

SIX AXIS PNEUMATIC MATERIALS HANDLING ROBOTIC ARM

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Abstract - Moving materials utilize time and space. Material handling is a necessary, but wasteful and expensive activity in manufacturing and distributing. Material handling is a specialized activity for a modern manufacturing concern. It has been estimated that about 60-70% of the cost production is spent in material handling activities. Insufficient material handling accounts for additional costs in two main ways: idle time and cost of labor. Effective material handling solutions can reduce a production or distribution cost by significant amounts. The technology of pneumatics has gained tremendous importance in the field of workplace rationalization and automation from old-fashioned timber works and coal mines to modern machine shops and space robots. Certain characteristics of compressed air have made this medium quite suitable for used in modern manufacturing and production industries. The air is compressed in an air compressor and from the compressor plant the flow medium is transmitted to the pneumatic cylinder through a well laid pipe line system..

Key words: Robotic Arm, Material Handling System, Pneumatics.

1. INTRODUCTION

Effective material handling is the most important part of manufacturing and distributing operations because without it, a final product cannot be turned into profit. The technology of pneumatics has gained tremendous importance in the field of workplace rationalization and automation from old-fashioned timber works and coal mines to modern machine shops and space robots. Certain characteristics of compressed air have made this medium quite suitable for used in modern manufacturing and production industries.

Material handling an integrated system involving such activities as moving, handling, storing and controlling of materials by means of gravity, manual effort or power activated machinery Material handling is an important area of concern in flexible manufacturing systems because more than 80 % of time that material spends on a shop floor is spent either in waiting or in transportation, although both these activities are non-

value added activities. Comparing the source of operation hydraulic and pneumatic, Pneumatic source having good response over hydraulic and gives safe and cost effective material handling. Efficient material handling is needed for less congestion, timely delivery and reduced idle time of machines due to non-availability or accumulation of materials at workstations. Safe handling of materials is important in a plant as it reduces wastage, breakage, loss and improves the overall efficiency of plant.

Hence with concern of major area in production field in order to improve the product quality, productivity, improve the personnel effort, improve the efficiency of plant and improve the safety the pneumatic based six axis material handling system select as flexible system in manufacturing area.

2. DESIGN METHODOLOGY

Methodology includes the method to achieve the final objectives of project. Following are some method or sequence of activities used in project to achieve final objectives.

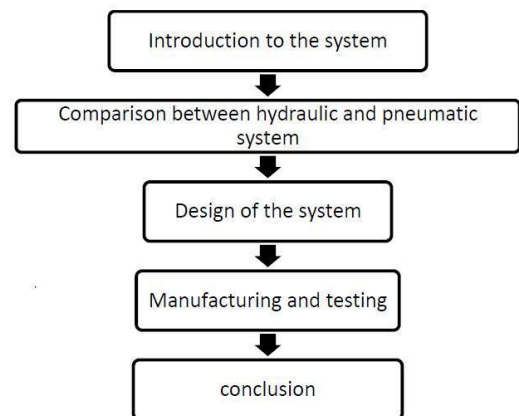


Fig. 1 Flow chart of methodology

3. Proposed System

The automation plays an important role in saving human effort in most of regular and frequently carried works. The most common work is pick and place of jobs or work piece from source to desired position. Present day industry turned towards computer based program automation as it increase the productivity and delivery

of end products. The inflexibility and hard automation is used in highly automated truck in the past have to led used of automated arms which is capable of performing the variety of manufacturing function in a flexible environment and at lower cost. The pick and place mechanical arm is human based controlled based system that detection of object human detect presence of object and move the machine accordingly.

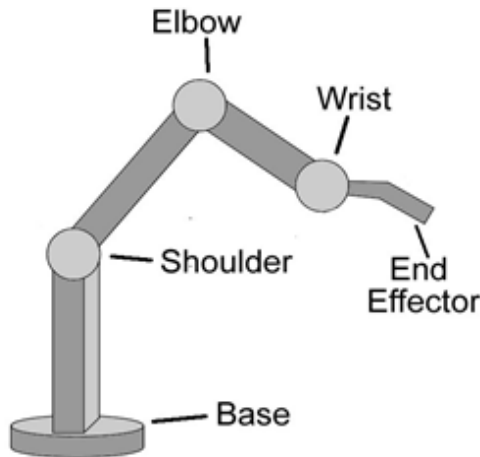


Fig.2 simple robotic arm

The robot's manipulative arm is the mechanical unit. This mechanical unit is also comprised of a fabricated structural frame with provisions for supporting mechanical linkage and joints, guides, actuators (linear or rotary), control valves, and sensors. The physical dimensions, design, and weight carrying ability depend on application requirements .It consist of following parameters.

