Design & Development of a Two-jaw parallel Pneumatic Gripper for Robotic Manipulation

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CERTIFICATE

This is to certify that the Project entitled ***"Design & Development of a Two-jaw parallel Pneumatic Gripper for Robotic Manipulation."*** submitted by **Ardhendu Prasad Nanda** in partial fulfillment of the requirements for the award of **Bachelor of Technology Degree** in **Mechanical Engineering** Session 2005-2009 at **National Institute of Technology, Rourkela** is credible and authentic work carried out by him under my supervision and guidance.

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Abstract

The handling of abstract materials and mechanisms to pick and place are widely found in factory automation and industrial manufacturing. There are different mechanical grippers which are based on different motor technologies have been designed and employed in numerous applications. The designed robotic gripper in this paper is a two jaw actuated gripper which is different from the conventional cam and follower gripper in the way that controlled movement of the jaws is done with the help of pneumatic cylinders using air pressure. The force developed in the cylinder is very gentle and is directly delivered to the jaws in a compact way. The design, analysis and fabrication of the gripper model are explained in details along with the detailed list of all existing pneumatic grippers in market. The force and torque for the gripper have been calculated for different set of conditions. The working of the model is checked for and observation for pay load is recorded at various pressures.

The highly dynamic and highly accelerated gripper model can be easily set at intermediate positions by regulating the pressure. Pneumatic grippers are very easy to handle and are generally cost-effective because air hoses, valves and other pneumatic devices are easy to maintain.

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Chapter 1

Introduction

ROBOT CLASSIFICATION

An industrial robot is a complex and technical system which consists of multiple subsystems and always works within a specified robotic workspace **[1.0].** These subsystems individually add up to the total working of the industrial robot and perform all the carefully defined functions on its own. The three of the more important subsystems comprises of (i) the robotic control system (ii) kinematics of the robot, and (iii) the drives.

Kinematics

The word "Kinematics" here specifies to the spatial arrangement, relating to the sequence and structure of different movement axes which are in relation to each other. An industrial robot may have four basic types of movement which are as follows: (i) Cartesian, (ii) Cylindrical, (iii) Polar and (iv) Jointed-arm.

Cartesian Co-Ordinate type Robot:-It is a kind of robot which has a column and another part called arm. It is also sometimes called an x-y-z robot, where x-y-z indicates the different axes along which the robot can move. The lateral motion is generally along x-axis, longitudinal motion occurs along y-axis, and vertical motion along z-axis. Thus, the arm has the freedom to move up and down along z-axis; the arm has the power to slide along its base on the x-axis; and then it can oscillate to move to and fro along the work area on the y-axis. This type of robot was developed mainly for arc welding purposes, but it is also suited for many other assembly and industrial operations.

Cylindrical Co-Ordinate type Robot:-It is one of the variations of the Cartesian robot. Such type of robot has a part called base and other one called column, where the column is able to rotate about any radius. It also carries an extending arm which has the freedom to move up and down on the column anytime to provide more freedom of movement for the system. The cylindrical co-ordinate robot is mainly designed for handling different machine tools and assembly structures.

Polar Co-Ordinate type Robot:-It is also called the spherical co-ordinate robot which consists of a part called rotary base, the second part known as elevation pivot, and the third one called extend-and-retract boom telescope axis. These robots has the feature to work based on the spherical co-ordinates and thus has much higher flexible working application. The primary applications of such type of robots are found particularly in spot welding.

Jointed-Arm type Robot:-It resembles a type of human arm. It usually stands erect on a part called base. While it can move along the "shoulder" joint, just above the base, it has also the freedom to rotate on the base. The robot also has the freedom of movement to rotate about its "elbow" and "wrist" joints. Along with the inclining and bending at the wrist, generally 6 degrees of freedom is obtained from this type of robot. This type of robot is the most popular form of a robot and has various applications in welding and painting work.

Control Systems

The control systems of a robot used in an industry are used to determine its flexibility and efficiency, within the defined limits which are set prior to the initial structure design..

Requirement of the Control System:-The control system provides a sequence, generally logical sequence for different robots which they are to follow up. The control system provides all the theoretical position values which are required for each step and thus continuously measures the actual positioning of the robot during each movement. When the robot functions, the control system quickly calculates the actual/theoretical/difference, along with other measured values and the stored data (such as theoretical speeds etc), and produces actuating variables which are required to drive the robot.

Different Types of Control Systems:-

(1) Control system-The point-to-point type and

(2) Control system- The continuous path.

- **Point-to-point control system:-**With this control system, the robot stores the point where it has to pick up a part and the desired point where it is required to release that part

in the space. It then calculates the best path to traverse between the two points which it is required to follow later. This type of control system is used when initial and final points only matter and are always repeatable. This control systems work well where loading and unloading applications is carried out.

- **Continuous Path Control System:-**This control system is one in where the robot can be programmed beforehand to follow a path which is irregular type. In this control system, the path to be traversed by the robot is represented by a series of large number of points in close proximity with each other; which are then stored in the memory space of the robot. When the robot is made to work, it exactly follows the same path as it had stored the corresponding co-ordinates. This can be used for jobs when the robot is required to travel a defined specific path, such as applications like welding and painting.

Drive

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.
- **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:-** Pneumatic drive 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.

AUTOMATION IN INDUSTRY

Automation is termed as use of different control systems such as numerical control, programmable logic control or other industrial control systems in concern with computer applications or information technology(such as Computer Aided Design or Computer Aided Machining) to manipulate all the industrial machinery and processes, thus reducing the need for human intervention **[1.1]**. As always said, for growth of industries, automation is must and should supersede the mechanical growth. Where mechanization provides human operators with machinery to assist them along with the muscular requirements of work, automation decreases the involvement for human sensory and mental requirements as well. Automation plays a dominant role in the world economy these days and in daily application in industries. As for these days, the twenty first century engineers are increasing their research to combine automation with mathematical and organizational systems to facilitate new complex systems which has wide applications.

- **Automated manufacturing:**

  Automated manufacturing mainly symbolizes to the use of automation to reproduce things usually obtained in a factory. The automation technology has many advantages and thus it influence in the manufacturing and production processes.

The main advantages of the automated manufacturing are higher consistency and quality, reduced lead times, simplification of production process, reduced man handling & improved work.

Home Automation

It is also termed as domotics which represents a practice of increased use in household automated appliances and residential complexes, where electronic things are used to solve practically non-feasible things, which were largely expensive or not possible earlier by any means.

