A Research Paper on Spray-Painting Robot for Painting Irregular Workpieces

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Abstract - *The present research paper aims at design of a cost-effective Spray-Painting Robot which is capable of painting irregular workpieces with highly contoured surfaces. With advent of Electrostatic spray-painting techniques, it is imperative to automate the painting process due to the electrical hazards posed. Intelligent Robotic systems used for painting need complex path planning algorithms and thus can become very costly. The main objective of this Robot is to detect the object position and plan the path accordingly. This improves the operation efficiency and reduces paint wastage.*

Key Words: Spray-Painting Robot, LIDAR, 4-Axis Robot, Electrostatic Painting, Wrap-around Effect.

1. INTRODUCTION

Spray painting is a painting technique where a device sprays a coating (paint, ink, varnish, etc.) through the air onto a surface. The most common types employ compressed gas— usually air—to atomize and direct the paint particles. Painting robots and industrial robots in general have a reputation of only being affordable to the largest and most technologically adept companies. Today's reality, however, is far different as robots of all kinds are now highly viable for a full range of smaller, general industrial markets and applications. Painting robots now have the ability to control all aspects of spray parameters. Fan air, atomization air, fluid flow, voltage, etc., can all be controlled by the robot control system. The said robotic system provides the same performance as that of complex Robotic Arms at a fraction of its cost.

2. LITERATURE REVIEW

1) Andreas Pichler et-al, A method has been developed for automatic spray painting of unknown parts. The input for the system does not include any pre-established CAD models or other information about the parts. The parts are entirely specified by geometry models, provided by a laser scanning system and customized feature extraction methods. Up to now the parts were scanned by one laser scanner only. The parts of the surfaces that were visible to the scanner were modelled in a 3D geometry model, which was used to automatically generate the motions of the spray gun. Collisions between the spray gun and the part and conveyor system were automatically avoided by a collision avoidance module from AMROSE, Ltd.

2) Ijeoma W. Muzan et-al, Technology is growing at a pace that no one has been able to measure or quantify accurately. We have witnessed the invention of robots, machines, electricity etc. Industrial Robots can be used for different applications which simply cut across industrial and personal purposes. They perform different tasks based on how they have been programmed or taught manually. The result was able to boost the quality of painting, safety was improved with the usage of all the painting materials, and the cost of painting was reduced by using less paint.

3) Shigeru Ikemotoa et-al, The goal of this research is the development of a learning system for the coating and painting tasks carried out in automobile repair. In this study, the characteristics of skilled spray gun handling for automobile repair painting were analyzed and compared with those with little or no experience. The spray gun movements of the experts were characterized by longer length, longer time, higher speed, and narrower swing range, compared with the non-experts. The results showed that spray gun handling of experts is characterized by longer running length, longer spray time, higher speed, and narrower spray gun swing range when compared with that of non-experts.

4) Wei Chenand et-al, Painting robot is a kind of important and advanced spray equipment. It is widely used in automotive manufacturing. The figure of a product and the tool parameters can strongly influence the quality of painting. In order to achieve the new spraying operation standards, new painting models and tool planning algorithms are active research for many years. Automated tool path generation is the key technology of robotic offline programming method. At present, generating paint gun trajectories for plane and regular surfaces have achieved satisfactory results. Experiments are performed to measure the material thickness on a freeform surface for both optimal and non-optimal tool path. Experimental results show that the optimal tool path takes less process time compared with the non-optimal tool path. And the results demonstrate the advantages of the optimal path planning algorithm.

5) K.V. Chidambara, et-al, Paper gives information Optimization of Robotic Spray Painting process parameters. The robotic spray painting is affected by different parameters like paint flow, shaping air, turbine speed, high voltage and viscosity. In

the present work the output quality of robotic spray painting is measured in terms of Dry film thickness(DFT).
6) J. Domnick, et-al, The present contribution summarizes ongoing investigations of the Fraunhofer-Institute for Manufacturing Engineering and Automation aiming to extend the range of applicability of numerical simulations applied to the electrostatically supported painting process with high- speed rotary bells.

3. DESIGN OF ROBOT

For structural stability base structure has a diamond pattern that has 4 bars on which carriage traverses in the vertical direction. The members provide structural strength as well as rolling surface for bearings on the carriage. This part also houses the base hydraulic cylinder in the center which facilitates the motion of the carriage. The carriage slides on the base structure with the help of roller bearings. The carriage provides guideways for the movement of the spray-gun mount. The movement to the spray gun mount in two directions i.e. and Z axes is given by hydraulic actuators. The inclined portion of the structure is given so that the base actuator when on retracted position gives the perfect height for clearing the obstruction provided by the wall at the bottom in the booth.

Motion to the robot. The gun is mounted on a mount which has a slider which helps the motion, the mount also has an encoder motor which facilitates the tilting motion of the spray gun. Thus, making it a 4-axis robot. All the structural members in the robot except for the base structure are made up of aluminum alloy making it strong and light in weight. The base structure is made of Mild steel for better compressive as well as tensile strength.

