Design And Fabrication of Three Directional Pick And Place Robotic Arm

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Abstract- *Picking and placing the object from the conveyor belt is the important task in the packing section of an industry. Pick and place manually, needs manual power and time. This is an attempt to design efficient mechanism for picking and placing by automating them by constructing the 3-directional robotic arm using Pneumatic cylinders which are controlled by the PLC. The system consists of a PLC which controls the movements of the pneumatic cylinders based on the inputs coming from the sensors placed on the conveyor belt. The robotic arm is having the capability to move along the three axis (X, Y and Z). A mechanical gripper is placed at the end of the robotic arm which is used for holding the objects on the conveyor belt.*

Keywords- PLC, SCADA.

I. INTRODUCTION

Now a days, robots are increasingly being integrated into working tasks to replace humans especially to perform the repetitive task. In general, robotics can be divided into two areas, industrial and service robotics. International Federation of Robotics (IFR) defines a service robot as a robot which operates semi or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations. These mobile robots are currently used in many fields of applications including office, military tasks, hospital operations, hazardous environment and agriculture.

A. BACKGROUND

Pick-and-Place (PNP) (collect-and-place; pick-and-insert) is one of the key operations in programmable assembly where items are selectively picked up and placed in for PNP; e.g., SCARA (Selective Compliance Assembly Robot Arm), articulated, and spider robotic arms; dual-delivery robot; turret-type robot; multi-head gantry robot.[1] The robots may collaborate with human operators, assembly machines, or each other. Besides its extensive applications in structured and unstructured assembly, the PNP operations have applications in several other areas such as palletizing, ware housing, loading/ unloading of machines, machine tending, sorting, circuit board testing, inspection and remote maintenance, and robotic surgery, in various food, pharmaceutical, biomedical, packaging, electrical, and chemical industries.

The PNP operations are generally composed of the following stages:

1) Movement of the robot to place the gripper in the pickup position.
2) Pick up operation by the gripper.
3) Movement of the robot to place the gripper in the placement position.
4) Placement operation by the gripper.

B. ROBOTIC ARM DEFINITION

A robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. [2] The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The business end of the kinematic chain of the manipulator is called the end effectors and it is analogous to the human hand. The end effectors can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application.

The robot arms can be autonomous or controlled manually and can be used to perform a variety of tasks with great accuracy. The robotic arm can be fixed or mobile (i.e. wheeled) and can be designed for industrial or home applications.

II. BLOCK DIAGRAM

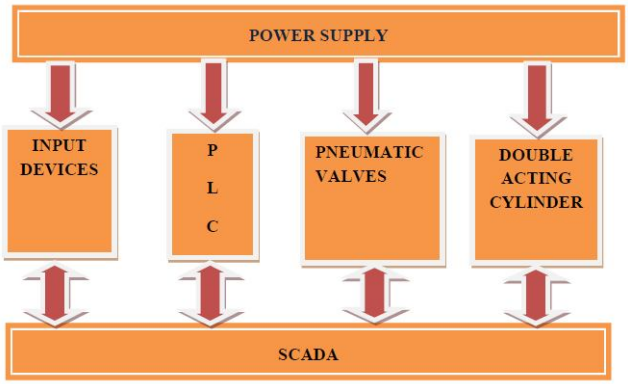

Fig 1: Block diagram

The robotic arm comprises of integration of Supervisory Control and Data Acquisition (SCADA), Programmable Logic Controllers (PLC), pneumatic gripper and solenoid valves. In the robotic arm, SCADA will be the central system that control and monitors all the data in the system. The 3 axis robot consists of three independent pneumatic cylinders which are the base for the 3 axis movements, and the pneumatic cylinders motion is controlled by DCV's which are in turn governed by PLC .

Figure 1 represents the block diagram of the system, whenever the PLC gets the input for picking or any other operation such as placing, packing based on the end-effectors used, the PLC generates the output based on the time duration required. Once the output is triggered then the DCV activate and the action is carried out.

