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Research Article

Automated painting and UV curing system based on Arduino

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Abstract

Painting is a process of applying paint on surface of any object. But painting is time and effort consuming process. It is also hazardous and exhausting technique which makes it an excellent case for automation. Ultraviolet curing known as UV curing is a photochemical process with high-intensity ultraviolet light is used to instantly cure or dry inks, adhesives or coatings. There is a strong need for automation in painting and curing of paint for manufacturing industries as it reduces the human effort, maintains consistency and helps in obtaining perfection. In this project, the design of an automated painting and Uv curing system is described. The design objective is to fulfill the foundation of simplicity, easy handling, low cost, reducing human effort and consistent painting. This project involves painting and UV curing of a raw MDF panel which moves on a conveyor for painting and curing purposes. The system includes IR sensors, dc motor, a spray gun and a UV lamp controlled by arduino microcontroller.

Keywords: *Automated painting etc.*

1. Introduction

1.1 Problem Statement

[1]Development of automated painting and UV curing system based on microcontroller.

1.2 Objective

With the increasing advancements in automation and consistency in painting for manufacturing industry, it is also important to develop a low cost system to meet the needs of the industry. As in case of this project the material for painting and curing will be a medium density fibre (MDF) board which is extensively used in furniture manufacturing industry. The main objective of this project are as follows:

- To develop a low cost painting and curing system.
- To obtain curing of the paint by using Ultra-violet (UV) light.
- To analyse the UV curing process.
- To fabricate the automated painting and UV curing system.

1.3 Scope

Scope of this project is to develop an automated painting and UV curing system. Overall scopes of this project are stated below:

1) Designing of an automated painting and curing system.
2) Fabrication of the automated system.(Includes fabrication of the chassis of the system, mounting of the components and programming of the microcontroller)
3) Analysis of the UV curing process.
4) Testing of the painting and UV curing application.

1.4 Methodology

Design

- Designing of the system for accurate painting and curing of MDF panel.
- Programming of the microcontrollers to achieve the control of the components.
- Circuit diagram for the control of the system.

Analysis

- Selection of the components for the system.
- Developing of codes for arduino micro controllers.

Fabrication

- Fabrication of the platform for the system.
- Mounting the components on the system.
- Circuit setup for the control of the system through micro controller.

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Testing

- Check the working of the system and modify if necessary.
- Analysis of the painting process for proper painting application.
- Analysis of the UV curing process for the curing of the paint on the panel.

2. Literature Review

H. Anderson *et al* (2002) were presented an approach for automatically spray paint families of unknown parts. It uses a sensing cell where the part geometry is acquired. From the part geometry process-relevant features are extracted and corresponding paint routines are found and grouped to obtain optimal painting trajectories. At last a collision free robot path and an executable robot program are generated and all steps are fully automatic and no intervention of an operator is needed. First implementations at industrial users show that the approach is feasible. Parts can be scanned and robot programs are generated automatically for a part rate of one per minute using conventional PC technology. It is planned to improve the Flex Paint process by using robot-mounted sensors to be able to scan sections of parts that are not visible with fixed sensors. Next extension may be methods to teach other than the current geometric features.

Mohamed T. Sorour *et al* (2011) explain the development of an autonomous robot to paint the interior walls of buildings. This robot consists of a painting arm with an end effector roller which scans not only walls vertically also a mobile platform to give horizontal feed to paint the complete area of the wall. At adjusted distance from the wall the controller starts. Different modules constituting the robot have been separately tested then integrated. Experiments have shown good ability of the robot in its intended tasks. This paper gives the algorithm for automating the process of painting a single wall. Overall system have been successfully integrated and tested. The robotic arm has succeeded in moving along the trajectory intended while keeping roller-wall contact at all times. The mobile platform has fulfilled its lateral feeding task in the desirable manner. A painting duration of the order 0.101 hour/m has been achieved and may be used for domestic use.

Pranit Singh *et al* stated that in this mechanized world, there is a growing urge of automatic execution of almost all our works. Humans avoid getting physically involved in the task; rather find machines to carry out our designated work. In other words, we are developing a painting machine for wall painting, but it needs to be incorporated with automatic features of robotics. They started off by programming the arduino to some basic functionalities and then establishing its connection with the bluetooth module. The next step involved the making of an android app which could be used over different devices supported by android. Then, they made use of an IC (L298) which helped in controlling the motors. The following conditions have been kept in mind prior to development:
(1) On feeding an input program, the structure starts painting accordingly.
(2) To carry out its function on any given position on the wall.
(3) The entire chassis and internal equipment weighs less than 4 kg in the prototype version.
(4) Several colors can be utilised at any given point.
Wall-e was basically developed with idea of reducing human errors and wastage of time. The prototype proves to be successfully delivering both these qualities along with efficient resource utilisation. For further enhancement we would like to add a drawing module in which the user inputs a certain image and with the help of image processing the system recognises the image and paints it on the wall.
Dr. Kaj Hedman *et al* (2009) describes the important differences in Ultra Violet cure profile which was observed for a fiber optic coating sample exposed to UV radiation. A poor cure characteristics was shown by the intensity of 1.0 mW/cm2 as compared to the intensities of 5.0 mW/cm^2 and also higher..

