Design And Development of Auto Solar Cleaning with Water Spraying System

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE DEGREE OF

Bachelor of Engineering
In
Mechanical Engineering

Submitted By

TUSHAR SHINGADE	**B150311012**
NIKHIL SANGULE	**B150310976**
RUSHIKESH MORE	**B150310928**
ABHISHEK MASE	**B150310922**

Under the Guidance of

Prof. P. S. PAWAR

Department of Mechanical Engineering,

PES's Modern College of Engineering

Pune – 411 005

[2021-22]

Progressive Education Society's

Modern College of Engineering, Pune

CERTIFICATE

This is to certify that the project work (402051) report entitled

Design And Development of Auto Solar Cleaning with Water Spraying System

Has Successfully Completed By

TUSHAR SHINGADE	**B150311012**
NIKHIL SANGULE	**B150310976**
RUSHIKESH MORE	**B150310928**
ABHISHEK MASE	**B150310922**

In the partial fulfilment of degree of

BACHELOR OF MECHANICAL ENGINEERING

In

SAVITRIBAI PHULE PUNE UNIVERSITY

Under the guidance of

PROF. P. S. PAWAR

During the Academic Year 2021-22

Prof. P. S. PAWAR	**Prof. Dr. S. Y. Bhosale**	**Prof. Dr. Mrs. K. R. Joshi**
Asst. Professor	Head of	Principal,
(Guide)	Mechanical Engineering	PES's MCOE, Pune

Progressive Education Society's

Modern College of Engineering, Pune

CERTIFICATE

This is to certify that the project work (402051) report entitled

Design And Development of Auto Solar Cleaning with Water Spraying System

Has Successfully Completed By

TUSHAR SHINGADE	**B150311012**
NIKHIL SANGULE	**B150310976**
RUSHIKESH MORE	**B150310928**
ABHISHEK MASE	**B150310922**

In the partial fulfilment of degree of

BACHELOR OF MECHANICAL ENGINEERING

In

SAVITRIBAI PHULE PUNE UNIVERSITY

Under the guidance of

PROF. P. S. PAWAR

During the Academic Year 2021-22

Internal Examiner **External Examiner**

ACKNOWLEDGEMENT

We would like to extend our profound esteem to all those who have helped us in the course of the project it would not have been possible to prepare this report without their valuable help collaboration, and supervision. We would like to express our sincere gratitude to Prof. P.S. Pawar our project guide, for his constant encouragement, support, and advice in the implementation of the project. We are extremely thankful to the head of our department Prof. Dr. S.Y. Bhosale for his constant support and belief in our project. We would also like to thank all the professors and staff members in the department for helping us out with conceptual doubts and helping us in the designing process. Lastly, we are grateful to our seniors and colleagues for guiding us and helping out with the project.

Tushar Shingade	Nikhil Sangule	Rushikesh More	Abhishek Mase
Seat No -	Seat No -	Seat No -	Seat No -
B150311012	B150310976	B150310928	B150310922

INDEX

ABSTRACT

Today energy demands are increasing sharply, therefore the need to conserve energy and utilize available energy efficiently is very important. There are many forms of renewable energy available, with the increasing demands there is a need to exploit renewable sources of energy. Solar is one of them and it is a time-dependent and intermittent energy source. Thus, it is important to store available energy and use later on when the need is greatest. While storing solar energy which will drive us towards the goal of universal energy access, there is one major drawback. This project aims to eradicate that drawback by designing and installing an automatic solar panel cleaning system. Dust accumulation on PV modules is the area of growing concern for the reliability of solar panels. So, developing such a mechanism that will maintain the efficiency of PV modules connected in arrays as in solar farms spread over a large area and also for the rooftop assemblies at low cost is the main concern. This paper includes the study of effects of change in efficiency of PV modules due to the accumulation of different dust particles found in different regions, factors governing for the decrease in efficiency accounts a lot due to soiling and developing an automated mechanism for cleaning. Labour-based cleaning methods for PV modules are expensive and uses a large amount of water. This prototype includes DC motors controlled by a drive unit that moves a cleaning head horizontally with or without using a spraying system. This results in an increase in efficiency of overall PV modules, the amount of renewable energy harnessed is more, less water usage and less water usage.

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE

F	Force acting on frame (N)
W	Weight of hole setup (kg)
pd	Perpendicular distance of the frame (mm)
A	Cross-sectional Area of L Strip (mm^2)
M	Bending Moment (N-mm)
I	Moment of Inertia (mm^4)
L	Length of Frame (mm)
W	Width of Frame (mm)
h	Height of Frame (mm)
Syt	Yield Stress (N/mm^2)
FOS	Factor of safety
P	Power (watt)
V	Voltage (volt)
I	Current (amp)
T	Torque (N-mm)
D	Diameter of Wheel (mm)

1. INTRODUCTION

Over the years, as non- renewable energy sources are exhausting drastically and increasing concern towards the environmental aspects, solar energy is widely accepted all over the world. Solar energy of all renewable energy sources has the greatest potential as it is available in abundance. Because of this environmentally safe and pollution free use has attracted the attention of many researchers in this field. Now a days a wide range of applications is found in the market which are based on solar power. These products based on solar PV are having increasing demand in the market as they are available at moderate prices. These products mostly include solar lanterns, solar heaters, blowers, networking instruments, coolers or fans, calculators, watches, net metering etc. This trend in solar PV cells use is expected to increase continuously in future. National Institute of Solar Energy has assessed the Country's solar potential of about 748 GW assuming 3% of the waste land area to be covered by Solar PV modules. Solar energy has taken a central place in India's National Action Plan on Climate Change with National Solar Mission as one of the key Missions. National Solar Mission (NSM) was launched on 11th January, 2010. NSM is a major initiative of the Government of India with active participation from States to promote ecological sustainable growth while addressing India's energy security challenges. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. The Mission's objective is to establish India as a global leader in solar energy by creating the policy conditions for solar technology diffusion across the country as quickly as possible. The Mission targets installing 100 GW grid connected solar power plants by the year 2022. This is line with India's Intended Nationally Determined Contributions (INDCs) target to achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources and to reduce the emission intensity of its GDP by 33 to 35 percent from 2005 level by 2030.

In order to achieve the above target, Government of India have launched various schemes to encourage generation of solar power in the country like Solar Park Scheme, VGF Schemes, CPSU Scheme, Defence Scheme, Canal bank & Canal top Scheme, Bundling Scheme, Grid Connected Solar Rooftop Scheme etc. Recently, India achieved 5th global position in solar power deployment by surpassing Italy.

Solar power capacity has increased by more than 11 times in the last five years from 2.6 GW in March, 2014 to 30 GW in July, 2019. As solar energy is timely dependent due to environmental factors such as cloud gathering, rainfalls, floods, sandstorms in desert areas etc., so it equally important to store solar energy. There are many ways to collect and store solar energy, the direct conversion of solar energy into electrical energy is achieved by the photovoltaic effect by using solar cells. Due to this, the use of solar energy and installation of PV arrays are taking place in large numbers but it is equally important to maintain its efficiency. Accumulation of dust on PV modules is the main area of concern which restricts the use of solar energy as it decreases the efficiency of solar panels.

This project is mainly focused on the effects of dirt and dust accumulation on PV modules which affects its efficiency, efficient operating strategies, design, and fabrication with a successful installation. Soiling and layers of dust accumulated on solar panel act as an obstacle for PV modules. There are different types of dust in different regions with varying sizes of dust particles due to local environment which can be cleaned. Cleaning solar panel, however, is not straight forward due to the issue of accessibility of panels. Since PV modules are located at places which are having high temperatures such as in desert areas, it is dangerous and difficult to reach out there for cleaning solar panels manually also it takes time to do it safely. Solar panels can lead to permanent damage to the glass and can also reduce its lifespan. Therefore, it is a better option to develop a system which can clean the panel array automatically. Since the project module is providing auto cleaning mechanism to remove the layer of dust particle from PV surface in order to achieve better efficiency.

2. LITURATURE REVIEW

As accumulation of dust on the PV panel reduces its transmittance which results in the reduction of the power output, thus resulting in loss of power generation. This particular problem is also responsible for the short life span of many interplanetary exploration missions such as Mars Exploration Mission of Curiosity Rover as the power output from their solar panel reduces over time because of the accumulation of dust. At a point of time density of dust increases to level where power output declines to the extent which is not able to support its vital functions. Further this problem has also resulted in huge losses for the solar power plant operators which suffer from reduced power output because of frequent dust storms. Most widely used method of cleaning the solar panels are through the manual labour. Apart from being time taking and cumbersome, there is also a risk of damage to the expensive solar panels by the unskilled labour which is involved in this method. The purpose of this project is to develop an Automatic self-cleaning mechanism for cleaning the solar panel so that the process can become more reliable and faster, thus increasing the power output of the solar power plant.

[1]. It provides an appraisal on the current status of research in studying the impact of dust on PV system performance. Kutaiba Sabah etal, have explained the Self-cleaning solar panels to avoid the effect of accumulated dust on solar panels transmittance this research is a combination of two ideas. The first one is the idea of the reduction of the effects of accumulated dust on the flat solar plate.

[2]. J. Zorrilla-Casanova et al, have discuss the Analysis of dust losses in photovoltaic modules the objective of this work is to quantify losses caused by the accumulation of dust on the surface of PV modules. with this aim, irradiance values measured by two mSi cells have been recorded every ten minutes during a year.

[3]. K.A. Moharram et al, have explained the Influence of cleaning using water and surfactants on the performance of photovoltaic panels The objective of this research is to remove dust deposited on PV panels using the minimum amount of water and energy, in this research the influence of cleaning on the PV panels using water as well as a surfactant was investigated experimentally using non pressurized water system.

[4]. This is help us to study the influence of cleaning on the performance of PV panels. S.A. Sulaiman et al, have explain the Effects of Dust on the Performance of PV Panels in these two types of artificial dust; i.e., dried mud and talcum powder, were used instead of real dust to represent the dust accumulation. The use of natural dust accumulation was avoided because it might not be well distributed on the surface of solar PV panel, since it would be exposed naturally to the environment and the dust settlement could be subjected to the wind effect.

[5]. A.M. Pavan et al, have explained the effect of soiling on energy production for large-scale photovoltaic plants. This can help us to study the operation and maintenance responsible in choosing the proper washing schedule and method for their plants and avoid wasting money and this work aims to evaluate the effect of soiling on energy production for large scale ground mounted PV plants in the countryside of southern Italy. The results presented in this work show that both the soil type and the washing technique influence the losses due to the pollution.

3. PROBLEM DEFINATION, SCPOPE AND OBJECTIVES

3.1 Problem Definition:

- The solar PV modules are generally employed in dusty environments which are the case tropical countries like India.
- The dust gets accumulated on the front surface of the module and blocks the incident light from the sun.
- It reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month.
- There are a lot of techniques for cleaning the solar panels; our idea is to design a smart solar panel that cleans itself automatically and remotely in order to maintain a high level of efficiency of the solar panel.

