iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35903

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI June 2021- Available at www.ijraset.com

Design and Development of Zero Turn Material Handling Robot

Sumit Sanjay Sutar[1], Kiran Shamarao Kadam[2], Suraj Balaso Sawant[3], Shubham Vilas Shinde[4], Abhishek Pralhad Patil[5], Akshay Vishwas Kamble[6], Hamida Shakil Jamadar[7]
[1, 2, 3, 4]*B. Tech Student* [5]*Assistant professor, Department of mechanical engineering, NMCE, Peth, Maharashtra, India*

Abstract: ***This paper aims to a zero*** **turn** ***material handling robot driven by pneumatic actuator as versatile end effectors for the material handling system. The arm consists of pneumatic hand and pneumatic wrist. The arm can grasp various objects without force sensors or feedback control of any. Therefore, this study aims to control wrist motion space. Hand shape is similar to the human hand with mechanical characteristic. Althe pneumatic actuators used as the drive source. This system develops the robot having rotary motion independent of the base. This model can be used to overcome the problem of space limitation and reduces the labour cost in small scale industries. It includes the robot arm, pneumatic cylinder and motors. Finally a zero turn robot with pneumatic system is fabricated.***

Keywords: **Zero turn, Pick and Place, Robotics, Pneumatic systems, Actuators, Pneumatic valve, *Robotic arm***

I. INTRODUCTION

This machine is related to the part of the human safety. Due to multinational collaboration of domestic companies with foreign countries near about 40% such organizations have their production facilities in India. Hence after globalization many clauses regarding factory act have been changed by the government of India, Ministry of human resource department &Company & labour act 1957. For all such companies domestic as well as multinational these rules & regulation are same in the organization having rotating & moving machineries the employee safety is given a first reference. As per the Japanese concepts- under ISO & procedure & clauses there are different kaizens about employee training & safety.[1]

A. Background

In the 19th century, industrial revolution takes place. After that industries are developed on the large scale. Products are required to produce by the mass production techniques to reduce the cost. For that purpose different techniques are developed. As many processes have to take place simultaneously, there is need for the help in working. For doing different work we need help. Special purpose machines are developed for this. In the perforation of different work for that robot is defined as a device or machine which works according to our order. Our order should be completed in time with precision so the term called Robot comes into play. "Robot – A servant play's important Role in it"

In the field of Technology, a day a replacement technique is ruled. It has its own characteristic thanks to which we've to adopt it. Today is that the World of "New Technology" which we've to require in practice. Robotics is one of the areas in the development. Robots are widely used in the Mechanical field. In the mechanical Industries, robots are widely used for the art of wing assembly, material handling, coating facility, manufacturing processes (cutting, drilling, welding etc.). Robots could accomplish many Boring repetitive tasks for us. Robot can do hazardous jobs and may reach places where it's difficult for citizenry to succeed in. Robots, which substitute the manned activities in space, are referred to as space robots. Robots are desirable for certain work functions in industries because, as unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions also; and that they can't be distracted from the task at hand.

Robots are superior in many aspects as compared to human being. The features which can be taken for comparison are as follows:

1) They are capable of producing a job of consistent quality, at a steady rate, with a greatly reduced probability of injection.
2) Continuous fatigueless working for several hundred hours is possible without any break.
3) They can work in unhealthy and unhygienic environment which is unpleasant for human beings.
4) They don't demand for any incentives or fringe benefits or other human related excuses.
5) In certain areas, they give better control over wastage e.g. powder coating, spray painting.

The most common Robots used today are on industrial model which assemble the parts, weld or paint, pick and place, lifting a weight and which looks like a machine. The material handling industrial robot is used to move, feed or disengage parts or tools to or from a location, or to transfer parts from one machine to another. A material handling robot can work 24 hours each day without worries or fatigue. The consistent output of a robotic system alongside quality and repeatability are unmatched. Robot is a mechanical body sometimes with the brain of a computer. Integrating the sensors and the actuators and with the help of the computers, we can use it to perform the desired tasks automatically. The Robotics Industries Association (RIA) defines an industrial robot as: "An industrial robot may be a reprogrammable, multifunctional manipulator designed to manoeuvre materials, parts, tools or special devices through variable programmed motions for the performance of a variety of tasks." Many robots have an articulated mechanical arm onto which various devices such as a gripper, grinder, and paint sprayer, welding gun, electromagnet or pneumatic wrench can be attached. The design and operation of those devices (called "end effectors") — which take the place of the human hand which is as important because the design of the robotic arm itself. The actuators of a robot can be operated pneumatically, hydraulically, electrically, mechanically or in some combination of the four basic drives.

B. Zero Turn Mechanism

Why is the zero degree turning mechanism wasn't shown in action?. The short and straightforward reason is because the model isn't ready to. Probably an enormous disappointment for several, and a few might directly conclude that it's then a poor model design. The zero degree turning option with skid steer had to be integrated somehow as this is often the unique feature and important characteristic of the vehicle. The challenge however was the way to combine this with the 'standard' 4WD and 4WS. An option would have been to power the left and right drive train and steer each wheel independently, but because that was already done by 'Coney' in this project concept is given something differently. The problem also with steering each wheel independently is that they easily find yourself misaligned, unless there are some electronics like within the real Hurricane. So first question and challenge was if it might be possible to unravel the matter of the various wheel configurations mechanically in such how that each one the wheels are related and connected with each other altogether positions, not forgetting that they also needed to be individually powered and suspended. For the standard steering mode, having the position of the left and right wheels connected with each other, also knew that by moving the whole link away from the wheels, they turn inwards. This had to be achieved by a controlled by using shaft slides in bush. The next challenge was to seek out an answer for switching from normal drive to skid steer drive, using just one input. In any case it was .In regular steering mode, the rear wheels turn in the opposite direction of the front wheels, which severely tightens the turning radius adding more accurate steering. In second mode, the rear wheels turn in the same direction as the front wheels, move to the side without changing the direction that it faces. This whole concept is amazing in own opinion.

