DESIGN & DEVELOPMENT OF SEMI- AUTOMATIC EXTERIOR WALL PAINTING MACHINE

Group No: 17

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Project Guide :

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OUTLINE

- Project Background
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- Modeling & Calculation
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- Conclusion
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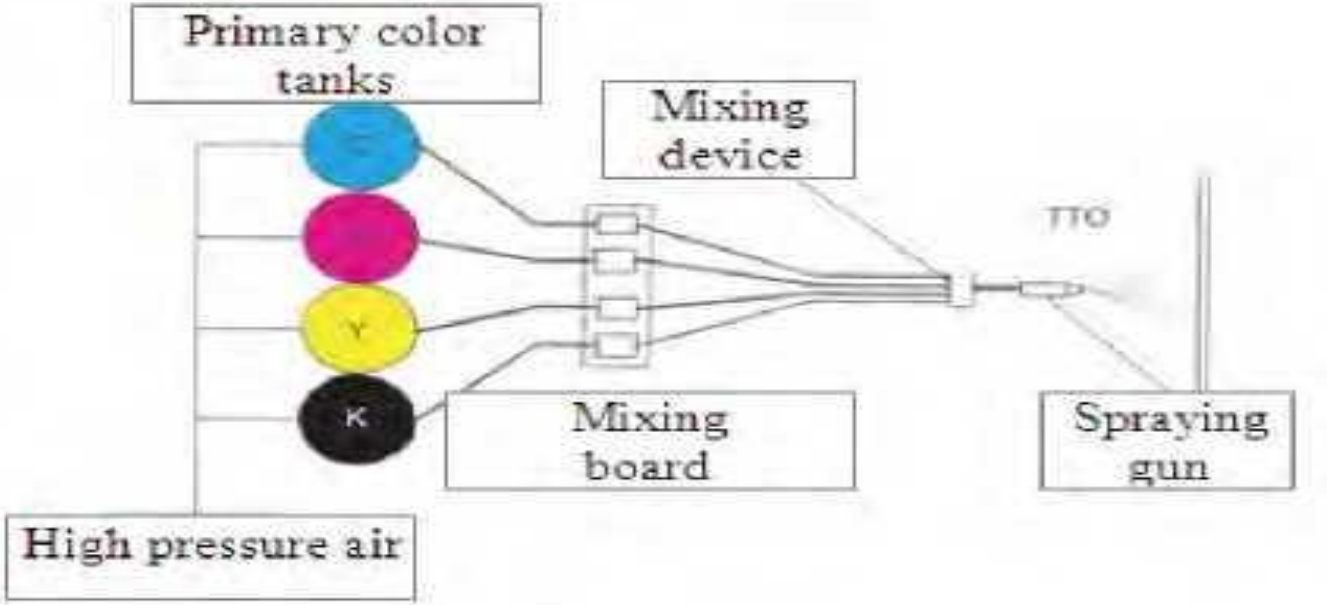
PROJECT BACKGROUND

- 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 and safety.
- The painting chemicals can cause hazards to the human painters such as eye and respiratory system problems. Also the nature of painting procedure that requires repeated work and hand rising makes it boring, time and effort consuming. When construction workers and machine 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.
- 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 an automated painting system.

LITERATURE REVIEW

❑Setup of an automated multicolor system for interior wall painting(2007):

- In this paper ,the researchers **Berardo Naticchia & et al.** have first the issue of a new miniature laboratory for developing lightweight and well-coordinated robotized systems is pursued, then a novel robot device for high quality multi-colour interior wall painting carried by a robot arm is developed and successfully tested. Their *new multi-colour spraying end-tool was developed and fixed on the robot arm, in order to be able to reproduce coloured artworks. Finally, a methodology to reproduce colours from digital format of artworks is presented, showing how accurate and efficient is this new robotized spraying device.*



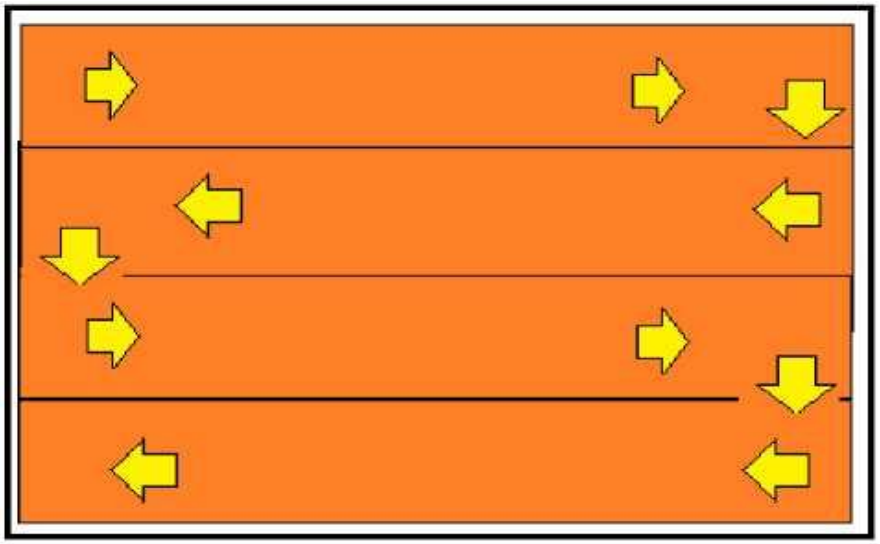
Sketch of the final multicolor mixing device.

➢ Conclusion:

- The mixing equipment developed throughout the research step described in this paper, they have shown that automated painting can be not only aimed at improving productivity, but also quality. In addition, two kinds of complementing ergonomics can be thought, one at reduced scale and the other one at human scale.

❑Conceptual Design Of Fixture For Automate Exterior Wall Painting And Design And Analysis Its Main Component(May 2013):

- **Jitendra N. Shelar & Prof. N. R. Gilke** have developed this project with the objective to designing of fixture for automated spray painting of building wall. Basically this fixture is design to paint outside wall of a building.
- Fixture is placed on top of tare ace wall and fixture is used to give vertical and horizontal motion to color pipe.
- It consists of two motors of which one is attached to lead screw for horizontal forward and backward motion.
- Other motor is attached to gear for vertical upward and downward motion of color pipe.



