



Stability and Intellectual Working of Road Divider Painting Machine

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Abstract: The central motive of the project is to design, develop and implement Automation in kerb painting machine which helps to achieve accurate and fast painting. Despite the advances in robotics and its wide spreading applications, air less painting has shared little in research activities. In general, the painting procedure requires so much efforts and time that makes it boring. When human efforts and technology are properly integrated in building tasks, the whole work can be better managed and savings in human labor and timing are obtained as a consequence. In addition, it would offer 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. These factors motivate the development of kerb painting machine. White and yellow paints are universal throughout the entire United States highway system. Yellow is always used to signify caution i.e broken yellow means passing zone using caution, white is used to designate the farthest to the right you may safely drive, it's also known as the fog line. Combine the above two and you get the combination of the solid yellow line with a broken yellow line. Meaning, if you are driving on the side of the broken line, you can't overtake any vehicle. But if you're driving on the solid line, you can overtake. We know that the road markings are not the usual safety thing and may be the very last thing to understand and follow. But following these rules may not be that bad! After all, we all have to take safe driving forward and make India a safe driving place..

Key words – Automation (robotics), safety, Kerb, Painting machine, IOT system.

1. INTRODUCTION

India has 151,019 km of National Highways as of March 2021. So, it needs regular painting which leads us to develop the intelligent divider painting machine. Intelligent divider painting machine is a semi-automatic divider painting machine, it is an updated version of existing manual divided painting machine which also known as kerb painting machine. The existing machine need constant man power and observation it basically sprays paint automatically rest all work is to be done by the operator. But in our case, we have designed our machine in such a way that most of the human input in whole process would be eliminated. The fundamental principal which are going to direct our machine the roller follower, the ultrasonic sensor and IR sensor. The roller follower it is the first and the basic option for the automation of machine which is totally mechanical and is cost efficient. Then comes the ultra-sonic sensor which is an accurate and most reliable, trusted one and also used in automobiles for driver less car.

Following it, our third mode would be the IR sensor and can be said as the most advance one which works on reflection of infra-red rays it also has some disadvantages which would lighten further. The machine is designed in such a way that it is semi-automatic machine which reduce the harm of the life of human which is working in uncomfortable climatic condition on the road. Also, the temperature in India is very high, which can affect the human body and also the risk of accident done on the highway and the expressway would be reduced with the help of our machine. Also our machine will used for washing the roads, to paint the wall, parking areas to the paint the residential building.

2. METHODOLOGY OF WORK

The principal of operation which are used in this machine are the roller follower, the ultrasonic sensor and IR sensor. The machine is designed in such a way that it is semi-automatic machine which reduce the harm of the life of human which is working



Figure 1.1 Painting on road divider

in uncomfortable climatic condition on the road as the as the temperature in India is very high due to which it affects the human body and also the risk of accident done on the highway and the Expressway would be reduced with the help of our machine.

2.1 Roller Follower Mode

First and foremost, approach for the machine to run with the help of roller follower, the roller follower is completely mechanical and does not need any electrical or electronics assistance and works on the principle of clamping. The roller follower is been attached to the divider and then as the motion of the carriage or body is done due to which the roller follower also move and the roller Move within the direction of the divided due to which the automation is been done in a mechanical way. The material for the roller would be rubber. This is shown in figure 2.1.

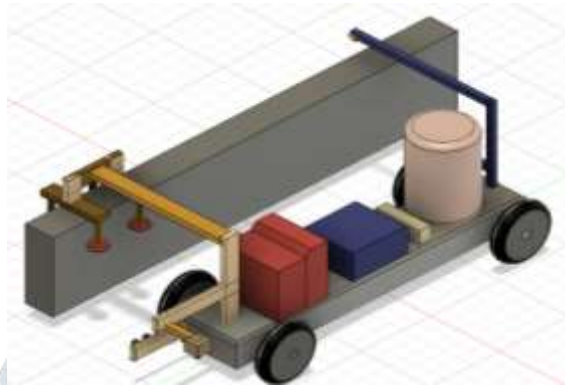


Figure 2.1 Painting machine (Roller follower)

2.2 Ultrasonic Sensor Follower Mode

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. The transducer of the sensor acts as a microphone to receive and send the ultrasonic sound. Ultrasonic sensors mimic echolocation used by bats, transmitting high-frequency sound waves to gauge the distance between objects within close range. Ultrasonic sensors can be used to complement other vehicle sensors, including radar, cameras, and radar, to get a full picture of the immediate surroundings of a vehicle. In our machine two ultrasonic sensors are mounted as per figure 2.2, one is at front side of machine and other is at back side of machine they measure distance and according to programming our machine's microcontroller collect data from this sensor and send it to front wheel.

