Design and Fabrication of Pneumatic Arm

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Abstract - *The designed pneumatic arm consists of four cylinders, a shaft works with lead screw mechanism capable of converting motion of piston to rotational motion of arm with help of using compressed air. The designed processes are carried out based on integrated information of kinematics dynamics and structural analysis of the desired robot configuration as whole. The highly dynamic pneumatic arm model can be easily set at intermediate positions by regulating the pressure using the flow control valve. As the pneumatic arm is constructed with light materials, so that it will be much easier for a person to handle it with proper manner. The handling of materials and mechanisms to pick and place of objects from lower plane to higher plane and are widely found in factories and industrial manufacturing.*

***Key Words*: Pneumatic, Piston, materials, mechanism**

1.INTRODUCTION

Material handling is a necessary and significant component of any productive activity. It is something that goes on in every plant all the time. Material handling means providing the right amount of the right material, in the right condition, at the right place, at the right time, in the right position and for the right cost, by using the right method. It is simply picking up, moving, and lying down of materials through manufacture. It applies to the movement of raw materials, parts in process, finished goods, packing materials, and disposal of scraps. In general, hundreds and thousands tons of materials are handled daily requiring the use of large amount of manpower while the movement of materials takes place from one processing area to another or from one department to another department of the plant. The cost of material handling contributes significantly to the total cost of manufacturing. Handling and storing materials involve diverse operations such as hoisting tons of steel with a crane; driving a truck loaded with concrete blocks; carrying bags or materials manually; and stacking palletized bricks or other materials such as drums, barrels, kegs, and lumber. The efficient handling and storing of materials are vital to industry.

2. LITERATURE REVIEW

2.1 Design and Fabrication of Pneumatic Arm for Pick and Place of Cylindrical Objects.

In this Paper Santosh C, et. al. [1] mention Robotic arm used to carry out highly repetitive, material handling and precision tasks such as spot welding, assembling, cutting, palletizing, spray painting etc. in manufacturing industries. It is a programmable device with similar attributed to that of a human arm and is best suited to hazardous environments where human intervention is highly undesirable.

2.2 Design and Development of a 3 axes Pneumatic Robotic Arm.

In this paper Biswas Palok et. al [2] describe Pneumatic robots are essential for material handling in chemical industries where electric or hydraulic robots are unsuitable due to fire hazard. A 3 axes (3 Degrees of Freedom) articulated pneumatic robotic arm was designed and assembled in this project along with its control system. Pneumatic rod less linear actuators were used as the main drive system for the robotic arm and were controlled by pneumatic 5/3-way proportional directional control valve. The design of the arm for this project implements crank mechanism to convert linear actuation displacement to angular displacement about the joint.

2.3 Design and Fabrication of Pneumatic Robotic Arm.

In this Paper Prof S. N Teli et. al [3] discusses about Design and fabricate pneumatic arm for pick and place of cylindrical objects. The handling of materials and mechanisms to pick and place of objects from lower plane to higher plane and are widely found in factories and industrial manufacturing. There are number of pneumatic arms are available which consists of so many mechanisms hence becomes expensive. The designed pneumatic arm consists of two cylinders, a shaft works with lead screw mechanism capable of converting motion of piston to rotational motion of arm with help of using compressed air. The designed processes are carried out based on integrated information of kinematics dynamics and structural analysis of the desired robot configuration as whole. The highly dynamic pneumatic arm model can be easily set at intermediate positions by regulating the pressure using the flow control valve. It can be used in loading and unloading of goods in a shipping harbour as the movement of goods is done from lower plane to higher plane.

3. OBJECTIVE AND MOTIVATION

3.1 OBJECTIVE

The main objective of our proposed work is Design and fabricate a pneumatic arm to pick and place objects from lower plane to higher plane by using Steel frame, Al cylinders, C-45 Pistons, manual operated pilot valve and grippers.

3.2 MOTIVATION

Pneumatic arm are mainly used to carry out material handling and precision tasks such as spot welding, assembling, cutting, palletizing, spray painting etc. in manufacturing industries. Pneumatic driven systems are of lower cost than hydraulic and electromechanical systems and perform well in carrying out arduous work. So here an attempt is made to design a machine which will be faster in action

4. PRELIMINARY STUDY OF PROJECT

Pneumatic arm consist of following main components:-

4.1 CHASSIS (FRAME)

We have used the ½ inch square pipe for the chassis of the pneumatic arm. When there are no suspension used in the pneumatic arm to lift the weight so the chassis must be able to absorb some of the jerks and vibrations, also it must be stiff enough, not to break or twist during the lifting of loads. In order to reduce the weight and cost, simple square pipes had been used in this frame.