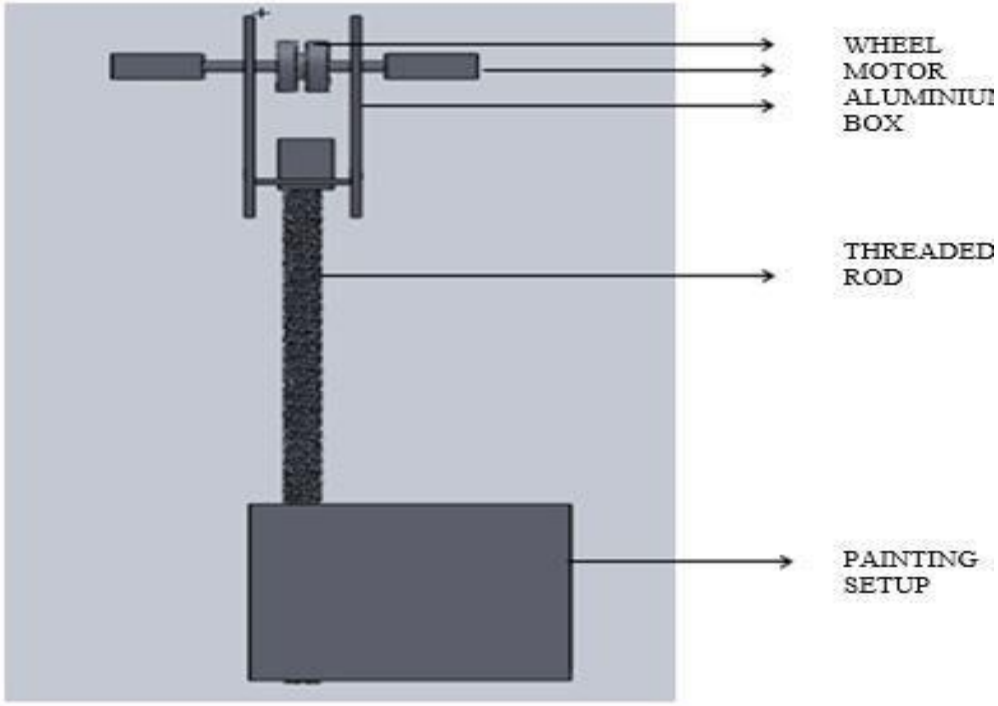
Path of spraying by pipe

➢ Conclusion:

- Fixture model is simple in construction and will work efficiently. With this fixture it will possible to avoid the risk of painting tall building at elevated height. It will reduce the cost and time of painting considerably as compare to manual painting. Analysis shows that lead screw is adequate to use in fixture.

❑ DESIGN AND FABRICATION OF WALL PAINTING ROBOT(March 2015):

- In this paper the researchers **Selvamarilakshmi D et al.** have made a robot which comprises of a set of heavy load capacity wheels moving along a railing and a pulley mechanism. Their design involves using a spray gun painting mechanism that moves vertically with the help of a lead screw from a platform mounted on a horizontal railing. Painting is achieved by the horizontal movement of the platform coordinated with the vertical movement of the lead screw attached with the spray gun, thus covering the plane of the wall in a zigzag manner.
- The robot also employs IR sensing to differentiate between the surface of the wall and other furniture to preclude painting undesirable areas.



Full Design of Painting Robot

➢ Conclusion:

- The fabrication of painting robot based on the specifications explained above is currently in progress. The method proposed here applies only for buildings with flat wall surfaces. If buildings of complex shapes were to use this method, complicated railing shapes should be called to play.

❑ DEVELOPMENT OF WALL PAINTING ROBOT(Jan 2014):

- In this paper, **Takuya Gokyu et al.** have developed The wall painting robot that can perform, as moving attracted on a wall as being pre-programmed, not only general type of coating in a single color through use of spray guns mounted on the arm but also picture painting in multiple colors based on picture data incorporated in the robot controlling computer. No.2 model, an improved type of the above, can perform not only the original functions but also various

other works on a wall such as wall

cleaning and tile separation sensing

through changing of an attachment.

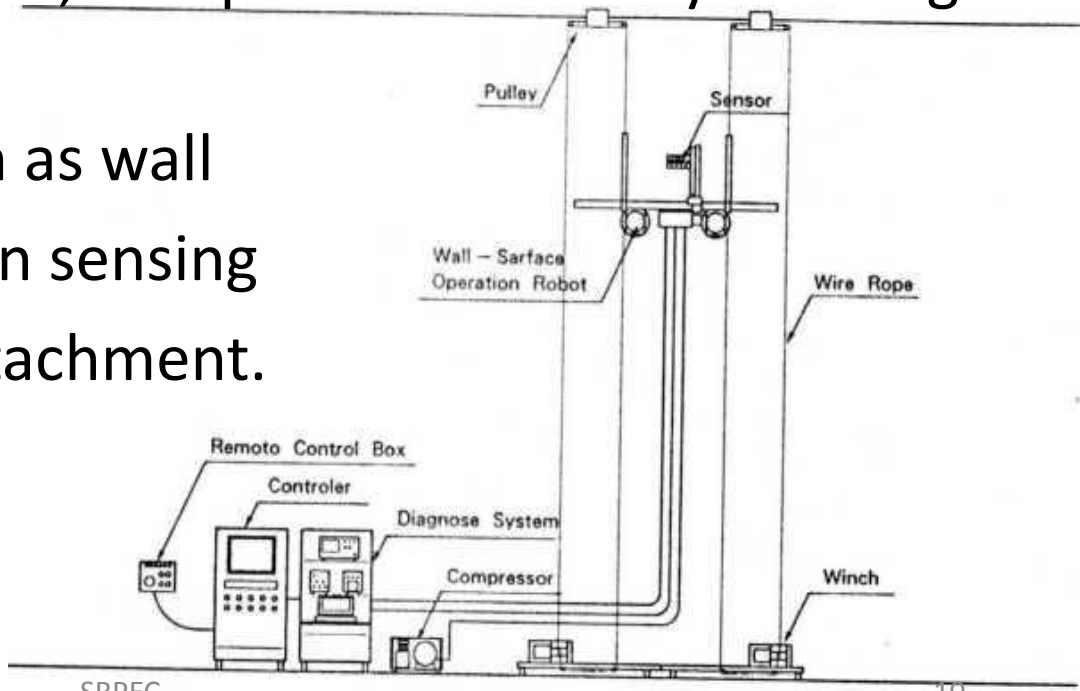


Fig. 5 System Configuration Drawing

➢Conclusion:

•Wall-Surface Operation Robot aims to automate and improve in efficiency a series of renewal works by adding, through changing of an attachment, new functions for cleaning, tile separation sensing and repair work to the original functions of picture painting in a single and multiple colors

❑ Conceptual Design and Feasibility Analysis of a Robotic System for Automated Exterior Wall Painting(2007):

- **Young S. Kim & et al.** have done *survey* on approximately 6,677,000 apartment housing units in South Korea. Exterior wall painting for such multi-dwelling apartment housings in South Korea represents a typical area to which construction automation technology can be applied for improvement in safety, productivity, quality, and cost over the conventional method.
- The primary objective of this study is to design a conceptual model of an exterior wall painting robot which is applicable to apartment housing construction and maintenance, and to conduct its technical·economical feasibility analysis.