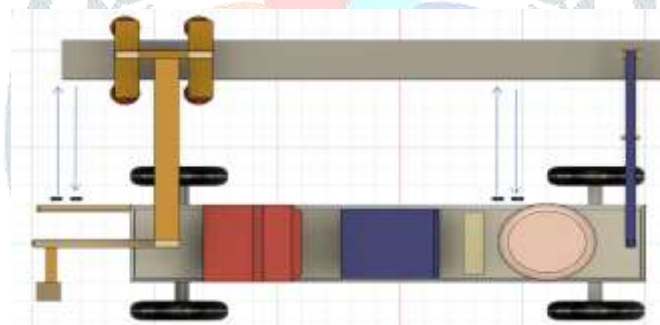


Figure 2.2 Painting machine (Ultrasonic sensor)

2.3 IR Sensor Follower Mode

In this Arduino based line follower robot we have used IR Transmitters and IR receivers also called photo diodes. They are used for sending and receiving light. IR transmits infrared lights. When infrared rays fall on white surface, it's reflected back and caught by photodiodes which generates some voltage changes. When IR light falls on a black surface, light is absorbed by the black surface and no rays are reflected back, thus photo diode does not receive any light or rays. Here in this Arduino line follower robot when sensor senses white surface then Arduino gets 1 as input and when senses black line Arduino gets 0 as input. It means our machine follow the white line (Figure 2.4) of road through IR sensor.

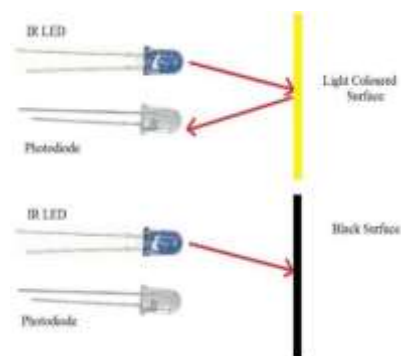


Figure 2.3 Painting machine (IR sensor)

2.4 Flowchart for working of system

In this flowchart we have defined the work flow or process so four machine. A flowchart can also be defined as a diagrammatic representation of an algorithm, a step-up-step approach to solving a task. The flowchart shows the steps as boxes of various kinds, and their order by connecting the boxes with arrows. A flowchart visually displays the sequence of activities in a process and who is responsible for those activities. There are 3 mode of working Mode1, Mode2 and Mode3. According to the situation, the entire working mode will work. All the modes are programmed in system.

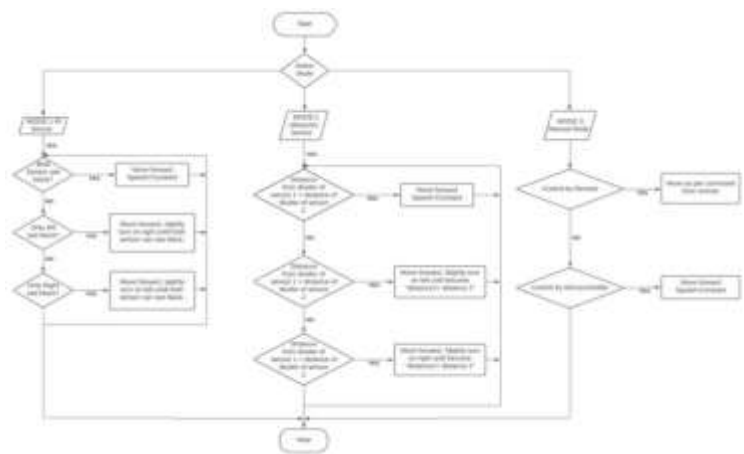


Figure 2.4 Flowchart of IOT system

3. DESIGN FORMATION:

In this machine, care should be taken while motion during working as overall load plays important role to get the stability. A system requires equilibrium condition in all kind of works. For Upward and downward slope of the road, overall center of gravity (CG) should be coinciding with geometrical center of gravity of main body.

