SEMI-AUTOMATIC WALL PAINTING MACHINE

Prof. S. R. Gore, Rutuja Sangale, Vijaykumar Shep, Akshay Sanap, Shubham Magar.

Department of Mechanical Engineering, MIT College of Engineering, Pune, Maharashtra, India
Department of Mechanical Engineering, MIT College of Engineering, Pune, Maharashtra, India
Department of Mechanical Engineering, MIT College of Engineering, Pune, Maharashtra, India
Department of Mechanical Engineering, MIT College of Engineering, Pune, Maharashtra, India

Abstract

The primary aim of the project is to design, develop and implement Semi-Automatic Wall Painting Machine which helps to achieve low cost painting equipment. Despite the advances in robotics and its wide spreading applications, interior wall painting has shared little in research activities. The painting chemicals can cause hazards to the human painters such as eye and respiratory system problems. Painting involves a lot of risk as painters have to hang down from large sized walls to paint the entire wall. Also the nature of painting procedure that requires repeated work and hand rising makes it boring, time and effort consuming. When construction workers and robots are properly integrated in building tasks, the whole construction process can be better managed and savings in human labour and timing are obtained as a consequence. The opportunity to reduce or eliminate human exposure to difficult and hazardous environments, which would solve most of the problems connected with safety when many activities occur at the same time. Through our analysis we came to know that a machine which would solve the above stated problem is highly required. These factors motivate the development of an automated robotic painting system.

Keywords:-*Spray printing, automatic feed, torque.*

Introduction

One of the major industries around the world are building and construction in this fast moving life construction industry is growing immensely. The difficulty in the work is due to insufficient labours. In construction industry, during the work in tall buildings or in the sites where there is more risky situation like interior area in the city. There are some other reasons for the insufficient labor which may be because of the improvement the education level which cause the people to think that these types of work is not as prestigious as the other jobs. The construction industry is labor-intensive and conducted in dangerous situations; therefore the importance of construction robotics has been realized and is grown rapidly. In the early 90‟s applications and activities of robotics and automation started aiming to optimize equipment operations, improve safety, enhance perception of workspace and furthermore, ensure quality environment for building occupant. After this, the advances in the robotics and automation in the construction industry has grown rapidly. Despite the advances in the robotics and its wide spreading applications, painting is also considered to be the difficult process as it also has to paint the whole building.

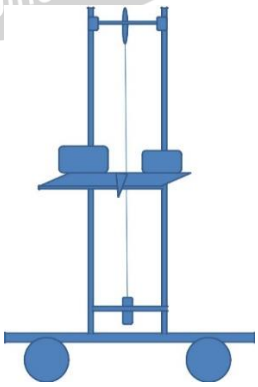

Fig.1- Frame

Automation in painting was introduced to reduce the number of labors and to make the work easier and safer. The automation for painting the external wall in buildings has been proposed. Above all these the internal wall painting has shared little in research activities. The painting chemicals can cause hazards to the painters such as eye and respiratory system problems. Also the nature of painting procedure that requires repeated work and hand rising makes it time and effort consuming. These factors motivate the development of an automated robotic painting system. Main aim of this project is to develop the interior wall painting robot. The semi-automatic wall painting robot is designed,using simple and portable components as shown in Fig.1. The robot is designed using few steels, conveyor shaft, spray gun and a controller unit to control the entire operation of the robot. This machine is compact because of high speed and pressure capabilities they have. They also have a very small weight to power output ratio and predictable performance i.e. losses are minimum due to less number of moving parts and so gives expected performance. Noise vibrations can be controlled and operations can be silent with the use of simple and elegant control systems. This machine has longer life, flexibility and it is efficient and dependable.Simple installation and easy maintenance are the key features of this system. Certain considerations while using this machine are to be kept in mind; the system operates in pneumatics, so it needs air tank or compressor and the electric shock is always there, which makes the machines ugly and dust and dirt are adhering to them. The parts like seals, packing and gaskets etc., have a very small lifespan and are very short but, they are essential to prevent leakage hence the system becomes costlier.The construction of the semi-automatic wall painting machine consists of two main parts. They are1. Mobile platform Frame stand Wheel DC motor Battery Control unit 2. Spray gun mount IR sensor Solenoid valve Sprocket flow control valve Spray gun.