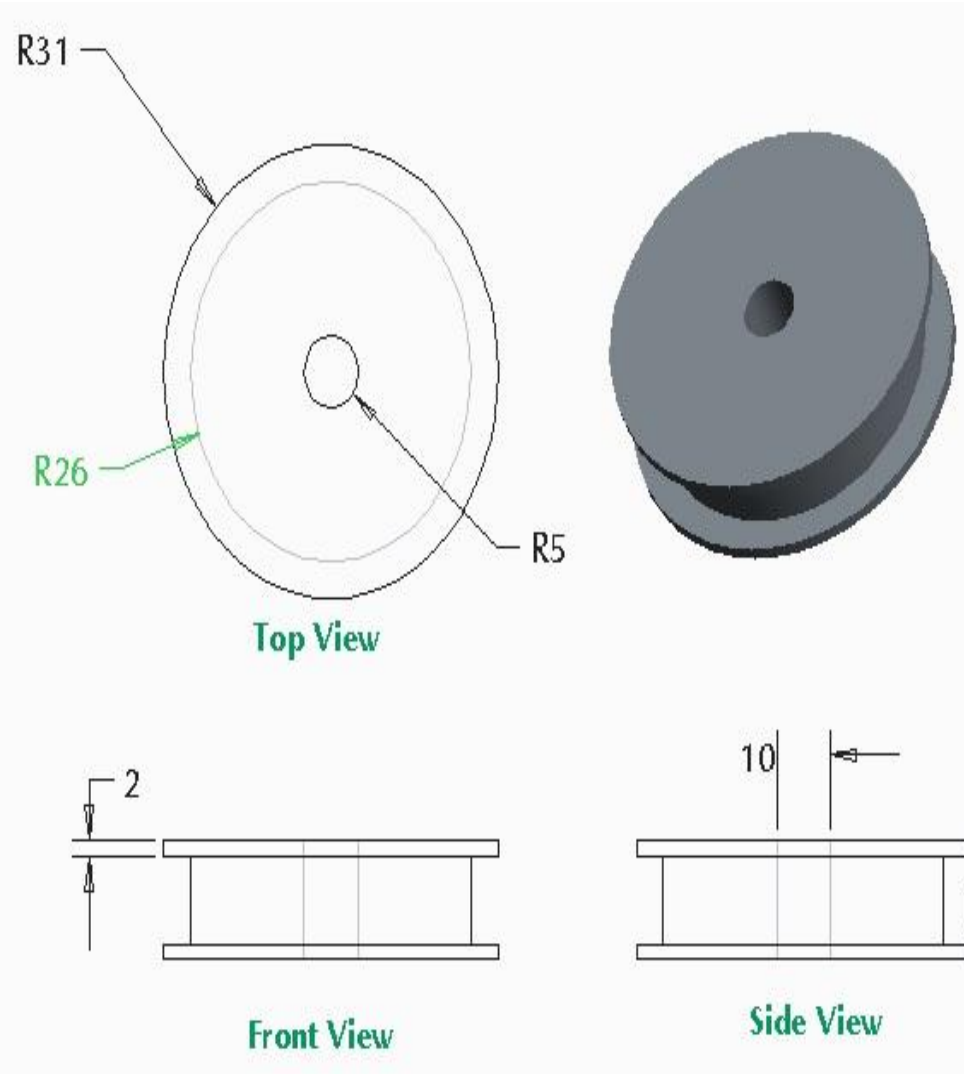
➢ Problems in conventional:

- Safety
- Quality
- Productivity
- Cost

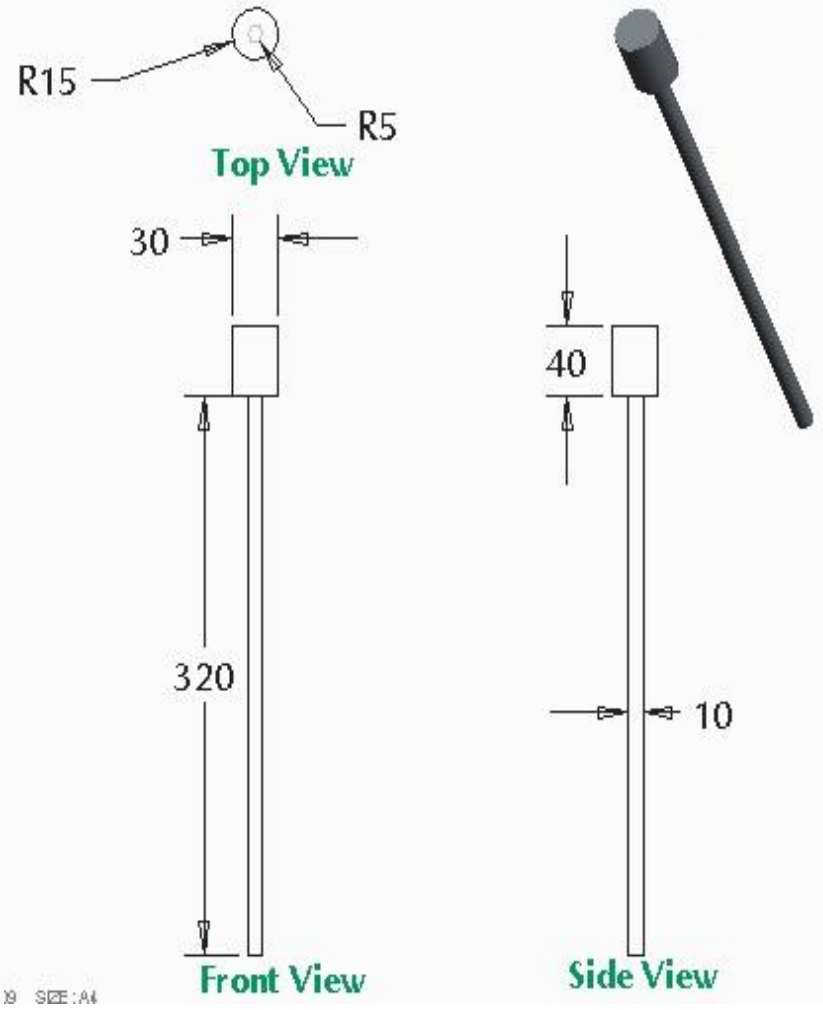
➢ Conclusion:

- This study analyzed the conventional painting process or apartment building construction, maintenance and its arising problems.
- Ladder truck save 47% of annual painting cost compare to conventional method and reduces no. of labours, improves safety, quality and productivity.