Advantages of Automation:-

- These days' human operators are being replaced in many tasks that involve hard physical, strenuous or monotonous work.
- Replacing humans in certain tasks that is required to be carried in non-safe conditions which includes heat or fire, space outside atmosphere, volcanic eruptions, nuclear reactors, underwater in sea or ocean, etc)
- Undertaking jobs which are difficult to perform by human beings like carrying heavy loads, transporting bigger objects, working with too hot or too cold objects or something like performing a work with high pace or utmost slowness.
- Economy improvement is one of the major advantages of the automation system. Sometimes some kinds of automation system imply improvement in economy of firms, enterprises or society. Examples may be taken, an enterprise recovering its total investment which it had incurred on a automated technology, when a state adds up to its income due to automation like Germany or Japan as in the 20th Century or when the humankind could use the internet which in turn uses satellites and other automated engines.

I.ROBOTICS

Robotics is a branch in science and Engineering of robot making which deals with design, development, manufacturing, application and real time use in day today's world. It is related to three branches mainly which are mechanics, electronics and software development.

Robotic Grippers:-These are the type of robots which have the capability to grasp definite objects and then reposition it according to requirement. The robotic grippers have two basic parts. They are the manipulators and end effectors.

The manipulators are the working arm of the robot whereas the End effectors are the hands of the robot. Generally the robots are connected with replaceable end effectors for which they can perform wide range of functions with same fixed manipulators. The end effectors are actuated by various mechanisms which include mechanical drives, electrical drives, hydraulic drives and Pneumatic drives.

Among this the widely used one is the hydraulic grippers but the most favorable one is the pneumatic gripper on which this paper is based on.

INTRODUCTION TO PNEUMATICS

Compressed Air is the air under pressure having values much greater than that of the atmosphere. When this compressed air is expanded to a lower pressure, a piston can be pushed using it, such as that in a jackhammer; it can go through small air turbines to turn shaft, as in a high-speed dental drill; or it can be expanded through a nozzle to produce a high-speed jet as in a paint sprayer. There are many pneumatic devices in which compressed air becomes a source of energy to perform various operations which includes riveting guns, air powered hammers, drills such as rock drills and other air powered tools. There are methods to use compressed air in coal mining tools thus reducing any chances of explosion which happens in case of electric tools which generally produces spark.

1.2 Need for the proposed Pneumatic Project:-

CONVENTIONAL SYSTEM:-

A *mechanical gripper* is an end effector that uses mechanical fingers actuated by a mechanism to grasp an object. The fingers, sometimes called the jaws, are the appendages of the gripper that actually make contact with the object either by physically constraining the object with the fingers or by retaining the object with the help of friction between the fingers. For a **Two jaw cam actuated rotary gripper** there is a cam and follower arrangement, often using a spring-loaded follower which can provide for the opening and closing of the gripper. The movement of cam in one direction would force the gripper to open, while the movement of the cam in opposite direction causes the spring to force the gripper to close. The advantage of this arrangement is that the spring action would accommodate different sized parts. Most mechanical drives used in grippers are based on cam and followers or rack and pinion gears as force convertors. Cam driven gripper jaws normally enjoy a relatively large stroke not normally achievable with other gear types. As a prime mover almost any form of electrically commutated DC servo motor is suitable **[1.2]**.

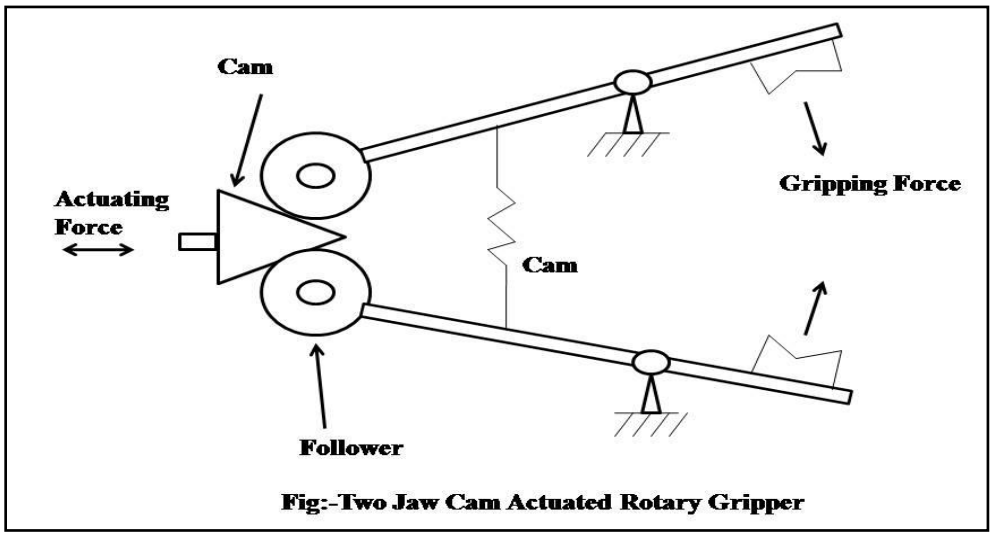


Fig1-Two Jaw Cam Actuated Rotary Gripper

DISADVANTAGES OF CONVENTIONAL SYSTEM:-

For most rotary actuators such as electric motors, the torque can be assumed to be constant over the complete gripping range. However, when the jaws close the motor stalls. For DC motors this can result in an excess of current resulting in overheating and eventually burn out. Switching off the motor current completely is unlikely to be a satisfactory solution especially where a good quality cam and follower mechanism is used, owing to the likelihood of the object working loose during motion. Also, thin and delicate materials of very small dimensions are difficult to handle by the electro-mechanical form of grippers.

1.3 Major Factors in Choosing a Pneumatic Gripper and Jaw Design:-

- **Orientation, dimensional variation and Part shape:-**
  If there are two opposing flat surfaces in the object, then the 2 jaw parallel gripper is desired as it can handle variations in the dimensions. Jaws may also be designed to handle cylindrical objects with the same 2 jaw concept. While designing the parallel gripper it is kept in mind that the retention or encompassing grip requires less force than the friction grip.
- **Part Weight:-**
  While a desired operation is performed on the object the grip force must be adequate to secure the object. Depending on the force requirement, the type of jaw must be designed so that it forms a part of it. While designing the gripper, it is to be kept in mind that a safety factor to the amount of force we select must be added and also about the factor corresponding to the air pressure.
- **Accessibility:**
  This applies both to the amount of room for the gripper jaws and for the work being performed on the object. An internal grip is required if the work is to the exterior of the object. Angular grippers are usually less expensive than parallel jaws but require additional space for the movement of the jaws.
- **Environmental:-**
  Grippers may be designed for purposes which are required in harsh environment or clean room applications.