The Mobile Platform Design

A. Frame Stand and Wheel frame stand is the steel welded in such a way that it can carry the whole equipment. The entire machine with the control unit, battery and DC motor in the mobile platform and the IR sensor, solenoid valve and spray gun in the roller shaft are welded strongly in welding laboratory .Four wheels are attached to the frame stand in order to move the machine in the direction specified which is controlled by the DC motor rotation which in turn is controlled by the microcontroller. Since it is obvious that if either the movement of front or back wheels are controlled automatically the movement of the other one will be controlled. The DC motor controls the movement of the back wheels such that the movement of entire machine is controlled. DC motors are part of the electric motors, transforming electrical energy into mechanical energy. The basic principle of DC motors is same as electric motors in general, the magnetic interaction between the rotor and the stator that will generate spin. DC motors are widely used in speed and direction control because control of these motors are easier than other motors. The DC drivecontrol the motion of the DC motor. DC drive changes the speed and direction of motion of the motor. Some of the DC drives are just a rectifier with a series resistor that converts standard AC supply into DC and gives it to the motor through a switch and a series resistor to change the speed and direction of rotation of the motor. But many of the DC drives have an inbuilt microcontroller that provides programmable facilities, message display on LCD, precise control and also protection for motors.Controlling of DC motor using Microcontroller 1. Microcontroller provides us only digital logic (1 or o) 2.Microcontroller can’t provide

with polarity 3. The motors can't be connected to Controller as mostly motors runs on voltage higher than +5V, and motors demands high current (depends),by use of "H Bridge" this can be removed. Here four transistors are used to change polarity 1) Specification of DC motor: The specification the DC motor used in this project is mentioned as follows: Voltage -12V No load speed -810 rpm Load speed -120rpm No load current -75mA Load current -1400mA Power -17WC battery. The controller unit battery is used to provide electric supply. Lead acid battery is used in this project. The lead-acid battery is a rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, their ability to supply high surge currents means that the cells maintain a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors. D. Control unit- The AT89c52 microcontroller is used in the control unit which controls the DC motors and the movement of spray gun fitted on the conveyor belt. Microcontroller unit is provided with the 5V signal and as soon as the supply is ON, LCD gets initialized. The input to the microcontroller is given by the controller as it sets into the setting mode and the moving and painting distances are given. DC motor rotation is controlled by microcontroller according to distances provided in order to control the wheel and conveyor belt movement. Spray gun turns ON and OFF with movement of conveyor belt which moveswhen IR receiver receives the signal.Relays are present in it. Relay controls forward and backward movement of the DC motor. IC AT89C52 is 8-bit microcontrollerwith low-power, high performance which contains 8kB of Flash programmable and erasable read-only memory (EPEROM) ,RAM(256 bytes), Number of input/output (I/O)lines is 32 , three 16-bit timers/counters, a interrupt architecture having6-vector 2-level, a full-duplex serial port, on-chip oscillator and clock circuitry. AT89C52 is designed as per static logic for operation down to zero frequency which will support two software selectable as for power-saving modes. CPU stops working in idle mode while RAM, timers/counters, serial port and interrupt systemcontinue the working which they are functioning. In power-down mode Oscillator is frizzed, but it saves the RAM contents. Until the next Hardware reset is activated all other chip functions are disabled. When the Microcontroller takes the decision to operate the machine as it receives the signals from IR sensor. When there is any object in the system this pulse signal received from IR sensor circuit. RL1 is in "OFF" position at starting time, which is provided to the conveyor motor (conveyor Movement). All classic and extended 8051 device variants are supported by The Keil Cx51 ANSI C Complier. Complete access is given to all CPU resources because of Compiler extensions. It also support up to 16MB memory. The Keil Cx51 generates code having high efficiency and high speed of hand-optimized assembly. The programs are shrinked by linker optimizations and new compiler into the smallest single-chip devices. Cx51 Version 9 is fully integrated by The Keil µVision4 IDE which provides Compiler control, Assembler, Real-Time OS, Project Manager and Debugger in a single, intelligent environment. Keil Cx51 is clearly the best choice for your 8051 project asit support for all 8051 devices and full compatibility with emulators and third-party tools. Full-wave rectification is the process which can improve sinusoidal input up to 100% which gives Power Supply Unit the DC level. Above configuration uses two diodes. During the period t = 0 to T/2, as per the basic configuration we see that one diode is conducting while the other one diode is in "off" state. Accordingly for the negative