Fig- 4.1.1: Chassis (Frame) before welding

4.2 DOUBLE ACTING AIR CYLINDERS (32X100MM)

Double-acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for out-stroke and one for in-stroke. Stroke length for this design is not limited, however, the piston rod is more vulnerable to buckling and bending. Additional calculations should be performed as well.

Fig- 4.2.1: Double acting air cylinders (32x100mm)

4.3 TEE FITTING PUSH (6MM)

Union push-to-connect fittings are available for use with 5/32, ¼, 5/16, 3/8 and 1/2 OD tube. Tubing connection and tightness are made possible by a stainless steel gripping collet and o-ring inside the fitting. Once inserted to the bottom of the fitting, the stainless steel collet grips the tube and prevents it from being disconnected until the release button is pushed.

Fig- 4.3.1: Composite Union Tee

4.4 SOLENOID VALVE 5/3 SOLENOID VALVE

"22" Series 4-Way solenoid operated valves feature single or double 12 VDC, 1 Watt solenoids. These 1/8 NPT (F) ported valves are available in a 5-Port 2-Position (5/2) or a 5-Port 3-Position (5/3) configuration. A latching solenoid replaces two solenoid valves in a 4-way, 2-Position "double solenoid" configuration; an energy and space saving option.

Fig- 4.4.1: Solenoid valve

4.5 PUSH FLOW CONTROL VALVE 1/8

Port mounted flow controls are ideal for adjusting the speed of extension and retraction for virtually any actuator. Most double acting applications are best served with meter-out style flow controls, which control the flow of exhaust air as it leaves the cylinder. By reducing the exhaust air flow rate, the flow control reduces the speed of travel of the cylinder rod.

Fig- 4.5.1: Push flow control valve.

4.6 PNEUMATIC POLYURETHANE PU HOSE TUBE PIPE (Ø= 6MM).

The pipes are suited for use in oil and fuel lines and petrol tank, breather pipes, for pneumatic controls as lubrication lines and others. These pipes have properties of handling the wide range of temperature changes, thus making these suitable for use in different climatic areas.

Fig - 4.6.1 : Polyurethane PU hose tube Pipes (6 mm)

4.7 SILENCER 1/8.

It used to reduce dynamic noise of the pneumatic components or device exhaust Easy installation and high nose reduction result, Quick and Reliable connections Used with: Cylinders, Valves, Crank cases, gear boxes, oil tanks, reservoirs, air tools.

Fig - 4.7.1: Brass muffler

4.8 AIR COMPRESSOR

In both home and commercial applications, one of the main roles of an air compressor is to provide power for pneumatic tools. Pneumatic tools include drills, impact wrenches, riveters, sanders and more — in fact, almost any conventional powered hand tool is available in an air-powered configuration.

4.9 STAINLESS STEEL CAPSULE PIPE (Ø=1 INCH).

Stainless steel Capsule pipe is the lightest material used for the arms. The pipe cost was Rs.50/ft, and we have ordered 14 feet of pipe. The total cost was Rs.700 for 14 feet of pipe. Out of which we have used 8 feet of pipe. 2 feet from shoulder to elbow and 2 feet from elbow to wrist, same for the other hand, 2 feet from shoulder to elbow and 2 feet from elbow to wrist.

4.10 BALL JOINT ROD ENDS HIGH POLISHED EYE BOLT.

Here, eye bolt is used for the free motion of the shoulders. Which allows the operator to move the arms freely and effortlessly. As shown in the figure 3.10 below, it has the eye kind of motion in it which rotates about 360 degrees in any direction.

Fig - 4.10.1 : Ball joint rod end eye bolt.

4.11 PISTON ROD END FORK CLEVIS 10MM.

These forks are used here for holding the other end of the piston rod with the arms. As shown in the below figure, both the cylinders have the forks at their end which holds the arm and gives it the motion of intake and exhaust.

