

## Design and Fabrication of Two Axis Pneumatic Arm

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**Abstract** - Nowadays, hydraulic systems are in use in many areas. As hydraulic have some disadvantages such as the seal of the hydraulic cylinder needs to be change periodically because it get wear out. As a result, leakage problem occurs in the cylinder. The price of hydraulic system is too high, so we are replacing it with pneumatic. So, in this pneumatic system, we are using the principles of pneumatics. As we know that air is freely available, so we can use it to obtain the mechanical advantages from this system. It consists of three pneumatic cylinders, two gears, D. C. motor and mechanical linkages. The cylinders are used to give movement to the arms and the gears are used to give rotary movement of 360 degrees. It can be used where low tonnage capacity work is required such as in agriculture sector and for industrial purposes.

**Key Words:** Hydraulic cylinder, Pneumatic, Pneumatic cylinder, D. C. motor, mechanical linkages.

### 1. INTRODUCTION

Pneumatic is a branch of technology, which deals with the study and application of use of pressurized gas to affect mechanical motion. Pneumatic cylinder turns air pressure into linear motion. They are like automobile piston except the piston (and connecting rod) is pushed by an influx of pressurized gas instead of a gasoline explosion. The piston must be returned to the starting position after each stroke. If a spring is used to return the piston, it is a single acting cylinder. If air pressure is used to return the piston, it is a double acting cylinder. Automation can be achieve through computers, hydraulic, pneumatic, robotics etc. of these source pneumatic form an attractive medium for low cost automation. Automation plays an important role in automobile. Nowadays almost all the automobile vehicle is being atomized in order to product the human being.

### 1.1 PROBLEM IDENTIFICATION IN HYDRAULIC SYSTEM

Presently only the Hydraulic JCB is present in the market. But this JCB has a some disadvantages such as

- 1) It's operation is based on hydraulic system i.e. on the fluid. Due to this there is problem of fluid leakage.
- 2) The hydraulic system required the more parts therefore it required the more maintenance.
- 3) Changing of fluid is continuously therefore it required the more amount of money
- 4) The hydraulic system mainly consist of piston and cylinder arrangement therefore the wear and tear is more if the lubrication is not done at correct time.
- 5) The cost of hydraulic JCB is more as compared to pneumatic JCB.
- 6) It's construction is complicated and heavy.

### 1.2 SOLUTION WITH PNEUMATIC SYSTEM FOR ABOVE PROBLEM

We decide the project to avoid the above mention problem of hydraulic JCB to make the prototype model of Pneumatic JCB. Pneumatic JCB consist of the compress air which is largely free available in the atmosphere, only we required the cost to compress it. The construction of Pneumatic JCB is simple. It required only the pneumatic circuit for operation. Its construction is simple and light weight. It required the small space for installation of pneumatic circuit. There is no problem of air leakage as compared to fluid leakage. The one main advantage of hydraulic JCB is that it capacity is large as compared to the pneumatic JCB. But the main problem is that if for small scale industry no choice of alternative JCB even if its requirement is small capacity load. Alternatively it purchase the large capacity hydraulic JCB by paid the more amount of money. Because for large capacity to pay a large amount of money. Therefore we decide to make a small capacity JCB for small scale industry at less cost.

## 2. PNEUMATIC SYSTEM

Pneumatic system in fixed installation such as a factories used compressed air because of sustainable supply can be made by a compressing atmospheric air. The air usually has moisture removed and a small quantity of oil added at the compressor to avoid the corrosion of mechanical components and to lubricate them.

Factory – plumbed, pneumatic- power user need not worry about poisonous leakage as the gas is commonly just air. Smaller –or stand –alone system can use other compressed gases which are an asphyxiation hazard, such as a nitrogen- often referred to as a OFN (oxygen-free nitrogen), when supplied in cylinders.

Any compressed gas other than air is an asphyxiation hazard- including nitrogen, which makes up 77% of air . compressed oxygen (approx. 23% of air) would not asphyxiate, but it would be an extreme fire hazard, so is never use in a pneumatically powered device.

