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# Design and fabrication of three axis robot for material handling in chemical industries

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**ABSTRACT**

Material handling system is an integrated system, which involves many activities such as moving, handling, storing and controlling of materials by means of manual or power actuated machinery. Due to the high resource consuming of material handling system and handling of hazardous materials, different types of robots used to handle the materials in chemical industries. The paper deals with the design and fabrication of robot for material handling applications. Three degrees of freedom robot was designed in this project. The robot arms are equipped with pneumatic actuators to perform arm movements and a pneumatically operated vice with IR sensor. The pneumatic actuators are interfaced with a unit that consists of PIC microcontroller to control the actuator. Testing and validation of the robot arm was carried out and the robot works properly.

**KEY WORDS**: Robot, Degrees of freedom, Microcontroller.

## 1. INTRODUCTION

In modern industries material handling plays an important role to increase the productivity and decrease the labor, product cost. Material handling can be defined as 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. 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 scrapes etc. Material handling equipment is generally separated into four main categories: storage and handling equipment, engineered systems, industrial trucks, and bulk material handling. Different types of material handling system are used in many industries to handle materials. Over the past few decades many researchers were dedicated to their work to develop an efficient material handling system for different industrial applications (Kulak, 2005; Gamberi, 2009; Sule, 1994).

After the invention of robot, the conventional material handling system has been converted into automated material handling system. The term robotics is practically defined as the study, design and use of robot systems for manufacturing. Robots are generally used to perform unsafe, hazardous, highly repetitive, and unpleasant tasks. They have many different functions such as material handling, assembly, arc welding, resistance welding, and machine tool load and unload functions, painting, spraying, etc. Robot is a reprogrammable multifunctional manipulator, designed to move specialized devices through a variable programmed motion. Nowadays most of the industries are using robot or automated guided vehicles to handle the materials in different applications. Different types of robots are used for different material handling applications. James (2003) developed a mobile robot to grasp accurately stationary material during pick-and-place operations between a predefined station and the mobile robot. An eye in vision system was employed to provide visual information for controlling the manipulator of the mobile robot. Different techniques such as image enhancement, edge detection, corner and centroid detection, camera model calibration method, robotic handle eye calibration method, using a camera with controlled zoom and focus, and task encoding scheme were employed in this model. Aravind (2009) developed a two degrees of freedom robot for material handling systems. This semi-automatic pick and place robot integrates object detection with the pick and place process whereby the detection of an object would power the object gripper. The prototype is a semi-manual operated robot which uses control devices in the form of switches to control operation of the system. Sho Maeda (2011) developed a pneumatic robot arm driven by pneumatic actuators for material handling applications. The arm consists of a pneumatic hand and pneumatic wrist. The hand can grasp various objects without force sensors. A four degree of freedom robot was designed, developed and implemented by Ashraf (2011) to handle lightweight materials and to position very accurately. They integrated robot with mobile platform to serve as an assistant for industrial workforce. Different servo motors and Lab VIEW platform were used in their design to link between arms and perform arm movements. The encoders were attached with servo motors to measure the speed of motors. Finally Testing and validation of the robot arm was carried out by the authors and results showed that it work properly. Shantanu (2012) designed a robot which follows the instruction of human operator and perform the task. Different sensors such as Flex sensors, ultrasonic sensor, Electronic compass and accelerometer used to measure the different parameters of robot. Hernando (2012) designed and developed a modular flexible collaborative robot prototype to demonstrate the proposed new generation of material handling methodology. The prototype can operate in an area

of about 4.7x2.4m including travel in about 1.3m. It has five powered axes driven by servo drives. The axes are the X-, Y- and Z-axes, rotation about the Z-axis and pivoting up and down of the end effector. Ravikumar (2015) designed and implemented a 4-DOF articulated arm robot for pick and place applications. Articulated arm consists of revolute joints that allowed angular movement between adjacent joint. Four servo motors were used in this project to perform four degree of freedom.

## 2. MATERIALS AND METHODS

**Structure and design of drilling machine:** The developed material handling system consists of four solenoid valves. Air is inlet into the system using a compressor. A rack and pinion arrangement present at the base of the frame used to convert linear to rotational motion. There are five cylinders used in the setup. One cylinder is used for the height adjustment, one for extension of the arm, one for tilt movement, one cylinder for clamping the gripper with the workpiece and one for the opening and closing of the automatic vice. Two IR sensors are used that are attached one to the gripper and the other to the automatic vice to sense the work piece. A PIC controller is programmed with timer functions to achieve the desired functions. The photographic view of setup is illustrated in Fig.1.