3.2 Objective of Project:

To overcome these unwanted effects, we have to Design and Develop a Solar panel cleaning system which have following objectives:

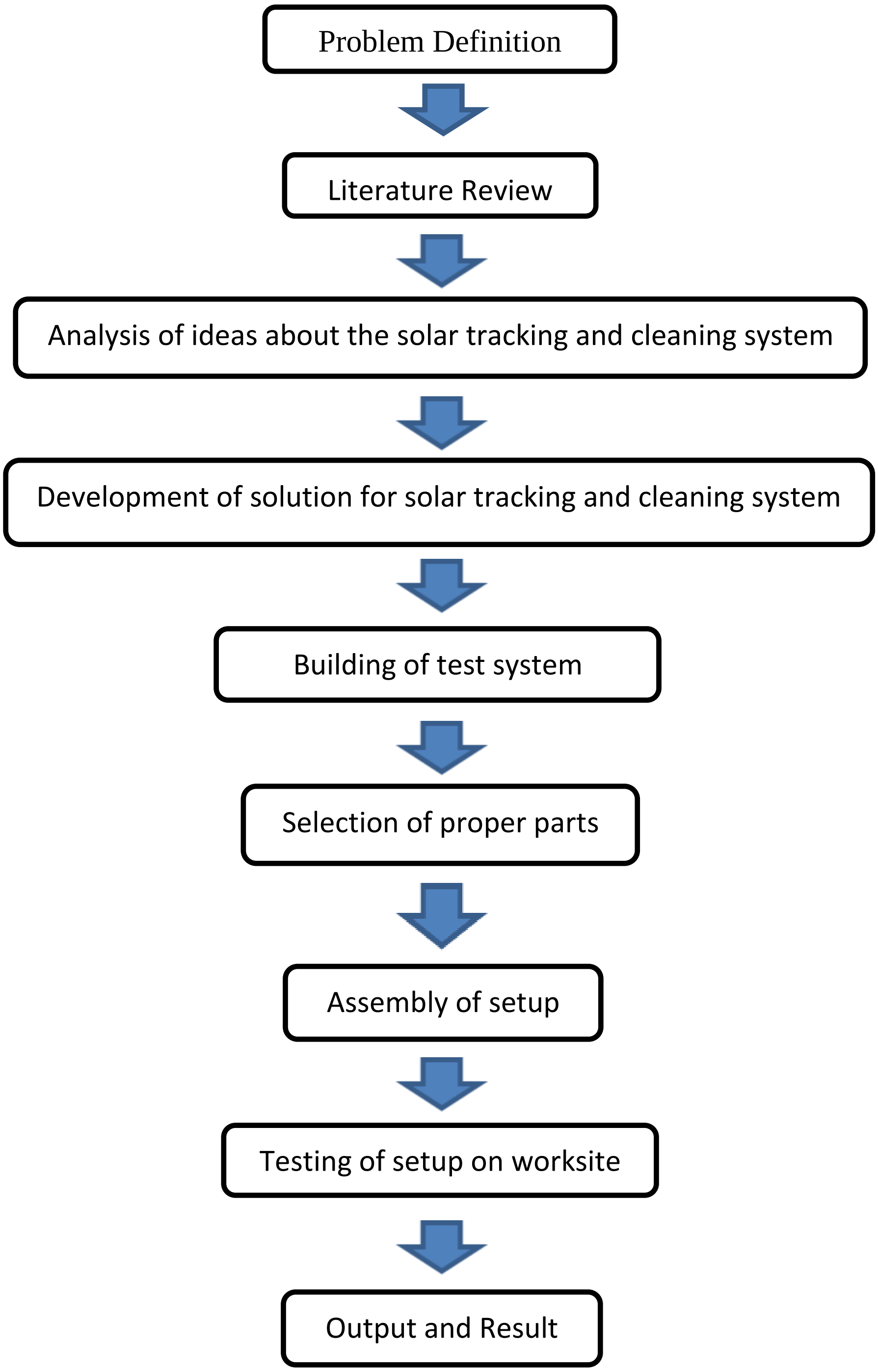
- To make the system automatic to avoid the manual work.
- To avoid dust associated problems on solar panels.
- To remove Sticky Dust by adding water sprayer.
- Increase the efficiency of Solar panels using Panel cleaning systems.

3.3 Scope of Project:

- About 60% to 70% of the energy demand of the country is met by fuel wood and agriculture residues.
- Solar energy is a renewable source of energy, which has a great potential and it is radiated by the sun.
- Solar energy is abundant source of energy. Because of its dispersed nature we are unable to use this energy inconvenient way.
- Future requirement of energy source is mandatory for Electric vehicles, hence solar panel plays a vital role in the market.
- This will also have a positive impact on the environment and climate change.

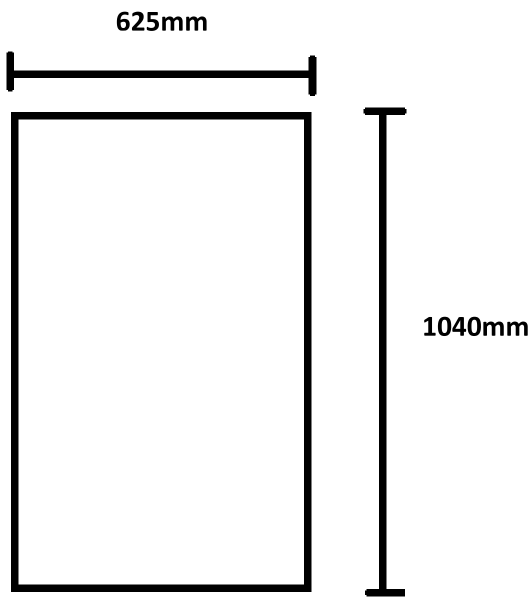
- In the coming years, technology improvements will ensure that solar becomes even cheaper. It could well be that by 2030, solar will have become the most important source of energy for electricity production in a large part of the world.

3.3 Methodology:



4.MATHAMATICAL CALCULATION

4.1 Calculation of Frame:



F = force acting on total frame including all setups with motors, brush, clamps & Shaft.

Weight of solar panel = 10 Kg approx.

Weight of Nozzle & arrangement = 3 Kg

Other weight = 1Kg

F.O.S = 2

Total weight = F.O.S *14 = 28 Kg

= 28*9.81

= 274.68N

= **275N**

Pd = Perpendicular distance of the frame which is = 1040/2 = 520 mm.

The distance is assumed to be 1m including full set up, because here we are creating a prototype, hence some of the Assumptions needs to be considered.

The material used for fabricating frame is Mild steel.

A cross-section of = 25*25*3 mm standard L angle plate

L-Type because it is easily available in the market.

We know,

$$M / I = \sigma b / y$$

M = Bending moment

I = Moment of Inertia about axis of bending that is; Ixx

y = Distance of the layer at which the bending stress is consider

(We take always the maximum value of y, that is, distance of extreme fibre from N.A.)

Bending moment (M) =force *perpendicular distance

= 275* 520

= 143000 N-mm

I = b(h3) / 12

= $25*(25^3) / 12$

=32552.0833 mm4

M = 143000 N-mm

I = 32552.0833

Sigma b = unknown?

Y = 25 / 2 = 12.5 mm

Sigma b = 54.99 N/mm2 or MPa

The allowable shear stress for material is σ allow = Syt / fos

Where Syt = yield stress

= 210 MPa

= 210 N/mm2

And FOS is factor of safety = 2

So σ allow= 210/2

= 105 MPa

= **105 N/mm2**

Comparing above we get,

σb < σ allow

i.e.

54.99 < 105 N/mm 2

So, design is safe.

4.2 Frame Material = Mild Steel:

4.2.1 Physical Properties of Mild Steel:

- High tensile strength.
- High impact strength.
- Good ductility and weld ability.
- A magnetic metal due to its ferrite content.
- Good malleability with cold-forming possibilities.
- Not suitable for heat treatment to improve properties.

4.3 Hydraulic Pump or Motor:

Assumption:

W = 2Kg = of water to be transferred from reservoir to the panel. = 2000grm

T = For a time of 1min = 60 Sec

Delta (h) = 1m

$$P = \frac{\mathrm{W}}{\mathrm{T}}$$

W = Fd

W = mg*Delta (h)

$\mathrm{P} = \frac{\mathrm{m}}{\mathrm{T}} * \mathrm{g} * \mathrm{Delta\ (h)}$

$$\frac{2\mathrm{Kg}}{\mathrm{min}}\ X\ \frac{1\mathrm{min}}{60\mathrm{sec}}$$

= 0.0334 Kg/sec

P = 0.0334 X 9.81 X 1

= **0.327 KW** required

Power of water pump

According to this we have selected water motor required as per the availability in Market.

4.4 DC Motor Selection:

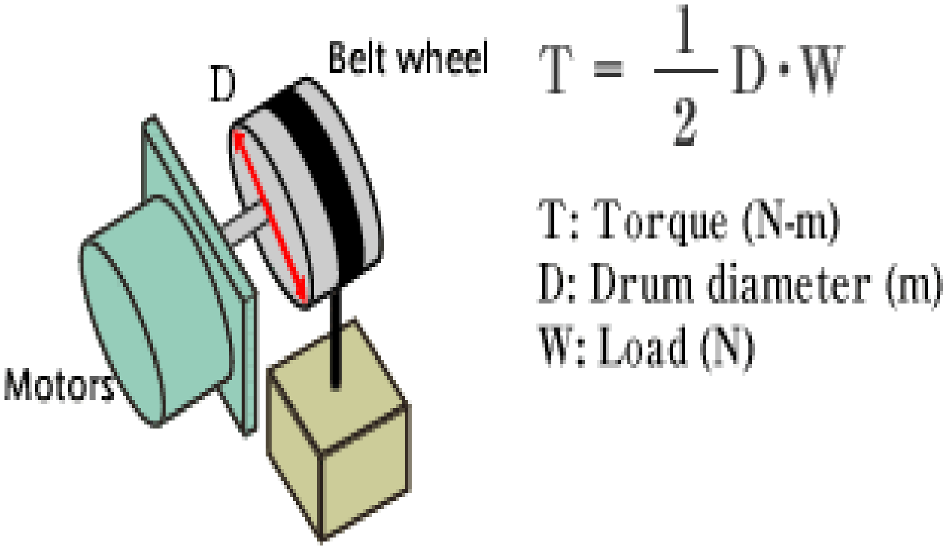


Figure 4.4: motor formulation

Weight of the cleaning setup Nozzle, roller brush, shaft & arrangement = 3Kg

T = 1/2. D.W

Where,

T = Torque

D = Diameter of wheel

= 85 mm

W = Total weight of setup

= 3kg

= 3*9.81

= 29.43 N

T = 1/2 x 85 x 29.73

= 1263.525 N-mm

= 1.263525 N-m this torque is divide among the 4 wheels.

