DESIGN AND ANALYSIS OF PNEUMATIC SYSTEM BASED EXOSKELETON ARMS

[1]Swapnil Manyar, [2]Hemant Mali, [3]Siddhesh Vishe, [4]Asst. Prof. Vinay kulkarni
Department of Mechanical Engineering, Alamuri Ratnamala Institute of Engineering and Technology Sapgaon, Thane, India[1,2,3,4]
swapnil31599@gmail.com[1], hemantmali9533@gmail.com[2], siddheshvishe1999@gmail.com[3]

ABSTRACT

The robotic exoskeleton systems are developed significantly to be used for human power assist and haptic interaction with human Motion. The designed pneumatic arm consists of two pairs of cylinders both the sides, a shaft efforts with lead screw mechanism able of converting a movement of piston to rotational movement of arm by utilizing the compressed air from pneumatic system.

The designed processes of the suit is carried out based on some integrated information of kinematic, dynamics and structural analysis of the desired exoskeleton configuration as a whole. The extremely dynamic pneumatic arm version can be simply place up at few intermediate spot by controlling the pressure using the flow control valve. This exoskeleton systems can be used for heavy lifting (pick and place) of objects in industry, Can be used along assembly line in various factories (e.g. Such as vehicle painting robots), rescue missions to clear the fallen structures.

Since, such exoskeleton directly interacts with a human body there are some mechanical limitations to its design. While designing such exoskeleton movable range of arms, safety and comfort Wearing, low inertia, adaptability are considered.

This paper briefly reviews the functionality and design of pneumatic system based hydraulic arms exoskeleton systems.

Keywords: Human Power Assist, Haptic Interaction, kinematic, dynamics and structural analysis, pick and place, limitations, safety.

1. INTRODUCTION

1.1 Background of the project

Material handling is a necessary and significant Component for any productive activity. It's one thing that goes on in each plant all the time Material handling means that providing the proper quantity of the proper material, within the right Condition, at the proper place, at the proper time and for the proper price, by victimisation the proper technique.

It is merely discovering, moving and lying down of materials through manufactrue. It applies to movement of raw materials, parts in process, finished good, packing materials, disposal of scraps, etc. in general, a whole lot and thousands heaps of materials square measure handled daily requiring the utilization of huge quantity of work force whereas the movement of materials takes place from one process space to a different or from one department to a different department of the plant. As a engineer it's our duty to reduce required human efforts by designing devices to either assist the human power with such devices or take this processes to automation.

The price of fabric handling contributes considerably to the whole cost of producing. a Handling and storing of materials Involve various operations like hoisting heaps of steel with A crane; driving a truck loaded with concrete blocks; carrying material baggage manually; and stacking palletized bricks or different materials like drums, barrels, kegs, and lumber. The economical handling and storing of materials square measure very important to trade.

1.2 About Pneumatic System

Pneumatics is that the use of compressed gas to form viable energy. Pneumatics have built-in air storage and it solely rely on the pressure created by putting the air within an enclosed space.

an compressor reduces the quantity of gas inside a machine. Reducing the volume also increases the air pressure because all the air molecules are compacted. You use valves with ports to open airflow; this will spur the molecules to move towards an actuator (in our case pistons), which in turn generates a force to power the machine. The pressure can be varied based on requirements and can be altered using valves. A gas system could be a system that uses compressed gas to try do work. They capture the air, transport it around a circuit or through series of pipes and valve and accomplish designated tasks with the generated energy.