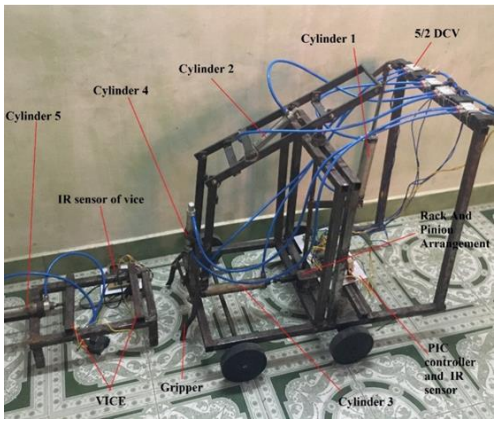


**Figure.1. Photographic view of the experimental setup**

## 3. RESULTS AND DISCUSSION

**Working Principle of Voice controlled drilling machine:** The working principle of the fabricated three axis robot is briefly described in this section. To design a pneumatic circuit FestoFluidsim pneumatic and hydraulic software version 4.2 was used in this project. The fluidsim software circuit diagram of the sequence is shown in Fig.2. The circuit diagram comprises of three double acting pneumatic cylinders each connected to a 5/2 double solenoid directional control valve. The compressed air from the compressor is directly supplied to all the three DCVs. The other two cylinders that are used for the gripper and the vice are actuated using an IR sensor. The electropneumatic circuit that is shown above is started when the push button operated make switch (start) is pressed. When the circuit is closed, the relay K1 is tripped thus by giving an option to break the circuit using a push button operated break switch. As the relay K1 is tripped, all the make switches that are labeled as K1 are made in contact with the circuit. When the cylinder is at extended position (A+), the make switch that is labeled as A+ makes contact with the circuit thus by tripping the relay R1where R1 is a relay with timer having off time set to 10sec. The make switch that is labeled as R1 will make contact with the circuit as when the relay R1 is tripped. As R1 makes contact with the circuit, the valve solenoid that is labeled as SOL1 is tripped. Now, the cylinder A is retracted to it's A- position. When the R1 is tripped, it will run for 10sec, so a break switch is brought into the circuit that is labeled as R1 that will break contact till the timer relay goes off. The break switch is brought into the circuit to avoid cascading problems. When the timer goes off the valve solenoid labeled as SOL2 is tripped thus by actuating the cylinder A to it's A+ position. The make switch labeled as K1, is making contact with the circuit since the circuit is closed. When the cylinder B is in its extended position (B+), the make switch labeled as B+ makes contact with the circuit thus by tripping the relay R2 where R2 is a relay with timer set with an off time of 6sec.When the timer relay R2 is tripped, the make switch that is labeled as R2 makes contact with the circuit and the valve solenoid that is labeled as SOL3 is tripped and the cylinder B is retracted to its B- position. Similarly here a break switch labeled as R2 is brought into the circuit will break contact with the circuit till the timer goes off. When the timer goes off the valve solenoid labeled as SOL4 is tripped thus by actuating the cylinder B to its B+ position. When the cylinder C is in its retracted position (C-), the make switch labeled as C- makes contact with the circuit thus by tripping the relay R3 where R3 is a relay with timer set with an off time of 3sec.When the relay R3 is tripped, the make switch labeled as R3 will make contact with the circuit and the valve solenoid labeled as SOL5 is tripped thus by actuating the cylinder C to its C+ position. A break switch labeled as R3 is brought into the circuit that will break contact with circuit until the timer goes off and when the timer goes off, the valve solenoid labeled as SOL6 is tripped thus by retracting the cylinder C to its C- position.

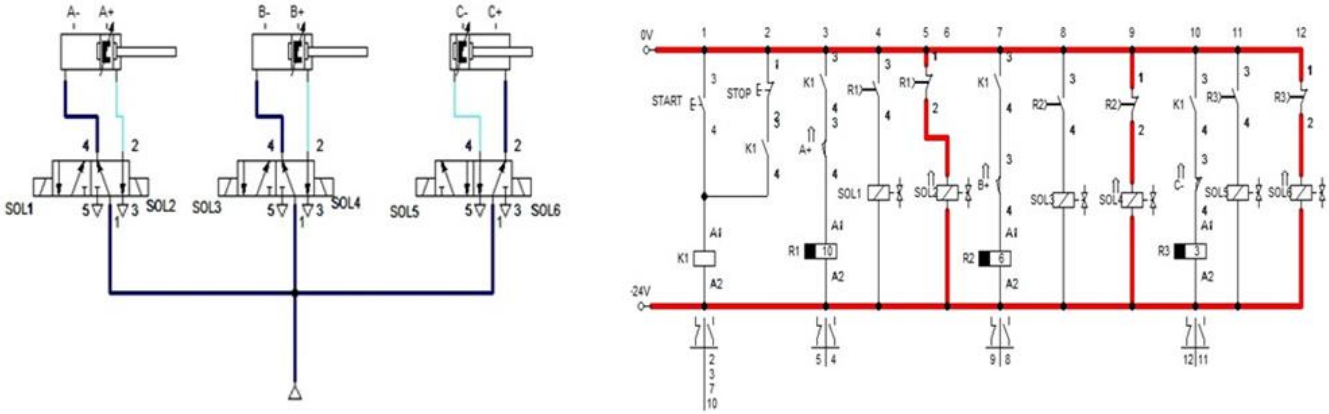


**Figure.2. Eelctropneumatic circuit diagram (Using Fluidsim)**

## 4. CONCLUSION

A three degrees of freedom robot which has the talent to handle hazardous materials in chemical industries was designed and fabricated. The robot was designed and manufactured using stainless steel materials and the pneumatic linear actuators were used to actuate the links to perform arm movements. The material handling system has a huge future scope which includes that the number of axes can be further increased to provide a larger base and to carry heavier loads, the efficiency of the system can be increased by applying functions simultaneously to multiple grippers, the robot can be made calibrated to the vice further to pick completed jobs from the vices and dropping them to required places.

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