3.1 Main body Layout:

In painting machine the main units are Generator, Sprayer, IOT system, Paint tank. It is necessary to keep system in balance while painting on road having upward slope & downward slope. From main units used in machine, the overall dimensions of plate of body are determined. the length and width are selected from the layout of unit with including the clearance between units.

Xcg = 900mm, Ycg= 250mm.

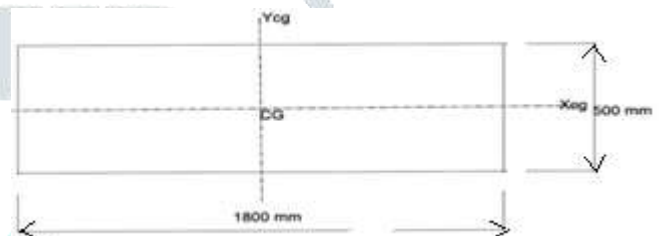


Figure 3.1 CG of optimum layout

3.2 Possible Layouts of CG:

Layout design is a fundamental branch of graphic design that concerns the arrangement of text and visuals. The effectiveness of every type of design, from print to web, is largely influenced by layout (Reference line= Left side Horizontal Black Line in figure). Our Machine’s total length is 1800mm so as per geometry Ideal CG of frame is located at centre (900mm far from Reference line, in right direction).After placing all components we determined different arrangements of component.

3.2.1 Layout 1 & calculation of CG:

In first layout the main unit can be placed having the order from left side reference line IOT System, Sprayer, Generator, Paint tank Along the X-axis and symmetric to it. By considering individual weight of all units. The overall Calculation of CG is given below.

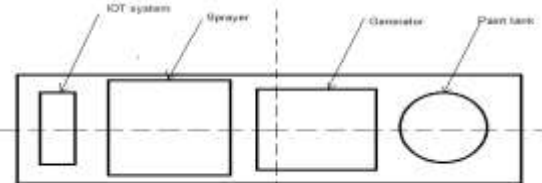


Figure 3.2 CG Layout I

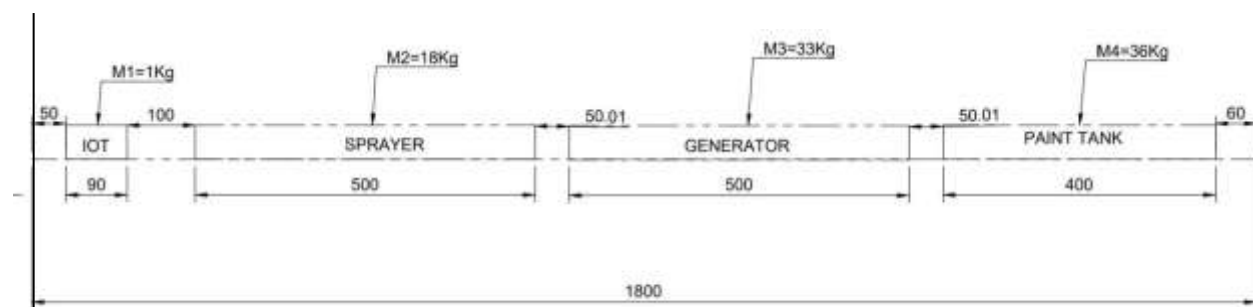


Figure 3.3 Layout I

$$X_{cg} = \frac{M1 \cdot x1 + M2 \cdot x2 + M3 \cdot x3 + M4 \cdot x4 + M5 \cdot x5}{M1 + M2 + M3 + M4 + M5} = \frac{1(0.095) + 18(0.49) + 33(1.040) + 36(1.540) + 8(0.9)}{96} = 1.10 \text{ m}$$

Xcg = 1.10 m = 1100 mm, Ycg = 250 mm

Where X_{cg} = Horizontal distance on X axis from Reference line, its gives us location of CG.M1,M2, M3, M4=Weight of component.

3.2.2 Layout II & calculation of CG:

In Second layout the main unit can be placed having the order from left side reference line Generator, Sprayer, IOT System, Paint tank Along the X-axis and symmetric to it. by considering individual weight of all units. The overall Calculation of CG is given below.