If any process is not happening in the way it is planned, there is a safety switch for resetting which resets the program and puts the robot in home position. The total process is governed through the SCADA screen and controlled. Emergency reset is also interfaced in SCADA so that the operator can control all the actions in the screen. The added advantage of using SCADA is the time delays; payload and reach can be said to the PLC so that the PLC activates in the same manner as required. The SCADA can be totally interfaced with the PLC in such a way that the entire system that is happening in the industry can be monitored and controlled.

III. HARDWARE IMPLEMENTATION

A. DOUBLE ACTING CYLINDER

Double acting cylinder in a double acting cylinder, air pressure is applied alternately to the relative surface of the piston, producing a propelling force and a retracting force. As the effective area of the piston is small, the thrust produced during retraction is relatively weak. The impeccable tubes of double acting cylinders are usually made of steel. The working surfaces are also polished and coated with chromium to reduce friction.

Two double acting cylinders are to be used.one for horizontal movement of the robotic arm. Another one is vertical movement of the arm.

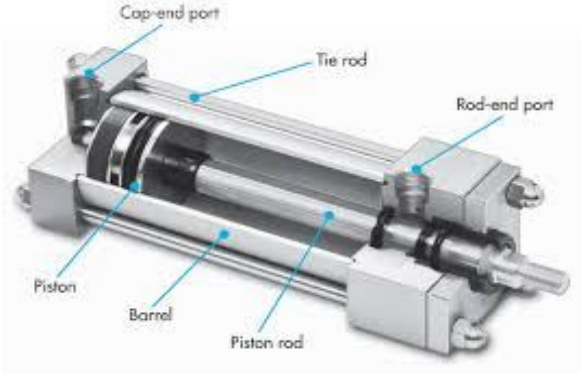

Fig.2 Double acting cylinder

Double acting pneumatic cylinder was used in the systems, which will more efficiency then the single acting cylinder. The double acting cylinder will receive the air pressure alternatively, producing a propelling force and a retracting force. The inlet and outlet valves of the cylinder were made up of steel. Chromium coated working surface is maintained to make the friction resistance in the cylinder. Solenoid valve, direction control valve, and PLC systems, pushbuttons were all used to control the double acting pneumatic cylinder. Double acting cylinder as shown in the above figure 2. Double Acting Cylinders are equipped with two working ports- one on the piston side and the other on the rod side. To achieve forward motion of the cylinder, compressed air is admitted on the piston side and the rod side is connected to exhaust. During return motion supply air admitted at the rod side while the piston side volume is connected to the exhaust. Force is exerted by the piston both during forward and return motion of cylinder.

B. SWITCHED MODE POWER SUPPLY

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics.

Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

Figure 3 shows the SMPS equipment. Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight is required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

Fig.3 SMPS Equipment

C. DIRECTIONAL CONTROL VALVE(DCV)

Directional control valves are one of the most fundamental parts in hydraulic machinery as well as pneumatic machinery. They allow fluid flow into different paths from one or more sources. They usually consist of a spool inside a cylinder which is mechanically or electrically controlled.

The movement of the spool restricts or permits the flow, thus it controls the fluid flow.

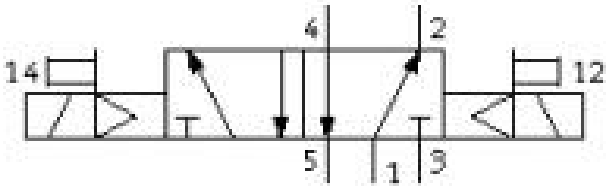

Fig.4 Circuit diagram of the 5/2 solenoid operated directional control valve

D. SOLENOID OPERATED

They are widely used in the hydraulics industry. These valves make use of electromechanical solenoids for sliding of the spool. Because simple application of electrical power provides control, these valves are used extensively. However, electrical solenoids cannot generate large forces unless supplied with large amounts of electrical power. Heat generation poses a threat to extended use of these valves when energized over time. Many have a limited duty cycle. This makes their direct acting use commonly limited to low actuating forces. Figure 5 shows the 5/2 solenoid operated directional control valve. Two DCV's are to be used. One for horizontal movement of the robotic arm. Another one is vertical movement of the arm.