of the input the conducting diodes. Thus the polarity is same across the load.Capacitor filter circuit is type of the filter circuit used here, where rectifier output is receiving end for a capacitor and a DC is generated across it. DC voltage is essentially none other than the filtered waveform with negligible ripples, which is ultimately load F is fed by it to the LCD(Liquid Crystal Display). A LCD (Liquid Crystal Display) uses the light modulating properties of liquid crystals (LC's) for electronic visual display, or video display. LCD is a flat panel display.Liquid crystals do not emit light directly. Liquid crystals used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. Video players, gaming devices, clocks, watches, calculators, and telephonesare the commonly used consumer. Cathode ray tube (CRT) are replaced LCDs in most applications. They are having in a wide range of screen sizes which are not available in CRT and plasma displays. As CRTs and Plasma display use phosphors, they can suffer image burning, as LCD don't contains phosphors it cannot lead to burning. So LCDs are susceptible to persistence. The microcontroller is connected to a16x2 LCD. LCD connection with microcontroller.Relays are being used throughout the automobile industry. Relays are used as remote control switches which comes in assorted sizes, ratings. A typical vehicle can have 20 relays or more. Connection of relay with the microcontroller. Relative motion between moving parts is constrainedby H Bearing, type bearing which is a machine element to get the desired motion. As per type of operation, the motions allowed or the loads (forces) directions broadly classify Bearings in different types. The design procedure of the bearing may provide free linear movement of the moving part or for free rotation around a fixed axis or it may prevent a motion by controlling the vectors of normal forces that bear on the moving parts.The structure of bearingI is shown in figure 2.

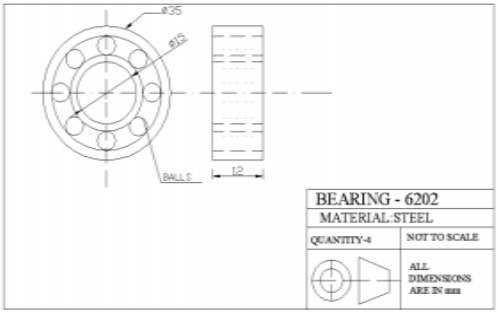

Figure 2

In the power transmission industry Spur gears are the most economical gears which are designed to transmit power between parallel shafts and transmit motion. Conveyor movement in either forward backwarddirection is guided by Spur Gear Wheel Mechanism. The gear wheel mechanism arrangement is shown in Figures 3 and fig. 4.