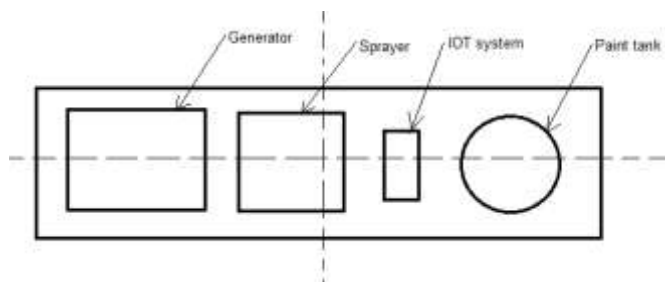


Figure 3.4 CG Layout II

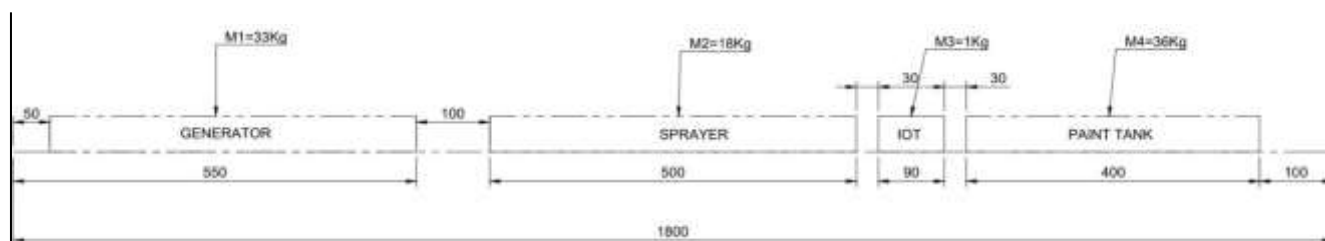


Figure 3.5 Layout II

$$X_{cg} = \frac{M1 \cdot x1 + M2 \cdot x2 + M3 \cdot x3 + M4 \cdot x4 + M5 \cdot x5}{M1+M2+M3+M4+M5} = \frac{33(0.3)+18(0.9)+1(1.225)+36(1.5)+8(0.9)}{96} = 922 \text{ mm}$$

$X_{cg} = 0.922 \text{ m} = 922 \text{ mm}, Y_{cg} = 250 \text{ mm}$

Where X_{cg} = Horizontal distance on X axis from Reference line, its gives us location of CG. M1, M2, M3, M4=Weight of component.

3.2.3 Layout III & calculation of CG:

In Third layout the main unit can be placed having the order from left side reference line IOT System, Generator, Paint tank, Sprayer Along the X-axis and symmetric to it. by considering individual weight of all units

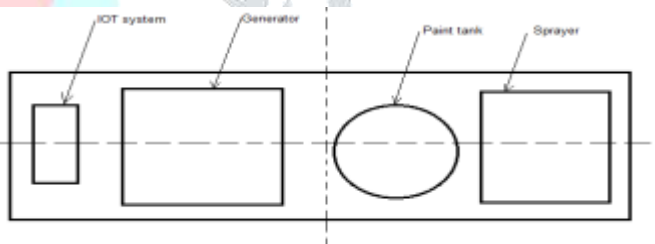


Figure 3.6. CG Layout III

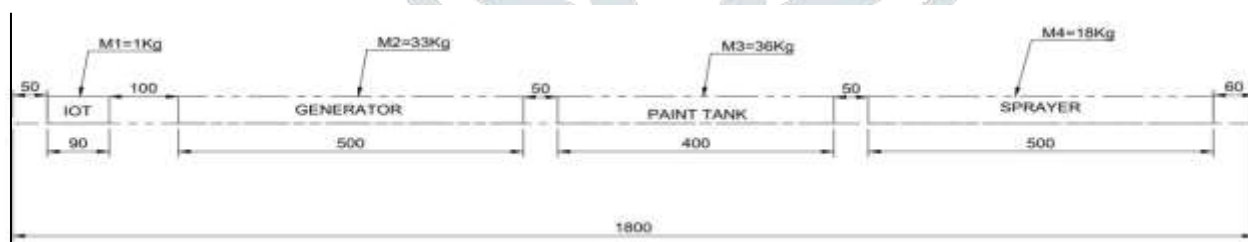


Figure 3.7 Layout III

$$X_{cg} = \frac{M1 \cdot x1 + M2 \cdot x2 + M3 \cdot x3 + M4 \cdot x4 + M5 \cdot x5}{M1+M2+M3+M4+M5} = \frac{33(0.3)+18(0.9)+1(1.225)+36(1.5)+8(0.9)}{96} = 878 \text{ mm}$$