II. THEORY

A. Types of Gripper

1) *Mechanical Gripper:* A mechanical gripper is end-effectors that use mechanical fingers actuated by a mechanism to grip an object. The fingers are the appendages of the gripper that actually makes contact with the object. The fingers are either attached to the mechanism or are an integral part of the mechanism. The use of replaceable fingers allow for wear and interchange ability. Different sets of fingers to be used with an equivalent gripper mechanism are often designed to accommodate different parts models.
2) *Magnetic Gripper:* Magnetic grippers are used extensively on ferrous materials. In general, magnetic grippers offer the subsequent advantages in robotic handling operations:

a) Variations in part size can be tolerated
b) Pickup times are very fast
c) They need ability to handle metal parts with holes
d) Only one surface is required for gripping

The residual magnetism remaining within the work piece may cause problems. Another potential disadvantages is the problem of picking up one sheet at a time from a stack. The magnetism tends to penetrate beyond the highest sheet within the stack, leading to the likelihood that quite one sheet are going to be lifted by the magnet**.** Magnetic gripper can use either one of the electromagnets or permanent magnets. Electromagnetic grippers are easier to regulate, but require a source of dc power and an appropriate controller. When the part is to be released, the control unit reverses the polarity at the reduced power level before switching off the electromagnet.

Permanent magnets don't require an external power and hence they will be utilized in hazardous and explosive environments, because there's no danger of sparks which could cause ignition in such environments. When the part is to be released at the top of the handling cycle, just in case of static magnet gripper, some means of separating the from the magnet must be provided.

3) *Vacuum Gripper:* Large flat object are often difficult to grasp. One solution to the present problem is that the use of vacuum gripper. Vacuum grippers are used for selecting up metal plates, panes of glass, or large lightweight boxes. Since the vacuum cups are made from elastic materials, they're complaint. The gripper is talent of errors in the orientation of the part and is especially suited for pick-and-place work. For handling softer materials, cups made from harder material are used. A compressed air supply and a venture are used to create a gentle vacuum that lifts the part.
4) *Adhesive Gripper:* Adhesive substances are often used for grasping action in gripper design. The requirement on the things to be handled is that they need to be gripped on one side only. The reliability of this gripping device is diminished with each successive operating cycle because the adhesive substance loses its tackiness on repeated use. To overcome this limitation, the adhesive are often loaded within the sort of endless ribbon into a feeding mechanism attached to the robot wrist.
5) *Hooks, Scoops And Other Miscellaneous Devices:* Hooks are often used as end-effectors to handle containers and to load and unload parts hanging from overhead conveyors. The item to be handled by a hook must have some sort of enable the hook to hold it. Ladles and scoops can be used

B. Jointed Arm (Articulated) Configuration Robots

There are two types of jointed arm (Articulated) Configuration robots:

1) Revolute Robots: Revolute robot, shown in Fig. provides three rotor y motions about three mutually perpendicular axes .Its configuration is similar to that of human arm. It consists of straight links, corresponding to the human forearm and upper arm, connected by a rotary joint. This configuration which provides spherical work envelop , has excellent work area to floor area ratio. The revolute robot, which has highly versatile configuration, is used for diverse tasks like spray painting, seam welding, spot welding assembly, heavy material handling, etc.