Figure 1: Pneumatic System

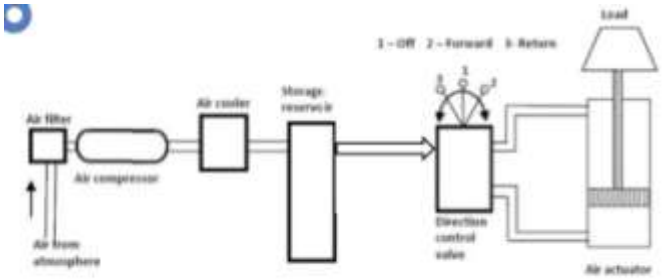

Fig. 1.1 Basic schematics of Pneumatic System

1.3 About exoskeleton or exosuit

Robotic exoskeletons, 1st seen in science-fiction movies, square measure currently showing in reality. This superb wearable technology is already getting used in trade and medication. Exoskeletons square measure wearable machines that enhance the talents of the folks that use them. rather like within the movies, exoskeletons will build their users stronger. they will offer support and cut back fatigue. Exoskeleton suit or exosuit can be known as powered exoskeleton, exoframe or exosuit, is a mobile Machine consisting primarily of an outer framework worn by a person, and a powered system of gas

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Figure 2: DAC piston

artificial Muscles (fluidic muscles) that delivers a minimum of a part of the energy for limb movement.

One of the foremost vital needs of any device that interacts with humans is safety. as a result of the skeletal system devices move below shut contact with the user, any reasonably malfunction may be seriously harmful to the user. Mechanical styles ought to so think about the probabilities of unannounced inaccurate operation of the device controller once the device is actively motivated. Limits to the range of motion can be set using a mechanical stopper or corresponding structural designs so that the exoskeleton should never force the wearer's body to move in an excessive Range of motion.

1.4 Statement of problem

During study of our project, we got acknowledged to various scenarios where in industries human efforts were being put in pick and place of loads, which of course results in less productivity from human. So our main objective to achieve through this project is to reduce the human effort by some sort of mobile device for assisting human power.

1.5 Aim and Objectives of study

The main objective of this project is to design the exoskeleton for human arms to assist the human power to assist pick and place movement from lower plane to higher plane

Other important objectives to achieve in this project are:-

- Fabricate a joint capable to be able to provide pick and place movement of arms without any damage to arms.
- To utilize the pressure from compressors in efficient manner.
- Fabricate cost effective exoskeleton and also develop general idea and thought process behind exosuits.

1.6 Scope and Study

This project includes Design and Fabrication of Pneumatic System based Hydraulic Arms and

- Study all possible joints involved in designing exoskeleton.
- Study pneumatic system mechanisms.
- Study fabrication of safer devices and also human safety in designing mechanisms.

2. PROJECT COMPONENTS

These are some key components used in project with various other materials not described here.

2.1 Double acting Pneumatic Pistons

Pneumatic cylinder pistons area unit mechanical devices that convert the energy in gas to linear motion.

Although there are many sorts of cylinders, their construction is fairly similar from one to a distinct. Basically, a cylinder is a sealed tube. Gas enters through a port at one end of the cylinder, inflicting the rod to maneuver. At the alternative end, a second port lets air escape. Understanding the fundamentals helps to indicate however completely different applications have an effect on the cylinder and connecting rod.

We have used double-acting cylinders (DAC) pistons in this project specifically, with DAC air is supplied to chambers on both sides of the piston. The higher pressure on one side of piston drives the piston to the other side. the DAC provide constant output throughout the full stroke of the piston and longer stroke length.

Table 1: Specifications of pistons

Sr. No.	Properties	Specifications
1	Cylinder type	Double acting cylinder
2	Bore size	32 mm
3	Stroke length	100 mm
4	Operating temperature	-20°c to 70°c
5	Operating pressure	1 bar to 10 bar

2.2 Push type Tee Fittings

Pneumatic push kind fittings area unit accustomed provide run free connecting of hoses in gas systems. They can also come with integrated pressure gauge or pneumatic silencers. They are also known T-joint.

T joint connectors in pneumatic systems are used for splitting input air supply line in to two lines.

Figure 3: Push-in type tee fitting

2.3 Solenoid Valve

Figure 4: Solenoid valve

Solenoid valves area unit the foremost often used management elements in fluidics. Their tasks area unit to shut off, release, dose, distribute or mix fluids.

They are found in many application areas.