So,

Torque required to drive the setup is = torque/no of motors used

= 1263.525/4

= 315.88 N-mm.

= 3.221 kg-cm

According to this we have selected motor required as per the availability in Market.

4.5 Motor for brush rotation:

- Weight of the brush = 500 grams assume = 4.905 N
- Diameter of the roller brush shaft= 10mm

T = ½.D. W

= ½ x 5 x 10

= 25 N-mm

= 0.025 Nm

= **0.255 Kg-cm**

According to this we have selected motor required as per the availability in Market.

4.6 System Architect:

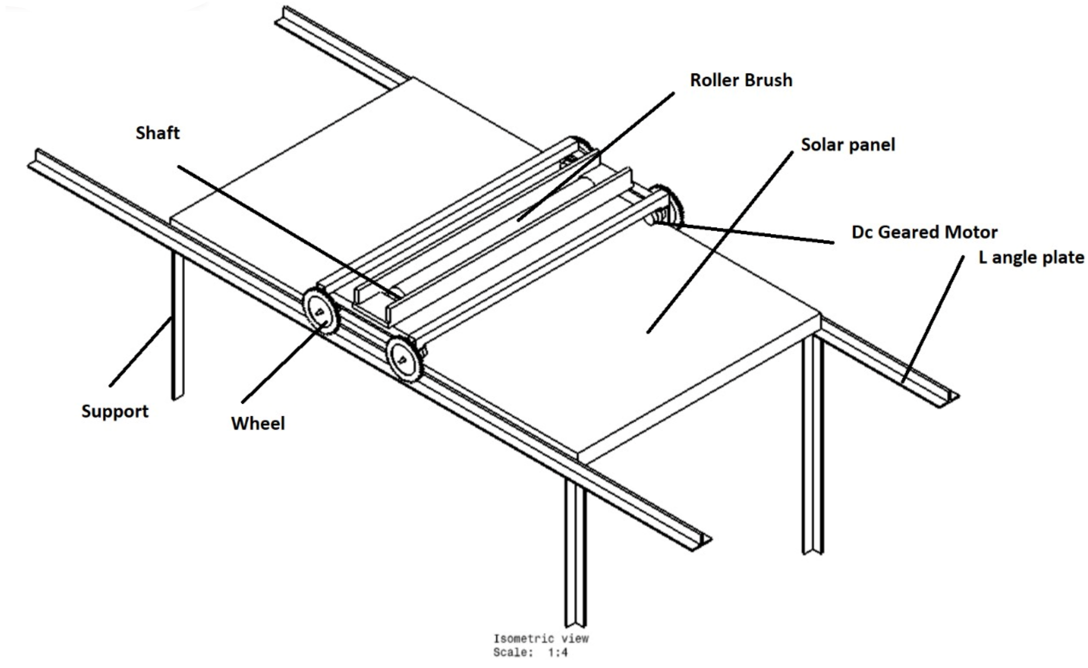


Figure 4.6: System Architect

5. EXPERIMENTAL WORK

5.1 Components Required:

Frame	=	Mild steel
Solar panel	=	12volts PV capacity
Brush	=	fabric roller or thin cleaner
Nozzle	=	3 quantity ,10 mm diameter
Pipe	=	Plastic 1mtr long 10 mm diameter
Water motor	=	1 quantity
DC Motor	=	4 quantity
Controller	=	Toggle Switch
Battery	=	12 volts capacity, 4.5 Amp
Bolts & Nut	=	as per requirement
Wheels	=	4 quantity.

5.1.1 Solar panel:

A solar cell panel, solar electric panel, photo-voltaic (PV) module or solar panel is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy to generate direct current electricity. A collection of PV modules is called a PV panel, and a system of PV panels is called an array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

- Product: Polycrystalline Solar Panel
- Rated Power Range: 1-100 W
- Watt: 100 W
- Voltage at Pmax (V): 17.3 V
- Module Voltage: 12 V
- Number of Cells: 36
- Module Dimension (L x W x T): 1040 x 625 x 35 mm
- Cell Efficiency: 0.176

Figure 5.1.1: solar panel

5.1.2 Water submersible motor:

A submersible water motor (or sub pump, electric submersible pump (ESP)) is a device which has a hermetically sealed motor close-coupled to the pump body. The whole assembly is submerged in the fluid to be pumped.

Specifications:

▪ Operating Voltage	5V
▪ Operating Current	130 to 220 mA
▪ Flow Rate	80 to 120 L/R
▪ Maximum Lift	40 to 110 mm
▪ Continuous Working Life	500 hours
▪ Driving Mode	DC, Magnetic Driving
▪ Material	Engineering Plastic
▪ Outlet Outside Diameter	7.5 mm
▪ Outlet Inside Diameter	5 mm

Figure 5.1.3: water motor

5.1.3 DC Motor:

A DC motor is any of a class of rotary electrical motors that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

- 150 RPM - 12V Centre Shaft DC Geared Motor
- RPM: 30
- Operating Voltage: 12V DC
- Shaft diameter: 6mm with internal hole
- Torque: 2 kg-cm
- Stalled torque: 15 Kg-cm
- No-load current = 60 mA (Max)
- Load current = 300 mA (Max).

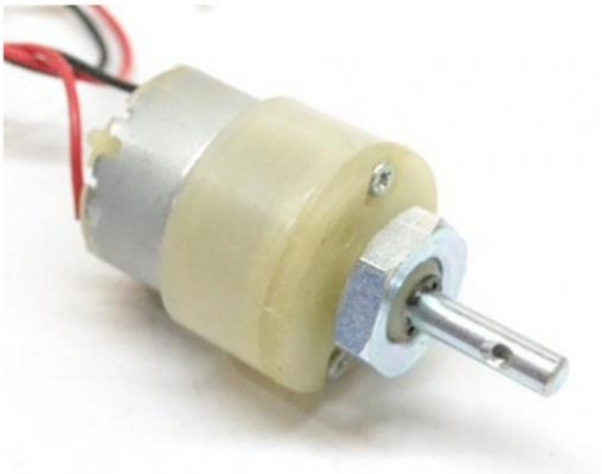


Figure 5.1.4: Dc Motor

5.1.4 Nozzle, Roller brush & Pipe:

A nozzle is a device designed to control the direction or characteristics of a fluid flow (specially 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 a nozzle, the velocity of fluid increases at the expense of its pressure energy.

Figure 5.1.4(A): Nozzle

A roller brush is a cleaning application tool used for painting large flat surfaces rapidly and efficiently. The roller typically consists of two parts: a "roller frame," and a "roller cover." The roller cover absorbs the dirt & dust from panel surface, the roller frame attaches to the roller cover.

Figure 5.1.4(B): Cleaning Brush

A pipe is a tubular section or hollow cylinder, usually but not necessarily of circular cross-section, used mainly to convey substances which can flow — liquids and gases (fluids), slurries, powders and masses of small solids. It can also be used for structural applications; hollow pipe is far stiffer per unit weight than solid members

Figure 4.1.4(C): Pipe

5.1.5 Toggle Switch:

A toggle switch is a type of electrical switch that is actuated by moving a lever back and forth to open or close an electrical circuit. There are two basic types: maintained contact and momentary toggle switches. A maintained switch changes its position when actuated and will remain in that position until actuated again, such as an ON/OFF function. It is also called as reverse and forward switch. It is used to change the direction of cleaning mechanism i.e. First forward then backward.

Figure 5.1.5: Toggle Switch

5.1.6 Battery:

Specifications:

- Material: Plastic
- Colour: White
- Pieces: 2
- Voltage: 12V
- Current: 5 Amp
- Power: 54 watts
- Safety instructions: charge fully before use. Keep away from children. Do not short circuit. Charge only once for 6 hours daily.

Figure 5.1.6: Battery

5.2 Design:

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation (EDA). In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software.

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions. CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space.

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

The design of geometric models for object shapes, in particular, is occasionally called computer-aided geometric design (CAGD)

USES:

Computer-aided design is one of the many tools used by engineers and designers and is used in many ways depending on the profession of the user and the type of software in question.

CAD is one part of the whole Digital Product Development (DPD) activity within the Product Lifecycle Management (PLM) processes, and as such is used together with other tools, which are either integrated modules or stand-alone products, such as:

Computer-aided engineering (CAE) and Finite element analysis (FEA)

Computer-aided manufacturing (CAM) including instructions to Computer Numerical Control (CNC) machines

Photorealistic rendering and Motion Simulation.

Document management and revision control using Product Data Management (PDM).

CAD is also used for the accurate creation of photo simulations that are often required in the preparation of Environmental Impact Reports, in which computer-aided designs of intended buildings are superimposed into photographs of existing environments to represent what that locale will be like, where the proposed facilities are allowed to be built. Potential blockage of view corridors and shadow studies are also frequently analysed through the use of CAD. CAD has been proven to be useful to engineers as well. Using four properties which are history, features, parameterization, and high-level constraints. The construction history can be used to look back into the model's personal features and work on the single area rather than the whole model.

Parameters and constraints can be used to determine the size, shape, and other properties of the different modelling elements. The features in the CAD system can be used for the variety of tools for measurement such as tensile strength, yield strength, electrical or electromagnetic properties. Also, its stress, strain, timing or how the element gets affected in certain temperatures, etc.

TYPES:

There are several different types of CAD, each requiring the operator to think differently about how to use them and design their virtual components in a different manner for each. There are many producers of the lower-end 2D systems, including a number of free and open-source programs.

These provide an approach to the drawing process without all the fuss over scale and placement on the drawing sheet that accompanied hand drafting since these can be adjusted as required during the creation of the final draft.

3D wireframe is basically an extension of 2D drafting (not often used today). Each line has to be manually inserted into the drawing. The final product has no mass properties associated with it and cannot have features directly added to it, such as holes. The operator approaches these in a similar fashion to the 2D systems, although many 3D systems allow using the wireframe model to make the final engineering drawing views.

3D "dumb" solids are created in a way analogous to manipulations of real-world objects (not often used today). Basic three-dimensional geometric forms (prisms, cylinders, spheres, and so on) have solid volumes added or subtracted from them as if assembling or cutting real-world objects. Two-dimensional projected views can easily be generated from the models. Basic 3D solids don't usually include tools to easily allow motion of components, set limits to their motion, or identify interference between components.

There are two types of 3D Solid Modelling

1.Parametric modelling allows the operator to use what is referred to as "design intent". The objects and features created are modifiable. Any future modifications can be made by changing how the original part was created. If a feature was intended to be located from the centre of the part, the operator should locate it from the centre of the model. The feature could be located using any geometric object already available in the part, but this random placement would defeat the design intent. If the operator designs the part as it functions the parametric modeler is able to make changes to the part while maintaining geometric and functional relationships.