Portable pneumatic tools and small vehicles such as a robot wars machines and other hobbyist application are often powered by compressed carbon di oxide because containers design to hold it such as a soda stream canisters and fire extinguisher are readily available, and the phase change between liquid and gas make it possible to obtain a large volume of compressed gas form a lighter container than compressed air would allow. Carbon di oxide is an asphyxia and can also be a freezing hazard when vented inappropriately.

### 2.1 Selection of a pneumatic system:

Mechanization is broadly defined as the replacement of manual effort by mechanical power. Pneumatic is an attractive medium for a low cost mechanization particularly sequential repetitive operational. Many factories and plants already have compressed air system, which is capable of providing the power energy requirement and the control system (although equally pneumatic control system may be economics and can be advantageously applied to other forms of a power)

The main advantage of an all pneumatic system are usually economic and simplicity the latter reducing maintenance to a low level. It can also have outstanding advantages in terms of a safety.

### 2.2 Advantages of pneumatic system :

- 1) Pneumatic systems tend to have long operating lives and require very little maintenance.
- 2) Because gas is compressible, the equipment is less likely to be damaged by shock.

- 3) The gas in pneumatics absorb excessive force, where as the fluid of a hydraulics directly transfers force.

- 4) Simplicity of design and control
- 5) Machines are easily designed using standard cylinders & other component. Control is as easy as it is simple ON-OFF type control.

### 2.3 Examples of pneumatic system:

- 1) Air brakes on buses and trucks.
- 2) Air brakes, on trains.
- 3) Air compressors.
- 4) Air engines for pneumatically powered vehicles.

## 3. MAIN COMPONENTS OF THE PROJECT :

- 1) Reciprocating Compressor
- 2) P.U. tubes
- 3) Direction control valve (Solenoid valve)
- 4) Spur gear
- 5) Roller ball bearing
- 6) D.C. motor
- 7) Base frame

### 3.1 Components specification:

#### 3.1.1. Base frame

The base frame is an structural element that supports the entire system. The frame carries the drive system at its lower end which comprises of the Spur gear. The drive motor is mounted on the base frame.

#### 3.1.2. Drive system (motor)

Drive system comprises of the DC motor with following specifications

Motor is an 12 volt DC motor , with following specification:

Voltage : 12 Volt DC

Power = 60 watt

Speed = 50 rpm

Mounting : Foot mounted

### 3.1.3. Pneumatic linear actuator

The pneumatic linear actuator is an Standard cylinder DNU-16-25-PPV-A. This cylinder is an double acting cylinder that is operated by an pneumatic valve 5/2 way. The valve is supplied compressed air from the compressor by means of an appropriate filter-regulator-lubricator (FRL) unit.

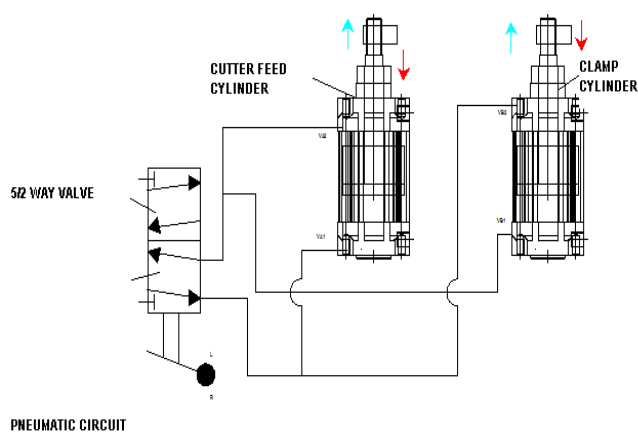
### 3.1.4. Position control system

The position system comprises of the following components;

- 1) 5/2 way, hand operated valves, center off, detent type
- 2) Pneumatic cylinder DPNC connectors

### 3.1.5. Pneumatic circuit

Pneumatic circuit uses two double acting pneumatic cylinders, one 5/2 way direction control valve and one flow control valve, functions of the above components have already being explained above.