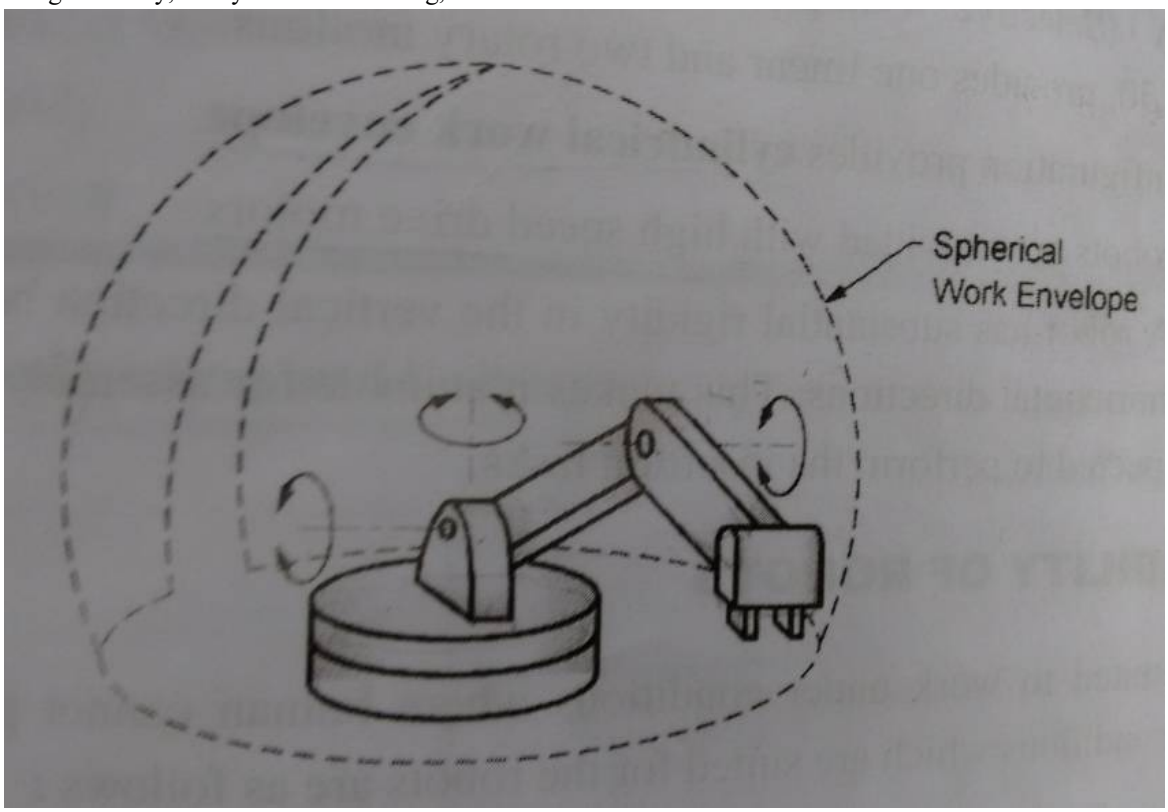

Fig.1. Revolute Robots

2) *Scara (Selective Compliance Assembly Robot Arm) Robots:* SCARA (Selective Compliance Assembly Robot Arm) robot, shown in Fig. provides one linear and two rotary motions. This configuration provides cylindrical work envelop. These robots are embedded with high speed drive motors. SCARA robot has substantial rigidity in the vertical direction but has compliance in the horizontal directions. This makes it suitable for assembly for assembly operation where it is expected to perform the insertion tasks.

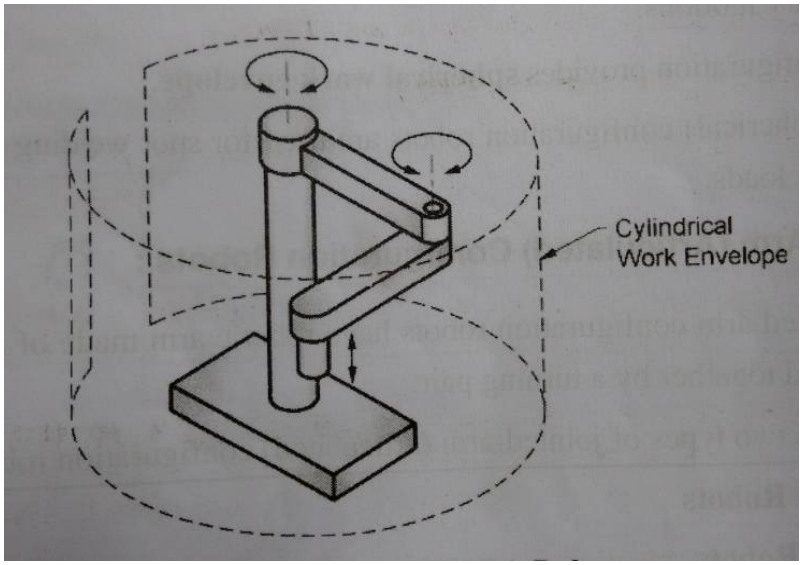

Fig.2 SCARA (Selective Compliance Assembly Robot Arm) Robots

C. Types Of Actuators

The different types of actuators used in robots are:

1) Mechanical actuator.
2) Hydraulic actuator.
3) pneumatic actuator.
4) Electric actuator.

D. End Effectors

The end effector used in robots can be either gripper or tool. The different types of grippers used in robots are: Mechanical grippers, vacuum grippers, adhesive grippers, expanded bladders, hooks and scoops.

E. Type Of Controller: The robot controllers are of following types:

1) Simple step sequencer.
2) Pneumatic logic system.
3) Electronic sequencer.
4) Microcomputer.
5) Minicomputer.

F. Application of robot:

The various applications of robots are listed below:

a) Machine loading and unloading
b) Material handling
c) Processing operations
d) Assembly
e) Inspection

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III. CONSTRUCTION

A. Frame

The frame is of material MS. The frame of our robot is basically divided into two parts.

1) *Lower Part:* Lower part of frame is basically used to support the components mounted on it. Whole load of robot is on the lower frame.
2) *Upper Part:* On the upper frame, motors, Arm plates, Rope, Grippers (are mounted. Upper frame with all components mounted on it can revolve in 360º by motor through gear motor.

