

Design of Automatic Paint Spraying Machine

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Abstract

The objective of the paper is to automate the spray painting process of pump casings that is mass-produced in industries. At present two workers work in a single paint booth, one for handling the component while the other worker paints the component. In this proposed paper, the pump casings are cylindrical components which are painted while being rotated by a three phase induction motor. A pneumatic cylinder is used to lift the paint gun so that the paint is applied to the entire height of the pump casing. The paint gun is actuated by another pneumatic cylinder. The process is controlled by ATmega16 microcontroller. An IR sensor placed at the top of the paint gun is used to detect if the pump casing is placed or not and to detect the upper limit of the pump casing so that the spray can be stopped when the paint gun reaches the top of the pump casing. The pneumatic cylinders are controlled using two electro-pneumatic solenoid valves, one for extension and the other for retraction. When the pump casing is placed, the paint spray starts and the paint gun is lifted. When the paint gun has reached the required height, the spray stops and the paint gun is lowered. Finally the pump casing is taken out. The paint spray system that can paint a cylindrical component with a maximum height of 30 cm and maximum diameter of 20 cm. A worker is needed only to handle the component, thereby reducing the number of workers per paint booth by one and also the time taken for painting is reduced.

Keywords: Paint Automation, Embedded Systems, Arduino Board, Pneumatic cylinder, sold works

Introduction

Automation plays an very important role in all fields of engineering. The biggest advantage of automation is that it is used to save power, energy and materials and to improve the quality, precision and accuracy.

The primary aim of the project is to design, develop and implement Paint Automation which helps to achieve low cost painting process. The chemicals used in painting cause health problems like to the human painters. The repeated painting makes the workers boring and strainful. When industrial workers and the automation systems are properly integrated in the industrial painting tasks, the whole process can be better managed and savings in human labor and timing are obtained as a consequence. It would offer the opportunity to avoid the human to work under hazardous environments. These factors motivate the development of the paint booth automation system.

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At present the spray painting is done manually by the workers. The paper discuss a method to automate the spray painting process. It uses spraying technique where the coating is done through the air onto a surface. This project is developed to reduce the manual work for the workers. The automotive painting system is a zero fault tolerance and it improves the quality.

Related Work

Automatic Wall Painting Robot by the students of K.S. Rangasamy College of Technology, Tiruchengode have framed a model for internal wall painting. The robot is designed by steel rods, spray gun and aoperator unit to control the entire operation of the robot. They also have a very small weight to power output ratio and predictable performance.

Electro mechanical vertical reciprocators are industrial based automatic painting systems which are used to paint the surfaces of rectangular components. The Reciprocator paint the entire surface of the component by moving the paint gun in a vertical

linear motion. The motion is achieved by using pneumatics.

SYSTEM Design

The design of the paint spraying machine involves the initial stages of concept design and their purposes. Selection of sensors and microcontroller were decided on the basis of complexity, easy of fabrication and simplicity.

Concept Design

In the concept design various mechanisms for the different systems like paint gun actuation, lifting the paint gun, rotating the component holder were made. Figure 1 shows the conceptual design of the paint booth arrangement. The model of the system consists of component holder, pneumatic system to lift the paint spraying gun. Then consists of a rotating cylindrical fixture where the components are placed, the cylinder was energized by the induction motor through the pulley.

The timing belt to transmit the power generated from induction motor to the cylindrical fixture.



Figure 1. Conceptual Design

Gun Actuation Mechanism

Actuation mechanism for the paint spray gun is used to control the flow of paint. The actuation mechanism consists of a mechanical arrangement, small wooden block and the pneumatic cylinder. Based on the input signal from the control unit by the pneumatic cylinder

will extract and retract. When the pneumatic cylinder is extended the Paint spray gun was triggered by the mechanical arrangement. Small wooden block is made to hold and align the spray gun with pneumatic cylinder in correct position without any mismatch. Figure 2 shows the actuation mechanism of the mechanical arrangement.