Solenoids give fast and safe amendment, high responsibility, long service life, smart medium compatibility of the materials used, low management power and compact vogue.

Solenoid Valve is a electro-mechanical device controlled electrically. It choices a coil that might be an electrical coil with movable magnetism core in its center. This electro-magnetic field controls the opening and closing of orifice through a plunger. A 2-way or 3 way solenoid can be used, Where two states are the open and close states where as third additional state can be distributions or mixing state.

2.4 Flow Control Valve

Flow control valves are used to modify flow rate of fluid (compressed air) in portion of the pneumatic system. The flow variability is simply adjusted through an effective orifice size, which can be achieved through various techniques

The Flow rate is dictated by both the size of hole and pressure at which fluid is being pushed into the hole. The

Figure 5: Flow control valve

difference between upstream and downstream pressure is known as pressure drop.

2.5 Pneumatic Hose Tube Pipe

Figure 6: Pneumatic PU hose tube pipe

Polyurethane (PU) hose tube pipes are used here because they have wide range of temperature handling capability.

2.6 Rod End Joint

This rod end joints are provided to attain greater degree of freedom (DOF), so the limb movement can't get restricted to the linear motion of piston extension. Same are used on the joint near shoulder to provide free movement

Figure 7: Flexible male and female rod end joints.

2.7 Air compressor

Air compressors have main role to power pneumatic components. The pneumatic component used pneumatic pistons are being powered here using air compressor. Infact any general powered device is available in air powered version of it nowadays.

2.8 Chassis Materials

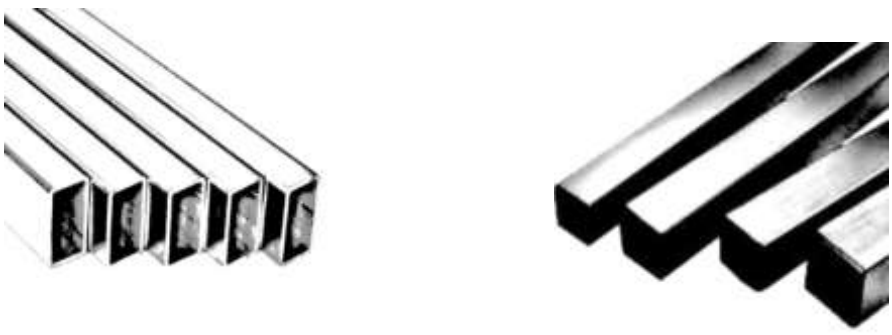

Figure 8: Mild steel pipes/tubes

Mild steel tube pipes used are chosen to reduce the weight of exoskeleton. They are used cause they are easy to weld when building chassis and provide good resistance to bending which is important to lift heavy weights.

2.9 Fork Clevis

Also known as Y-joints.

These forks area unit used for holding the alternative end of the rod with the arms. every The cylinders have the forks at their end that holds arm and offers it the motion of intake and exhaust.

Figure 9: fork clevis (Y-joint)

3. CALCULATIONS

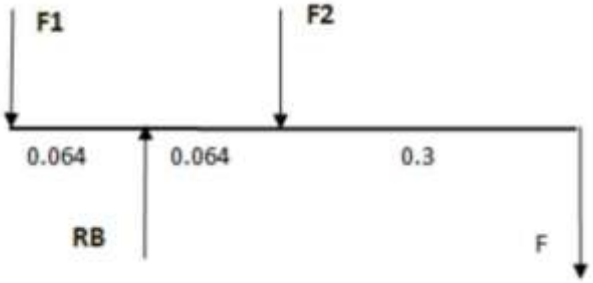

Figure 10: Schematics of stresses on arm

Since the system is in the equilibrium,

Taking moment about B,

$\sum MB=0$

$-(F\times0.364) + (F_2+F_1) \times 0.064=0$

Since, $F_2=F_1$ and F=25 Kg

$=171.67$ N

$171.67\times0.364=2\times F_2\times0.064$

$171.67\times0.364=2\times F_2\times0.064$

$F_2=488.18$ N

$F_1=488.18$ N

Summation of all forces across Y-axis

$\sum F_Y=0$

$F_1-F_2-R_B+F=0$

488.18-488.18-R_B+488.18=0

R_B=488.18 N

Assuming pressure in both cylinders are same

W=F=17.50×g

F=17.50×9.81

F=171.67 N

Where,

g=acceleration due to gravity.