- **Retention of the Object:-**

  Depending on the loss in air pressure, the gripper relaxes its grip on the object and hence the object may be dropped. Many of the spring assisted grippers are designed for this type of applications.

Chapter 2

Literature Review and Survey

In field of Robotics and Automation, many research works have been done by many researchers. Some of the distinguished ones which are relevant and carries basic information for this paper have been highlighted briefly.

- Ramesh Kolluru, Al Steward, Micheal J. Sonnier and Kimon P. Valavanis in their paper on "A Sensor based Robotic Gripper for Limp material handling " proved that series of flat apparel grippers which are based on principle of pressure differential and suction can pick and place fabric materials reliably and with acute precision without causing any change to the structural dimensions of the fabric**[2.0 a].**
- Junbo Song and Yoshihisa Ishida in their paper on "A Robust Sliding mode Control for Pneumatic Servo Systems" successfully simulated and applied the results of a robust sliding mode control scheme for pneumatic servo systems. It is proven that due to many of the uncertain bounds used in structural properties of pneumatic servo systems which are used in controllers design and also due to the insensitivity of the error dynamic to uncertain dynamics, the model is strong and a robust one **[2.0 b]**.
- Werner Dieterle in his book "Mechatronic Systems: Automotive applications and modern design methodologies" emphasized on the use of Mechatronic systems in field of agriculture and automobile engineering. The book describes different methodologies for cross disciplinary subjects, different model based mechatronic design systems and correspondingly the benefits of these technologies **[2.0 c]**.
- Robert B.van Varseveld and Gary M.Bone in their paper on "Accurate Position Control of a Pneumatic Actuator Using On/Off Solenoid Valves" have described the development of a inexpensive, fast acting and accurate position controlled pneumatic actuator. The paper describes to use On/Off valve using Pulse width modulation in place of rather costly servo valves. Also the overall efficiency of the actuators is compared with servo valves efficiency which is obtained by various other researchers **[2.0 d]**.
- Jiing-Yih Lai, Chia-Hsiang Menq and Rajendra Singh in their paper on "Accurate Position Control of a Pneumatic Actuator" have experimentally proven that their proposed control system of single open valve was far more better than the conventional off control valve strategy which proved that it was better to obtain the desired accuracy in position without having any mechanical stops in the actuator **[2.0 e]**.

Survey on Pneumatic Grippers

Dual Motion Gripper

For either large/small o-rings, or applications where picking or parts or seating is required automated seal and o-ring assemblies are made. The seals are spread and placed with the assembly machine with a o-ring placed in dual motion. The dual motion gripper have been made for part ejection and facilitating seating of parts. With the help of set screw in center the opening stroke is adjusted **[2.1]**

Fig2.1-Dual Motion Gripper

Grip Force	Around 275 N
Stroke Spread	15 mm
Stroke eject	6.3 mm
Weight	0.56 kg

Table 2.1-Details of Dual motion Gripper

Micro Miniature type Gripper-Parallel

This type of gripper is generally designed for handling tiny and delicate parts. The Miniature size facilitates for banks of grippers to be mounted side by side for close centerlines. It has a scavenge port and thus from the top it can be controlled.

Fig 2.2- Micro Miniature type Gripper-Parallel

Grip Force	Up to 40 N
Stroke Spread	4.8 mm
Weight	0.02 kg

Table2.2- Details of Micro Miniature type Gripper-Parallel

Compact Low Profile Parallel Gripper

The ideal gripper design for small parts handling is Compact parallel gripper with t-slot rib. These types of grippers are offered in four stroke sizes which may vary up to 1 inch (25.4 mm). For handling weight issues in case of robotic applications this type of long stroke and light weight grippers are designed.

Fig 2.3-Compact Low Profile Parallel Gripper

Grip Force	40-60 N
Stroke Spread	6-25.4 mm
Weight	0.07-0.14 kg

Table2.3-Details of Compact Low Profile Parallel Gripper

Miniature Rugged Parallel Gripper

These types of parallel grippers are small yet rugged. It has two types of grippers whose jaws ride on Armoloy TDC shafts. These grippers are the standards of jaw centering industry which supply higher gripping force to the amount of weight lifted. These grippers have a guided wedge design offers better strength and repeatability. This type of gripper is best for short stroke length and high strength applications.

Fig 2.4:-Miniature Rugged Parallel Gripper

Grip Force	60-97 N
Stroke Spread	4-6.5 mm
Weight	0.08-0.15 kg

Table 2.4:-Details of Miniature Rugged Parallel Gripper

Parallel Gripper of Ultra Light type

A high grip force to weight ratio is supplied by medium size two jaw parallel grippers supply. Some of the grippers are made of light weight titanium alloy and for longer life they are stacked in thickness in order of thousands. This type of gripper also has a guided wedge design that causes better centering of the jaws and can repeatedly effect longer strokes. For handling robotic applications with weight issues such grippers were developed.

Fig 2.5:- Parallel Gripper of Ultra Light type

Grip Force	62-180 N
Stroke Spread	9-13 mm
Weight	0.20-0.32 kg

Table 2.5:- Details of Parallel Gripper of Ultra Light type

Parallel Gripper with a T-Slot

Parallel gripper with T-slot rib is designed for picking parts which requires long strokes in a narrow space. These types of grippers are designed for various stroke sizes ranging from 0.4 inches (10.16 mm) to 1.2 inches (30.48mm).

Fig 2.6:-Parallel Gripper with a T-slot

Grip Force	40-180 N
Stroke Spread	10-31 mm
Weight	0.12-0.45 kg

Table 2.6:-Details of Parallel Gripper with a T-slot

Rigid Wide Body Parallel Gripper

The long stroked grippers feature rigid wide bearing design, which is developed for lifting bulkier materials or when long rigid tooling is needed. When high moment carrying capacity is needed the jaws are supported on shafts along the full length of the body and are sealed against the chips or particles. These type of grippers are designed for eight stroke sizes which varies from 0.8 inch (20.32 mm) to 7 inch (177.8 mm). Rigid jaw design and long stoke is offered by such type of grippers. Synchronous or non synchronized are two different types of jaw versions that is available in the market.