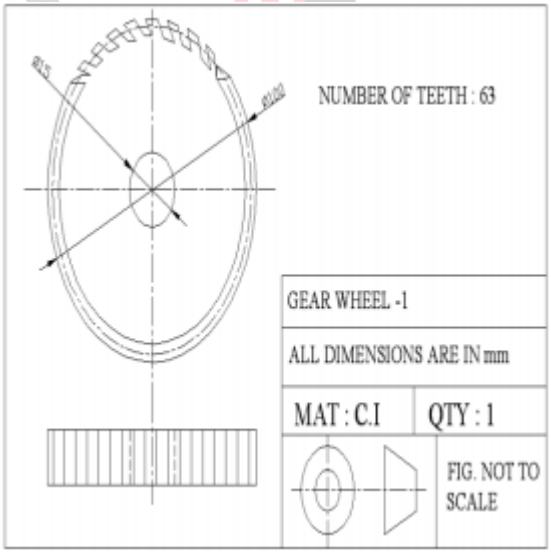

Fig 3. Gear Wheel Mechanism 1

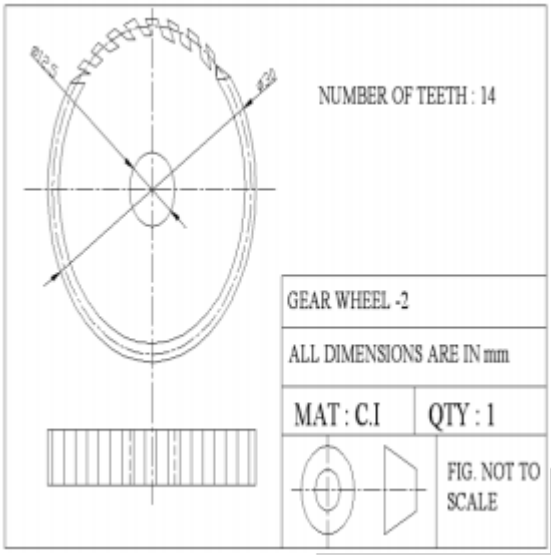

Fig.4 Gear Wheel Mechanism 2

SPRAY GUN MOUNT DESIGN

A. IR sensor is used for this project. The typical light source used in the sensor for machine to detect opaque object is IR. No programming, microcontroller and soldering are required in this project. IR Sensor (IR Receiver and IR Emitter): The basic principle of IR sensor is based on an IR emitter and an IR receiver. When power is supplied to it IR emitter will infrared light continuously. On the other hand, the IR receiver will be connected and perform the task of a voltage divider. IR receiver is imagined as a transistor with its W base current determined by the intensity of IR light received. 1) IR Sensor Features: Input voltage: 5VDC Sensing Range: 15cm Output signal: Analog voltage emitting element: Infrared LED 2) IR Transmitter and Receiver: IC 555 timer and BD140 are used to produce the IR wave forms. The 555 Timer is connected in a stable mode. The output of 555 timer is given to the transistor so that transistor is switched on/off simultaneously according to the pulse from the 555 timer. IR LED is connected to the transistor T1 (BD140).The IR transmitter circuit is used to transmit the Infra-Red rays. This Infra-Red rays are received by the receiver circuit is called "IR receiver". The Infra-Red rays are stopped, if any material is there in a conveyor. The IR receiver circuit receives the IR rays and provides control signal to the control circuit. At normal condition, the control circuit is used to off the solenoid valve and conveyor motor is in ON condition. There is any material in their conveyor meant; the control signal activate the solenoid valve, so that the painting operation occurs. The operating principle of solenoid valve is explained below. At the same time the conveyor motor is in OFF condition. The IR transmitting circuit is used in many projects. The IR transmitter sends 40 kHz (frequency can be adjusted) carrier under computer control where computer can turn the IR transmission on and off. IR carriers at around 40 kHz carrier frequencies are used in TV remote controlling and ICs for receiving these signals are quite easily available. At normal condition, the IR transmitter sensor is transmitting the infrared rays with the help of 555 IC timer circuit. IR receiver sensor receives the infrared rays. The Transistor T1, T2 and T3 are used as an amplifier section. At normal condition Transistor T5 is in OFF condition. At the same time relay is OFF and there is no signal given to the microcontroller unit. Obstacle crossing time: When any obstacle is crossing the path between sensors, T1 is switched ON. Transistor T2, T3 and T4 amplifies the signal and this amplified signal is given to the Transistor T5, so that it is switched OFF. In this process the Relay is switched ON. 3) Single Acting 3/2 Solenoid Valve: A solenoid is an electrical device which converts electrical energy into straight line motion and force. These are also used to operate a mechanical operation which in turn operates the valve mechanism. Solenoids can be push type or pull type. The push type solenoid is the one in which the plunger is pushed when the solenoid is energized electrically. The pull type solenoid is the one in which the plunger is pulled