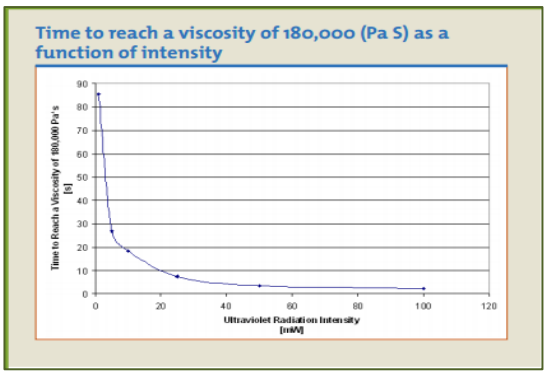
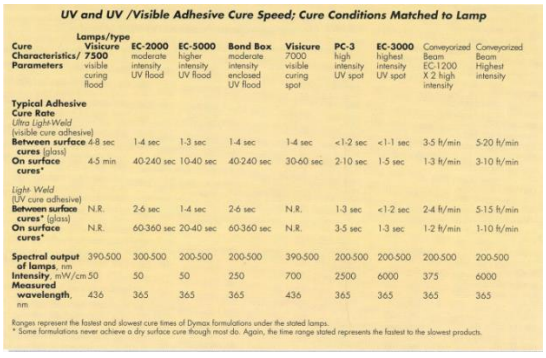


Fig 2.1 Time to reach specified viscosity vs UV radiation intensity

Clai Bachman *et al* (1995) studied the time and mechanism for UV curing in detail. He concluded with a list of benefits for the use of UV aerobic acrylic adhesive. He also studied the UV adhesive curing speed and cure conditions matched to lamp which are given below:



UV and UV /Visible Adhesive Cure Speed; Cure Conditions Matched to Lamp

Cure Characteristics/ Parameters	Lamps/type Visicure 7500 visible curing flood	EC-2000 moderate intensity UV flood	EC-5000 higher intensity UV flood	Bond Box moderate intensity enclosed UV flood	Visicure 7000 visible curing spot	PC-3 high intensity UV spot	EC-3000 highest intensity UV spot	Conveyorized Beam EC-1200 X 2 high intensity	Conveyorized Beam Highest intensity
Typical Adhesive Cure Rate									
Ultra Light-Weld (visible cure adhesive)									
Between surface cures (glass)	4-8 sec	1-4 sec	1-3 sec	1-4 sec	1-4 sec	<1-2 sec	<1-1 sec	3-5 ft/min	5-20 ft/min
On surface cures*	4-5 min	40-240 sec	10-40 sec	40-240 sec	30-60 sec	2-10 sec	1-5 sec	1-3 ft/min	3-10 ft/min
Light-Weld (UV cure adhesive)									
Between surface cures* (glass)	N.R.	2-6 sec	1-4 sec	2-6 sec	N.R.	1-3 sec	<1-2 sec	2-4 ft/min	5-15 ft/min
On surface cures*	N.R.	60-360 sec	20-40 sec	60-360 sec	N.R.	3-5 sec	1-3 sec	1-2 ft/min	1-10 ft/min
Spectral output of lamps, nm	390-500	300-500	200-500	200-500	390-500	200-500	200-500	200-500	200-500
Intensity, mW/cm	50	50	50	250	700	2500	6000	375	6000
Measured wavelength, nm	436	365	365	365	436	365	365	365	365

Ranges represent the fastest and slowest cure times of Dymax formulations under the stated lamps.
* Some formulations never achieve a dry surface cure though most do. Again, the time range stated represents the fastest to the slowest products.

Fig 2.2 UV adhesive cure speed

3. Components of the system

3.1 Arduino Uno

A microcontroller board based on the ATmega328 datasheet having name Arduino Uno is used and which has 14 digital input/output pins from which 6 can be used as PWM outputs. Also 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button was used.

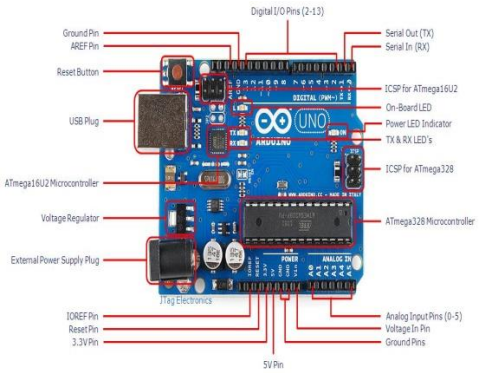


Fig 3.1 Arduino Uno Microcontroller

3.2 Conveyor Belt

The material used for conveyor belt in this system will be rubber. The applications for this type of belting include:

- Cut resistant.
- Low friction for accumulation.
- Electrically conductive.
- Troughed for bulk handling.
- Oil resistant.