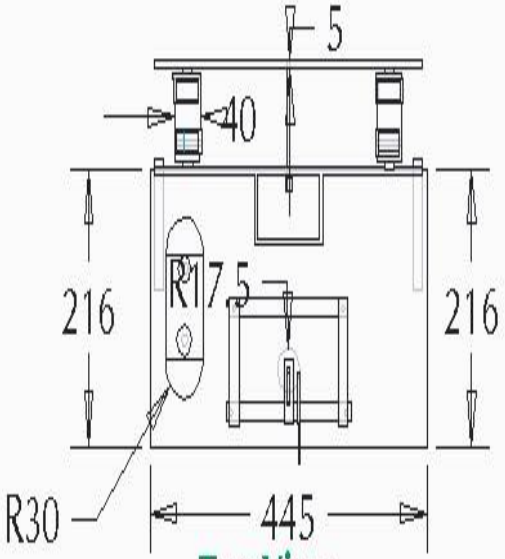
Modeling

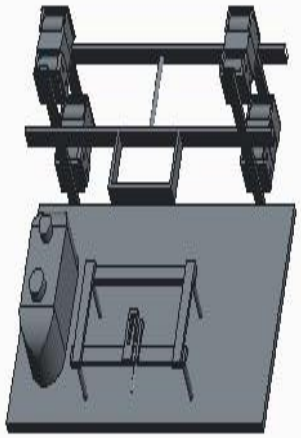


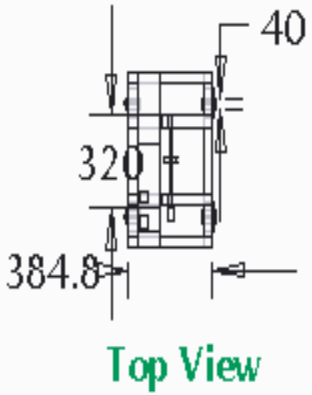
Pulley

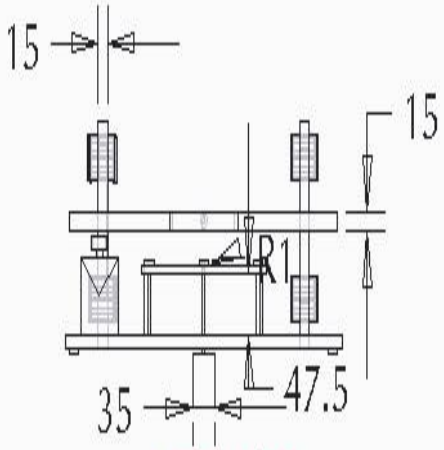


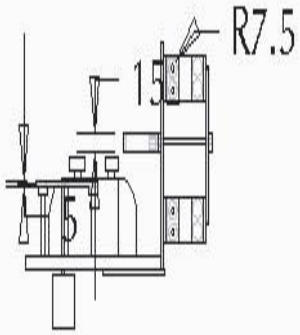
Shaft

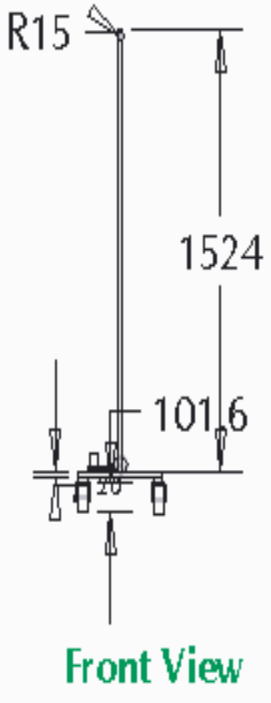


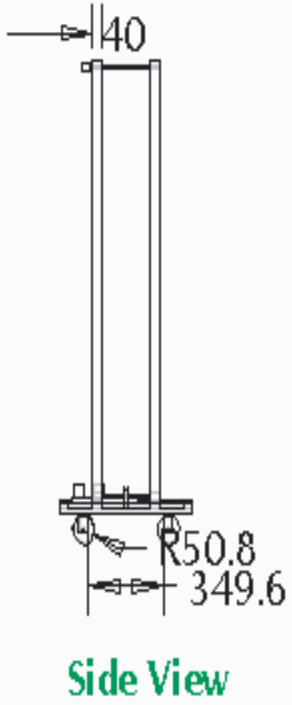












Moving Mechanism

Frame

Calculations

Density = Mass/volume => Mass = Volume ✕ density

- **Components & Weight:**

1. **Base:**

- Horizontal Members = 2.3023Kg ✕2= 4.60 Kg =45.126N

- Cross Members = 1.438 Kg ✕2= 2.877 Kg=28.22N

- Wooden Plate = 0.89 Kg = 8.73 N

Total Weight = 45.126+28.22+8.73= 82.07 N

2. **Vertical Channel :**

- 2 Vertical Channels = 8.70 Kg = 85.347 N

3. **Shaft on top of Channel Consisting 2 motors =** 0.4436Kg = 4.3517N

4. **Guided Pulley:**

- Pulley= 0.05386Kg = 0.528 N

5. **Moving Platform :**

- Air Compressor = 1.5 Kg = 14.715N
- Motor, Skotch Mechanism for Nozzle = 0.2218Kg = 2.1758N
- Wooden plate = 0.145Kg =1.422 N
- Paint Tank = 500 gm = 4.905N
- Aluminum Strip = 0.440 Kg = 4.32N

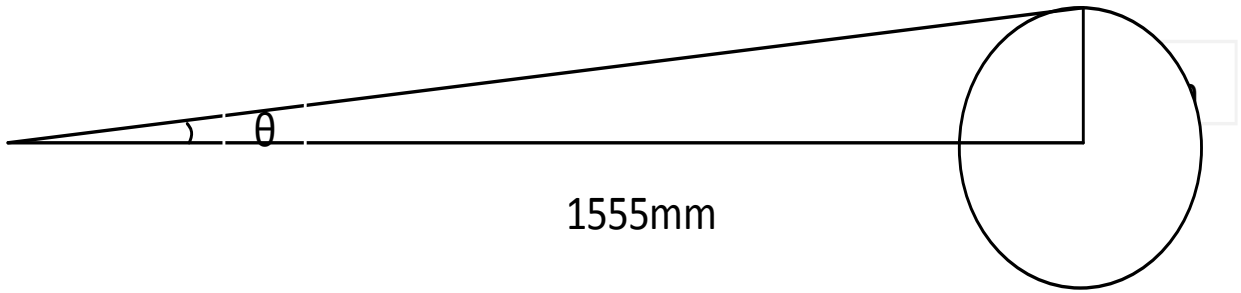
Total Weight = 14.715+ 2.1758+ 1.422+ 4.905+ 4.32