when the solenoid is energized. The Solenoid control valve is used to control the flow direction is called solenoid valve or cut-off valve. This solenoid cut-off valve is controlled by the electronic control unit. This solenoid valve is used for painting operation into the materials. Experimental Setup: The construction of Paint Spraying equipment consists of a frame which is used for mounting the components such as D.C motor, electronic timer unit, Battery, solenoid valves, flow control valve and spur gear arrangement. The stand (or) base is to carry the whole machine. End bearings with bearing caps are used to fix two conveyor roller to two ends of the frame stand. Spur gear mechanism is feasible to couple the D.C. permanent magnet motor to conveyor roller shaft. This complete setup is helpful to convey the material from one place to another place with the help of conveyor. B. With the help of IR Sensor Setup, IR transmitter and IR receiver circuit is used to sense the material. .Suitable arrangement of mounts are used to fix this setup to the frame stand. To spray painting in the material, a spray gun is attached to the frame. The spray gun operation is operated with the help of single acting solenoid valve and Microcontroller and flow rate is controlled by flow control valve. High pass filter is used to nullify the high frequency signal due to external unwanted signal. Simple R-C high pass filter circuit is used to perform above task. The Zener diode (5.6 Volt) also used to cut off the high voltage signal from the input signal. The sensors are giving the low output signal when there is any object on the conveyor. The experimental setup of spray gun in which the silver colored box resembles the spray gun. The board covered with the plastic box is the IR sensor circuit since it is covered with plastic box in order to avoid unnecessary detection on the sides. D. Microcontroller Setup, 12V signal from the battery is given to the power supply unit where it gets regulated to 5V. The 5V signal is feeded to the microcontroller unit. Once the supply is ON, LCD gets initialized. The microcontroller sets to setting mode and asks for the feed of moving and painting distance and is feeded as input to microcontroller. The microcontroller (by using microcontroller program) “ON” the relay -1 (conveyor Motor stop-Connected to port-p2.0)) and “ON” relay-2 & 3 (solenoid valve is ON-Painting Operation) for estimated seconds and returns to “OFF” again the relay-1 and operation continues. Reset switch is pinned to the pin number 32 of the microcontroller unit. When the IR receiver receives the signal, the conveyor belt initiate and spray gun goes to ON condition. If the conveyor belt terminates then spray gun goes to OFF condition. The steel platform is welded together to carry the entire setup of machine which is fitted with four wheels at bottom for the mobility of the machine. RESULTS AND DISCUSSIONS. IR Sensor Results. The Fig.17 is the output for the IR sensor at normal condition. Since the relay operates at 12V, a 12V supply is feeded from the battery.Fig.18 shows the result of IR sensor at the presence of wall. When the machine is at certain distance from the wall it can sense the wall and the LED glows to indicate it. These sensed signals will be transmitted to the controller to control the solenoid valve. Microcontroller Unit Results the microcontroller unit is connected to the 12V battery but it requires 5V supply, hence voltage regulator is used to convert 12v to 5v.when supply is given the lcd gets initialized and it displays as „semi-automatic wall painting machine“. After lcd initialization „moving distance“ is displayed in the lcd display followed by „painting distance“ and the distance is given as input by using increment and decrement button. For the machine to start painting the start button has to be pressed. The machine continues to paint till the wall ends by having painting distance as its breath

of the wall. The movement of the machine will be in one direction along the wall.