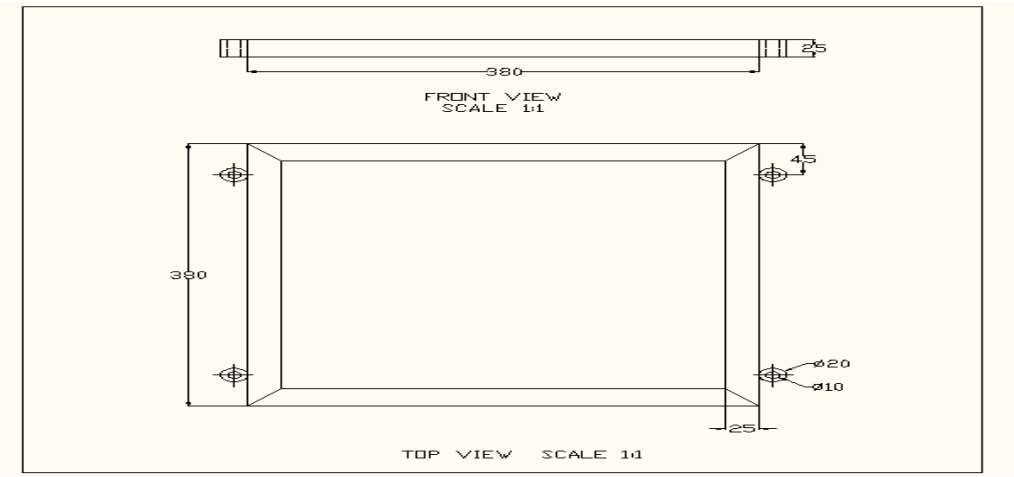

Fig.3 Frame of the system

B. Motors

In this robot, 6 D.C motors are used.5 motor of them are mounted on the lower frame and one on the upper frame. These motors are directly connected to main A.C power supply. We used these three motors at different locations for different specific work.

1) *Lower Drive Motor:* This all motor is mounted on the lower frame and used to drive the all wheel.
2) *Central Motor:* This motor is also mounted on the upper frame and used to rotate the arm plate 360º.

C. Pneumatic System Component

1) Pneumatic CylinderThe cylinder converts the energy of compressed gas into the linear motion. The air enters the cylinder and pushes the piston from one end of the cylinder to the opposite. There are two main sorts of cylinders-single acting and double acting. A single acting cylinder has just one air connection while a double acting has two. In single acting cylinder, the piston is forced out by the pressure of air. When the air supply is removed and air inside the cylinder is allowed to piston moves back, driven by the force of spring. By restricting the escaping air (exhaust),it is possible to hamper the return movement of the piston. The double acting cylinder has two air connections. When compressed gas is supplied to at least one connector and therefore the end is allowed to exhaust to atmosphere (i.e. the air is allowed to flee freely), the piston is driven to the opposite end of the cylinder. When air applied to second connector and first is allowed to exhaust to the atmosphere, the piston returns back. This type of cylinder gives more power on return stroke than single acting cylinder .Also ensures that piston is effectively locked in the position at both ends of its stroke. Pneumatic cylinders (sometimes referred to as air cylinders) are mechanical devices which produce force, often together with movement, and are powered by gas (typically air). To perform their function, pneumatic cylinders impart a force by converting the P.E. of gas into K.E. . This is achieved by the gas having the ability to expand, without external energy input, which itself occurs thanks to the pressure gradient established by the gas being at a greater pressure than the atmospheric pressure. This air expansion forces a piston to maneuver within the specified direction. The piston may be a disc or cylinder, and therefore the connecting rod transfers the force it develops to the thing to be moved. Once actuated, compressed gas enters into the tube at one end of the piston and, hence, imparts force on the piston. Consequently, the piston becomes displaced (moved) by the compressed gas expanding in an effort to succeed in air pressure. In pneumatic systems often found that even rare and brief system failure is unacceptable in settings. In such situations locks can sometimes function a security mechanism just in case of loss of air supply (or its pressure falling) and, thus, remedy or abate any damage arising in such a situation. Due to the leakage of air from input or output reduces the pressure then the specified output.

a) *Types:* Although pneumatic cylinders will vary in appearance, size and performance, they typically fall under one among the precise categories shown below. However there also are numerous other sorts of pneumatic cylinder available, many of which are designed to satisfy specific and specialized functions.

2) *Single Acting Cylinders:* Single acting cylinders (SAC) use the pressure imparted by compressed gas to make a drive in one direction (usually out), and a spring to return to the "home" position.

a) *Double Acting Cylinders:* Double Acting Cylinders (DAC) uses the force of air to maneuver in both extends and retracts strokes. These cylinders have two ports, one to allow air in, one for outstroke and one for in stroke.

b) *Sizes:* Air cylinders are available during a sort of sizes and may typically range from a little 2.5 mm air cylinder, which could be used for selecting up a little transistor or other electronic component, to 400 mm diameter air cylinders which might impart enough force to lift a car. Some pneumatic cylinders reach 1000 mm in diameter, and are utilized in place of hydraulic cylinders for special circumstances where leaking hydraulic oil could impose an extreme hazard.

3) *Pressure, Radius, Area and Force Relationships:* Although the diameter of the piston and therefore the force exerted by a cylinder are related, they're indirectly proportional to at least one another. Additionally, the standard mathematical relationship between the 2 assumes that the air supply doesn't become saturated. Due to the effective cross sectional area reduced by the world of the connecting rod , the in stroke force is a smaller amount than the outstroke force when both are powered pneumatically and by same supply of compressed gas.

The relationship, between force on outstroke, pressure and radius, is as follows:

$$F = P \times \pi R^2$$

This is derived from the relationship, between force, pressure and effective cross-sectional area, which is:

F =P A

With an equivalent symbolic notation of variables as above, but also A represents the effective cross sectional area. On in stroke, an equivalent relationship between force exerted, pressure and effective cross sectional area applies as discussed above for outstroke. However, since the cross sectional area is a smaller amount than the piston area the connection between force, pressure and radius is different. The calculation isn't more complicated though, since the effective cross sectional area is simply that of the piston less that of the connecting rod .

For in stroke, therefore, the relationship between force exerted, pressure, radius of the piston, and radius of the piston rod, is as follows:

$$F = p(\pi r_1^2 - \pi r_2^2) = p\pi(r_1^2 - r_2^2)$$

Where:

F represents the force exerted
r_1 represents the radius of the piston
r_2 represents the radius of the piston rod
π is pi, approximately equal to 3.14159.