= 27.53 N

Total Weight = 82.07 + 85.347+ 4.3517+ 0.528+ 27.53

= 199.826 N ≅ 200 N

6. Pulley:



$\theta = 1.1420^0$

$T = mgCos\theta = 27.53\ Cos(1.1420) = 27.52\ N$

$Width\ (B) = 1.25 \times 10 = 12.5\ mm$

$\sigma_t = \rho v^2$

$= 1190 \times 0.0508^2$

$= 3.070\ N/m^2$

7. Rope:

Stresses in Rope:

$$\sigma_d = \frac{w + W}{A} = \frac{0.0981 + 30}{\frac{\pi}{4} \times (10)^2} = 0.3832 \text{ N/mm}^2$$

Working Condition

$$W_a = \frac{(w+W) \times a}{g} = \frac{30.0981 \times 0.001622}{9.81} = 0.00496 \text{ N}$$

$$\text{Stress} = \frac{(w+W) \times a}{A} = \frac{(0.0981+30) \times 0.00162}{\frac{\pi}{4} \times (10)^2} = 6.3184 \times 10^{-5} \text{ N/mm}^2$$

8. Velocity:

$$\text{Base Wheel velocity} = \frac{x}{t} = \frac{1}{3} = 0.33 \text{ m/min}$$

$$N = \frac{v}{\pi d} = \frac{0.33}{3.14 \times 0.01} = 10.5 \text{ rpm}$$

$$\text{Moving Mechanism Velocity} = \frac{x}{t} = \frac{1.524}{3} = 0.608 \text{ m/min}$$

$$N = \frac{v}{\pi d} = 19.36 \text{ rpm}$$

Nozzle Platform Velocity = 3.102m/min

$$N = \frac{v}{\pi d} = 98.78 \text{ rpm}$$

9. Motor(DC Geared):

Motor For Moving Mechanism,

$$T = \frac{P \times 60}{2\pi N} = \frac{(12 \times 1) \times 60}{2\pi \times 20} = 5.732 \text{ Nm}$$

Motor For Wheel,

$$T = \frac{P \times 60}{2\pi N} = \frac{(12 \times 1) \times 60}{2\pi \times 10} = 11.459 \text{ Nm}$$

Motor For Nozzle,

$$T = \frac{P \times 60}{2\pi N} = \frac{(12 \times 0.5) \times 60}{2\pi \times 99} = 0.579 \text{ Nm}$$

10. Clamp:

Bending Moment

$$= (14.715 \times 0.058) + (2.1770 \times 0.038) + (4.32 \times 0.118)$$

$$= 1.4459 \text{ Nm}$$

Bending Stress,

$$\sigma_b = \frac{MY}{I} = \frac{12 \times 1.44 \times 0.038}{0.175 \times (0.085)^3} = 6109.87 \text{ N/m}^2$$

11. Friction in tyres of moving mechanism:

$\mu = 0.20$

$\theta = \tan^{-1} \mu$

$= 11.30$

Load Tension T = 27.53N

Friction Force (↓) :

$T - mgSin\theta = F$

$F = 27.53 - 27.53Sin11.30$

$= 22.1356$ N

$N = \frac{F}{\mu} = \frac{22.1356}{0.2} = 110.67$ N

$R = NCos\theta = 110.67\ Cos(11.13)$

$= 108.58$ N

Direct load , $\sigma = \frac{P}{A} = \frac{200}{0.38 \times 0.69} = 762.77$ N/m^2

Bending Moment in Base,

$M = \frac{Wl}{4} = \frac{200 \times 304.8}{4} = 15240$ N.mm

Components

- **DC GEARED MOTOR**
- **AIR COMPRESSOR**
- **TRANSFORMER**
- **RECTIFIER**
- **NOZZLE**
- **SHAFT**
- **FRAME**
- **ROCKER SWITCH**

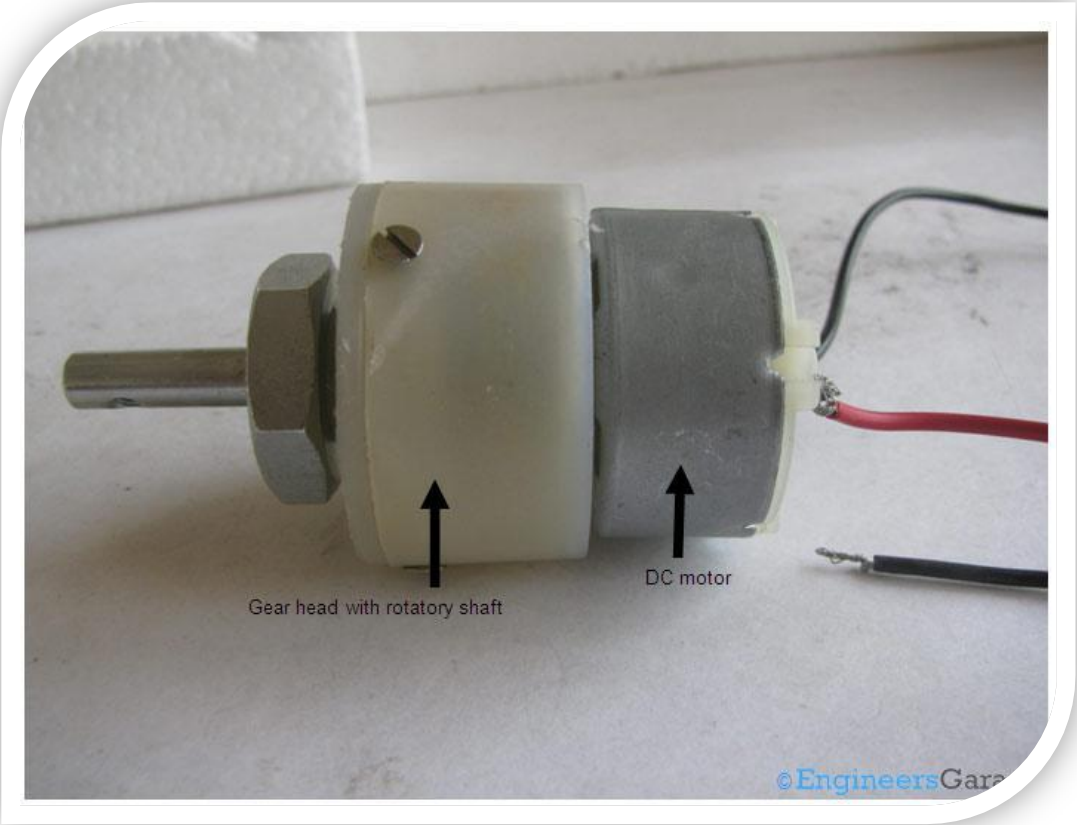
DC Geared Motor:

- Geared DC motors can be defined as an extension of DC motor which already had its Insight details demystified here. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed.