$X_{cg} = 0.878 \text{ m} = 878 \text{ mm}, Y_{cg} = 250 \text{ mm}$

Where X_{cg} = Horizontal distance on X axis from Reference line, its gives us location of CG.M1,M2, M3, M4=Weight of Components

3.3 Braking Calculation:

By taking road slope of 15° at uniform speed. There are many forces acting on machine like reaction force, gravitational force, acceleration, friction force etc. now, generally 15° slope is a maximum slope for road for downward & upward slope(as per NHAI norms).

W=weight ,h=Height of CG from surface ,
 X=Distance of CG from point A, l=wheelbase,
 μ=coefficient of friction, Ra=Reaction force at point A
 Rb=Reaction force at point B.

As show in figure assume that our machine is climbing a slope of 15 ° angle. There two reaction forces Ra & Rb in Y direction and friction forces are acting in X direction so we must balance the all forces in X direction as well as Y direction for that we do summation of all force in X & Y Direction.

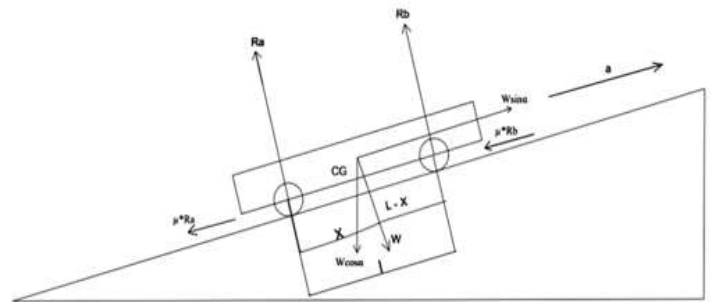


Figure 3.8 Braking on Upward slope

Forces sin X-direction are two friction force μRa & μRb in same direction and acceleration in opposite direction.

$$\sum F_x = 0$$

$$\mu(Ra + Rb) + W\sin\alpha = ma$$

$$\mu(Ra + Rb) + W\sin\alpha = W/g * a \text{-----(1)}$$

Forces in y-Direction are two reaction Ra and Rb are in upward direction and wcosα is in downward direction,

$$\sum F_y = 0$$

$$Ra + Rb = W\cos\alpha$$

$$Rb = W\cos\alpha - Ra \text{-----(2)}$$

Now we take two moments about CG height h and about distance x,

$$\sum M = 0$$

$$\mu*(Ra+Rb)*h + Ra*x = Rb*(l-x)$$

Putting Rb value from Eq.2

$$\mu*Ra*h + \mu*(w\cos\alpha - Ra)*h + Ra*x = (W\cos\alpha - Ra)*(l-x)$$

$$\mu*Ra*h + \mu*W\cos\alpha*h - \mu*Ra*h + Ra*x = W\cos\alpha*l - W\cos\alpha*x - Ra*l + Ra*x$$

$$\mu*W\cos\alpha*h = w\cos\alpha - W\cos\alpha*x - Ra*l$$

$$Ra*l = W\cos\alpha*l - W\cos\alpha*x - \mu*h*cos\alpha$$

$$Ra = W\cos\alpha[l - x - \mu h] / l$$

Now,

$$Rb = W\cos\alpha - W\cos\alpha [l-x-\mu h]/l$$

$$= W\cos\alpha * l - W\cos\alpha * l + W\cos\alpha * x + W\cos\alpha * \mu h / l$$

$$= W\cos\alpha [x + \mu h] / l \text{----- (3)}$$

Now putting all the original dimensions in the equation Ra,

$$l=1300\text{mm}, h=425\text{mm}, \alpha=15^\circ, \mu=0.7$$

$$Ra = W\cos\alpha (l-x-\mu h)/l = 120 * \cos 15^\circ \{ 1.3 - 0.65 - [(0.7) * (0.425)] \} = 115.908 [0.3525] / 1.3 = 48.815 \text{kg.m}$$

$$Rb = W\cos\alpha (x + \mu h) / l = 120 * \cos 15^\circ \{ 0.65 + [(0.7) * (0.425)] \} / 1.3 = 115.908 * 0.7288 = 84.47 \text{kg.m}$$

Now we balance the forces in x-direction for that we putting the value in Eq.1

$$Ra + Rb = W\cos\alpha$$

$$84.47 + 48.815 = 115.908$$

$$133.55 = 115.908 \text{----- (4)}$$

From the equation 4 we can say that the forces in x direction are almost balance. Now for the Y direction the friction force is balance with the acceleration .in the acceleration there are three conditions we have consider like Machine is on upward slope, machine is on downward slope and Straight road. For that we are putting the value of Rb in Eq.1.