F_1=Force applied by cylinder 1 in (N)

F_2=Force applied by cylinder 2 in (N)

N=Newton

W=Weight in kg

Standard sizes of gas cylinder accessible in market (in diameter)

We have used 3.2cm=0.032meter

Pressure requires in cylinder = force/area

p=f/a

p=48818÷(π/4×d²)

p=488.18÷(π/4×0.032²)

p=607002.03 Pascal

p=6.07 bar

p~6 bar

Therefore around 6 bar pressure is required in each piston to lift the weight of around 17.50 Kg on one side of piston Therefore, on experimenting with both arms around 35kg of weight can be lifted.

4. DISCUSSION AND RESULT

The project "Design and analysis of pneumatic system based hydraulic arms" is being fabricated and tested based on real world scenarios. In testing mode we have used it in garaging stations to constantly pick and place

motor parts which are heavy and cause fatigue to humans when done repeatedly. The exoskeleton successfully lifted several variations of weights in testing mode.

Maximum intensity of pressure applied to the system = 6kg/cm²

- Theoretical load, w=34.50kg
- Actual load, w=29kg

The actual value of load that the mechanical suit can lift is less than the theoretical value due to following reason;

- Frictional losses These are mechanical losses, emerges from friction between piston cylinder interface, friction at the joints and friction between air and inner surface of tube.

Table 2: Bill of Materials

Sr. No.	**Material**	**Quantity× cost per unit**	**Cost (INR)**
1	Pneumatic piston	4×1040	4160
2	Tee joint	6×60	360
3	Solenoid valve	1×1050	1050
4	Brass muffler (silencer)	2×20	40
5	Flow control valve	8×270	2160
6	Pneumatic pipe	15m×40	600
7	Steel tubes	14ft×80	1120
8	Square tubes	12ft×80	960
9	Teflon tape	1×20	20
10	Universal Joint	150×4	600
Total Cost			11070

Air discharge 100% leak proofing isn't potential for any gas system. There will be some air leakages at the connectors, joints, etc., leads to the reduction in intensity of pressure or simply pressure drop.

Variation of cross sectional area in upward and downward stroke. Due to presence of piston rod, the actual cross sectional area of piston subjected to high pressure air in a high pressure air in upward stroke will be less as compared to the downward stroke

i.e. $F_r=P(\pi r_1^2-\pi r_2^2)$

$=P\pi(r_1^2-r_2^2)$

Applications of pneumatic in industries

- Material handling

- Automotive industry
- Welding
- Material handling
- Computer manufacturing

Medical emergencies

5. CONCLUSION

The look and fabrication of gas arm for decide and place is completed with economic and effective concerns. it's managementled by manually flow management and direction control valves. gas arm movement and rotation is finished by gas cylinder employing a coiling slot mechanism. The magnet valve is additionally a gas mechanism that holds objects. The model is predicted to raise objects of thirty kilo weight. The effective style and Implementation of multi handling decide and Place gas Arm has been performed. The operation of assorted arm linkages and therefore the elements has been extensively tested and therefore the needed corrective measures were taken. therefore the target of coming up with and producing of a decide and place golem at low value was productive and reasonable.

It's been well-tried that running value of the gas arm is additionally terribly less. this will facilitate to cut down labor and improve profits at very low initial investment. The planned model is incontestable through associate degree application of example of universe. Bly considering the higher than benefits and additionally by observing varied advantages, this project are often used within the business. I do herewith conclude by speech that this project are often an element for making a bearing on serving to paralytic or the disabled peoples United Nations agency area unit idle and poor.

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