2.Direct or Explicit modelling provide the ability to edit geometry without a history tree. With direct modelling, once a sketch is used to create geometry the sketch is incorporated into the new geometry and the designer just modifies the geometry without needing the original sketch. As with parametric modelling, direct modelling has the ability to include relationships between selected geometry (e.g., tangency, concentricity). Top end systems offer the capabilities to incorporate more organic, aesthetics and ergonomic features into designs. Freeform surface modelling is often combined with solids to allow the designer to create products that fit the human form and visual requirements as well as they interface with the machine.

5.3 ISO CATIA V5 Design:

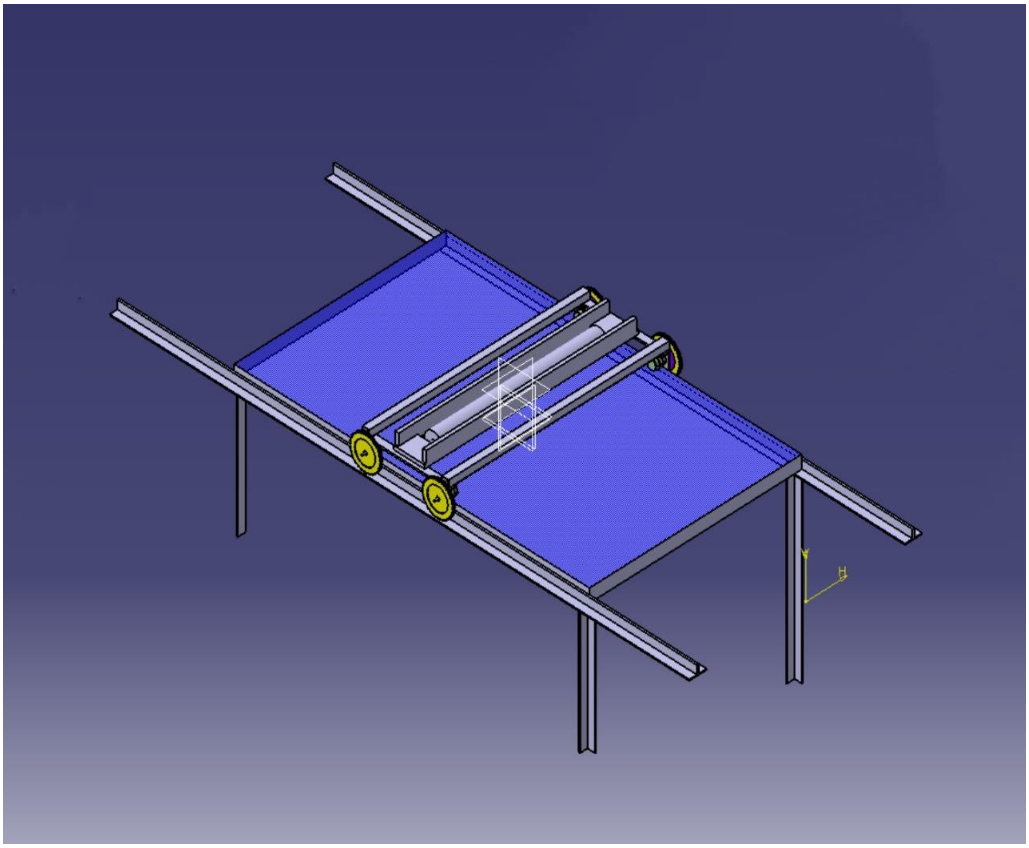


Figure 5.3 (1): Iso matric view

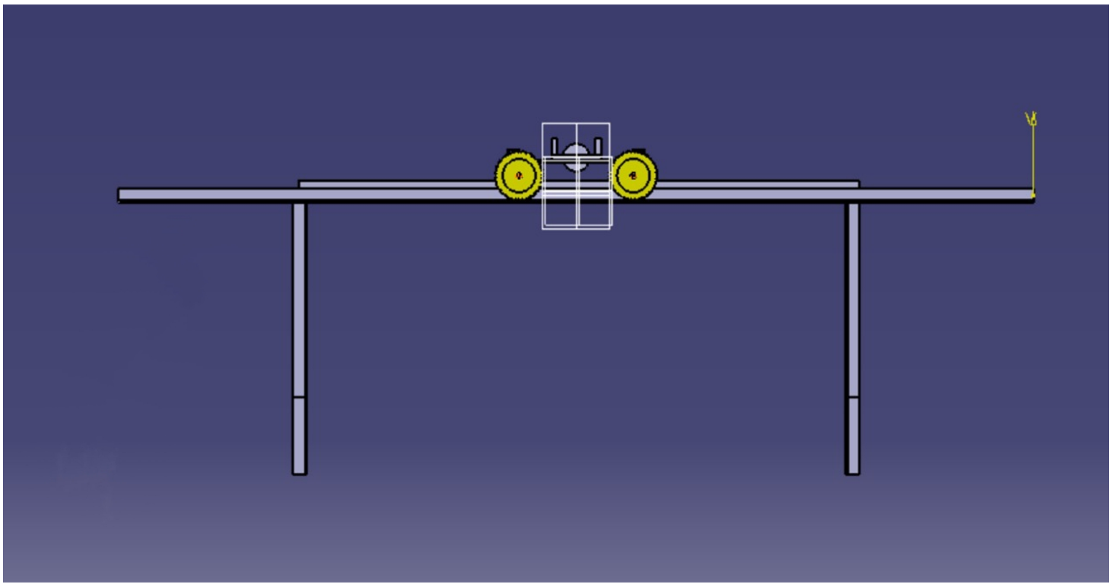