For Upward slope : [$\alpha=15^\circ$]

$$\mu(Ra + Rb) + W\sin\alpha = W/g \cdot a$$

$$a = g(\mu\cos\alpha + \sin\alpha) = 9.8(0.7\cos15^\circ + \sin15^\circ) = 9.16\text{m/s}^2$$

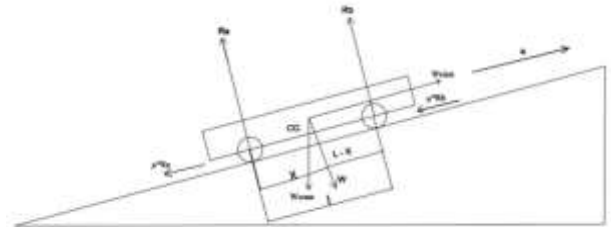


Figure 3.9 Upward slope

For Downward slope : [$\alpha= -15^\circ$]

$$\mu(Ra + Rb) + W\sin\alpha = W/g \cdot a$$

$$a = g(\mu\cos\alpha - \sin\alpha) = 9.8(0.7\cos15^\circ - \sin15^\circ) = 4.08\text{ m/s}^2$$

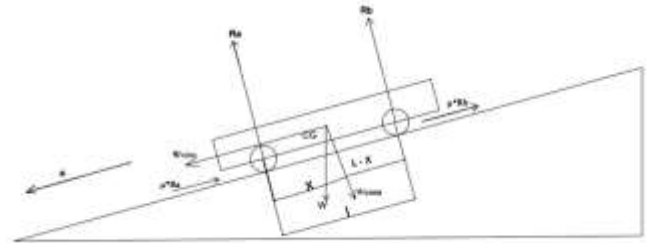


Figure 3.10 Downward slope

For Straight road : [$\alpha=0^\circ$]

$$a = g(\mu\cos\alpha + \sin\alpha)$$

$$= g\mu = 9.8 * 0.7 = 6.86\text{ m/s}^2$$

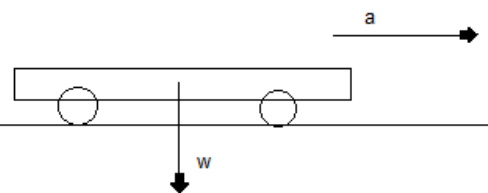


Figure 3.11 Straight road

3.4 Fuel Tank Capacity:

Discharge rate of nozzle: 1min / 380ml (Maximum) Machine speed:-36.5m/min

For 1km = 1000x380/36.5 = 10410ml/km For 3km=10410x3=31.3liter

The capacity of tank is 35 liter thereby the machine can paint continuous for 4 km in single filling.

4. PERFORMANCE OF CONTROLLER:

A block diagram is diagram of system in which the principal parts or function are presented by block connected by lines that show the relationship of the blocks. In our system main component is controller .Ultrasonic sensor, IR sensor and manual mode work as a input devices .Servo motor, motor drivers, DC motors and nozzle work as output devices. Main power source is generator.

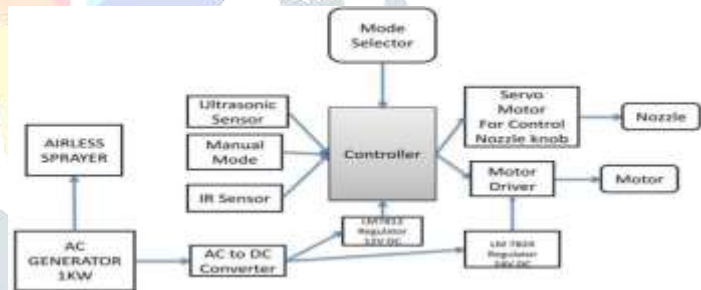


Figure 4.1 Block Diagram

4.1 Servo Motor:

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing. In our system servo motor is used to control the nozzle knob and steering mechanism.