4. DESIGN OF HYDRAULIC SYSTEM

With a variety of applications, hydraulic systems are used in all kinds of large and small industrial settings, as well as buildings, construction equipment, and vehicles. Paper mills, logging, manufacturing, robotics, and steel processing are leading users of hydraulic equipment. As an efficient and cost-effective way to create movement or repetition, hydraulic system-based equipment is hard to top. It's likely your company has hydraulics in use in one or more applications for these reasons.The purpose of a specific hydraulic system may vary, but all hydraulic systems work through the same basic concept. Defined simply, hydraulic systems function and perform tasks through using a fluid that is pressurized. Another way to put this is the pressurized fluid makes things work.The power of liquid fuel in hydraulics is significant and as a result, hydraulic are commonly used in heavy equipment. In a hydraulic system, pressure, applied to a contained fluid at any point, is transmitted undiminished. That pressurized fluid acts upon every part of the section of a containing vessel and creates force or power. Due to the use of this force, and depending on how it's applied, operators can lift heavy loads, and precise repetitive tasks can be easily done.Results obtained from modelling in Fluid-Sim show slight discrepancies compared to the general mathematical representation of a hydraulic system. Advantages of using Fluid-Sim toolbox for simulation of the system is seen through easy access modelling and user-friendly options. While performing the simulation of the system software allows dynamic movement of the hydraulic system components (e.g. cylinder extension and retraction) while performing the simulation itself.
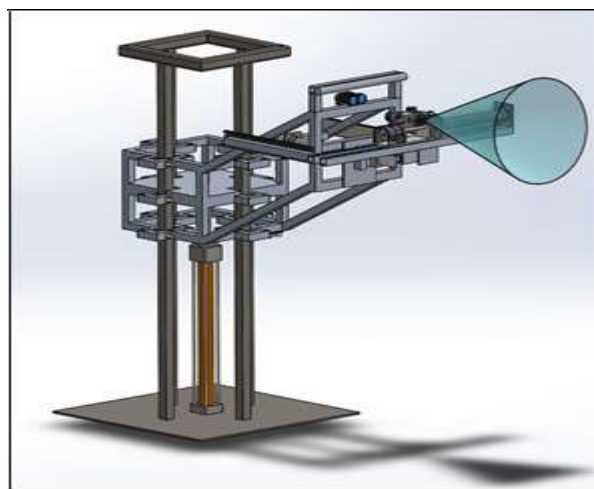

Figure 1:CAD Model of Robot

The 2-axis motion in horizontal plane(x-z) is given to the gun via hydraulic cylinders for obtaining the correct position given by the sensor to the system. The actuator in the X- direction is responsible for positioning the gun in front of the axle. The other actuator in the Z-direction is utilized to keep the distant between the gun tip and the axle surface constant to ensure a consistent coat of paint on the axle. While the 2 cylinders that of lift and base actuator give the vertical
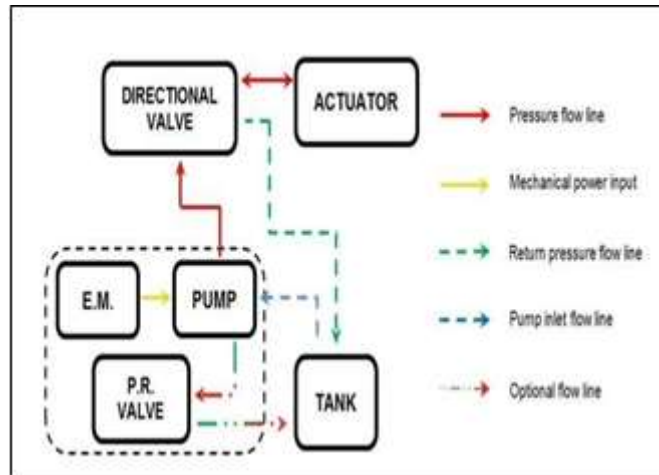

Figure 2:Block Diagram of Hydraulic System

The Lidar emitter emits a laser pulse which is incident on the object and the receiver receives a reflected ray. The time elapsed between the sending and receiving is used to determine the distance of the object. At an object boundary there will be a sharp change in the signal. This helps in determining the extremities of the object. Thus, by using triangulation techniques the mean position of the object can be obtained.

The lidar sensor mounted on the robot detects the extremities of the axle at every instance as it moves upwards. Thus, determining the position and the topography of the axle. This is used to position the spray gun in such a way to maximize the spray area on the axle. Since the lidar sensor gives the distance of the axle from the gun, the system is programmed accordingly to keep this distance constant.