Figure5.3 (2): Front view

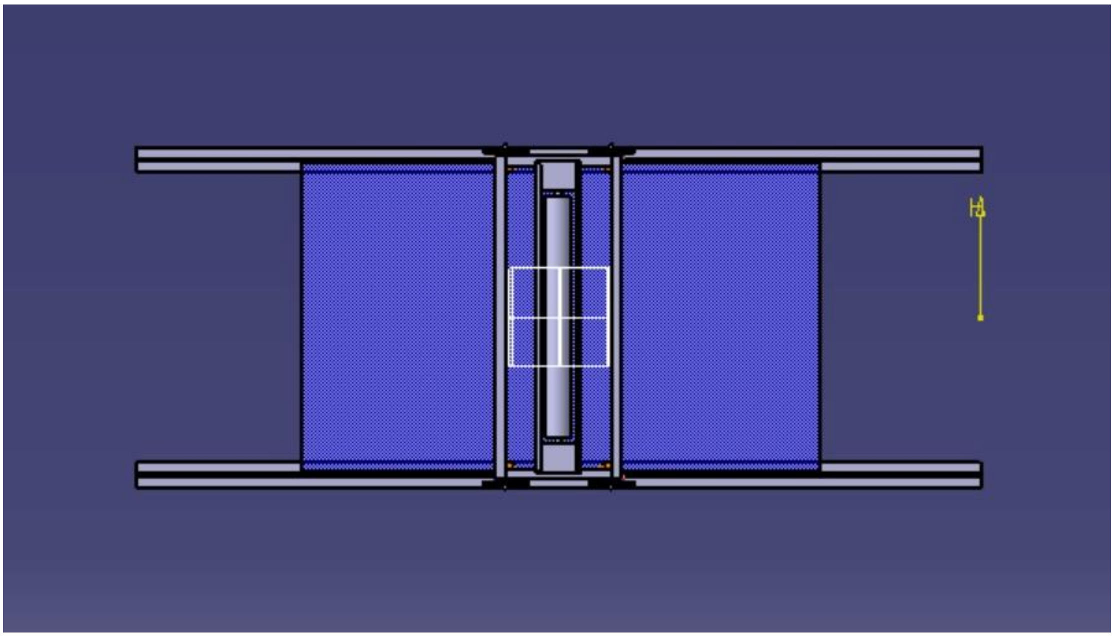


Figure 5.3 (3): Top view

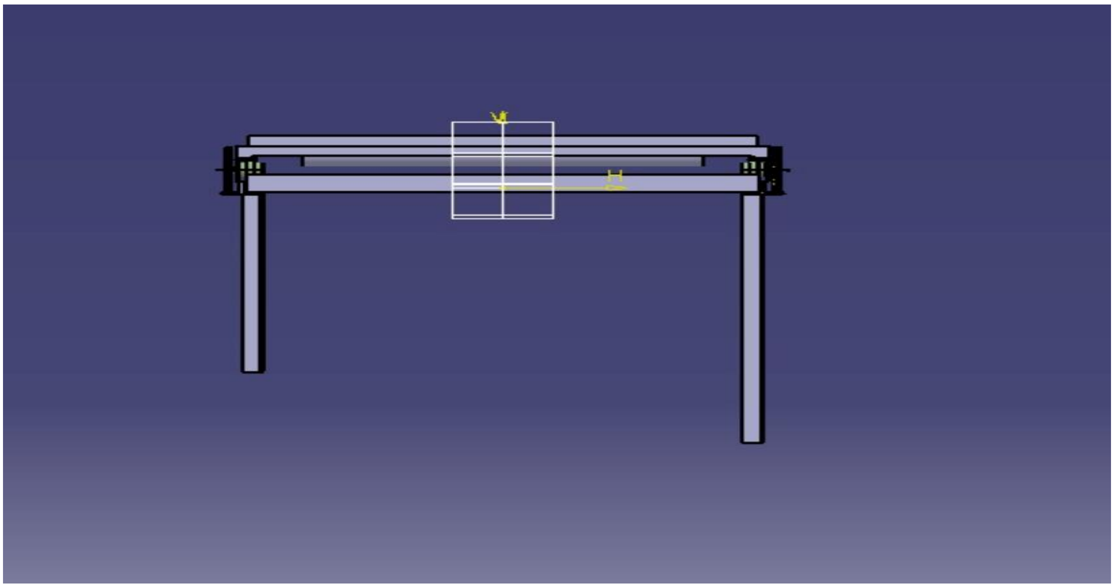


Figure 5.3 (4): Left hand side view

5.4 Drafting Front & Side View:

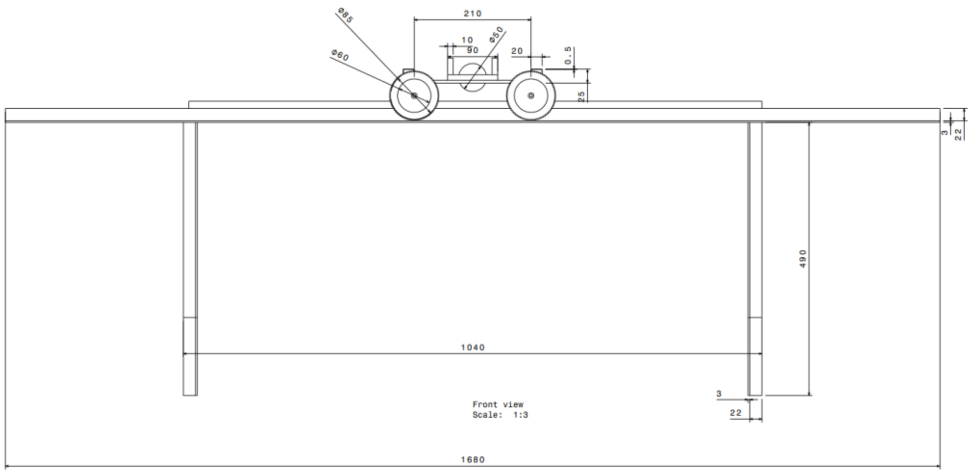


Figure 5.4.(1): front view

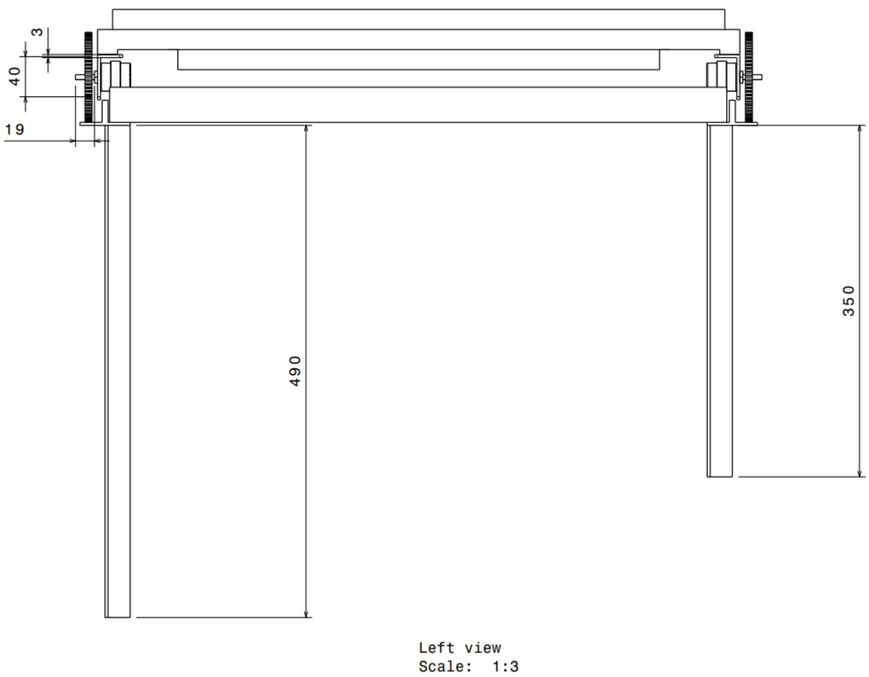


Figure 5.4.(2): Left hand side view

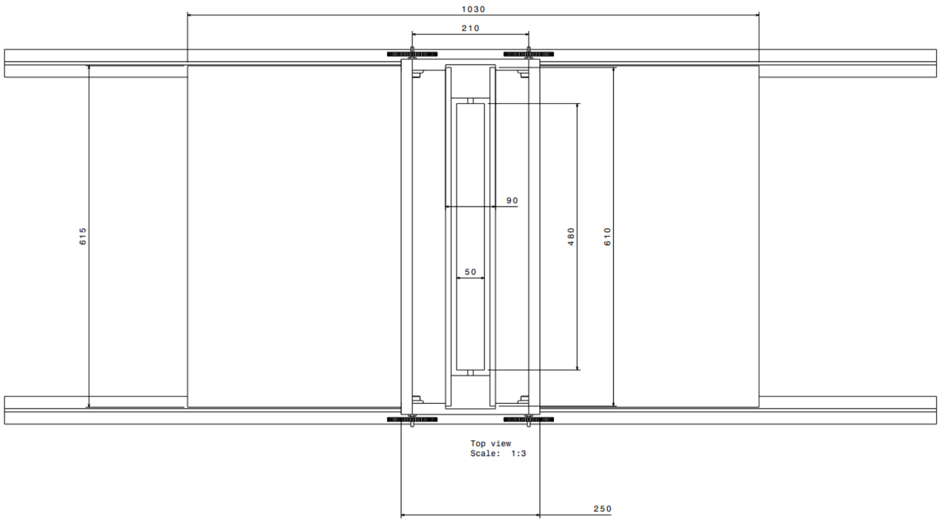


Figure 5.4.(3): Top view

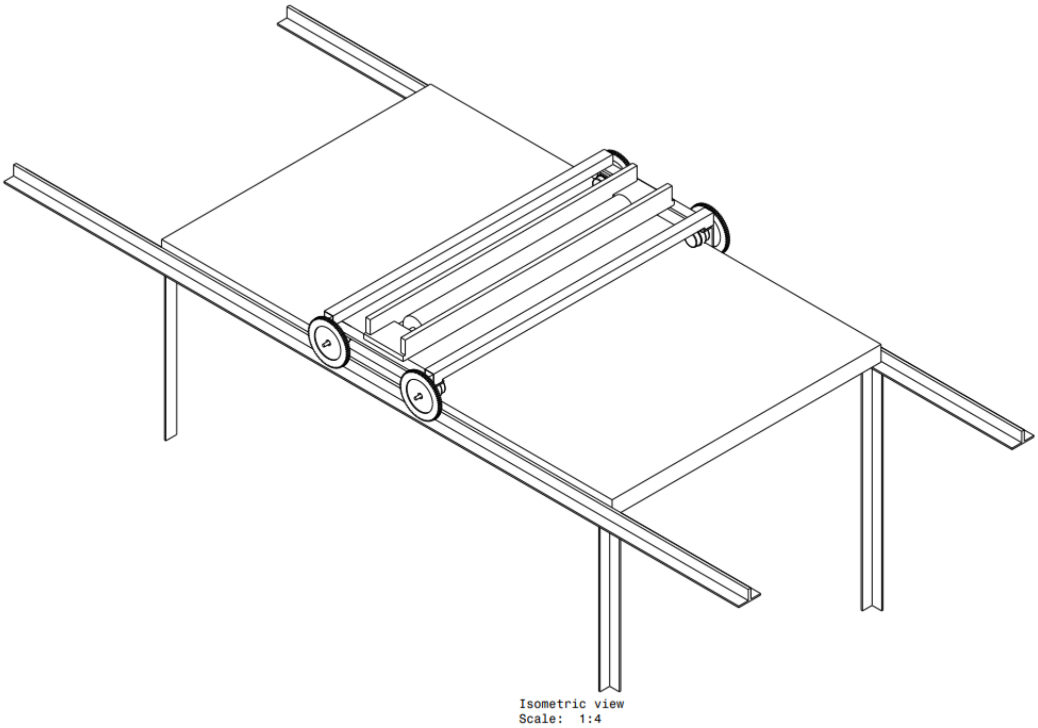


Figure 5.4.(4): ISO Matric drifting view

5.5 Manufacturing Process:

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material. The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing.

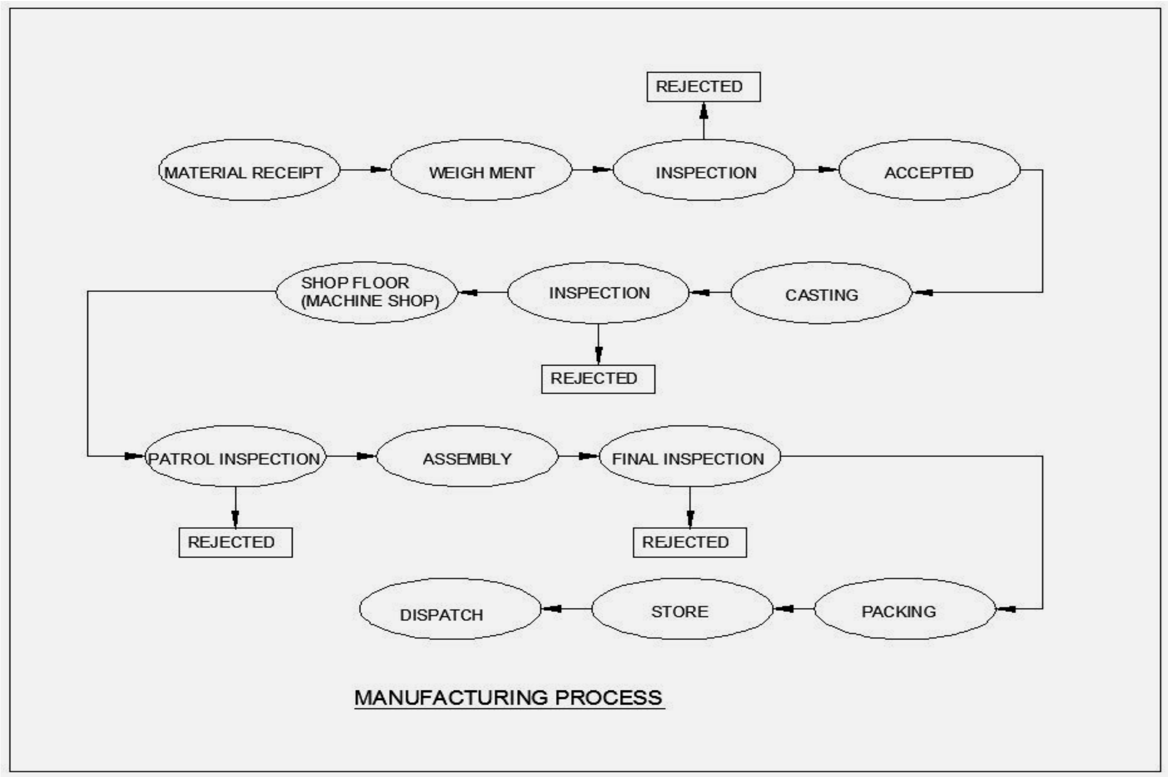


Figure 5.5: Manufacturing process

5.5.1: Metal Cutting:

Metal cutting or machining is the process of by removing unwanted material from a block of metal in the form of chips.