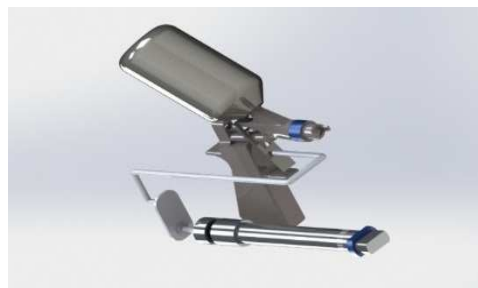


Figure 2. Gun Actuation Mechanism

Pulley

Pulley is used to transfer the mechanical power from the electric motor to the work holding arrangement. Based on the requirement the rotational speed of the work holding arrangement can be varied using

suitable pulley arrangement. The movement of component holder is achieved by belt and pulley mechanism due to its less complexity, simplicity in design and fabrication. Figure.3 shows the pulley arrangement for this project.

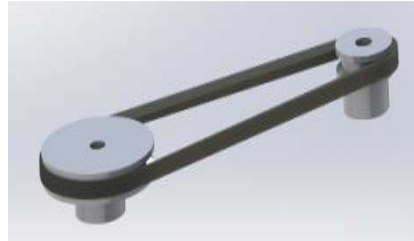


Figure 3. Pulley Arrangement

Frame Design

Frame is the base part of the paint booth automation project. Entire components of the paint booth was

take place on the top of the frame, so the frame design is made with suitable spaces for holding and orienting the components. Figure.4 shows the design of the frame.



Figure 4. Frame Design

The entire structure is made using L clamps to reduce the weight and material cost. Two ball bearings are to be placed in the middle for smooth rotation of

component holder. Figure.5 shows the final assembly design.

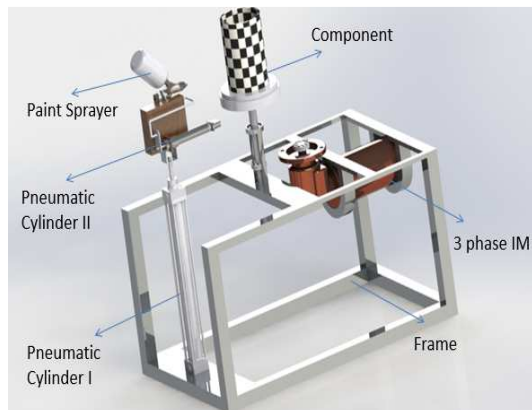


Figure 5. Assembly Model

Hardware

Base Frame

The base frame stand is the steel welded in such a manner that to hold the whole equipment. The steels

are welded strongly in welding workshop with an idea to carry the entire paint booth with the control unit, battery and Induction motor in the platform and the IR sensor, solenoid valve and spray gun in the pneumatic cylinder arrangement. The arrangement of the frame is shown in Figure 6.



Figure 6.Base Frame

Induction Motor

A 3 phase induction motor is used for rotating the pump casing.

Specification of Induction Motor

- Voltage rating :415 V
- Frequency :50 Hz
- Current rating :.36 A

- IP rating :IP 44/65
- Rated Torque :17.5 Nm
- Rated Speed : 25 rpm

Pulley

A pulley belt mechanism is used to transmit the rotational motion. The final output speed becomes twice that of the speed of the motor by using a 1:2 ratio pulley as shown in Figure 7



Figure 7.Pulley Arrangement

Rated Speed of Motor = 25 rpm
 Output speed from pulley = 25 x 2
 = 50 rpm

Work Holding Fixture

A fixture is a device used to fix a work piece in a given coordinate system relative to the tool. It will constrain the all degrees of freedom of a work piece. Generally the painting is fast based process, so the component to be painted must be easy to clamp and unclamp.

Control Unit

The control board is the heart of the paint booth automation system. It controls the motoring operation, pneumatic cylinder’s extension and retraction, based on the IR sensor’s output and the power button input. The arrangement of the control unit is shown in Figure 8.