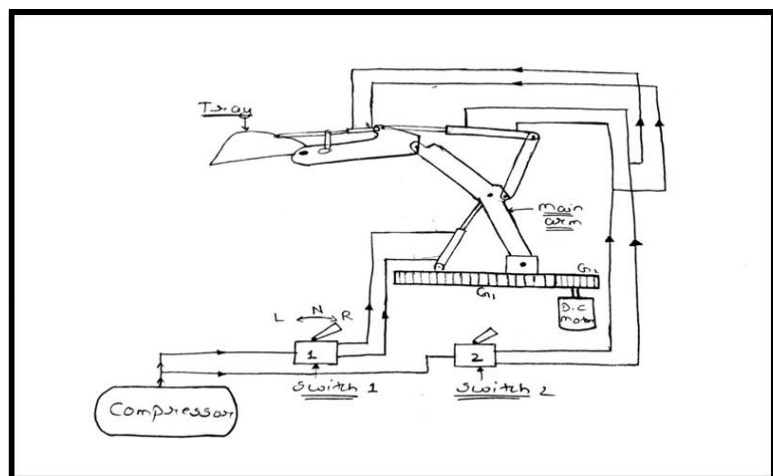
### 4. WORKING OF THE MODEL

- 1) The working of "TWO AXES PNEUMATIC ARM" is fully depends on the principles of pneumatics.

- 2) There are 3 pneumatic cylinders which control the movement of respective one arm.
- 3) There is one main arm as shown fig. which is control by one cylinder, the 2<sup>nd</sup> cylinder is there is to operate the 2<sup>nd</sup> arm. And the 3<sup>rd</sup> cylinder is connected to give movement to the tray.
- 4) There are 2 switches (switch 1 & switch 2) used to operate the cylinders. The first switch is used to operate the cylinder of the main arm and 2<sup>nd</sup> switch operates the rest of the two cylinders.
- 5) This assembly is mounted on one gear which gives rotary motion of 360degrees. This gear is rotate by one D. C. Motor.
- 6) The compressor compresses the air at some pressure and this pressurized air is used to obtain the mechanical advantage of the arms.
- 7) When switch 1 is used, the first cylinder performs its work and the main arm has the displacement instantly.
- 8) Similarly, switch 2 give motions to the rest of the two cylinders as the piping of these are connected together.

So, in this way we can give the motion of the tray according to our need.

### 5. DESIGN OF THE COMPONENTS



### 5.1 Design of pneumatic cylinder

1) Maximum pressure applied by piston cylinder actuator=10 bar =1 N/mm<sup>2</sup>

2) Force (F):

As per formula,  $F=P \times \pi d^2/4$

$$F=1 \times \pi (25)^2/4$$

$$F=491 \text{ N}$$

3) Volume of cylinder (V):

As per formula,  $(V) = A \times L$

Where,

A=area of cylinder in mm<sup>2</sup>

L= length of cylinder in mm<sup>2</sup>

V=volume of cylinder

$$V = \pi d^2/4 \times L$$

$$= \pi \times 25^2/4 \times 50$$

$$= 24.543 \times 10^3 \text{ mm}^3$$

4) Discharge (Q): = volume/ time

$$= 24.543 \times 10^3/60$$

$$= 409.06 \text{ mm}^3/\text{sec}$$

5) Area of piston(A) :

$$A= \pi d^2/4$$

$$= \pi \times 25^2/4$$

$$= 490.87 \text{ mm}^2$$

6) Piston speed (S) :

As per formula,  $s=28.8 \times Q/ A$

Where,

S= velocity in mm/ sec

Q= volume of flow mm<sup>3</sup> /sec

A= area of piston in mm<sup>2</sup>

$$S=28.8 \times 409.06/490.87$$

$$= 24 \text{ mm/sec}$$

### 5.2 Design of gear (meshed pair):

1) Selecting tooth profile

Select 20° full depth profile of gear tooth

$$\phi=20^\circ \text{ full depth}$$

2) Selecting no of teeth

No of teeth on pinion ( $t_p$ )=21

No of teeth on gear ( $t_g$ )=96

Velocity ratio (V.R) =  $t_g / t_p$

$$= 96/21$$

$$= 4.57$$

3) Pitch diameter ( $D_p$ )

$$D_p = t_p \times m$$

$$= 21m$$

Where, m=module

4) Pitch line velocity ( $V_p$ )