Figure 4.2 Servo motor

4.2 Motor Driver:

A motor driver acts as an interface between the motors and the control circuits. So the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. Motor driver is used to control the motion of the DC motor.



Figure 4.3 Motor driver

4.3 Airless sprayer:

An airless sprayer works by pumping paint at a very high pressure, up to 3,000 psi, through a hose and out a tiny hole in the spray gun tip. The tip is designed to break up the paint evenly into a fan-shaped spray pattern of tiny droplets. ... First, the fine particles of paint don't all stick to the surface. Using different tips, you can spray thin liquids like stain, lacquer and varnish or thicker liquids like latex house paint. With a little practice, you can use an airless sprayer to apply a perfectly smooth finish on doors, cabinets and woodwork.



Figure 4.4 Airless paint sprayer

4.4 AC Generator:

An AC generator is a machine that converts mechanical energy into electrical energy, generated as an alternating current sinusoidal output waveform. AC generators are also known as alternators, and are classified according to their rotor construction. In our system ac generator is used as main power source.



Figure 4.5 AC generator

4.5 AC to DC Converter:

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The reverse operation is performed by the inverter.



Figure 4.6 AC to DC Converter

4.6 Nozzle:

A spray nozzle is a precision device that facilitates dispersion of liquid into a spray. Nozzles are used for three purposes: to distribute a liquid over an area, to increase liquid surface area, and create impact force on a solid surface.



Figure 4.7 Nozzle

5. RESULT & DISCUSSION:

For balancing the machine, stability is more important and we have calculated the CG of the optimum layout from the geometry. Also we have find out the CG all possible layout by taking the different position of the components and the masses of the components by using the standard formulas and the results are given below:

Table5.1 Parameter of CG:

Sr. No.	Layouts	Xcg (mm)	Ycg (mm)	CG of Frame (mm)	Remark
1	Layout I	1100	250	900	Unbalanced, Because Overall CG (Xcg) of Machine is far from CG of frame.
2	Layout II	922	250	900	Balance ,Because Overall CG(Xcg)of Machine is optimum close to CG of frame.
3	Layout III	878	250	900	Unbalanced ,Because Overall CG (Xcg)of Machine is far from CG of frame.

In this table we compare three different layouts base on that the most balance system is determine. As per our calculation Layout II is Optimum balanced. Because the value of cg of the layout II is optimum near to cg of frame so it is optimum balanced condition for all kind of roads slope.

Table 5.2 Value of Braking conditions:

Sr. no.	Conditions	Ra(Reaction force at point a) [kg.m]	Rb(Reaction force at point B)[kg.m]	a (acceleration) [m/s ²]
1.	Upward slope	48.815	84.47	9.16
2.	Downward slope	48.815	84.47	4.08
3.	Straight road	48.815	84.47	6.86
4.	α=10°	48.815	84.47	5.54

In this table we mention the value of all reaction forces and acceleration forces in which we get the value of acceleration for different condition is different.

From the above data, the acceleration value for the upward slope at the angle of 15° which is taken from the National Highway Authority of India (NHAI) is 9.16m/s² which is maximum and for the downward slope at the angle of 15°, the value for the

retardation is 4.08m/s^2 which is minimum value and the value for the straight road is 6.86m/s^2 . At the angle of 10° , the value of the acceleration is 5.54m/s^2 .

6. CONCLUSION

Outset up is totally different from the other in the way that we have used in the ultrasonic sensor, IR sensor for the automation and also the roller follower which is a mechanical application and which differentiate our project from the other existing kerb painting machine or divided printing machine. Main parameter is panting rate meter/hour. We have compared the human with machine with the reference to the panting speed as well as efficiency. The final conclusion from the calculation the human wares lower with the speed of 219 m/h while the machine is taking 2200m/h. In this comparison of human and machine we see that the human take 5sec to paint 1feet of divider and our machine take 5 seconds to paint 10feet's of divider. So from this comparison we conclude that the human can paint 219 m. in one hour whereas our machine paint 2200 m. in same time so our machine is 10 times faster than human. In this system from the front edge that is from generator, sprayer, IOT and paint , the value CG of frame is 900mm and after putting all the components the value of CG is 922mm which very negligible , so the system is stable from the given data.

7. ACKNOWLEDGMENT

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