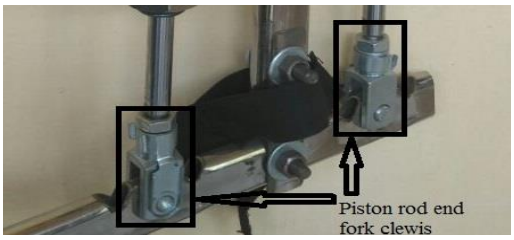

Fig - 3.11: Piston rod end fork clewis

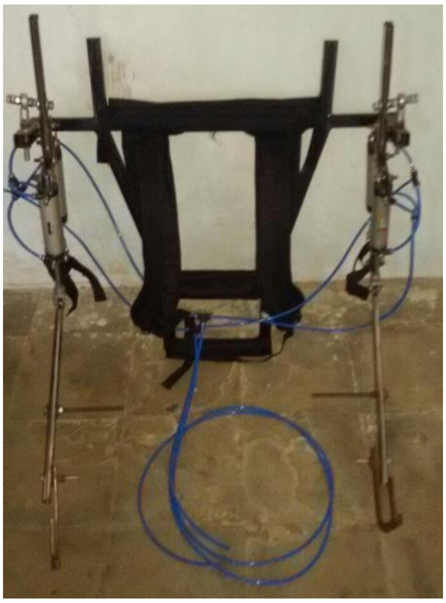

Fig – 3.12 : Photograph of Pneumatic Arm

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5. DESIGN OF PNEUMATIC ARM

Force exerted on the arm at the front side and at the back side of the elbow joint.

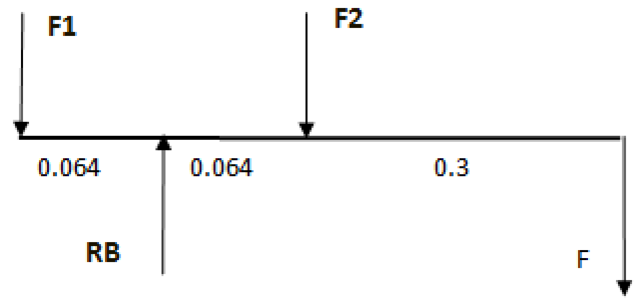

Fig - 5.1 : Stresses on arm

TAKING MOMENT ABOUT B

$\sum MB=0$

$F\times0.364-(F2+F3)0.064=0$

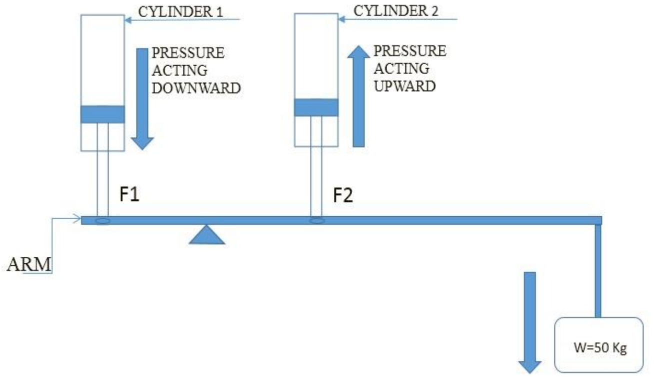

Fig - 5.2 : Schematic diagram of arm

SINCE F2=F1 AND F=294.3 NEWTONS

$294.3\times0.364=2\times F2\times0.064$

F2=836.91 NEWTONS.

F1=836.91 NEWTONS.

SUMMESION OF ALL FORCES

$\sum FY=0$

$-F1+F2+RB-F=0$

$-836.91+836.91+RB-836.91=0$

RB=836.91 NEWTONS.

Assumptions pressure in both cylinders are same

$W=F=30\times g$

$F=30\times9.81$

F=294.3 NEWTON

Where g=acceleration due to gravity.

F1=Force acting by cylinder 1 in (N)

F2=Force acting by cylinder 2 in (N)

N=Newton

W=Weight in kg

Standard sizes of pneumatic cylinder available in market (in diameter)

E.g. =5cm=0.05meter

Pressure requires in cylinder = force ÷area

$p=f\div a$

$p=836.91\div\prod/4\times d^2$

$p=836.91\div\prod/4\times0.05^2$

p=426234.763 Pascal

p=4.26 bar

P=61.80 psi. Since 100000pascal=1bar and 1bar=14.5 psi From assumption -pressure required in both cylinder are equal. Therefore pressure required in both cylinder=120.74psi