External Structure:

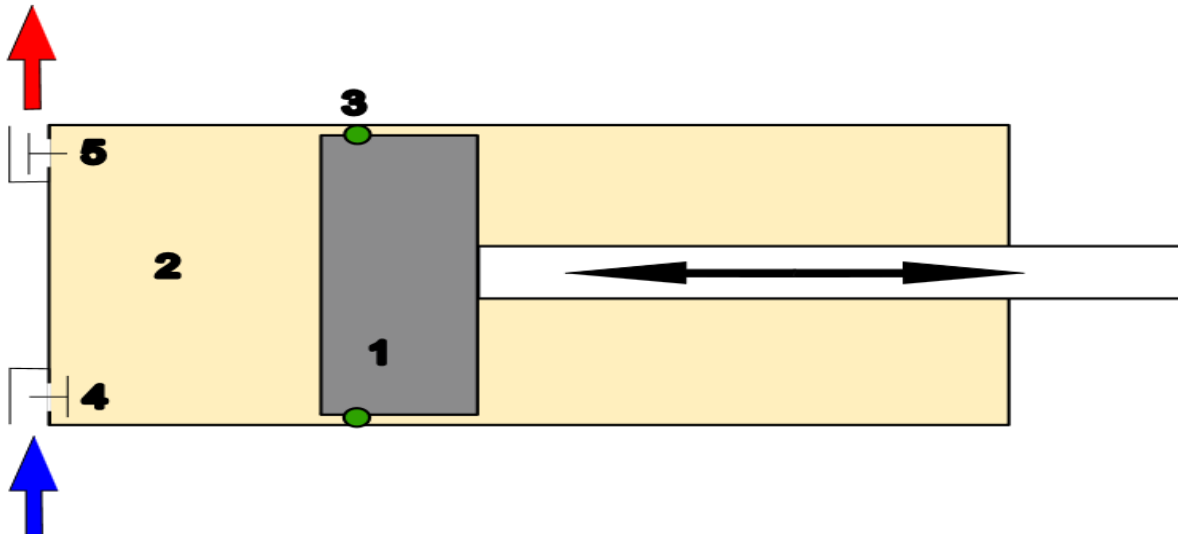
- At the first sight, the external structure of a DC geared motor looks as a straight expansion over the simple DC ones
- The lateral view of the motor shows the outer protrudes of the gear head. A nut is placed near the shaft which helps in mounting the motor to the other parts of the assembly.
- Also, an internally threaded hole is there on the shaft to allow attachments or extensions such as wheel to be attached to the motor.
- the outer body of the gear head is made of high density plastic but it is quite easy to open as only screws are used to attach the outer and the inner structure. The major reason behind this could be to lubricate gear head from time to time.

- The plastic body has a threading through which nut can be easily mounted and vice versa from the gear head.
- We have used 4 motors of 30rpm, 12v for wheels,2 of 45rpm for upper shaft & 1 of 100 rpm at Skotch Yoke Mechanism



Air Compressor:

- An air compressor is a device that converts power (usually from an electric motor, a diesel engine or a gasoline engine) into kinetic energy by compressing and pressurizing air, which, on command, can be released in quick bursts. There are numerous methods of air compression, divided into either positive-displacement or negative-displacement types.
- A **Reciprocating or piston compressor** is a positive-displacement compressor that uses pistons driven by a crankshaft to deliver gases at high pressure. The intake gas enters the suction manifold, then flows into the compression cylinder where it gets compressed by a piston driven in a reciprocating motion via a crankshaft, and is then discharged. We've used compressor of 300 psi.



Transformer:

- A Transformer takes in electricity at a higher voltage and lets it run through lots of coils wound around an iron core. “. A single-phase Transformer can operate to either increase or decrease the voltage applied to the primary winding. Because the current is alternating, the magnetism in the core is also alternating. Also around the core is an output wire with fewer coils. The magnetism changing back and forth makes a current in the wire. Having fewer coils means less voltage. When it is used to “decrease” the voltage on the secondary winding with respect to the primary it is called a **Step-down Transformer**. When a Transformer is used to “increase” the voltage on its secondary winding with respect to the primary, it is called a **Step-up Transformer**.
- Here ,we are using Step down Transformer for getting a Voltage drop of 12V from 230V.

Nozzle:

- A Nozzle is a device designed to control the direction or characteristics of a fluid flow (especially to increase velocity) as it exits (or enters) an enclosed chamber or pipe.
- A nozzle is often a pipe or tube of varying cross sectional area, and it can be used to direct or modify the flow of a fluid (liquid or gas). Nozzles are frequently used to control the rate of flow, speed, direction, mass, shape, and/or the pressure of the stream that emerges from them. In nozzle velocity of fluid increases on the expense of its pressure energy.