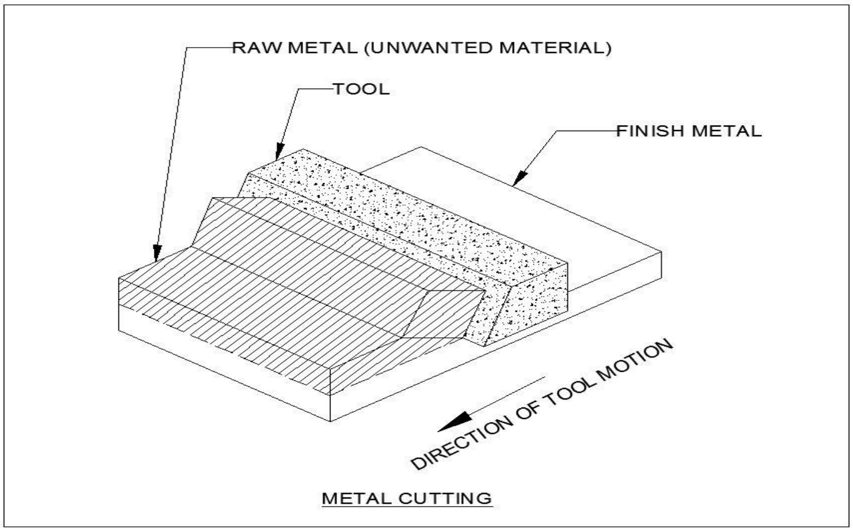


Figure 5.5.1: Metal cutting

Cutting processes work by causing fracture of the material that is processed. Usually, the portion that is fractured away is in small sized pieces, called chips. Common cutting processes include sawing, shaping (or planning), broaching, drilling, grinding, turning and milling. Although the actual machines, tools and processes for cutting look very different from each other, the basic mechanism for causing the fracture can be understood by just a simple model called for orthogonal cutting.

In all machining processes, the work piece is a shape that can entirely cover the final part shape. The objective is to cut away the excess material and obtain the final part. This cutting usually requires to be completed in several steps – in each step, the part is held in a fixture, and the exposed portion can be accessed by the tool to machine in that portion. Common fixtures include vise, clamps, 3-jaw or 4-jaw chucks, etc. Each position of holding the part is called a setup. One or more cutting operation may be performed, using one or more cutting tools, in each setup. To switch from one setup to the next, we must release the part from the previous fixture, change the fixture on the machine, clamp the part in the new position on the new fixture, set the coordinates of the machine tool with respect to the new location of the part, and finally start the machining operations for this setup.

Therefore, setup changes are time-consuming and expensive, and so we should try to do the entire cutting process in a minimum number of setups; the task of determining the sequence of the individual operations, grouping them into (a minimum number of) setups, and determination of the fixture used for each setup, is called process planning. These notes will be organized in three sections:

(i) Introduction to the processes,

(ii) The orthogonal cutting model and tool life optimization and

(iii) Process planning and machining planning for milling.

5.5.2 Sawing:

Cold saws are saws that make use of a circular saw blade to cut through various types of metal, including sheet metal. The name of the saw has to do with the action that takes place during the cutting process, which manages to keep both the metal and the blade from becoming too hot. A cold saw is powered with electricity and is usually a stationary type of saw machine rather than a portable type of saw.

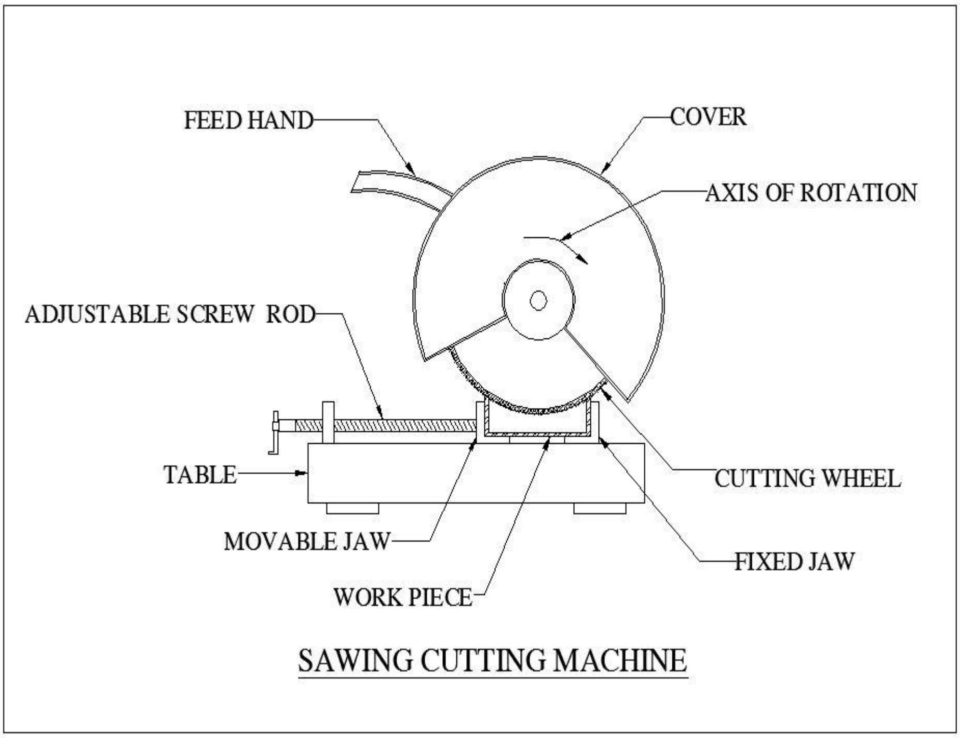


Figure 5.5.3: Sawing cutting machine

The circular saw blades used with a cold saw are often constructed of high speed steel. Steel blades of this type are resistant to wear even under daily usage. The end result is that it is possible to complete a number of cutting projects before there is a need to replace the blade. High speed steel blades are especially useful when the saws are used for cutting through thicker sections of metal.

Along with the high-speed steel blades, a cold saw may also be equipped with a blade that is tipped with tungsten carbide. This type of blade construction also helps to resist wear and tear. One major difference is that tungsten tipped blades can be re-sharpened from time to time, extending the life of the blade. This type of blade is a good fit for use with sheet metal and other metallic components that are relatively thin in design.

5.5.3 Welding:

Welding employs pinpointed, localized heat input. Most welding involves ferrous-based metals such as steel and stainless steel. Weld joints are usually stronger than or as strong as the base metals being joined.

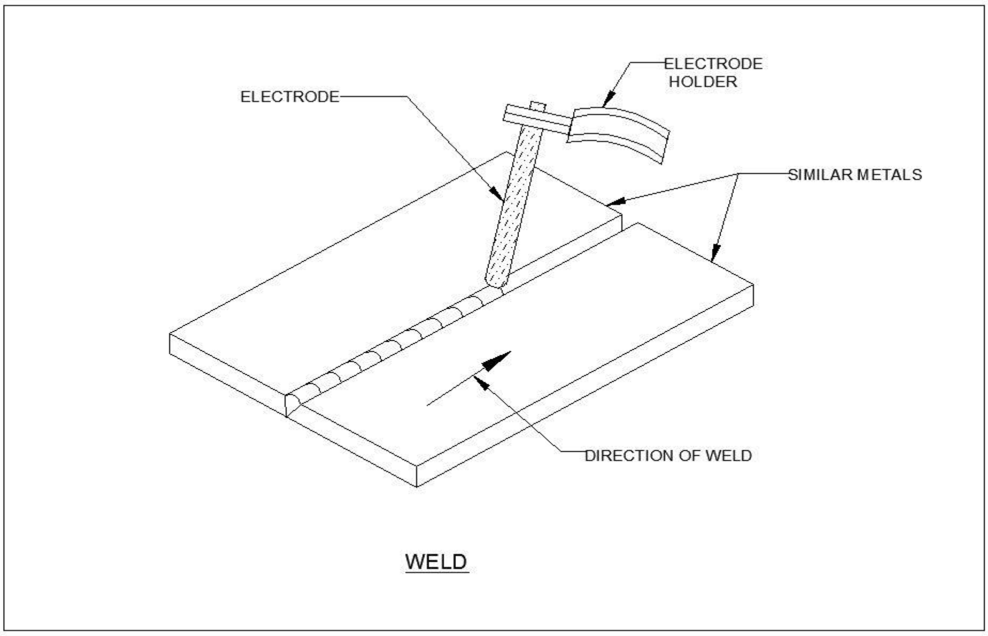


Figure 5.5.4: Welding

Welding is used for making permanent joints. It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

Several welding processes are based on heating with an electric arc, only a few are considered here, starting with the oldest, simple arc welding, also known as shielded metal arc welding (SMAW) or stick welding.

In this process an electrical machine (which may be DC or AC, but nowadays is usually AC) supplies current to an electrode holder which carries an electrode which is normally coated with a mixture of chemicals or flux. An earth cable connects the work piece to the welding machine to provide a return path for the current. The weld is initiated by tapping ('striking') the tip of the electrode against the work piece which initiates an electric arc. The high temperature generated (about 6000^{o}C) almost instantly produces a molten pool and the end of the electrode continuously melts into this pool and forms the joint. The operator needs to control the gap between the electrode tip and the work piece while moving the electrode along the joint.

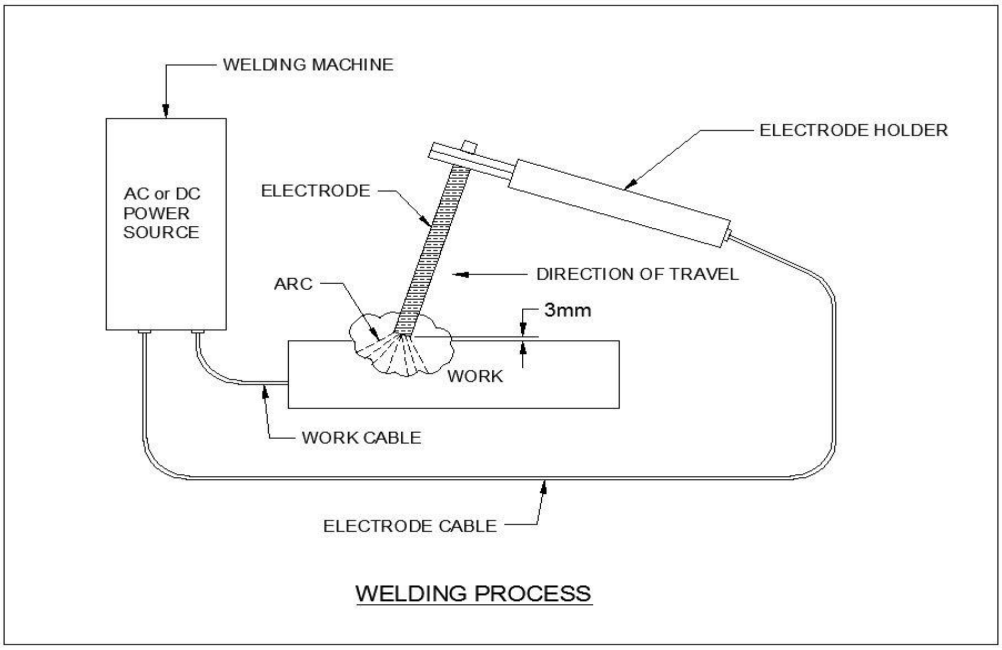


Figure 5.5.4: Welding process

In the shielded metal arc welding process (SMAW) the 'stick' electrode is covered with an extruded coating of flux. The heat of the arc melts the flux which generates a gaseous shield to keep air away from the molten pool and also flux ingredients react with unwanted impurities such as surface oxides, creating a slag which floats to the surface of the weld pool. This forms a crust which protects the weld while it is cooling. When the weld is cold the slag is chipped off.