Fig.5 5/2 solenoid operated directional control valve

E. PUSH BUTTON

Fig.6 push-button

A push-button (also spelled pushbutton) or simply button is a simple switch mechanism for controlling some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal. The surface is usually flat or shaped to accommodate the human finger or hand, so as to be easily depressed or pushed. Buttons are most often biased switches, although many un-biased buttons (due to their physical nature) still require a spring to return to their un-pushed state. Terms for the "pushing" of a button include pressing, depressing, mashing, hitting, and punching. 5 push buttons are to be used in the system.

Working of the 5 push buttons are,

1. Auto cycle
2. Horizontal movement
3. Vertical movement
4. Gripper open
5. Gripper close

F. COMPRESSOR

A compressor is a mechanical device that increases the pressure of a gas by reducing its volume. An air compressor is a specific type of gas compressor. Compressors are similar to pumps: both increase the pressure on an air and both can transport the air through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible; while some can be compressed, the main action of a pump is to pressurize and transport liquids. Figure 7 shows the compressor.

Fig.7 Compressor

G. RELAY

Relays can be used for switching as well as protection application. A relay is used to switch a circuit such that current through it can be diverted from present circuit to another. This switching operation can be performed either manually or automatically. Manual operation for switching a relay is performed through push buttons and other conventional switches. In most of the cases control circuit output drives the relay for automatic operation.

Figure 8 shows the relays. In the robotic arm 8 relays are to be used. A relay is an electromechanical device having electrical, magnetic and mechanical components. The relays control the electric circuit by opening or closing the contacts of that circuit. An electromechanical relay consists of three terminals namely common (COM), normally closed (NC) and normally opened (NO) contacts. These can either get opened or closed when the relay is in operation.

These relays can work on both AC and DC supply sources.

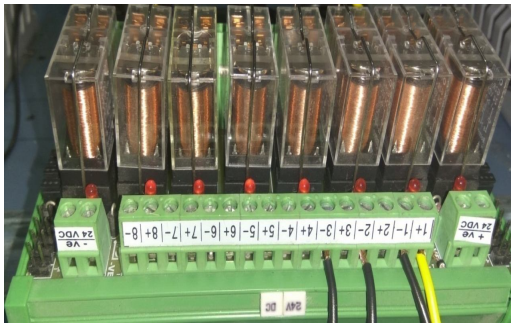

Fig.8 Relays

H. ROBOTIC GRIPPER

A robotic gripper as shown in figure is an automatically controlled, reprogrammable and multipurpose programmable in three or more axis is used. A 3-axes mechanical sustenance is a form of mechanical support, generally reprogrammable, through interconnected utilities towards a humanoid provision.

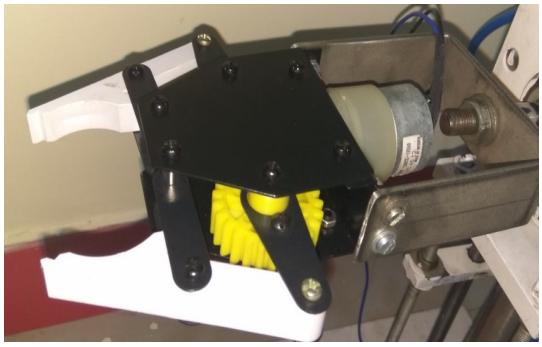

Fig.9 Robotic gripper

Figure 9 shows the Robotic gripper, the associates of such a manipulator are associated by joints permitting either rotational motion (such as an articulated robot) or translational (linear) movement. It is used to pick and place the components.