6. AUTOMATIC LUBRICATION SYSTEM (ALS)

The guideways under the spray gun have sliding metal parts. Due to friction between these parts, there is a need of lubrication. A lubrication system is designed such that a nozzle delivers lube oil at the lubrication grooves. The oil is stored in a tank and a pipe connects it to the deliver nozzle. A metering valve is used to regulated the flow of lube to the guideways. The lubricant selected needs to be a paint repellent as there is some possibility of spray particles settling on the guideways.
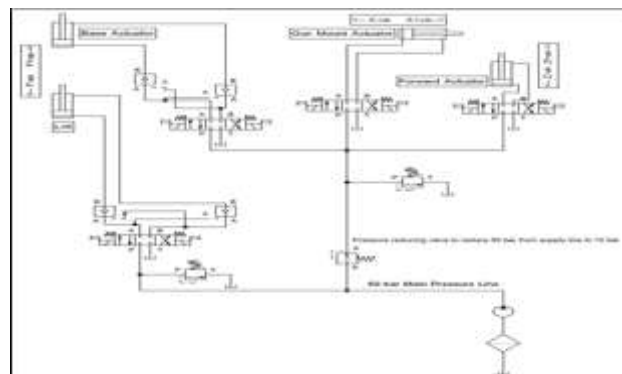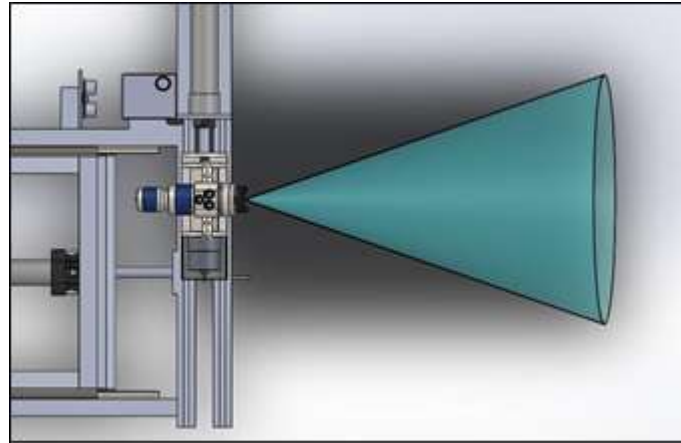

Figure 3:Hydraulic System
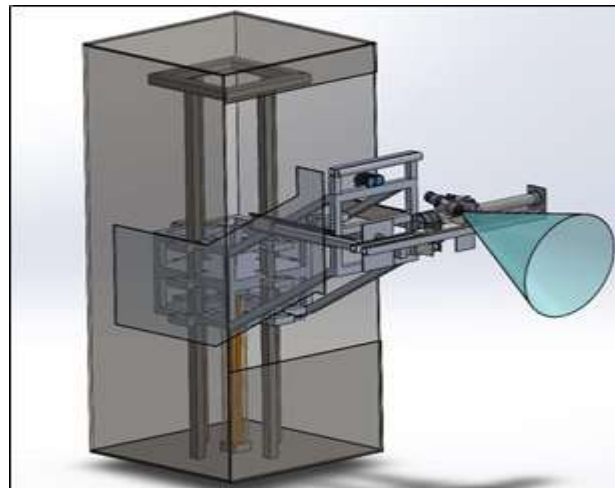
Figure 4:Lidar

5.USE OF LIDAR IN THE SYSTEM

Figure 5: ALS

7.ELECTROSTATIC PAINTING

Electrostatic painting is a manufacturing process that employs charged particles to more efficiently paint a workpiece. Paint, in the form of either powdered particles or atomized liquid, is initially projected towards a conductive workpiece using normal spraying methods, and is then accelerated toward the work piece by a powerful electrostatic charge. Electrostatic spray charging improves the transfer efficiency of spray finishing equipment. The transfer efficiency improvements occur because the electrostatic forces help overcome other forces, such as momentum and air flow, that can cause the atomized materials to miss the intended target. Electrostatic methods save coating material, time, and labor. More of the material is attracted to and adheres to the target, and less material is lost in the spray booth and the surrounding environment. Electrostatic methods also lower solvent emissions into the air since less coating material is needed to coat each part.

8. ULTRASONIC SENSOR

As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception.

An optical sensor has a transmitter and receiver, whereas an ultrasonic sensor uses a single ultrasonic element for both

emission and reception. In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately. This enables miniaturization of the sensor head.

The distance can be calculated with the following formula:
Distance L = 1/2 × T × C
L= distance
T= time between the emission and reception C=sonic speed.
 (The value is multiplied by 1/2 because T is the time for go- and-return distance.)

9. RESULT

Chart 1: Result Chart

Efficiency of the robot was greater than the manual efficiency which is seen in the chart above and thus the difference can be noted

8. CONCLUSIONS

Automation increases operator efficiency. Need of skilled labor is eliminated. Implementation of electrostatic spray-painting reduces the paint consumption by 9%. Thus, increasing the profit margins. Electrostatic spray-painting for large scale production increases productivity and consistency in quality, reducing rework and minimizing rejection.
Accurate path planning of spray pattern helps to further eliminate double coats and run-offs. The system paints only when an object is detected. The sensors detect the boundaries and topographies and depending on it can paint multiple types of axles.

This system can be integrated with minimum changes to the existing system.

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