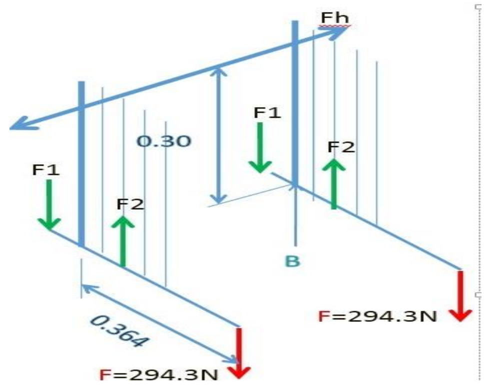

Fig - 5.3: Pressure exerted on

Pressure exerted on shoulder

Taking moment about b

$F\times0.364-fh\times0.3=0$

$294.3\times0.364=fh\times0.3$

Fh=357.08n fh=force on horizontal element

But also dead weight of body have to consider into calculation, since it also exerting the loads on shoulder

Therefore fh+body weight=total weight coming on shoulder

357.08+49.05=406.13n

Since body weight= $5kg=5\times g=5\times9.81=49.05n$

Pressure on shoulder=

F÷area of belt

$P=406.05\div50^2=0.16\ n/mm^2$

6. EXPERIMENTATION

6.1 AIR COMPRESSOR

- Manufacturing Company: - INDO-AIR compressors PVT. Ltd.
- Capacity of air compressor

6.2 DOUBLE ACTING AIR CYLINDERS

- Manufacturing Company: - TEXTRA.
- Dimensions of cylinder: - Diameter is 32mm & Length is 100mm.
- Type: - Double Acting Air cylinders.

6.3 SOLENOID VALVE

- Body: Aluminium Anodise.
- Pressure: 0.15 to 0.8 Mpa.
- Temp: 5 to 55°C.
- Seals: Nitrile / NBR.
- Volt: 12V.
- Media: Air (Filtered & Lubricated).

6.4 Estimated Cost of Component

Table - 6.4.1: Cost of Component

Sr no.	Components	Price/unit (Rs.)	Quantity	Total cost (Rs.)
1.	Steel tubes	50	14 feet	700
2.	Cylinder	750	4	3000
3.	Flow control valve	80	4	320
4.	Tee fittings	30	6	180
5.	Square tubes	50	12 feet	600
6.	Solenoid valve	450	1	450
7.	Teflon tape	15	1	15
8.	Pipes	20	10 m	200 m
9.	Silencer	20	2	40
10.	Connector	20	2	40
11.	Single eye fork	360	4	1440
Total				6985

7. RESULT AND DESCRIPTION

- The above table represents the performance of pneumatic arm.
- Operations is to be done three times to check the capabilities of the pneumatic arm.
- And as shown above, different weights or loads were lifted at the time of operation.
- It takes some time about 1.5 to 1.9 seconds to lift the load of 5 Kg in first three operations.
- It takes some time about 1.3 to 1.6 seconds to lower the load.
- It takes some time about 1.9 to 2.2 seconds to lift the load of 10 Kg in next three operations.
- It takes some time about 1.5 to 1.7 seconds to lower the load.
- It takes some time about 6.5 to 6.9 seconds to lift the load of 15 Kg in next three operations.
- It takes some time about 1.3 to 1.4 seconds to lower the load.

Table – 7.1: Results Table

Operation no.	Weight	Lifting	Return	Distance covered
1	5 Kg	1.9 sec	1.6 sec	46
2		1.6 sec	1.4 sec	
3		1.5 sec	1.3 sec	
4	10 Kg	1.9 sec	1.5 sec	42
5		2.2 sec	1.7 sec	
6		2.2 sec	1.7 sec	
7	15Kg	6.5 sec	1.4 sec	35
8		6.5 sec	1.4 sec	
9		6.9 sec	1.3 sec	

8. CONCLUSION

The design and fabrication of pneumatic arm for pick and place is completed with economic and effective considerations. It is controlled by manually flow control and direction control valves. Pneumatic arm movement and rotation is done by pneumatic cylinder using a helical slot mechanism. The solenoid valve is also a pneumatic actuator which holds objects. The model is expected to lift objects of 30 kg weight. The effective Design and Implementation of multi handling Pick and Place Pneumatic Arm has been performed. The operation of various arm linkages and the components has been extensively tested and the required corrective measures were taken. Hence the objective of designing and manufacturing of a pick and place robot at low cost was successful and affordable.

It's been proved that running cost of the pneumatic arm is also very less. This will help to cut down labor and improve profits at very low initial investment. The proposed model is demonstrated through an application of example of real world. By considering the above advantages and also by looking at various benefits, this project can be employed in the industry. I do hereby conclude, by saying that this project can be a factor for creating an impact on helping paralyzed or the handicapped peoples who are jobless and poor.

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