Fig 2.7:- Rigid Wide Body Parallel Gripper

Grip Force	110-600 N
Stroke Spread	20-180 mm
Weight	0.3-4.5 kg

Table 2.7:- Details of a Rigid Wide Body Parallel Gripper

Pneumatic Three Jaw Parallel Gripper

The Three jaw parallel grippers are designed for four models which includes a patented T-slot design. The gripping strokes has a wide range which varies from 0.2 inch (5.08mm) to 0.9 inch (22.86mm) and correspondingly the forces varies from 120 N to 1250N.

Fig 2.8:-Pneumatic Three jaw Parallel Gripper

Grip Force	120-1250 N
Stroke Spread	5-23 mm
Weight	0.5-6 kg

Table 2.8:-Details of a Pneumatic Three jaw Parallel Gripper

Two Jaw Style Toggle Lock Angular Grippers

In these types of grippers the angular jaw travels an angle of total 180 degrees thus compelling the jaws of the grippers to retract back completely from the gripping which eliminates another required axis of travel. The Jaw rotations can be adjusted for a varied angle from -2 to 90 degrees which is associated with individual jaws and thus makes the gripper suitable for many industrial applications. Such type of grippers features in two jaw or three jaw design, both of which are fail safe toggle locking and is -2 degree past parallel.

Fig 2.9:-Two Jaw Style Toggle Lock Angular Grippers

Grip Force	80-3600 N
Stroke Spread	180 degrees
Weight	0.08-2.8 kg

Table 2.9:-Details of Two Jaw Style Toggle Lock Angular Grippers

Three Jaw Style Toggle Lock Angular Grippers

In such type of grippers a movement of 90 degrees for individual jaw compels the gripper to move back from the gripping thus eliminating another required axis of travel The Jaw rotations can be adjusted for a varied angle from -2 to 90 degrees which is associated with individual jaws and thus makes the gripper suitable for many industrial applications. These types of grippers offers unique three jaw design, both of which are fail safe toggle locking and is -2 degree past parallel.

Fig 2.10:-Three Jaw Style Toggle Lock Angular Grippers

Grip Force	7-900 N
Stroke Spread	180 degrees
Weight	0.5-4 kg

Table 2.10:-Details of Two Jaw Style Toggle Lock Angular Grippers

Single Jaw Parallel Gripper - One Fixed Jaw Style

These types of grippers have a compact pneumatic gripper actuator provided with t-slot rib designed to use in close surfaces where large loads are required. Such type of grippers is suitable where one jaw is positioned to zero. These grippers have a T-slot bearing design which is supported along the length of the body to bear heavy loads. There are multiple mounting surfaces on the system which guides loads to be clamped by the top surface or by the gripper end plate. Such type of grippers are offered in four stroke sizes which has a variable range from 0.2inches (5.08 mm) to 2.5 inch (63.5 mm) and have corresponding bore sizes of 0.5 and 0.75 inch. On both sides of the gripper the stroke adjustments are standardized and are sensor ready for different applications.

Fig 2.11:- Single Jaw Parallel gripper-One Fixed Jaw Style

Push Force	60-160 N
Stroke	12-51 mm
Weight	0.07-0.25 kg

Table 2.11:- Details of Single Jaw Parallel gripper-One Fixed Jaw Style

Chapter 3

Objectives

OBJECTIVES:-

1. To design a mechanical gripper with the assumed physical dimensions.

It includes the study of history of different pneumatic grippers and the physical parameters associated with a gripper. Parameters such as the maximum pressure of the cylinder, the arm length, no of degrees of freedom associated with the gripper, its physical movement and other things are taken care of.

2. To select appropriate pneumatics for the proposed gripper model

It includes the selection of appropriate pneumatic cylinder, the desired pressure regulator level, the actuating solenoid valve, the type of male connectors, the tube carrying the compressed air and the Y-push fit type junctions.

3. To fabricate the gripper for a desired and calculated pay load

It includes obtaining aluminium bars of desired dimensions, the required guide ways, correspondingly the required nuts and bolts and fabricating them in the work shop for obtaining a pay load of approximately 20 kg.

4. To test the gripper in Lab conditions

The gripper was tested in lab condition which includes gripping different materials with the friction grip and the encompassing grip in static and dynamic conditions.

5. To measure the maximum gripping force developed by the gripper.

The maximum gripping force was calculated by the amount of maximum payload it can carry in static condition. For this an encompassing grip is preferred where the gripping force is almost one fourth of that of the force obtained in friction grip.

Chapter 4

Pneumatic Gripper -Design/Diagram

WORKING PRINCIPLE:- The parallel jaw gripper has at least two fingers which can be moved towards each other along one axis. Usually, the fingers can be moved independently from each other in order not to shift the object, but they are only able to perform simple operations like open and close **[4.1]**. Thereby, a longitudinal or side movement is impossible. A parallel jaw perform, a manual control to steer the gripper must be possible for enabling the highest flexibility. The principles which are followed in this type of parallel jaw gripper are:-

- The force closure grip: The characteristic of the force closure grip is that the gripper keeps the object in a stable state by compensating all forces and torques created by the object. The sum of all forces and sum of all torques must equal zero($\Sigma F=0;\Sigma M=0$).

  The force closure grip can be differentiated into a grip with friction and without friction. The force closure grip without friction is much idealized and not very common in daily use, therefore it is no further mentioned. The force closure grip with friction requires at least contact points for gripping a planar object and at least 4 contact points for a three-dimensional object.
- The form closure grip is the second principle for gripping objects. This grip is feasible, because the gripper is a negative model of the object (or a part of it) which limits the movement of the object within the gripper in any direction, also when changing the gripper orientation. The force is compensated on well specified contact surfaces. Tangential load, pressure load and torque are not considered, but are instead reduced to the corresponding forces. The gripper must either make use of a special geometry(i.e. negative model of the object), or a significant number of fingers are required.