Work Envelop: The set of points Representing the maximum extent or reach of the robot arm or working tool in all direction.

Payload: The ability to carry, continuously and satisfactorily given maximum weight at a given speed.

Velocity: The maximum speed at which the tip of a robot is capable of moving at full extension, expressed in inches or millimeter per second.

Cycle: Time it takes for the robot to complete one cycle of picking up a given object at a given height , moving it to a given distance lowering it, releasing it, and returning to the starting point.

Accuracy: A Robot's Ability to position the end effector at a specified point in space upon receiving.

Repeatability: The ability of a robot to return consistency to a previously having attained that position.

Resolution: The smallest incremental change in position that it make or its control system can measure.

The manipulator: Which is the robot's, consists of segments jointed together with axes capable of motion in various direction allowing the robot to perform work. The end effectors which is a gripper tool, special devices, or fixture attached to the robot's arm actually performs the work.

4. PROBLEM DEFINITION

In every manufacturing unit the components are manufactured far away from the assembly unit so that, the main task is components should be present in right time, at right place, in right quantity, as every manufacturing system enhancing has motive to reduce inventory. The problems were, damage to the treatment provided to components during transportation, damage to the physical structure of components during handling which may create delay in assembly unit and directly on productivity. This project deals with designing of material handling equipment for better and organized material flow which will also have ergonomics consideration. The problems arising are as follow

1. Damage of components in transportation from manufacturing unit to assembly unit. Damage to the paint and treatment given to the components.
2. Damage to the component, may lead to problem in assembly also More time is required in material handling, this may lead to delay in the flow of lean manufacturing

To ensure that the right material in the right amount is safely delivered to desired place at right time with minimum cost and control of material by using pneumatic based six axis material handling equipment.

5. Project Objective

The main objective of the project is to reduce the time required for material handling in the manufacturing unit at the right time and with the minimum cost and hence project has following some objectiveSystem provides proper control over the material without any damage or mishandling which interns leads to increase in quality of the material. Facilitate the reduction in material damage as to improve quality. Easy to use, the system easy to manufacture so that simple operating possible and no skilled labor required for operation. This will result in less complex system.

6. Scope

The technology of pneumatics has gained tremendous importance in the field of workplace rationalization and automation from old-fashioned timber works and coal

mines to modern machine shops and space robots. Certain characteristics of compressed air have made this medium quite suitable for used in modern manufacturing and production industries. It is therefore important that technicians and engineers should have a good knowledge of pneumatic system, air operated valves and accessories. A pneumatic system consists of a compressor, pipe lines, control valves, drive members and related auxiliary appliances. The air is compressed in an air compressor and from the compressor plant the flow medium is transmitted to the pneumatic cylinder through a well laid pipe line system. To maintain optimum efficiency of pneumatic system, it is of vital importance that pressure drop between generation and consumption of compressed air is kept very low.

7. DESIGN AND CALCULATIONS

This chapter includes the details about design and calculation of rack and pinion and bearing. Also selection of standard parts, they are selected on basis of important parameters which affect on the design of that parts.