4) *Cylinder*

The two main basic criteria for determining the cylinder diameter are

a) The load to be moved

b) The operating speed

The calculated forces are the theoretical static thrusts .It is effective to select cylinder having 15 to 20% higher rating of alloy for internal friction, other mechanical losses in the system and loss of line pressure. If high piston speed and acceleration loads are called for cylinder are still ineffective. In the case of external type cushioning exhaust flow control buffer cylinder are employed to restrict the air path and to provide the necessary cushioning effect. Here the piston can work effectively at high speeds.

5) *Piston:* Aluminium, brass, copper, cast iron and steel are some of the materials used for piston depending on whether the application involved light or heavy duty. Further, piston may be one piece in consideration to the type of packing used. For example,"U" ring requires one piece construction where cup packing requires three piece construction. The different types of packing are generally used include the cup type."U" rings,"O" rings and synthetic packing depending on the service condition.

6) *Piston Rod:* Piston rod material should be ground and polished steel possessing the specified lastingness for the appliance intended. Standard rod ends could also be anyone of the subsequent type namely male threaded, female threaded and plane end and bored. Commercially piston rods are made from high tensile steel and are hard chrome plated. Piston rods for cylinders with large stroke length should be resistance. Further connecting rod could also be single ended(rod projecting from one cover) or double ended(rod projected from both covers).Double ended piston rods are more advantageous as they supply better alignment and one end may transmit the force while other end operates limit switches.
7) *Pneumatic Valve:* The connection from pressure regulator connect to 5/2 DC valve hand lever operated. Be car of hand lever we give easily motion to sliding mechanism.

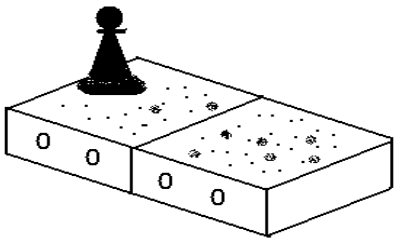

Fig.4 direction control valve

8) *Pressure Regulator:* The pressure regulator is used to manage the required pressure for the pneumatic system. It uses a piston to sense downstream pressure fluctuations. The piston, in turn, works against a gaggle spring pressure. Because the pressure downstream drops it's sensed by the diaphragm and therefore the popper valve opens. This adjusts the position of the poppet; this limits the downstream pressure to the pre-set valve. A gas compressor could also be a robot that increases the pressure of a gas by reducing its volume. Compressors increase the pressure on a fluid and can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the number of a gas. Liquids are relatively incompressible, while some are often compressed, the foremost action of a pump is to pressurize and transport liquids.
9) *Wheels:* Our robot is wheeler robot, four wheel drive. These four wheels are mounted on D.C. motor. Wheels are made up of Nylon.
10) *Arm:* There are two single, continuous, horizontal arm, which is fixed at one side to the top plate. Up and down movement of the horizontal arm which allows picking up of the material at any desirable height. It also supports piston and gripper arrangement.