When compressed air is released from the compressor through the pressure regulator, it rapidly flows into the 5/2 way valve. The desired pressure level can be maintained by observing the pressure readings on the dial gauge. The maximum pressure at which the system can be operated is 10 bar, but mostly we will be working at pressure levels far below that, preferably less than 5 bar. The compressed air moves into the 5/2 way valve which when activated either manually or by solenoid electric circuit allows the compressed air into the inlet port of the two

double acting air cylinder(max supply pressure of 10 bar) which are placed exactly opposite to each other. A 5/2 way valve could be used in place of a 5/3 way valve which is an advanced valve which regulates the amount of compresses air flow, thus controlling the stroke length of the piston rods. The cylinder has a bore diameter of 50 mm and stroke of 50 mm too. The entry of air into the cylinder pushes the piston and thus the piston rods undergoes a power stroke to move outwards which increases the distance between the gripper surfaces .Thus this movement opens the grippers which helps in releasing the object. For the other way round, when the compressed air flow is reversed then the air flows out from the cylinder into the valve and into the compressor through the regulator. This accounts for the return stroke of the piston rod which helps to grasp the load as the distance between the gripper surfaces decreases. The pressure is maintained as per the gripping force which is required. The distance between the grippers is the width of the object which is required to be grasped. Both the gripper arms move in a drilled guide way which is made with the help of two iron rods which forbids the motion along any other axis.

COMPONENTS USED AND CONNECTIONS:-The robotic gripper consists of two links which moves in opposite direction to each other and remains parallel always **[4.2].** The motion of the gripper arms occur along the direction in which the piston shaft of the air cylinder moves. The gripper rods are then connected to the gripper jaws which are generally made up of rubber. The gripping force is determined by the type of gripper jaws which are used. There are two types of grips which determine the gripping force:-friction grip and encompassing grip. The gripping rods are connected to the shaft of two pneumatic cylinders which are placed in opposite positions to each other. The movement of the rods occurs by the intake and exhaust stroke where the piston rods move out and into the cylinder resulting in the motion of the rods across the pin joint. The movement of the piston rods causes the robotic gripper to close or release the object as per requirement. The pneumatic cylinders are controlled by compressed air movement flowing in and out of the cylinder through the path ways which are connected by male connectors. The respective pipe lines from the similar guide ways of the two cylinders are connected by a Y-union. The Y-union connects two pipes lines and feeds in compressed air through a single pipe line after which they are distributed equally into the two pipe lines for the reciprocating motion

of the shaft. The single pipe line from the inlet and another single pipe line from the outlet are connected to a 5/2 way valve. The 5/2 way valve is a type of valve which manages the flow of air into the cylinder for the controlled motion of the gripper. The valve can be manually operated or may be controlled with the help of a solenoid circuit which is connected to the AC current supply. The 5/2 way valve has 5 ports:-1 inlet, 2 outlets and 2 exhaust. The pipe lines are connected to the valve ports with the help of male connectors. The air into the valve port is regulated by a pressure regulator to which a pressure gauge is connected. The pressure gauge shows the air pressure on a dial according to which the air pressure can be regulated by the pull and twist arrangement on the regulator. The knob is pulled and air pressure is adjusted by turning the knob clockwise which increases the air pressure and then the knob is pushed back to lock the pressure. The inlet port of the regulator is connected to a compressor which generates and maintains the air pressure.