7.1 Material selection

Material selected: Plain carbon steel
 Material grade: 30C8
 Chemical composition:

Chemical Element	C	Ni	Si	Mn	Cr
% by mass	0.12 - 0.20 %	0.60 - 1%	0.15- 0.35%	0.60- 1%	0.4 - 0.8%

Mechanical Properties : Tensile strength (Sut) = 500 N/mm2 Yield strength (Syt) = 400 N/mm2 Hardness (H) = 179 HB Elongation (e) = 21%
 4.2 Frame section Fabrication is the process used to manufacture steelwork components that will, when assembled and joined, form a complete frame. The frame generally uses readily available standard sections that are purchased from the steelmaker or steel stockholder, together with such items as protective coatings and bolts from other specialist suppliers. Wide range of section shapes and sizes are readily available. Different sections are used in the main body of equipment because of their difference in loading conditions. Sections used in equipment are C-Sections, L-section, Square tube, Circular tube.
 4.3 Selection of standard parts Design process is all about standardizing the element as much as possible. Standardization is the process of implementing and developing technical standards based on the consensus of different parties that includes firms, users, interest groups, standards organizations and governments. Standardization can help to maximize compatibility, interchangeability, safety, repeatability, or quality.

The standard parts such as pneumatic cylinder, wheels and direction control valve selected during the design

and manufacturing of equipment with their specification are as follows

Selection of pneumatic cylinders

The parameter such as Cylinder thrust, Air consumption, .Piston velocity, and type of mounting.

the cylinder thrust is a function of Cylinder thrust in N.(f), Diameter of piston in mm (d), Operating air pressure in bar (P), frictional resistance, etc. The air consumption data for a cylinder is required to estimate the compressor capacity. The calculations include air consumption during forward as well as return stroke. The free air consumption for forward stroke is calculated as follows:

Free air consumption = piston area x (operating pressure + 1.013) x stroke The free air consumption for return stroke is also calculated similarly and added to arrive at total free air consumption of cylinder during one complete cycle

Factors governing the piston velocity are: the operating pressure, opposing forces, inside diameter and length of the air line between the control valve and cylinder and the size of the control valve. The piston velocity may be increased or decreased with the help of a quick exhaust valve or flow control valve respectively. The average piston speed at no – load is between 100 – 500mm/ sec. Depending on the frequency of operation and the speed required, proper type and size of valve needs to be selected.

We use three types of cylinder in equipment are as follow:

Cylinder having bore diameter as 20mm and stroke length 75mm is used to revolve or rotate the rack and pinion. The piston end is connected to rack with which it can travel in longitudinal direction and results to rotate the pinion and as whole vertical arm is rotate along with actuators.

The next cylinder with the specification as 50mm bore diameter and 100mm as stroke length is used to list the vertical arm. we select this cylinder as having maximum capacity so as to whole weight about (5 to 8 kg) is to be carried by this vertical arm.

Next cylinder is 50 mm bore diameter and 50 mm stroke length. The cylinder is used to carry the horizontal arm weight which can inclined at an angle of 30° to 45°. Hence arm can be lift up and down as per the requirement.

Next cylinder is used for controlling the motion of final arm and also for controlling or actuating the gripper motion of 25 mm bore diameter and 50 mm stroke length.

Calculations

Rack and pinion

Assumption:

Gear ratio (G) = 1.5
 No of teeth on pinion as $60 > 18$ (to avoid interference)
 [10]
 $Z_1 = 60$
 Therefore, $G = Z_2 / Z_1$
 Hence $Z_2 = 90$
 $D = 55 \text{ mm}$
 $R = 27.5 \text{ mm}$
 Solution:
 $m = 5L3.14 = 1.59 = 2$
 $m = 2 \text{ mm}$
 Least pressure angle to avoid interference:
 Let,
 $\Phi =$ least pressure angle to avoid interference
 $m = r \sin 2\phi$
 $2 = 27.5 \sin 2\phi$
 $\Phi = 15.634^\circ (14^\circ \text{ to } 20^\circ)$
 Length of the arc of contact =
 13 mm
 Length of the arc of contact
 $= 13.48 \text{ mm}$
 $P_c = \pi d / t$
 $= \pi * 55 / 60$
 $= 2.87 \text{ mm}$
 Therefore,
 The no. of pairs of teeth in contact =
 Length of arc / circular pitch
 $= 13.48 / 2.87$
 $= 4.69$
 $= 5$
 So minimum no. of teeth in contact is 5
 Power required
 We know that pressure in the system $P_{\text{system}} = 0.8 \text{ Mpa}$
 or 8 bar
 $P_{\text{system}} = F/A$ (cylinder selected 20×75)
 $F = 251.32 \text{ N}$
 Also $P = F \times V$
 $V = 6.28 \text{ m/s}$
 Hence,
 $P = 251.32 \times 6.28$
 $= 1.57 \text{ Kw}$
 and $M_t =$

