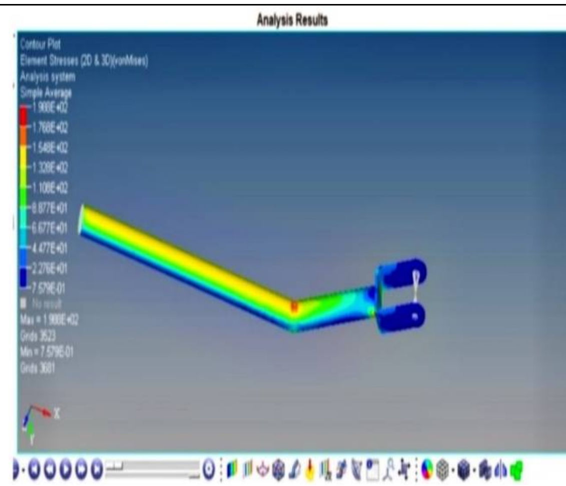


Figure 7. Analysis on Ram Rod

Material: MS Plate
Dimensions: 19*2mm Yield
Stress: 440MPa
Induced Stress: 196MPa

## IX. CONCLUSION

This design uses extremely simple ideas and mechanisms to achieve a complex set of actions and is intended to imitate the action of the operators. Such Hydraulic Grippers are cost effective for small scale industries. The cost can be justified with increased production rates. The mechanical design. and parts that have been fabricated are extremely simple. The prepared mechanism has been successfully constrained and executed to carry out the required work of picking up the weight of the object like a table tennis ball and to put them in to the placed at different location.

The Hydraulic Gripper Arm will –

1) Reach the greatest distance to deliver a given object.
2) Pick up the heaviest possible object.
3) Rotate as well as reach and grab.
4) Function in an assembly line.
5) Pick any object with ease.
6) Battle against another arm for an object

## X. DISCUSSION

Hydraulic grippers currently present in the market need many improvements in design and fabrication. It is just a proof of concept. There are several innovations we can do in the future for hydraulic gripper. Some which we thought and having the possibility of work in the future are –

1) Machine Vision and Al can be used to make the arm self-dependent and perform the task without any human intervention.
2) An innovative design involves jaws that change their orientation to the shape of the object.
3) Use of microcontroller and a compressor to automate the hand operation.

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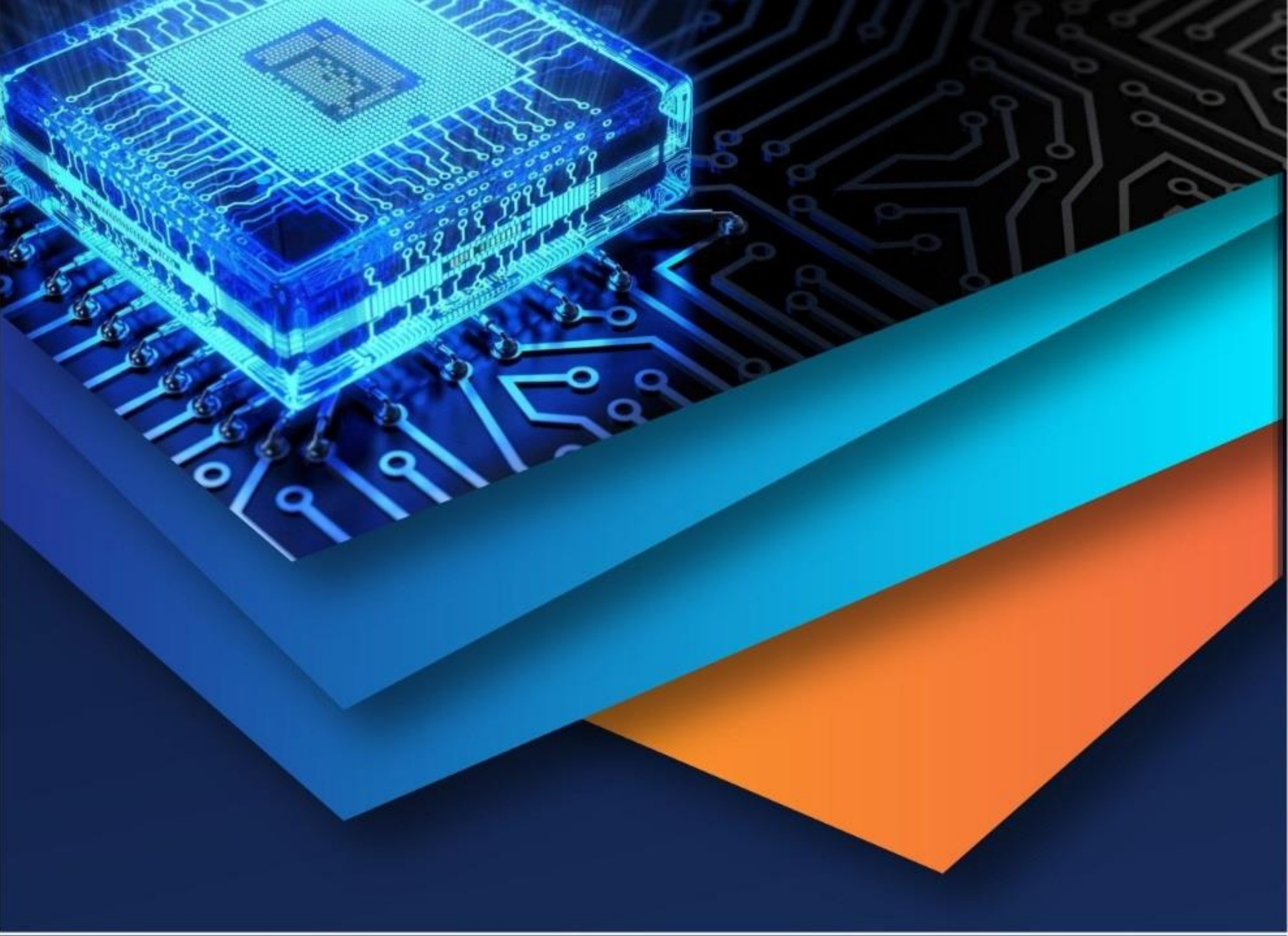

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