HARDWARE DETAILS:-

1. AIR CYLINDER, DOUBLE ACTING,

BORE DIA – 50MM, STROKE – 50MM,

MAX SUPPLY PR. – 10 BAR

CUSHIONING AT BOTH END

Model No.- A12 050 050 O

Make – JANATICS

2. 5/2 WAY, 1/4" BSP, CIOL 220V AC,

DOUBLE , SOLENOID VALVE

Model No.- DS55SS61-A

Make – JANATICS

3. AIR PR. REGULATOR,

WITH PR. GAUGE (0 – 10) BAR

Model No.- R13614+A2G02

Make – JANATICS

4. UNION ‘Y’ PUSH FIT TYPE

FOR TUBE OD 08MM

Model No.- WP2400808

Make – JANATICS

5. MALE CONNECTOR PUSH FIT TYPE

THREAD ¼” BSP & FOR TUBE OD 08MM

Model No.- WP2110851

Make – JANATICS

6. PU TUBE OD 08MM

Model No.- WH02B08

Make – JANATICS

7. 2 ALUMINIUM BARS of length approrimately 20 inches

8. 2 Iron Rods of thickness 4 mm and length 18 inches

9. GRIPPER MATERIAL-Rubber

10. BASE MATERIAL-PLYWOOD

11. Nut and Bolts of dia 8 mm and length 4 inches.

CIRCUIT CONNECTION:-

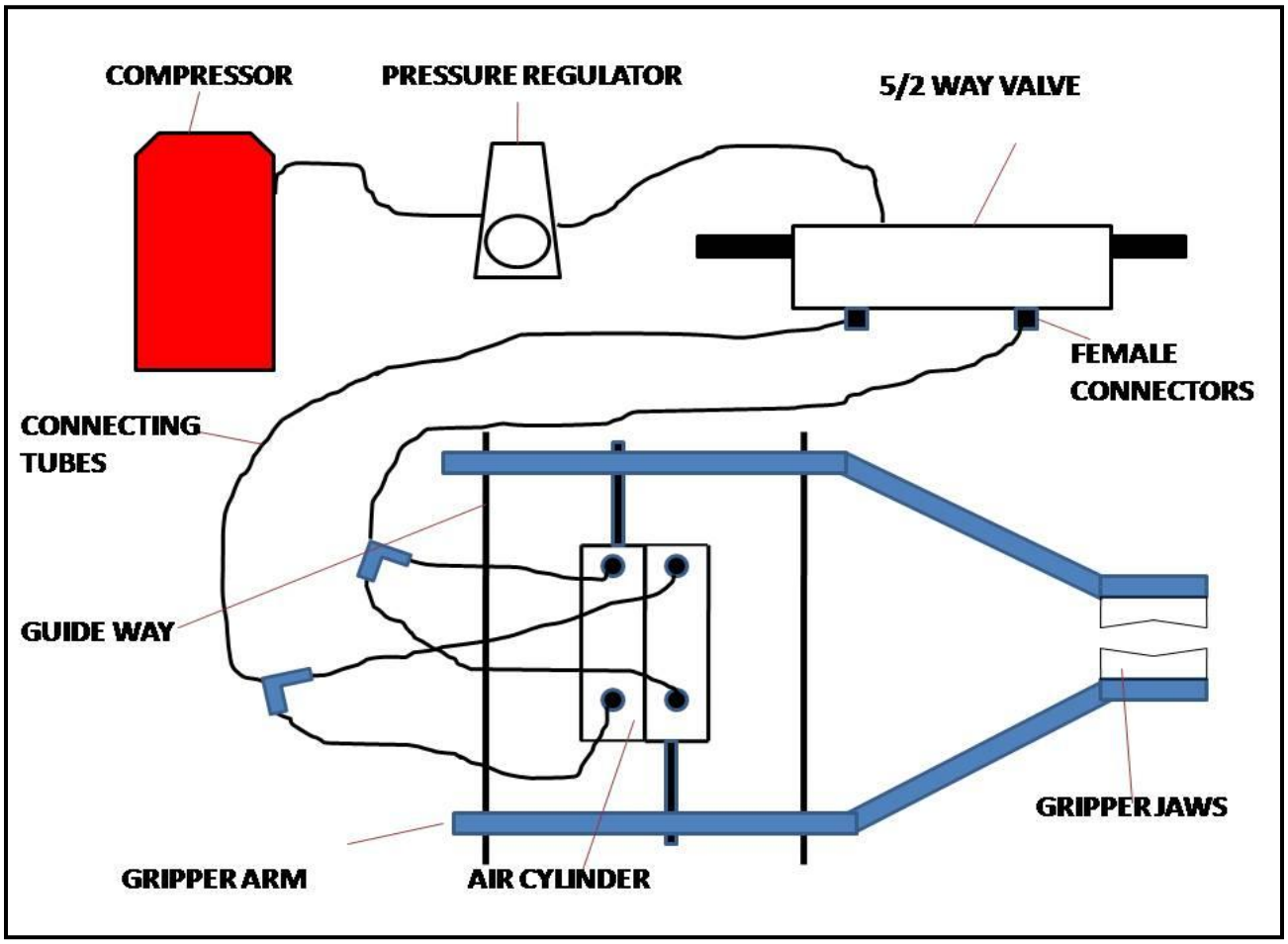


Fig 4.1:-Circuit connection

This is how a pneumatic robotic gripper acts and the calculations required for the design are as follows:-

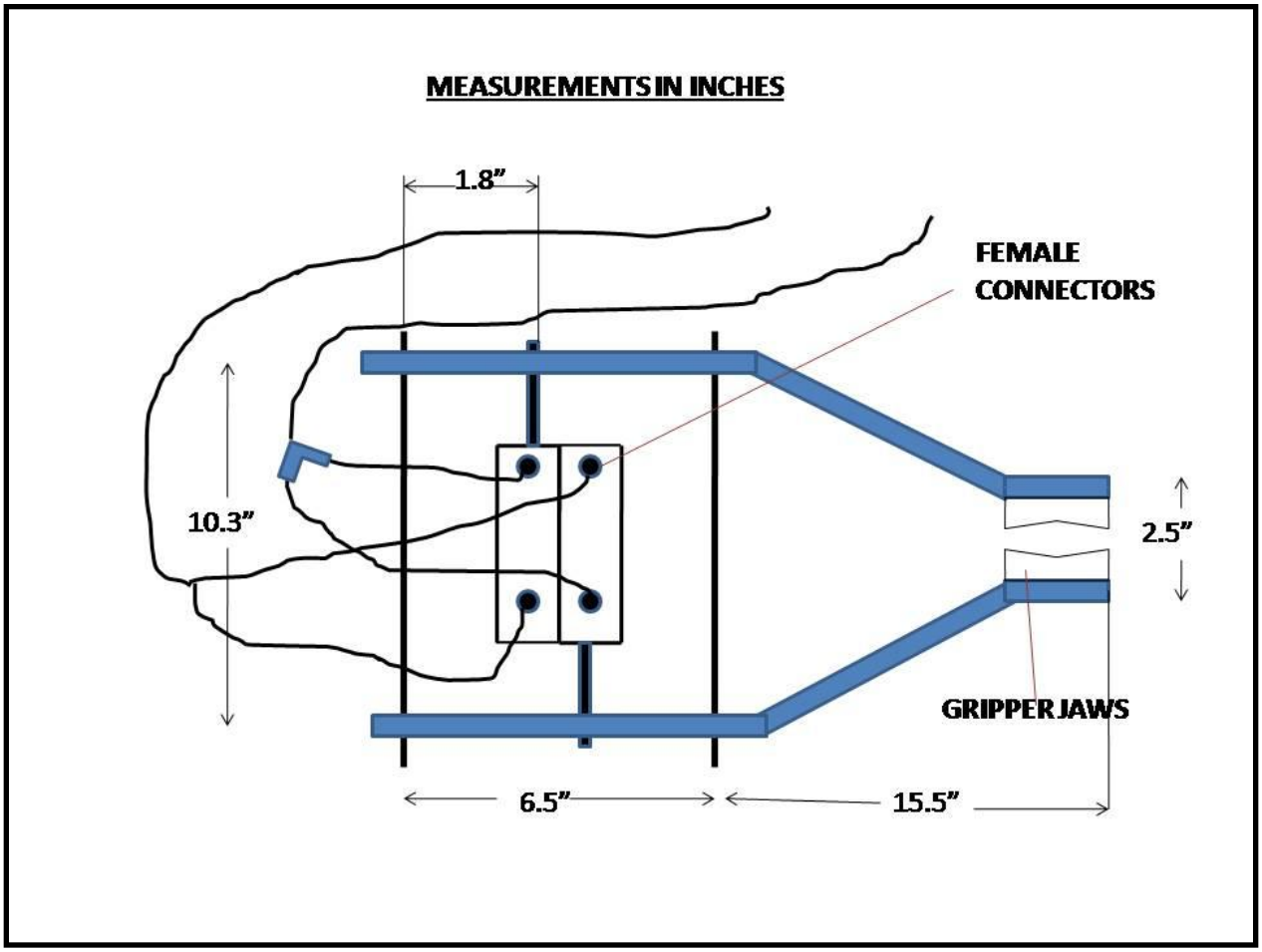


Fig 4.2:- Dimensions of the system

Maintenance Instructions & Trouble shooting for valve:-

1. Before dismantling the valve, the air source to the valve is cut off and the valve is operated several times to exhaust the air in it.
2. The valve is removed from the machine and is dismantled, cleaned thoroughly and reassembled.
3. The valve can also be tested by connecting the valve to the double acting cylinder and then operating it.
4. The problems and troubles are noted and therefore the probable causes and its remedies from the table are ascertained **[4.3]**.

Trouble shooting:-

1. Leak observed at exhaust ports.	May be due to non-lubrication and spool gets strucked. May be due to dust formation in the valve assembly Defective seal	Clean the Spool assembly, Housing and operate with proper lubrication. Clean the valve and lubricate, ensure the air is filtered. Replace the Spool Assembly
2. Leak observed between housing and solenoid end cover.	Defective Nutring Defective End cover seal	Replace the Piston assembly Replace the End cover seal.
3. Leak observed between housing and end cover.	Defective End cover seal.	Replace the End cover seal.
4. Lifter knob gets damaged.	Improper usage of the lifter knob.	Replace with new end cover assembly.