The SMAW process cannot be used on steel thinner than about 3mm and being a discontinuous process, it is only suitable for manual operation. It is very widely used in jobbing shops and for onsite steel construction work. A wide range of electrode materials and coatings are available enabling the process to be applied to most steels, heat resisting alloys and many types of cast iron.

5.5.4 Drilling:

Drilling is a cutting process that uses a drill bit to cut or enlarge a hole of circular cross-section in solid materials. The drill bit is a rotary cutting tool, often multipoint. The bit is pressed against the work piece and rotated at rates from hundreds to thousands of revolutions per minute. This forces the cutting edge against the work piece, cutting off chips (swarf) from the hole as it is drilled.

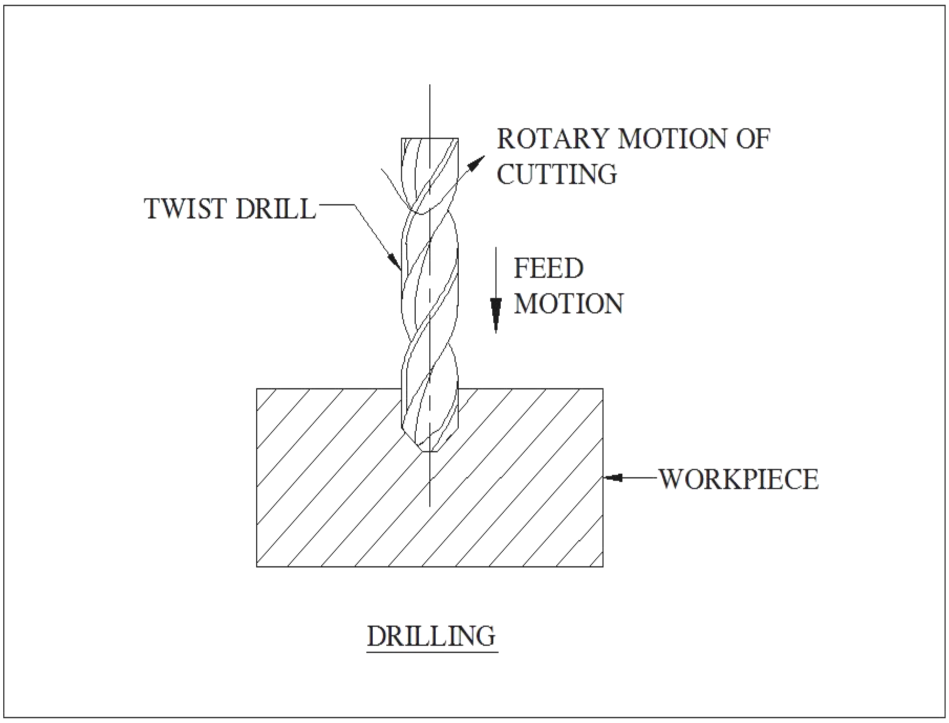


Figure 5.5.4: Drilling.

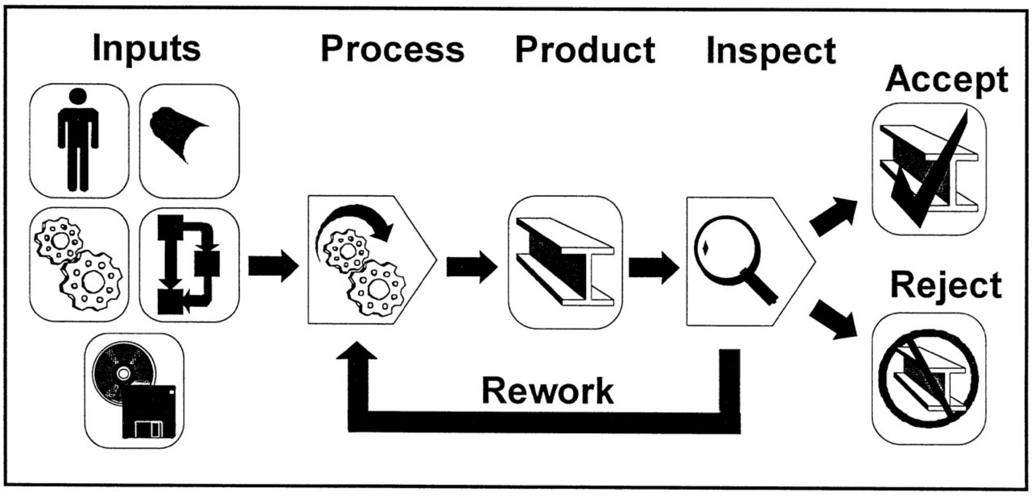
The geometry of the common twist drill tool (called drill bit) is complex; it has straight cutting teeth at the bottom – these teeth do most of the metal cutting, and it has curved cutting teeth along its cylindrical surface. The grooves created by the helical teeth are called flutes, and are useful in pushing the chips out from the hole as it is being machined. Clearly, the velocity of the tip of the drill is zero, and so this region of the tool cannot do much cutting. Therefore, it is common to machine a small hole in the material, called a centre-hole, before utilizing the drill. Centre-holes are made by special drills called centre-drills; they also provide a good way for the drill bit to get aligned with the location of the centre of the hole. There are hundreds of different types of drill shapes and sizes; here, we will only restrict ourselves to some general facts about drills.

5.6 Working:

- Construction starts with a solar panel mounting on a rigid frame. A cleaning mechanism will be placed on the panel and toggle switch is fitted to cleaning mechanism to change the direction of cleaning mechanism. Three nozzles are mounted on cleaning mechanism to provide water to achieve good cleaning and two L shape metal strips are fitted at end of rigid frame. Toggle switch for controlling direction of the motor in clock & anti-clock wise direction.
- As the DC power supply start then, motor attached to roller brush starts to rotate in a particular clock wise direction and motors attached to cleaning mechanism also rotates in clock wise direction. Parallelly water motor also start and water spray on the solar panel via nozzle. Arrangement starts to move in forward direction along with solar panel.
- When cleaning mechanism reached at the end then toggle switch strike to L shape strip and direction of cleaning mechanism get change and motors starts rotate in anti-clock wise direction. Also brush motor rotate in anti-clock wise direction and hole cleaning mechanism move in reverse direction. Water motor OFF automatically when cleaning mechanism move in anti-clock direction. In that way cleaning is done. Cleaning mechanism reached at initial position then toggle switch strike to L shape metal strip and direction change automatically and so on.

5.7 Inspection:

Critical appraisal involving examination, measurement, testing, gauging, and comparison of materials or items. An inspection determines if the material or item is in proper quantity and condition, and if it conforms to the applicable or specified requirements. Inspection is generally divided into three categories: (1) Receiving inspection, (2) In-process inspection, and (3) Final inspection. In quality control (which is guided by the principle that "Quality cannot be inspected into a product") the role of inspection is to verify and validate the variance data; it does not involve separating the good from the bad.



Assembly

An assembly line is a manufacturing process (most of the time called a progressive assembly) in which parts (usually interchangeable parts) are added as the semi-finished assembly moves from work station to work station where the parts are added in sequence until the final assembly is produced. By mechanically moving the parts to the assembly work and moving the semi-finished assembly from work station to work station, a finished product can be assembled much faster and with much less labour than by having workers carry parts to a stationary piece for assembly.

6.RESULTS

As said in the problem description, how is dust reduces efficiency of the solar power plants and how effective is automatic cleaning system is better to comparing to another systems. Below are the data which show how effectively the cleaning system works. Formula to find efficiency of solar panel.

Efficiency = 100-[(Pe*100)/Ps]

Pe = Power before cleaning

Ps = Power before cleaning.

6.1 Result table:

Sr. No.	Dates	Before Cleaning Pe in (watts)	After Cleaning Ps in (watts)	Efficiency (%)
1	01/04/2022	87.8	98.5	10.7
2	04/04/2022	88	98	10.2
3	07/04/2022	89	99	10.1
5	10/04/2022	87	98.8	11.9
6	13/04/2022	87.5	98.1	10.8
7	16/04/2022	87.9	99.1	11.7
8	19/04/2022	88.5	98.8	10.4
9	22/04/2022	88.5	98.5	10.2
10	25/04/2022	87	98	11.2
11	28/04/2022	87.5	98.8	11.4
12	01/05/2022	87.6	98.9	11.4
13	04/05/2022	89	98.8	10.0
14	07/05/2022	89	99	10.1
15	10/05/2022	88.1	97.9	10.0
16	13/05/2022	87.8	98.9	11.2
17	16/05/2022	88.8	98.7	10
18	19/05/2022	89.1	99	10
19	22/05/2022	89.2	99.3	10.2
20	25/05/2022	87.7	99	11.4

Table 6.1: Result Table

From above table Efficiency of a solar panel is increasing by approximately 10 % after cleaning regularly.

6.2 Graph:

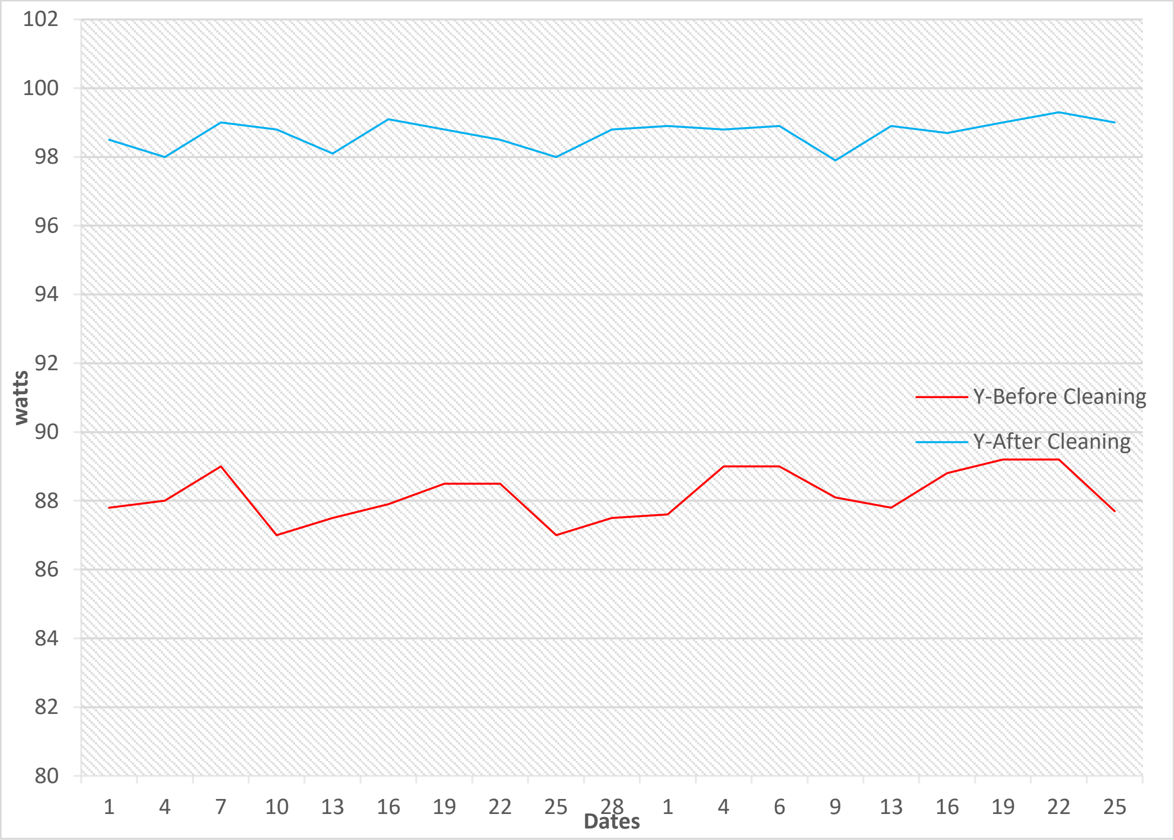


Figure 6.2: Graphical representation of power generation before and after cleaning the panel.