$= 249.87 \text{ N-m}$
 Tangential force act on pinion
 $P_t = 9086.18 \text{ N}$
 Radial force act on pinion
 $P_r = P_t \tan \alpha$
 $= 3307 \text{ N}$
 Addendum $= hf = m = 2 \text{ mm}$
 Dedendum $(hf) = 1.25 m = 2.5 \text{ mm}$
 Clearance $(C) = 0.25 \times m = 0.5 \text{ mm}$
 Working Depth $(hk) = 2m = 4 \text{ mm}$
 Whole depth $(h) = 2.25m = 2.25 \times 2 = 4.5 \text{ mm}$
 Tooth thickness $(s) = 1.57m = 3.1416 \text{ mm}$
 Tooth space $= 1.57 m = 3.1416 \text{ mm}$
 Fillet radius $= 0.4 m = 0.8 \text{ mm}$
 Pneumatic cylinder
 Double acting pneumatic cylinder for given telescopic
 action to two arms
 first telescopic length is 100mm, hence we select the
 cylinder having specification of 50×100
 Volume of air exhaust $(v) = l \times a_1$
 $= 1.96 \times 10^{-4} \text{ m}^3$
 Out stroke force $(F) = P \times a_1$
 $= 1568 \text{ N}$
 Effective area $(A) = a_1 - a_2$
 $= 5.02 \times 10^{-5} \text{ m}^2$
 In stroke force $(f) = P \times A$
 $= 1527.84 \text{ N}$
 Total load on cylinder is equal to total set up weight
 including arm and upper cylinder = 10 Kg
 Therefore $1527.84 \text{ N} > 98.1 \text{ N}$
 Double acting pneumatic cylinder for rotary movement
 between arms
 for the angular movement between the two arms we
 select the cylinder having specification 25×50
 similarly, volume of air exhaust $(v) = l \times a_1$
 $= 2.35 \times 10^{-5} \text{ m}^3$
 Outstroke force $(F) = P \times a_1$
 $= 251.2 \text{ N}$
 Effective area $(A) = a_1 - a_2$
 $= 2.63 \times 10^{-4} \text{ m}^2$
 Instroke force $(f) = P \times A$
 $= 210.4 \text{ N}$

Load on the cylinder is 5 kg, hence $210.4 \text{ N} > 49 \text{ N}$, cylinder is safe.



Fig 2 Catia model

8. CONCLUSIONS

Low weight system. The system weight minimized at every point and reduce the material required hence achieve low cost automation.

Overall manufacturing time by designing efficient material movement reducing. Production rate increases and manufacturing time is reduced as the material flow is continuous and efficient

Creation and encouragement of safe and hazard-free work condition. Safety must be given first priority and proper measures should be taken to improve safety conditions.

The parts are placed such that it considers human capabilities and limitations which will reduce human effort while loading and unloading.

The cost of equipment will be reduced by 15% of existing equipment and become for flexible than existing pneumatic based material handling system.

System provides proper control over the material without any damage or mishandling which interns leads to increase in quality of the material. Facilitate the reduction in material damage as to improve quality. Easy to use, the system easy to manufactured so that simple operating possible and no skilled labor required for operation. This will result in less complex system

9. FUTURE SCOPE

Pneumatic based materials handling equipment's are used Materials handling problems involve surveys, plant and equipment layouts, routing, packaging and storage of materials. It is also used for handling the bulk material such as gases, liquid semi-liquid etc. It is also used in heavy construction projects, there is now a choice of special methods and equipment's of materials handling. It influences the civil engineers in project planning.

For the extraction, handling and transportation of coal and ore in case of both underground mines and open pit operation Cost of extracting the materials has been reduced to the minimum. for handling of material such as fuel and ash. The design of many processing machines is influenced by the need for integrating various material handling features or attachments to modern machine mechanisms. The automotive engineer develops trucks and trailer as efficient materials handling vehicles, designed for speedy loading and unloading, ensure cargo is secured properly, and safe transportation of a variety of materials.

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