C. Design Of Zero Turn Mechanism

1) Detailing Of Zero Turn Mechanism

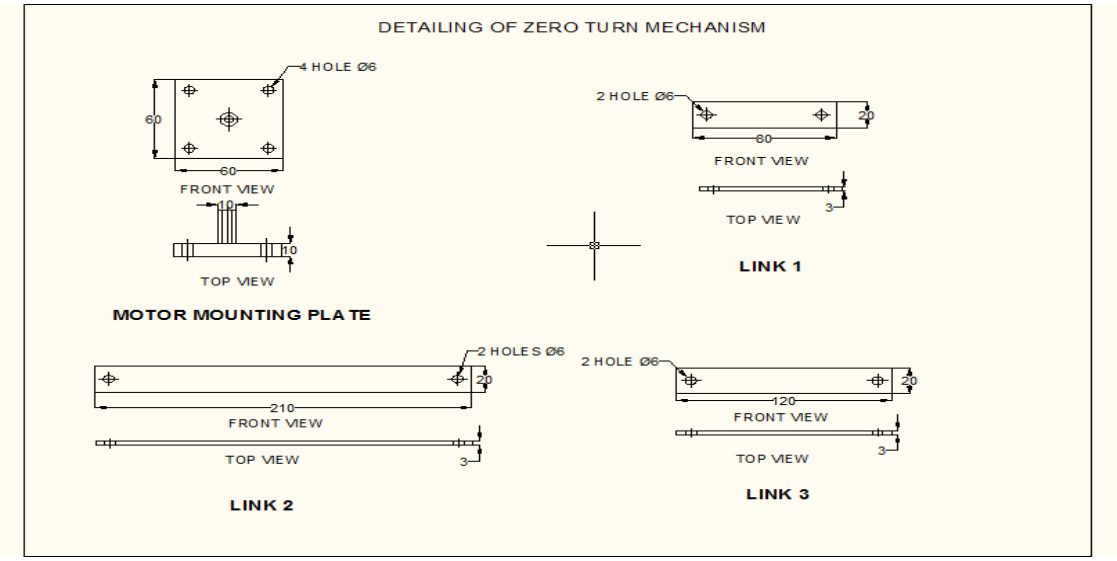

Fig.5 Detailed diagram

2) Assembly Of Zero Turn Mechanism

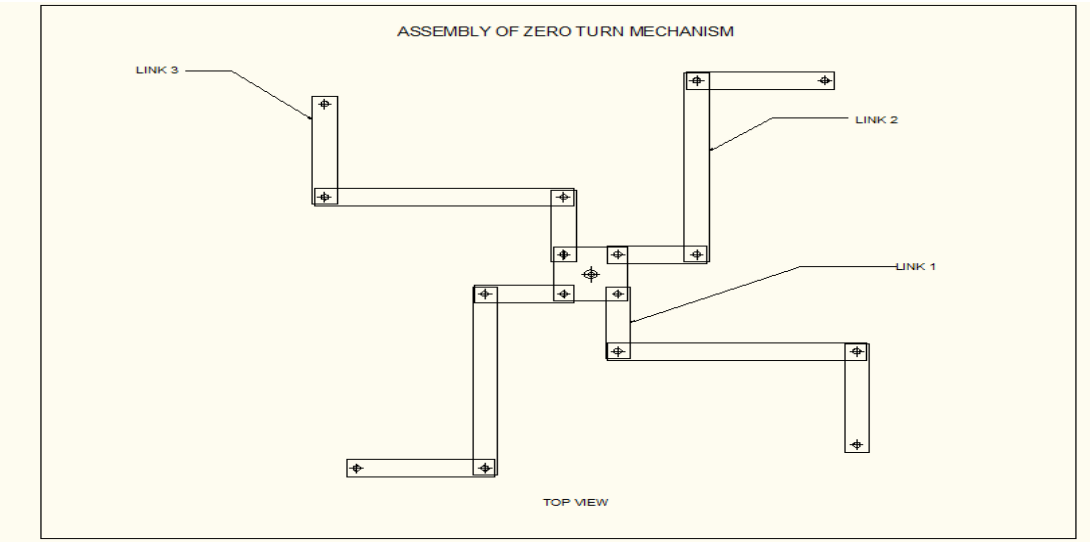

Fig.6 Zero turns mechanism

IV. WORKING

In this project pneumatic as well as electric actuators are used to actuate the robot. Working of the robot is explained by using following step.

A. Voltage Regulator

It is the electronics device used to convert AC to DC. First AC electric signal is given to the voltage regulator then it converts AC to DC and that signal is given to the remote.

B. Remote

It is device used to control the motion of robot. Remote used in this project consist of four switches. First switch is used to control the forward and backward motion of two motor on the left side of robot. In the same way second switch is used to control the motion of two motors on the right side. Third switch is used to control the motor used for zero turn mechanism. Fourth switch is used to control the motion of motor used to rotate arm supporting plate.

Fig.7 Working Model Of Zero Turn Robot

C. *Pneumatic Cylinder*

The compressed air from compressor is given to the pneumatic cylinder through pressure regulator. The motion of the each cylinder is controlled by direction control valve (DCV).Vertical cylinder control the up down motion supporting structure. Upper vertical cylinder controls the motion of arm. And third one controls the motion of gripper to hold the object.

D. *Arm and Gripper*

Gripper is connected to the arm and motion of gripper is control by the pneumatic cylinder. Arm is mounted on the arm supporting plate and motion of the arm is also control by using pneumatic cylinder. Gripper is used to hold the object.

Fig.8 Arm And Gripper

V. OBSERVATION AND CALCULATION

In our attempt to design a pneumatic robot, we have adopted a very careful approach. Total design work has been divided into two parts mainly,

1) System Design
2) Mechanical Design

System design mainly concern with the various physical concerns and ergonomics, space requirements, arrangements of various components on the main frame of machine, number of controls, positions of this controls, ease of maintenance, scope of further improvements, height of machine components from the ground etc. In mechanical design, the components are categorized into two parts.

a) Design of Parts
b) Parts to be purchased

For design parts, detailed design is done and dimensions thus obtained are compared to next highest dimensions which are readily available in the market. This simplifies the assembly as well as post production servicing work. The various tolerances on work pieces are specified in the manufacturing drawing. The process sheets are prepared and passed on to the manufacturing stage. The parts are to be purchased directly are specified and selected from standard catalogues.

A. *Design Of Arm*

Selecting mild steel for arm, S_{ut} for MS =650 N/mm^2
Square pipe is used for the arm having size (25×25×2) mm
Let, L= length of arm =380 mm
Force on the arm = Total weight of arm and the weight to be lifted
= 5×9.81
= 49.05 N
Moment, M = F×L
M =49.05×380
M =18639 N-mm

Moment of inertia for square pipe calculated above,

I=9232+9232= 18464 mm^4, $y = 12.5$mm

We know that, $\sigma_{actual}=\frac{M}{I} \times y$

$\sigma_{actual}=\frac{18639}{18464} \times 12.5$

σ_{actual}=12.61 N/mm^2

$\sigma_{permissible}=\frac{S_{ut}}{FOS}$

$\sigma_{permissible}=\frac{650}{2}$

= 325 N/mm^2

$\sigma_{actual} < \sigma_{permissible}$

Therefore design is safe

B. Design Of Base Frame

Base frame is structure on which whole robot assembly is mounted.

For design of base considering approximate weight on the base frame is 15 kg

W=15kg

Force =W × g

F=20×9.81

F=196.2 N

There are four key points shown in fig where total weight acts. So, considering load is equally at the each point i.e. on the each link.

Force acting on each link,

F1 $=\frac{196.2}{4}$ = 49.05 N

Let,L_1= Length of link 1

L_1= 380 mm

So bending moment (M) for link 1 is given by

M=$F_1 \times L_1$

M=49.05×380

M=18639 N-mm

We are using MS square pipe .MS square pipe has comparatively high strength in twisting and bending than flat MS.