Table 4.1:-Trouble shooting

CALCULATIONS:-

Gripping force:- $2\mu F_g = mg$

$$= \frac{0.1 \times 9.8}{2 \times 0.2} = 2.45\ N$$

Max actuating force:-

$$F = P_a \times \frac{\pi D^2}{4}$$

$$= 10 \times 10^5 \times \pi \times (0.050)^2/4$$

$$= 1962.5\ N$$

Requirements for Functioning of a Gripper:-

When a grip is being designed, there are two first order elements which should be considered. They are the gripping force and sliding torque. These are the factors which must be calculated correctly to make sure for a successfully functioning gripper that will last 5 to 25 million cycles **[4.4]**.

Gripper Force requirements:-

The type of gripper jaws which is used generally has a major role in determining the force which is required in the functioning of a gripper. The gripper jaws are generally of 2 types or are found in two styles:-

Friction grip and Encompassing grip.

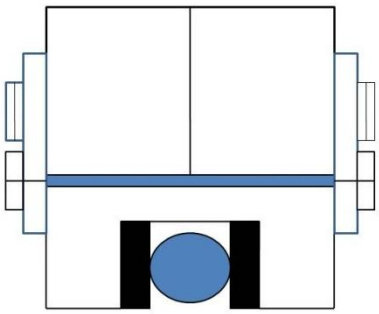


Fig 4.3:-Friction Grip

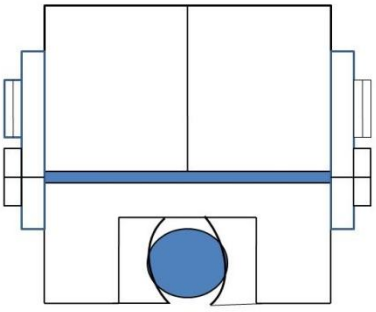


Fig 4.4:-Encompassing Grip

While the encompassing style is generally preferred over the friction grip because it provides more strength and is stable, the dimension that the jaw encompasses the gripper part should be deducted from the gripping stroke..

Rule of Thumb:-

The rule of thumb states that the encompassing grip requires one fourth the force required to hold the same object as in case of a friction grip. It is called as the jaw factor.

Jaw factor for a Friction grip is assumed as=4

Jaw facto for Encompassing Grip=1

Force required to Grip= Part weight(1+Part Gr)* Jaw style Factor

Force Required for 1.5 kg

Fricion grip= 1.5*10(1+1.5)*4= 150 N

Encompassing grip=1.5*10(1+1.5)*1=37.5 N

Force Required for 0.5 kg

Friction grip=1.5*10(1+1.5)*4= 50 N

Encompassing grip=0.5*10(1+1.5)*1= 12.5 N

Robotic Gripper Torque Requirements

The torque in a gripper is generated by two sources generally:-

i. Torque developed by the gripper arms on itself
ii. Torque developed by the acceleration & weight of the part

Torque from robotic gripper:-

GRIPPER TORQUE=gripper Force*Length of the jaw (It is the distance from the gripper face)

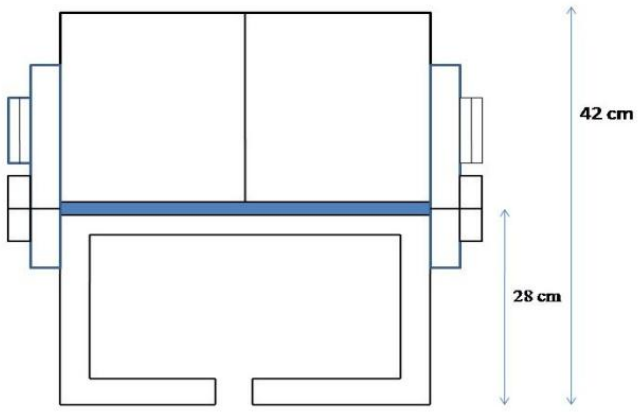


Fig 4.5:-Gripper Torque

Jaw Torque (friction grip)= 150*0.28= 42 N-m

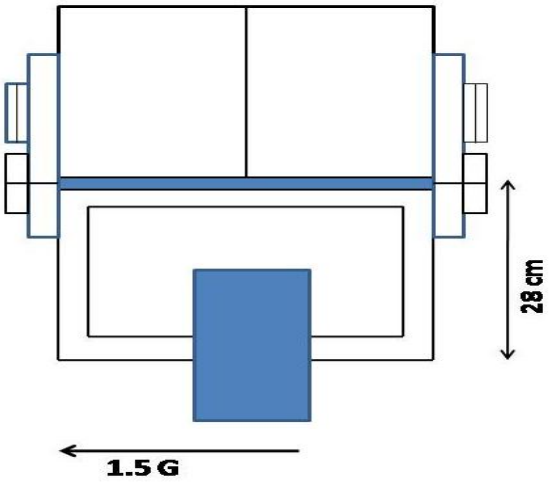
The length of the gripper arm has a major role in the designing and specification of the pneumatic gripper..

Torque generated by acceleration & weight of the part:-

Part torque=Acceleration(Gr)* jaw length

=1.5*10*0.28 m

=4.2 N-m



If the acceleration of the robot is cross wise

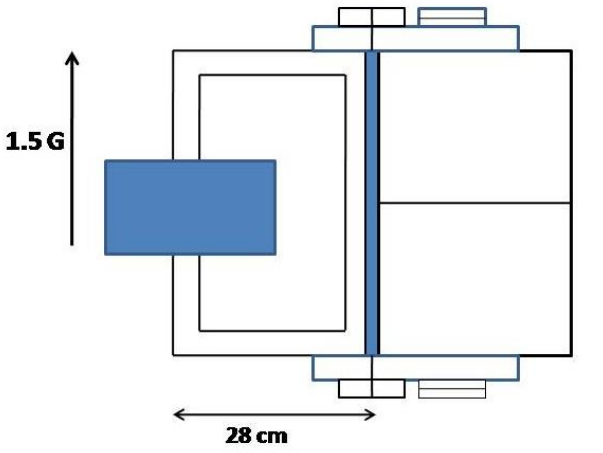


Fig 4.6:-Gripper with acceleration

In such a case the effect of one G is to be taken as acceleration due to gravity tries to apply torque on the jaws.