I. DC GEARED MOTOR

DC Gear motor is also called DC Geared Motor, Geared DC Motor and gearhead motor or gearbox motor. It consists of an electric DC motor and a gearbox or gearhead; these gearheads are used to reduce the DC motor speed, while increase the DC motor torque. Therefore user can get lower speed and higher torque from gear motor. The motor is to be used for gripper opening and closing purpose.

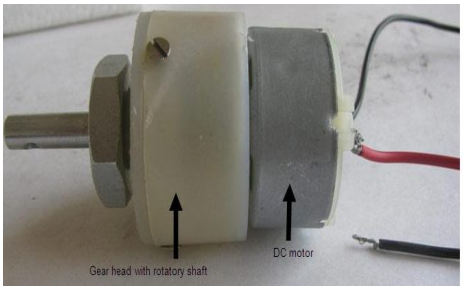

Fig.10 DC geared motor

J. HOSE

A hose is a flexible hollow tube designed to carry fluids from one location to another. Hoses are also sometimes called pipes. For pneumatics air hoses are to be used. 6 hoses are to be used in the robotic arm.2 inlets for compressor.2 outlets of the first DCV to horizontal cylinder. 2 outlets of the second DCV hose to vertical cylinder.

Fig. 11 Hoses

K. COMMUNICATION CABLE

Fig.12 Communication Cable

Communication cable is to be used for communicating with the PLC and SCADA with the robotic arm. Figure 12 shows the Communication Cable.

IV. SOFTWARE USED

A. PROGRAMMABLE LOGIC CONTROLLER

Programmable logic controller also called as programmable controller is a digital computer used for controlling of machinery on factory assembly line. PLC is an industrial computer control system that continuously looks after the condition of input devices and makes the decision based upon the custom program to control the condition of output devices.

It was first developed in the automobile industry to provide flexible, shock-resistance and easily programmable controllers to replace hard-wired relays and timers. Since then they have been widely used as highly-trusted automation controllers applicable for harsh environments. It converts the values into pulses as per the program. PLC sends command to the servo driver to command AC servo to rotate to the prescribed speed and number of rotations.

a. DELTA

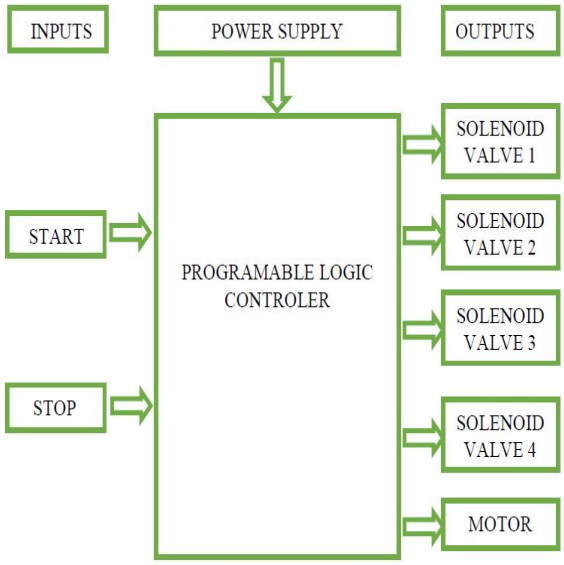

Fig.13 PLC block diagram

Delta group of companies is headquartered in TAIWAN Delta Group is the world's largest provider of switching power supplies and DC brushless fans, as well as a major source for power management solutions, components, display solutions, industrial automation, networking products, and renewable energy solutions. Delta Group has sales offices worldwide and manufacturing plants in Taiwan, China,

Thailand, Mexico, India and Europe. For more than 40 years, Delta Group has pursued the mission: “To provide innovative, clean and energy-efficient solutions for a better tomorrow." With its focus on continuous innovation, Delta has become a global leader in a range of products and has received the Forbes Asia "Fabulous 50" Award for several consecutive years.