Shaft:

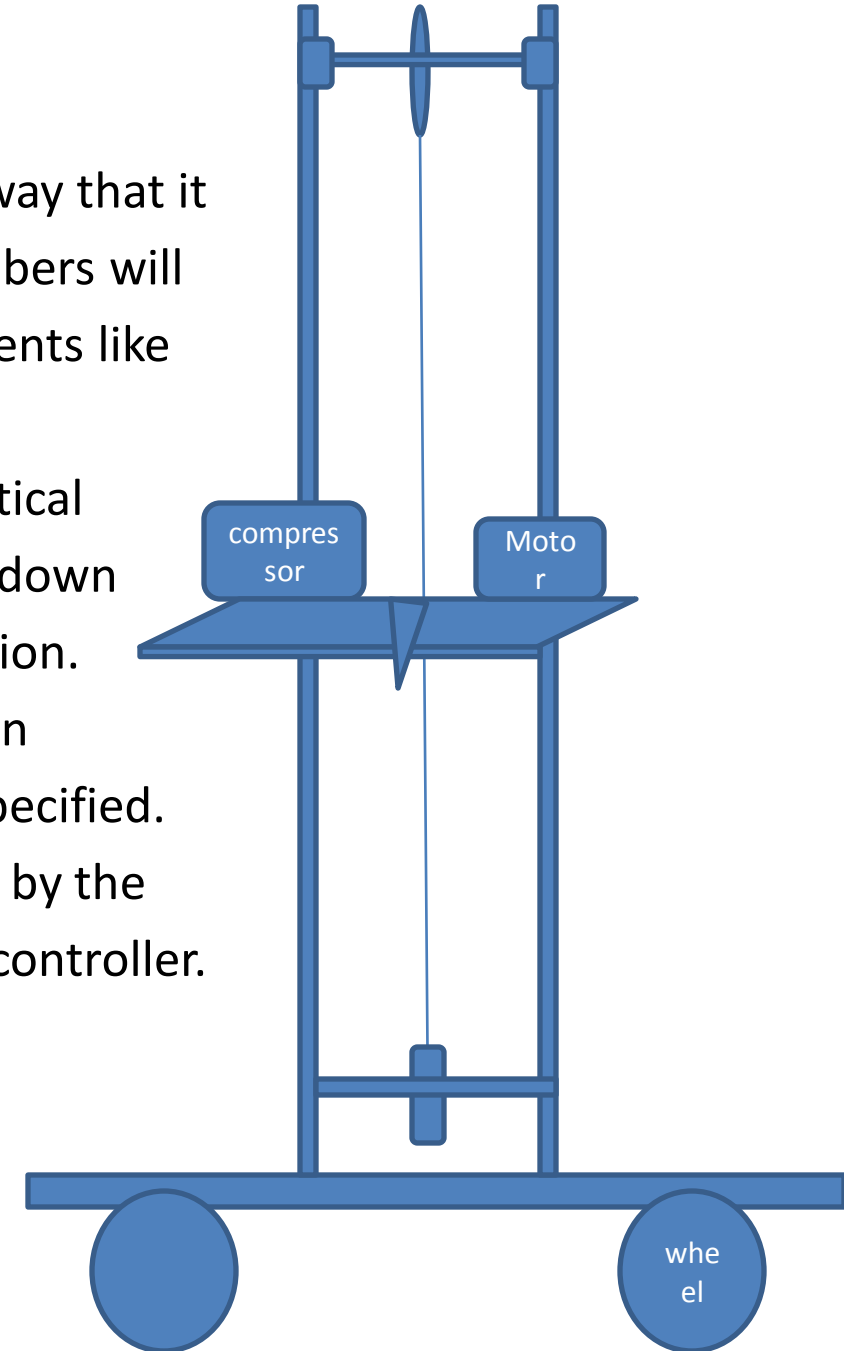
- Material: Stainless Steel
- A shaft is connected at both the end with the output shaft of a geared motor, which will rotate the shaft and ultimately motion ids transmitted to pulley mounted on shaft .

Frame:

Material : Mild Steel

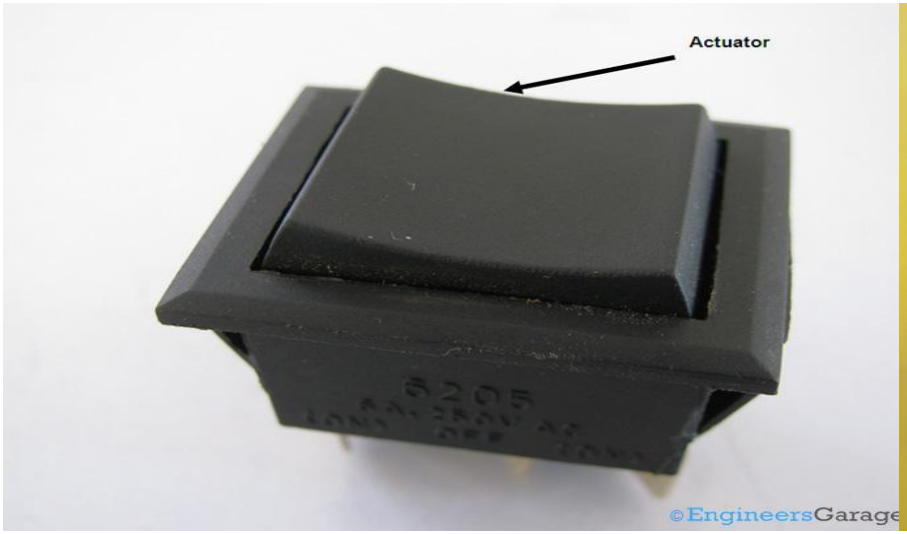
- The frame stand is the steel bolted in such a way that it can carry the whole equipment. Vertical members will carry the mobile platform consisting Components like compressor, nozzle, paint tank &motor.
- This mobile platform will be connected to vertical members of frame by rollers to allow the up-down motion to platform controlled by pulley rotation.
- Four wheels are attached to the frame stand in order to move the machine in the direction specified.

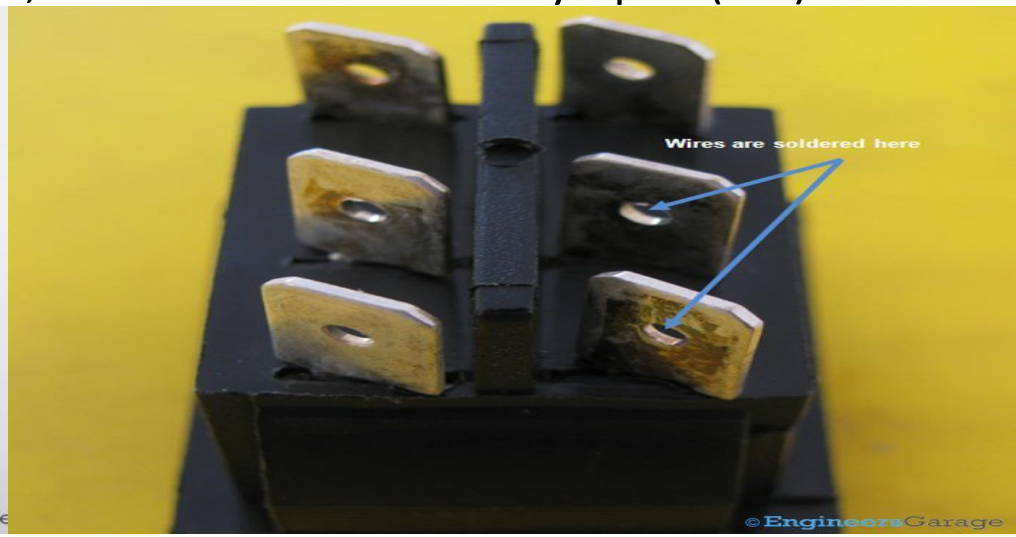
The movement of these wheels are controlled by the DC motor rotation which is controlled by the controller.