Above plot shows the graphical representation of power in watts before and after cleaning of the solar panel. The plot represented by red colour gives the insights about power generation before cleaning the panel, whereas blue line represents power generation after the cleaning of solar panel. It is clearly visible from the plot the power generation has a drastically changed after cleaning the solar panel by approximately 10 watts.

7.ACTIVITY CHART

Sr. No.	Activity	AY 2021-22											
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1	Literature Survey												
2	Problem Definition												
3	Material Selection												
4	Analytical calculation												
5	3D Designing												
6	Market survey												
7	Purchase of component												
8	Fabrication development												
9	Code development												
10	Testing												
11	Thesis Writing												

Table 7.1: Activity Chart

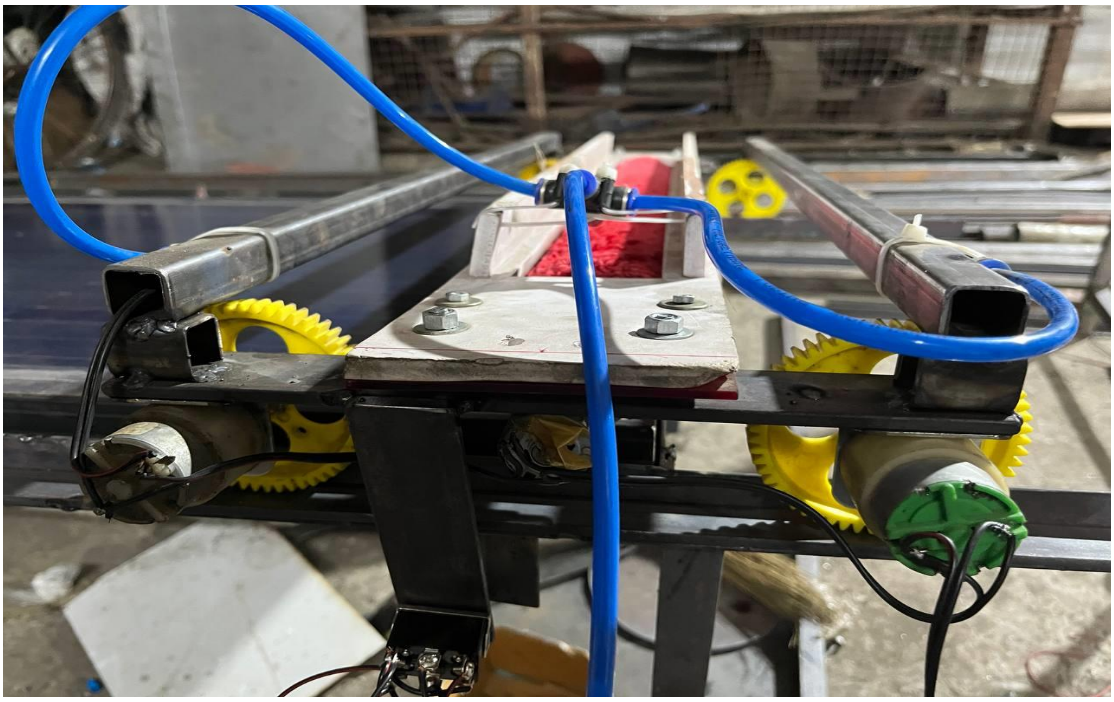
8. CONCLUSION

As we can see deposition of dust (biological or chemical) leads to a decrease in efficiency of solar panel which affects its performance. So, cleaning of solar panel is equally important, also in this project we have discussed different types of cleaning systems and coiling methods that can be applied as well. Compared to other methods our system is the best and more importantly is a cost effective. The effect of presence of dust was studied using artificial dust, using our mechanism. The system developed by us is to overcome following problems faced after solar panel installation: reduced power due to dust accumulation, cost reduction for the overall cleaning of solar panel, manual labour for cleaning which has inevitable physical harms are avoided, reduced time for cleaning. By replacing conventional cleaning methods of the solar panel with the automation we can maintain the efficiency without affecting its performance. Hence, periodically dust must be removed from solar panel, in order to ensure the highest performance.

Hence the design & fabrication of solar panel cleaning system has been successfully completed and the system is working as per the standard requirement.

9.EXPERIMENTAL SETUP

9.1 Experimental Images:



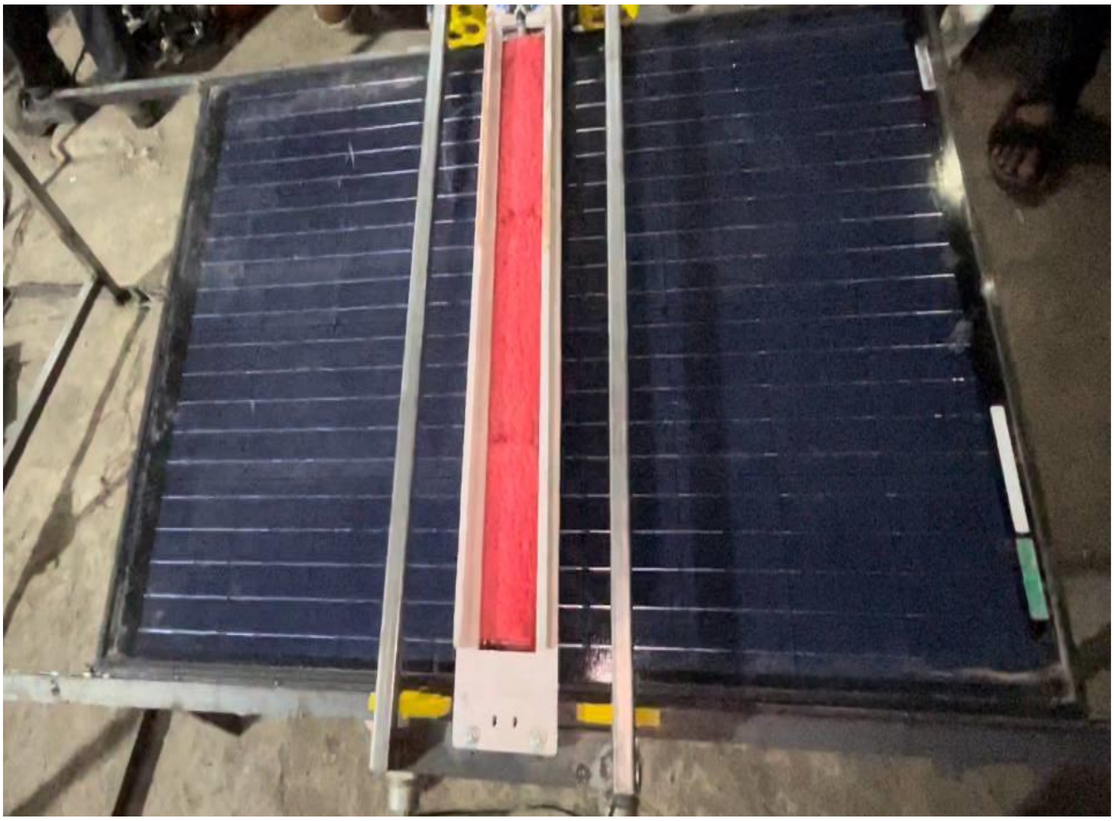


Figure 9.1: experimental Images

9.2. Bill of material:

Sr. No	Parts and Specifications	Number Of Quantities	Cost In Rupee
1	Solar Panel (1040*625*35)	1	3500
2	Water Motor	1	150
3	DC Motor	4	600
4	Frame (Mild Steel)	-	500
5	Roller Brush	1	200
6	Square Pipe	1	100
7	Toggle Switch	1	100
8	Battery	2	600
9	Battery Charger	1	300
10	Fabrication	-	2300
11	Transportation	-	750
	Total	**=**	**9100**

Table 9.2: Bill of material

10.REFERENCES

[1] "Design and Development of Solar Panel Cleaning Machine", Dabhi Chirag, Gandhi Mayank, Jadeja Mandipsinh, Prajapati Parimal. International Journal of Advance Engineering and Research Development Scientific Journal of Impact Factor (SJIF): 4.72 Special Issue SIEICON-2017, April - 2017 e-ISSN: 2348-4470 p-ISSN: 2348-6406.

[2] M. Mazumder et al., "Electrostatic removal of particles and its applications to self-cleaning solar panels and solar concentrators," in Developments in Surface Contamination and Cleaning: Elsevier, 2011, pp. 149-199.

[3] "IMPROVEMENT OF EFFICIENCY OF SOLAR PANEL USING DIFFERENT METHODS" published Rupali Nazar, LJEEE, Volume 07, Issue 01, Jan- June 2015, ISSN-2321-2055 (E).

[4] "Shajan K. Thomas, Shelvin Joseph Sarrop TS and Sahad Bin Haris" Solar Panel Automated Cleaning (SPAC) System ".in 2018 International Conference on Emerging Trends and Innovations in Engineering and Technological Research (ICETIETR), 2018.

[5] NASA Jet Propulsion Laboratory, "Spirit Gets Energy Boost from Cleaner Solar Panels", Press Release February 12/2009, http://www.jpl.nasa.gov/news/news.cfm?release-2009-020a.

[6] Improvement of Efficiency of Solar Panel Using Different Methods. Rupali Nazar MTech. Student, Department of Electrical and Electronics Engineering. Lingaya's University, Faridabad, (India). IJEEE, Volume 07, Issue 01, Jan- June 2015.