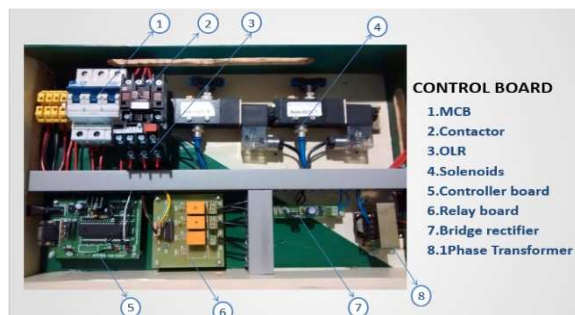


Figure 8.Control Board

Paint Spraying System

A spray painting system module consists of a spray painting gun, a pressured container with a compressed air system and flexible tubing system.

This type of system has a transfer efficiency ranging between 20% and 50%. A conventional spray gun uses air to atomize paint. Paint flows through a long tube which is pressurized from 8 to 30 psi. Figure 9 shows a spray gun with compressor.



Figure 9. Paint Spraying Gun with Compressor

There, the atomizing air breaks the paint into small particles and coated on the surface which is to be painted.

Pneumatic Cylinder

For this project, system Double Acting Cylinder as

shown in Figure 10 is used. Pneumatic cylinders are mechanical equipments which uses compressed gas to produce necessary force in a reciprocating linear motion. Pneumatics has the lowest cost than other actuators. Pneumatic cylinder is used to start or stop the spraying process by pressing its handle.



Figure 10. Pneumatic Cylinder

In this project there are two Double Acting Cylinders are used. These cylinders have the same input air pressure but differs in their stroke length. The cylinder I is used for the paint sprayer actuation and the cylinder II is used for the up-down movement of the paint sprayer.

To detect the object presence the IR sensor was placed on the top of the pneumatic cylinder. If the object is detect by the IR sensor it send the signal to the control unit and the control unit sends the actuation signal to the pneumatic cylinder I and II. The actuation of these cylinders causes the paint sprayer actuation and the elevating the whole paint spraying system. If the maximum height reached or if the IR sensor not detect the object presence it immediately stop sending signals to the control unit. Then the pneumatic cylinders retract back to its original position.

Solenoid Valve

A solenoid valve is an electromechanical device which is controlled by an electric current. Their tasks are to shut on and off.

Specifications of Solenoid:

- Type : 5/2 Solenoid operated spring return valve
- Power : 4.8 W
- Voltage level: 220 V AC
- Pressure : 10 bar
- IP Rating : IP 65

Results and Discussion

When the system is switched on, the motor starts rotating and keeps on till the system is switched off. The worker loads the job on the holding fixture. The

job when loaded, is detected by an IR sensor. This causes the spray painting process to start by actuating the paint gun. The pneumatic cylinder holding the paint gun extends making the paint to cover the entire surface area of the job. When the paint gun is lifted above the job size, the IR sensor stops detecting the

job. This stops the spray paint and the pneumatic cylinder retracts to its starting position. The job will be unloaded by the worker and the next job can be inserted. Figure 12 shows the flow of the process to be executed.

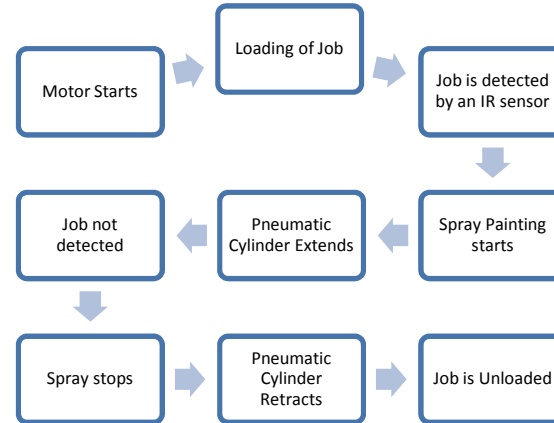


Figure 11. Work flow

This main idea of this project is to reduce the human interference in the painting process of the pump casing in industry is successfully done. By improving the component fixture design it can be made to accommodate various sizes of components. The automated painting process with less human interference results improvement in accuracy and the quality of the painting is enhanced. The number of workers needed per paint booth is reduced by one since the worker only has to handle the pump casing. Also the cycle time for the painting operation of a single component was reduced and the productivity of the paint booth is enlarged.

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