CALCULATIONS:-

Lead screw (M16 threads)

Pitch= 2 mm (means one rotation equals 2mm upward or downward)

For 1 feet,

1 feet=300mm approximately,

No. of rotations = $\frac{total\ distance}{distance\ in\ one\ rotation}$

$= \frac{300}{2}$

= 150 rotations

Time taken for painting dist. In one rotation (in min)

For 50 rpm motor = $\frac{Total\ no.of\ rotation}{rotations\ per\ min}$

$= \frac{150}{50}$

= 3 min

For 100 rpm motor = $\frac{Total\ no.of\ rotation}{rotations\ per\ min}$

$= \frac{150}{100}$

= 1.5 min

For painting 9 feet wall (for painting 10 ft. wall, we need to paint only 9 ft. as spray dimensions are (1ft*1ft)

Distance in one rotation = Perimeter = π*d

$= \frac{22}{7} * 100$

(diameter = 100mm)

=314.28mm

Distance travelled by wheel in one rotation = 314.28mm

Total distance = 9 ft.

= 9 * 314.8

= 2745mm

No. of rotations for 9 ft. =

$$\frac{Total\ distance}{Total\ distance\ in\ one\ rotation}$$

$= \frac{2745}{314.8}$

= 8.73

≈ 9 rotations

Total Time taken to pain wall

For 50 rpm motor,

Time taken =

$$\left(No.of\ roatations * time\ for\ 1\ rotation\right)$$

= (9 * 3)

= 27 min.

Total Time taken to pain wall

For 100 rpm motor,

Time taken =

$$\left(No.of\ roatations * time\ for\ 1\ rotation\right)$$

= (9 * 1.5)

= 13.5 min.

Speed = $\frac{distance}{time}$

$= \frac{314}{3}$ = 104.33……..for 50 rpm motor

$= \frac{314}{1.5}$ = 209.33……for 100 rpm motor

Weight of moving platform :-

Plate= 100*280*12

V=π*x*y*L

V=3.14*12*100*40= 336000 mm^3 = $3.3*10^{-4}$mm

M=ρ*V

M_1= $7700*3.3*10^{-4}$= 2.5kg

Weight of lead screw

V=$\pi*r^2*h$

$V=3.14*8^2*2750= 55.2640\ mm^3$

$M_2=\rho*v$

$M_{2=}7700*552.640*10^{-6}= 4.25$ kg

Total load $=M_1+M_2$+spray gun weight+other weight

Total load =2.5+4.25+3+0.25= 10kg
To calculate torque required to raise this load

$$T_r = \frac{Fdm}{2}\left(\frac{l+(\pi\mu dm)}{\pi dm-\mu l}\right)+\frac{F\mu cdc}{2}$$

T_r- torque required to raise load N-m
F - Load in N
d_m- mean diameter of thread
d_c- mean collar diameter
l - Thread pitch distance in mm
μ - coefficient of friction for thread
μ_c - coefficient of friction for collar
where,

F = 10 kg = 10 * 9.81 = 98.1 N
$\mathbf{d_m}$= 11 mm
$\mathbf{l_{(pitch)}}$ = 2mm
$\mathbf{d_c}$= 14 mm
μ= 0.25
μ_c= 0.25

$$\mathbf{T_r} = \frac{98.1*11}{2}\left(\frac{2+(\pi*0.25*11)}{(\pi*11)-(0.25*2)}\right)+\frac{98.1*0.25*14}{2}$$

= 340 N-mm = **0.340 N-m**

$$= \frac{0.340}{0.098006} = 3.47\text{kg-cm}\approx\mathbf{3.5}\ \mathbf{kg\text{-}cm}$$

CONCLUSION

Technology by which a process or procedure is performed without human assistance is known as automation.

In other words, automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention. Some processes have been completely automated.

Automation has been achieved by various means including mechanical, hydraulic and pneumatic, electrical and electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques. The benefit of automation include labor savings, savings in electricity costs, savings in material costs, and improvements to quality, accuracy and precision.

Semi-automatic painting project which we chose by understanding the need in automobile industry revolution and increase in production tremendously.

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