b. COMPONENTS OF PLC

The language itself is a set of connections between logical checkers (contacts)and actuators (coils). If a path traced between the left side of the rung and the output, through asserted (true or closed) contacts, the rung is true and the output coil storage bit is asserted 1. If no path is traced, then the output is false (0) and the coil by analogy to electromechanical relays is considered de-energized. Ladder logic has contacts that make or break circuits to control coils. Each coil or contact electromechanical relays, a ladder program can refer any number of times to the status of a single bit, equivalent to a relay with an indefinitely large number of contacts. Contacts may refer to physical or hard inputs to the PLC from devices such as pushbuttons and limit switches via an integrated or external input module, or may represent the status of internal storage bits, which may be generated elsewhere in the program. Each rung of ladder language typically has one coil at the far right. Some manufacturers may allow more than one output coil on a rung.

1. ( ) - Regular coil. It is energized whenever its rung is closed.
2. (\\) - "Not" coil. It is energized whenever its rung is open.
3. [ ] - Regular contact. It is closed whenever its corresponding coil or an input which controls it is energized.
4. [\\] - "Not" contact. It is open whenever its corresponding coil or an input which controls it is energized.

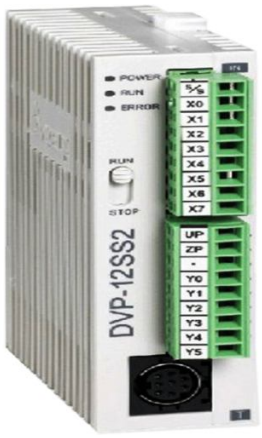

Fig.14 DVP-14SS2

B. SCADA

a. INTOUCH

INTOUCH goes beyond simplistic graphics to enable application builders to focus on creating meaningful content that will drive enterprise-wide operations productivity and cost savings. InTouch empowers operators to optimize their routine human interactions with industrial automation systems. This results in a quantifiable net increase in operator effectiveness. Our unique approach through situational awareness libraries provides contextualized information that operators need to quickly and accurately address abnormal situations before they impact operations.

Used in more than one-third of the world’s industrial facilities, in virtually every country and industry, InTouch HMI software continues to deliver business value in engineering simplicity, operational agility and real-time performance mastery.

SCADA is the system that manages the other systems - it usually has quite a bit of human input and doesn’t usually contain logic, it sends and reads information from the local system, be it a PLC, robotic controller etc.

A SCADA system refer to a system consisting of a number of remote terminal units (or RTUs) collecting field data connected back to a master station via a communications system. The master station displays the acquired data and also allows the operator to perform remote control tasks. The accurate and timely data (normally real-time) allows for optimization of the operation of the plant and process. A further benefit is more efficient, reliable and most importantly, safer operations. This all results in a lower cost of operation compared to earlier non-automated systems.

V. RESULTS

The robotic arm was designed and fabricated and connected through PLC and checked for pick and place application. The SCADA screen has been developed and has been interfaced with PLC in order to monitor the working of the arm.

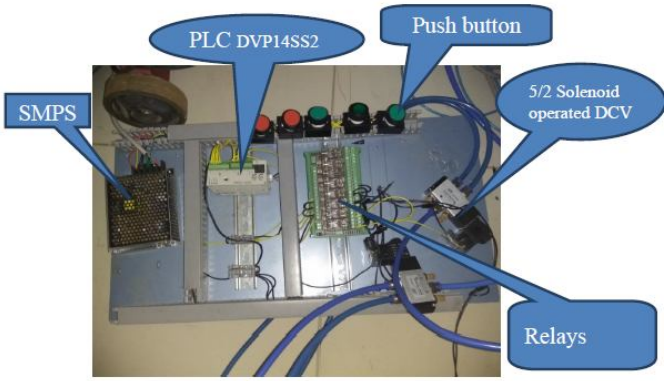

Fig.15 Components of the robotic arm

Figure 15 shows the components of the robotic arm. The whole process is controlled and monitored in SCADA system. So if the system fails the process can be handled in SCADA. SCADA is nothing but software for controlling the process and monitoring the whole system. A third party server has been implemented to communicate the SCADA and the PLC. The third party server is called KEPSERVER. Using this we create a server and connect PLC and make an alias map as SCADA so that both of the technologies can speak with each other. Figure 16 shows the robotic arm.