So selecting MS square pipe (25× 25×2) mm

Calculating moment of inertia (I)

Cross section of square pipe is shown in fig.

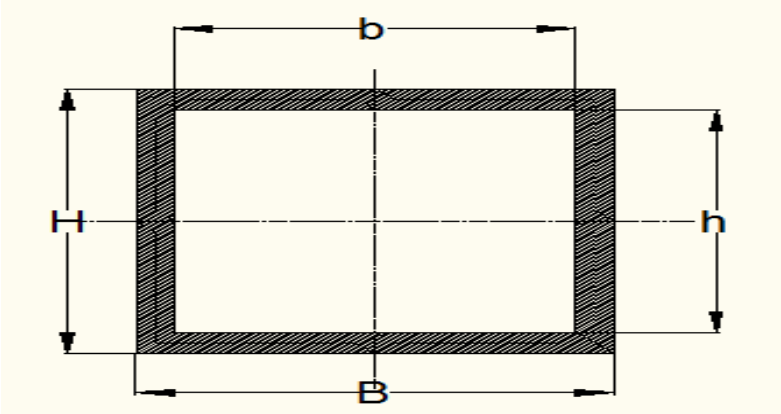

Fig.9 Square pipe cross section

B=25 mm, H=25 mm, b=23 mm ,h=23mm
Area, A=B× H-b× h
A= (25× 25)-(23× 23)
A=96 mm^2
Moment of inertia about X-X

$$I_{xx}=\frac{BH^3}{12}-\frac{bh^3}{12}$$

$$I_{xx}=\frac{(25\times25^3)}{12}-\frac{(23\times23^3)}{12}$$

I_{xx}=9232 mm^4
Moment of inertia about Y-Y

$$I_{yy}=\frac{HB^3}{12}-\frac{hb^3}{12}$$

I_{yy}=9232 mm^4
Therefore, $I=I_{xx}+I_{yy}$
I=9232+9232=18464 mm^4
Pipe is square therefore distance of C.G from x-axis $y=\frac{B}{2}$=12.5 mm
We know that,

$$\frac{M}{I}=\frac{\sigma}{y}$$

Therefore, $\sigma_{actual}=\frac{M}{I}\times y$

, $\sigma_{actual}=\frac{18639}{18464}\times 12.5$

σ_{actual}=12.61 N/mm^2
S_{ut} for MS =650 N/mm^2
Assuming FOS is 2

$$\sigma_{permissible}=\frac{S_{ut}}{FOS}$$

$$\sigma_{permissible}=\frac{650}{2}$$

= 325 N/mm^2

$\sigma_{actual}<\sigma_{permissible}$
Therefore design is safe

C. Design Of Shaft

There are four shaft used for four motor mounting plate .Each shaft carries load equal to one fourth of the total load
Total approximate weight of the robot with the object which to be handled is considered is 20 kg
W= m×g
=20×9.81
=196.2 N
Therefore, force on the shaft =$\frac{196.2}{4}$=49.05 N
Considering shaft is made up of MS material having S_{yt}= 320 N/mm^2

$$\sigma_t=\frac{F}{A}$$

$$\sigma_t=\frac{49.05}{\frac{\pi}{4}\times d^2}$$

Now, $\sigma_{permissible}=\frac{S_{yt}}{FOS}$

$\sigma_{permissible}=\frac{320}{2}=160 N/mm^2$

$\sigma_t=\sigma_{permissible}$

$\frac{49.05}{\frac{\pi}{4}\times d^2}=160$

d=0.6247 mm

but d=0.6247 mm is very small therefore selecting shaft with diameter 10 mm

D. Motor Selection

1) Upper Motor Selection

Considering total weight of upper part is 10 kg.

The required rpm at upper part is near about 20 to 30 rpm.

W= m×g

W= 10×9.81

W=98.1 N

Therefore selecting the DC gear motor with speed 30 rpm and torque 120 N-cm

2) Lower Motor Selection

There are four motors required for four wheels.

Considering approximate weight of the robot is 20 kg, therefore weight on the one motor is 5 kg.

Speed required for each wheel is 20-30 rpm.

W= m×g

W= 5×9.81

W= 49.05 N

Wheel are very close to the base frame so neglecting length of shaft ,therefore torque on the each wheel is 49 N-cm .

Therefore selecting DC gear motor with speed 30 rpm and torque 120 N-cm

E. Remote Compressed Air Tank:

The main disadvantage of our robot is that, the compressed air should be supplied to the robot at every location when it moves from one position to another. We have to supply this compressed air by using the pneumatic hose.

If there is a compressed air supply tank which can move along with the robot, the above problem can be overcome. But it will increase the load to be carried with the robot. But the robot can cover any distance and it can go at any desirable position. When compressed air tank become empty it can be again recharged with compressed air.

F. Automated Robot By Using Programming:

The robot developed by us is manually operated. Thus it need full attention of worker to operate the robot. This robot can be modified to fully automated robot by using the programming. This automated robot can perform any specified work in minimum time and with high accuracy. It can be used to transfer the job from one work station to another If the path of the operation is given through programming.. This robot does not need any operator or attention. Line tracker robot is another improvement that can be done for specific work.