From data book page no 164 table XVI-1

$$V_p = \pi \times D_p \times N$$

Where,

$D_p$  =pitch circle dia. Of pinion

$$= t_p \times m$$

Where,

M=module of gear

$$D_p=21 \times m$$

Therefore,

$$V_p = \pi \times 21 \times m \times 40/60 \times 1000$$

$$= 0.043m \text{ m/sec}$$

5) Tangential tooth load ( $F_t$ )

From data book table no XVI-1

$$F_t = P_d / V_p$$

$$= 1 \times 10^3 / 0.043m$$

$$= 23255/m \text{ N}$$

6) Bending strength ( $F_b$ )

By lewis equation  
 From data book table no XVI-1  
 $F_b = S_o \times C_v \times b \times y \times m$   
 Where,  
 $C_v = \text{velocity factor}$   
 $C_v = 0.30$   
 $B = 10 \text{ m (assumed)}$   
 $Y = \text{modified lewis from factor}$   
 For  $20^\circ$  full depth  
 $Y = 0.485 - 2.87 / t$

$$= 21 \times 4$$

$$= 84 \text{ mm}$$

Pitch line velocity ( $V_p$ )

$$V_p = \pi \times D_p \times N$$

$$V_p = \pi \times 21 \times 4 \times 40 / 60 \times 1000$$

$$= 0.175 \text{ m/sec}$$

For pinion  
 $Y_p = 0.485 - 2.87 / t_p$   
 $Y_p = 0.485 - 2.87 / 21$   
 $Y_p = 0.348$

Tangential tooth load ( $F_t$ )

$$F_t = 23255 / 4$$

$$F_t = 5813.75 \text{ N}$$

For gear  
 $Y_g = 0.485 - 2.87 / 96$   
 $Y_g = 0.455$

Bending strength

$$F_b = S_o \times C_v \times b \times y \times m$$

$$= 456 \times 0.34 \times b \times 0.348 \times 4$$

$$= 215.81 \times b \text{ N}$$

$$F_t = F_b$$

$$5813.75 = 215.81 \times b$$

$$b = 26.93 \text{ mm}$$

$b = \text{Face width of gears}$

As,  
 $(S_o y)_p = 456 \times 0.348$   
 $= 158.68$

but  $b(\text{min}) = 8.5 \times m$

$$= 8.5 \times 4$$

Where,  
 $S_o = 456 \text{ Mpa}$   
 For SAE 3245 heat treated  
 $(S_o y)_g = 456 \times 0.455$   
 $= 207.48$

$$(S_o y)_p < (S_o y)_g$$

$$b = 34 \text{ mm}$$

Hence pinion is weaker in bending  
 $(F_b)_p = S_o \times C_v \times b \times y \times m$   
 $= 0.30 \times 10 \text{ m} \times m \times 158.68$

$$(f_b)_p = 476.04 \text{ m}^2$$

Bending strength

$$F_b = 456 \times 0.34 \times 34 \times 0.348 \times 4$$

$$= 7337.73 \text{ N}$$

$$\text{As } F_b > F_t$$

Hence design is safe.

7) Find out module ( $m$ )

Equating  $F_t$  and  $F_b$

$$23255 / m = 476.04 \text{ m}^2$$

$$M^3 = 23333.33 / 476.04$$

$$M = 3.65$$

From table no XVI-7 page no 169

Selecting std. value of module

$$M = 4$$

8) Calculate actual value

Pitch circle dia. ( $D_p$ )

$$D_p = 21 \text{ m}$$

## 6. CONCLUSIONS

From above experimentation it is found that, by using pneumatic system we can perform less tonnage of work such as agro industrial work, ash handling, etc. The compressor used to compress the atmospheric air and that compressed air is used in pneumatic cylinder to give motion to the arm. It

offers an efficient and less expensive alternative for the hydraulic system.

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