3.3 Spray Gun

Spray gun is used for the paint application on the MDF panel vertically. It uses compressed air from an air compressor that will spray the paint on the surface of the panel. The gun will start spraying as soon as the panel will enter the painting booth by the conveyor belt.

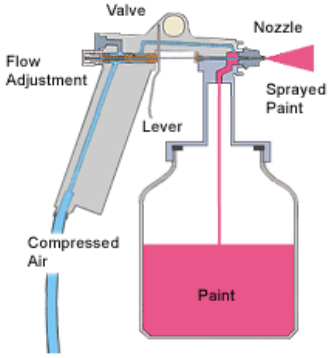


Fig 3.3 Spray Gun

3.4 IR Proximity Sensors

An electronic instrument which is used to sense specific characteristics of its surroundings by either emitting and/or detecting infrared radiation is called an Infrared Sensor. The IR sensor is used to detect the MDF panel just before the painting booth and will send signal to the arduino. This will help the microcontroller to reduce the motor speed and spraying the paint for proper paint application on the panel.

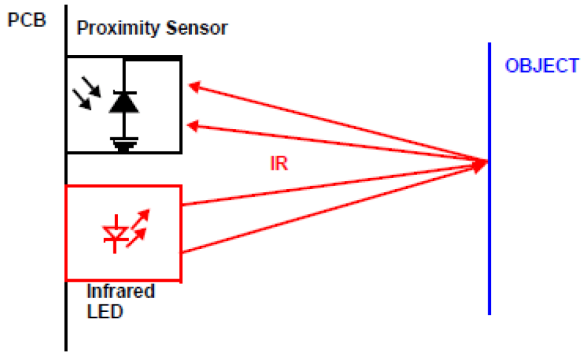


Fig 3.4 Working of IR proximity sensor

3.5 UV Lamp

Mercury vapor lamps are most commonly used for curing products with UV light. High voltage passes through the bulbs, which vaporizes the mercury. It in turn creates an arc within the mercury that emits a spectral output in the UV region. It has an output in the short wave UV range between 220 and 320 nm and in longwave range at 365 nm. These lamps are a good choice for thin ink layers and clear coatings that produces hard surface cures and high gloss finishes.

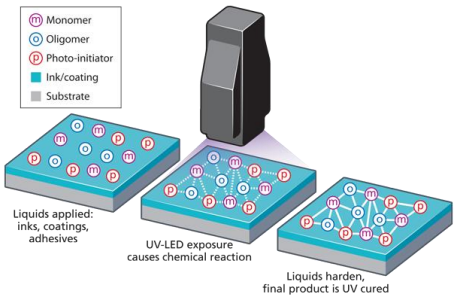


Fig 3.5 UV curing process using UV lamp

4. Costing

1	Rubber conveyor	1 meters	2000/-
2	Dc brushless motor	1 nos.	2500/-
3	Spray gun	1 nos.	1500/-
4	Uv lamp	1 nos.	2000/-
5	Frame	1 nos.	2000/-
6	Arduino microcontroller	1 nos.	3000/-
7	Air compressor	1 nos.	7000/-
	Total cost of components		20000/-

Total cost = Total Cost of Standard Components + Total Machining Cost
= 20000 + 5000
= Rs. 25000/-
Hence total project cost = Rs. 25000/-

5. Advantages of UV Curing

The primary advantage of curing is that the final product is ready for the shipment in a very short time. With speeding up the production, curing also can reduce errors and flaws, as the amount of time that dust, flies or any airborne object has to settle upon the object is reduced. This increases the quality of the final product and allows for higher consistency.

Some more advantages can be stated as it takes up very less space as the manufacturers don't have to wait for them to dry. This in turn improves the efficiency of the manufacturing processes and saves a lot of valuable time.

6. Applications

The automated painting system can be used in almost all painting and coating applications. Some of the applications of automated systems are stated below:

- In automobile industry for painting of automobile parts.
- In Furniture manufacturing industry for painting of furniture.
- For lacquer and primer coatings.
- For scratch resistant coatings.
- For corrosion resistant coatings.

Uv curing is widely used for curing the freshly painted products to obtain high quality products.

Conclusion

The use of automation in painting systems results as follows:

- Reduced painting time.
- Maintaining consistency of the quality of products.
- Reduced human efforts.
- No skilled labour required.
- Speeding up the production.
- Less chances of painting errors.

UV curing process can be used to achieve the following:

- Better surface finish.
- Scratch resistant surface.
- Wear resistant surface.
- Reduced flaws and errors.
- Increase in the quality of finished product.
- Reduced drying time.
- Greater consistency.

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