1) *Walking Robot:* Instead of using the wheels for the locomotion, we can make the walking robot. If the obstacle came in the path of the wheeler robot it could not move. But we can use the walking robot in that case very effectively.
2) *Actual Industrial Prototype:* We developed just a model of the pneumatic robot. In this we have used pneumatic piston-cylinders with small stroke. But if we want to develop a robot that is to be used in the factory floor, we can use the piston-cylinders with higher stroke to get the large movement of the arm. Also high lifting capacity electromagnet can be used to lift the heavy weight magnetic material.
3) *Lifting Of Non-Magnetic Material:* If we want to lift the non-magnetic material or job then it is not possible to lift it with the electromagnet. We can design the movable jaw or arm to lift the non-magnetic material instead of electromagnet.

VI. CONCLUSION

The challenge however was the way to combine this with the 'standard' 4WD and 4WS. An option would have been to power the left and right drive train and steer each wheel independently, but because that was already done by 'Coney' in this project concept is given something differently. The problem also with steering each wheel independently is that they easily end up misaligned, unless there are some electronics like in the real Hurricane. So first question and challenge was if it would be possible to solve the problem of the different wheel configurations mechanically in such a way that all the wheels are related and connected with each other altogether positions, not forgetting that they also needed to be individually powered and suspended. For the standard steering mode, having the position of the left and right wheels connected with each other, also knew that by moving the whole link away from the wheels, they turn inwards. This had to be achieved by a controlled by using shaft slides in bush. The next challenge was to seek out an answer for switching from normal drive to skid steer drive, using just one input. In any case it was.

In regular steering mode, the rear wheels turn in the opposite direction of the front wheels, which severely tightens the turning radius adding more accurate steering. In second mode, the rear wheels turn in the same direction as the front wheels, move to the side without changing the direction that it faces. This whole concept is amazing in own opinion.

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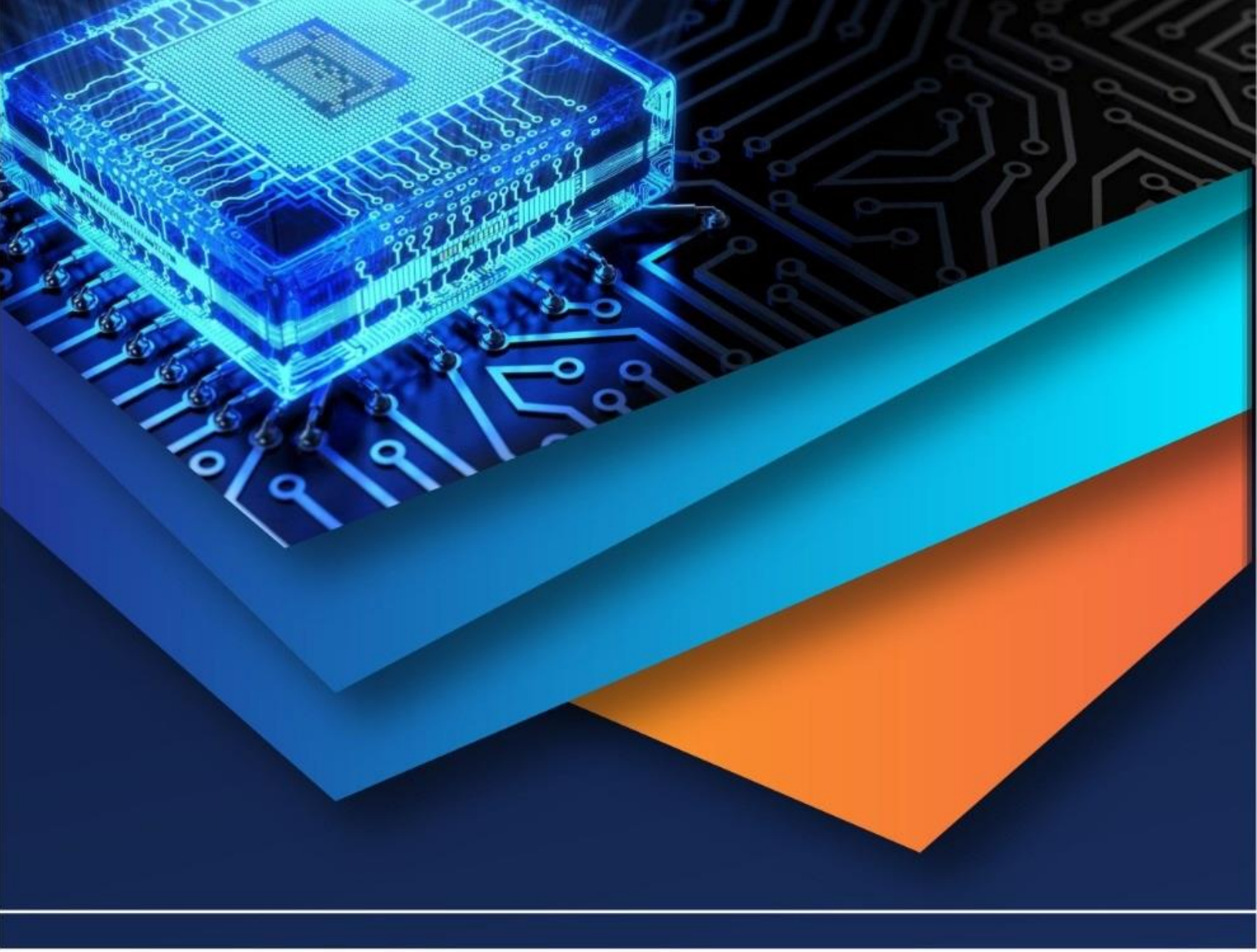

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