Part Torque=0.28*10*2.5=7 N-m

Grand total of all Torques on the Gripper:-

The Total torque that is developed on the gripper is the sum of the torque developed on the jaw and the Torque developed on the part.

Total Torque= Jaw length* Gripper Force+ Jaw length*Part Weight*(Acceleration+1 G if up & down)

Total torque=42+4.2=46.2 N-m

Actuating Force:-

F=P×A

$F = P_a \times \frac{\pi D^2}{4}$ = P×10^5×π×$(0.050)^2$/4

When P=1,F=196.25 N

P=2,F=392.5 N

P=3,F=588.75 N

P=4,F=785 N

P=5,F=981.25 N

P=6,F=1177.5 N

P=7,F=1373.75 N

P=8,F=1570 N

P=9,F=1766.25 N

P=10,F=1962.5 N

THE ASSEMBLED SET UP:-

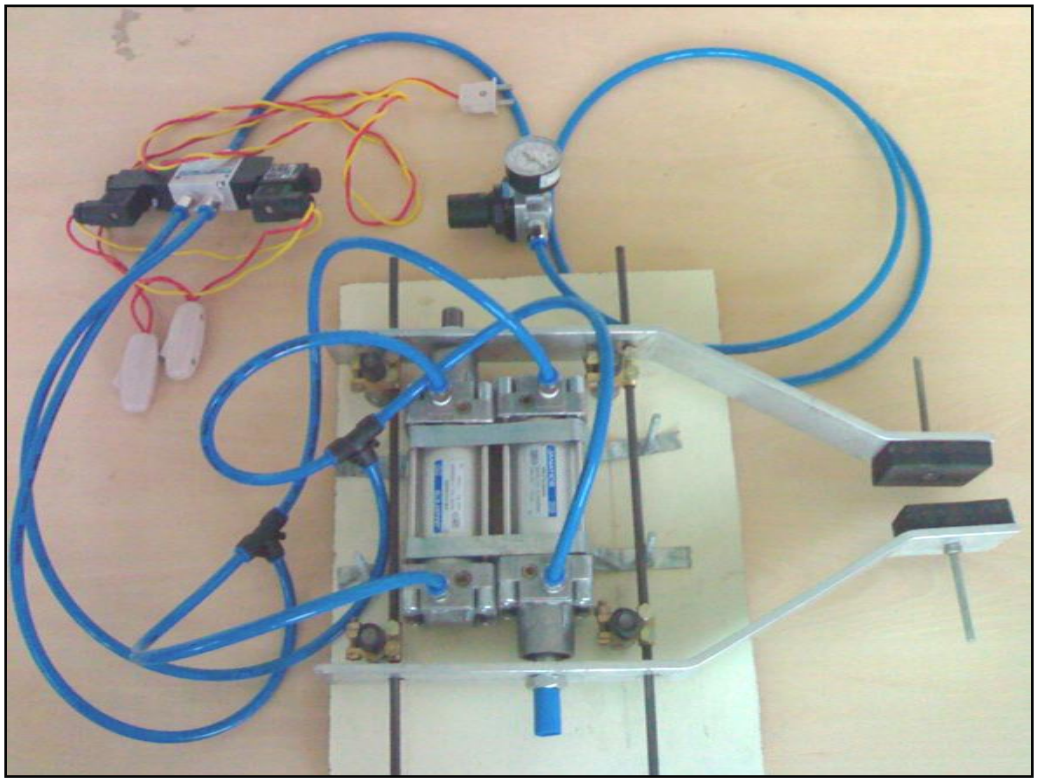
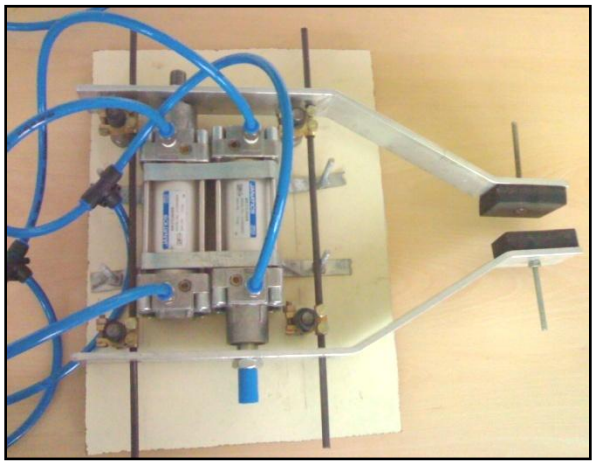


Fig 4.7:-The Assembled Set up

INDIVIDUAL SECTIONS:-



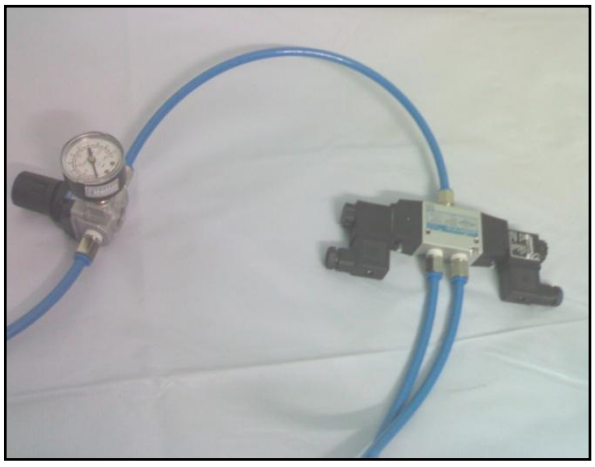


Fig 4.8:- Individual sections

CONCLUSION:-

From the model we have found out that the pneumatic gripper has many advantages and is one of the modern techniques in the world of robotics which makes pick and drop work easier and much faster than the conventional techniques.

- Highly dynamic operation and high acceleration possible.
- Intermediate positions can be set easily by regulating pressure.
- Easy to handle thin sheets and other low dimension materials which require intelligent handling.
- Low cost

The Pneumatic grippers offer the most attractive features and are a common choice and this explanation can be inferred from the work carried out in the project. The grippers arms were made of aluminium which allowed the gripper to be lightweight, yet durable for machine loading of metal parts. Such Pneumatic grippers are generally cost-effective because air hoses, valves, and other pneumatic devices are easy to maintain. Replaceable finger inserts for the gripper fingers can be manufactured from a variety of materials in future to ensure gentle part handling and a firm grip. Different types of gripping surfaces, gripping materials and different dimensions of gripping arm can be made to test the gripping force of the pneumatic robotic gripper.

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