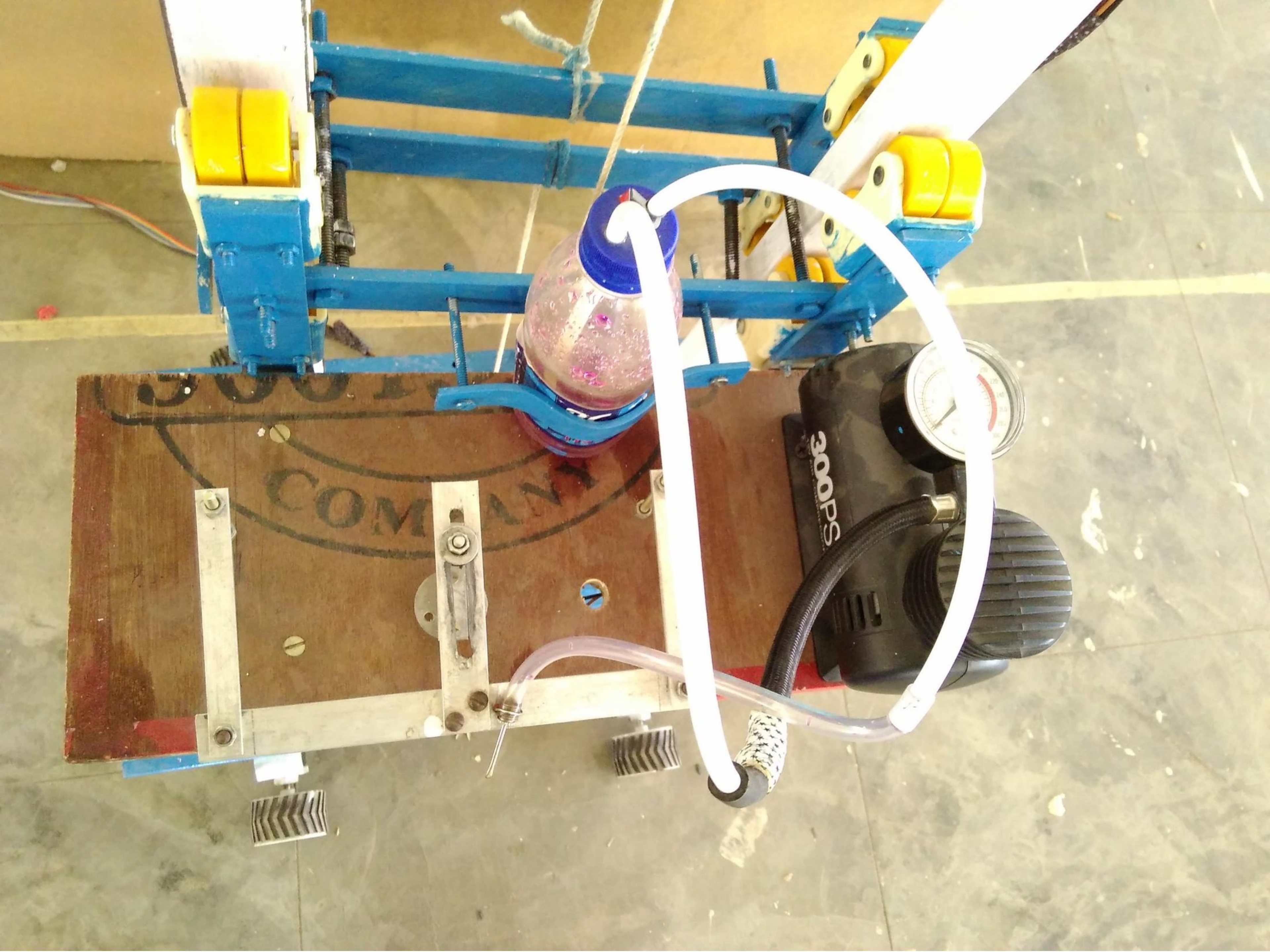


Rocker Switch:

- Shown in the fig. below a conventional momentary rocker switch. This is a normally open (NO) switch and conducts when its actuator is pressed in either direction. The outer structure is made from thick polymer material and it provides sturdiness to the switch.
- The bottom of this switch has 6 contacts/legs embedded in the epoxy of the outer casing. The pins are arranged in a pair of 2, thus making 3 pairs which denote the ON, OFF and ON position of the switch. The contacts have circular cut sections from where wires can be connected or soldered to the switch.
- The switch taken in this insight has the default state at the centre and the other states at either direction. In this switch, default state is normally open (NO) while






300PS

OBJECTIVE

- The actual targets for development of the wall painting machine, in order to solve the aforementioned situation, were set as follows:

1) To make machine structure simple to enable easy mounting as well as for safety.
2) To perform only painting in a single color.
3) To be usable only on external walls of structures but also in various other places such as on walls of civil structures.

METHODOLOGY

- Start
- Find the definition of project
- Survey of field construction & gather information
- Redefine definition of project
- Design of components
- Modification
- Fabrication of working model
- Testing & Modification
- Conclusion

WORKPLAN

June – July	Literature review on the topic
August-September	Designing the components based on their functions
October – November	Modification of design
December-February	Fabrication of components, assembly and Experimental work ,noting the performance of the machine
March - May	Final Report preparation for the project.

SCOPE OF PROJECT

- This type of machine can be used at construction sites and at multi floor building for exterior wall painting.

Conclusion

- With this fixture it will be possible to avoid the risk of painting tall building at elevated height. The machine is specially designed for painting the outside or exterior Flat wall of the structure .
- It eliminates the hazards caused due to the painting chemicals to the human painters such as eye and respiratory system problems and also the nature of painting procedure that requires repeated work and hand rising makes it boring, time and effort consuming. The machine is cost effective, eliminates works on scaffolds, reduces work force for human workers and reduces time consumption.

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Weblinks:

- http://electrical4u.com/electrical/wp-content/uploads/fleming-left-hand-rule-1.png
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