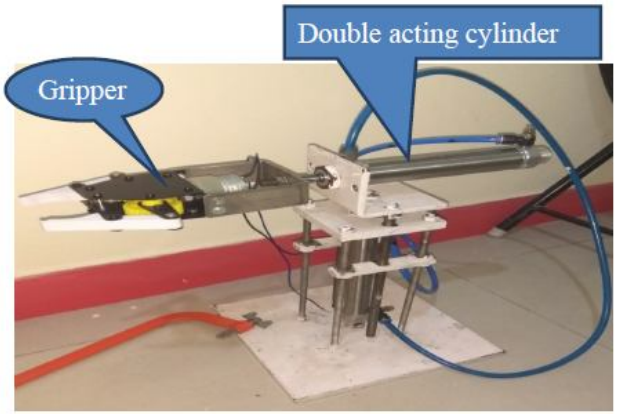

Fig. 16 Robotic arm

VI. CONCLUSION

- The concepts for programming the PLC has been studied and implemented successfully for the logic of the robotic arm.
- The purpose of SCADA and Importance has been learnt and Animations has been created for the robotic arm.
- The SCADA has been designed in such a way that the Process can be controlled from SCADA also.
- The main aim is to develop a 2D robot that can be used for material handling, and the same has been fabricated.
- All the objectives has been verified and achieved full fledge.
- The robotic arm has been checked and verified for two operations of auto pick and place function and also manual control.

VII. FUTURE SCOPE

- Can be used in all material handling applications.
- Can be interfaced with extra axis for achieving more efficiency.
- Even by changing end effectors it can use it for general welding purposes.
- Using PLC we can establish communication to even HMI and Drives for interfacing with conveyors.

REFERENCES

[1] Z. Drezner,S.Y.Nof, “On optimizing bin picking and insertion plans for assembly robots”,IIETrans.16(3)(1984)262–270.

[2] L.Feng, J.Borenstein, D. Wehe, A Completely Wireless Development System for Mobile Robots. ISRAM conferecence, Montpellier, France, May 27-30, 1996, pp.571-576

[3] Wan MuhamadHanif Wan Kadir, Reza EzuanSamin, Babul Salam Kader Ibrahim,“Internet Controlled Robotic Arm”, Page No.1065 – 1071,IRIS 2012.

[4] MohdAshiqKamarilYusoff, Reza EzuanSamin, Babul Salam Kader Ibrahim, “Wireless Mobile Robotic Arm”,Page No.1072 – 1078,IRIS 2012.

[5] Enrique Hortal , Eduardo Ianez, Andres Ubeda, Carlos Perez-Vidal, Jose M. Azorin,“Combining a Brain–Machine Interface and an Electrooculography Interface to perform pick and place tasks with a robotic arm”,Page No.181–188,2015.

[6] A.Hosovsky, J.Pitel, K.Zidek, M.Tothova, J.Sarosi,L.Cveticanin,“Dynamic characterization and simulation of two-link soft robot arm with pneumatic muscles”Page No.98–116,2016.

[7] DipakAphale ,VikasKusekar “PLC Based Pick and Place Robot with 4 DOF”,IJIRSET, Vol. 5, Issue 2, February 2016.

[8] Mohsen Moghaddam ,ShimonY.Nof, "Parallelism of Pick-and-Place operations by multi-gripper robotic arms",Page No.135–146, 2016.
[9] S.C. Gutierreza, R. Zotovic, M.D. Navarro, M.D. Meseguer,"Design and manufacturing of a prototype of a lightweight robot arm", Page No. 283–290,MESIC 2017.
[10] Hsien-I Lin, "Development of an intelligent transformer insertion system using a robot arm", Page No.209–221,2018.