# Solar Radiation Tracking using Pneumatic System to Increase the Efficiency Compared to Conventional Stationary Solar Panel System

**Saumitra Shekhar Pathak[1], Pinaki Mahesh Halale[2]**

*[1,2]Student, Dept. of Mechanical Engineering, Savitribai Phule Pune University, India*

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**Abstract -** *The position of the sun keeps on changing every day. The design of Solar panels as we know is entirely dependent on the position of the sun. The maximum amount of radiation falling on the panel derives more outcome, also the solar panel work at their highest efficiency when the panel and sunrays are perpendicular to each other. So the main aim of this project paper is to design such a system which can track the maximum solar radiations using a pneumatic circuit*

***Key Words***: Solar Panel, Radiation, Track, Pneumatic Circuit, Efficiency.

## 1. INTRODUCTION

The performance of solar power plants is best defined by the Capacity Utilization Factor (CUF), which is the ratio of the actual electricity output from the plant, to the maximum possible output during the year. The estimated output from the solar power plant depends on the design parameters and can be calculated, using standard software. But since there are several variables which contribute to the final output from a plant, the CUF varies over a wide range. These could be on account of poor selection /quality of panels, the rating of modules at higher temperatures, other design parameters like other loss, atmospheric factors such as prolonged cloud cover and mist. It is essential therefore to list the various factors that contribute to plant output variation. The performance of the power plant however depends on several parameters including the site location, solar insulation levels, climatic conditions specially temperature, technical losses in cabling, module mismatch, soiling losses, MPPT losses, transformer losses and the inverter losses. There could also be losses due to grid unavailability and the module degradation through aging. Some of these are specified by the manufacturer, such as the dependence of power output on temperature, known as temperature coefficient. The following factors are considered key performance indicators in the following project paper:

1. Radiation at the site
2. Losses in PV systems
3. Temperature and climatic conditions
4. Design parameters of the plant
5. Inverter efficiency

### 1.1 PURPOSE & SCOPE OF STUDY

Ground mounted photovoltaic systems are usually large, utility-scale solar power plants. Their solar modules are held in place by racks or frames that are attached to ground based mounting supports. Ground based mounting supports include:

1. Pole mounts, which are driven directly into the ground or embedded in concrete.
2. Foundation mounts, such as concrete slabs or poured footings

Ballasted footing mounts, such as concrete or steel bases that use weight to secure the solar module system in position and do not require ground penetration. This type of mounting system is well suited for sites where excavation is not possible such as capped landfills and simplifies decommissioning or relocation of solar module systems.
Roof-mounted solar power systems consist of solar modules held in place by racks or frames attached to roof-based mounting supports. Roof-based mounting supports include:

1. Pole mounts, which are attached directly to the roof structure and may use additional rails for attaching the module racking or frames.
2. Ballasted footing mounts, such as concrete or steel bases that use weight to secure the panel system in position and do not require through penetration. This mounting method allows for decommissioning or relocation of solar panel systems with no adverse effect on the roof structure.
3. All wiring connecting adjacent solar modules to the energy harvesting equipment must be installed according to local electrical codes and should be run in a conduit appropriate for the climate conditions.

Solar trackers increase the amount of energy produced per module at a cost of mechanical complexity and need for maintenance. They sense the direction of the Sun and tilt or rotate the modules as needed for maximum exposure to the sunlight. Alternatively, fixed racks hold modules stationary as the sun moves across the sky. The fixed rack sets the angle at which the module is held. Tilt angles equivalent to an installation's latitude are common. Most of these fixed racks are set on poles above ground. Panels that face West or East may provide slightly lower energy, but evens out the supply, and may provide more power during peak demand.

## 1.2 ANALYSIS OF NEED

The main objective of this project is to design and analyse such a mechanism which will increase panel's efficiency by tracking solar radiation keeping the cost minimum. If the cost is minimum, then and only then it is feasible to install such a system in a solar power plant of MW capacities. Current system increases efficiency but are expensive to install, work and maintain. This project showcases an alternative solution for these problems.

The advantages of this tracker can be listed as:

- Cost efficient system.
- Less complicated to ease the operations.
- Energy consumed to run this system is very less.
- Space required for installation is low.
- Manpower required to run plant will reduce for tracking.
- Efficiency of panels will increase which results in more energy production.
- No wastage of solar energy.

The general procedure used to design Photovoltaic tracker includes thorough literature survey of current systems and solar radiation in different parts of the country. Furthermore, the designing of pneumatic circuit and calculation of efficiency will be carried out.

## 2.1 WORKING PRINCIPLE

The main purpose of designing such a mechanism is to reduce the energy consumption of current mechanisms yet increase the amount of solar radiations tracked by the same system by implementing the tracking circuit. Currently, all the mechanisms that are used consume most of the energy produced by the panel itself so in this designed mechanism we will use pneumatic system to rotate photovoltaic panels using a compressor, pneumatic cylinder, solenoid valve, PNRV & FCVs. To operate this mechanism compressor, need not to be switched on every time; solenoid valve can hold compressed air for longer period of time. Solar panel will rotate according to the sun's location by mechanical means.

## 2.2 SLECTION OF MECHANISM

A pneumatic circuit has been prepared for operation of cylinder. A double acting cylinder has been selected to make motion in two directions whereas pilot operated NRV is used for stopping the cylinder in any intermediate position. So as long as pilot signal is applied, air is free to flow to and from the cylinder. When the pilot signal is removed, the valve acts as a conventional non return valve and prevents air from exhausting from cylinder, thus stopping the motion. Flow control valve are used to allow controlled flow of air in one direction and free flow in the other direction. Solenoid Directional control valves are vital in any pneumatic circuit, directing or blocking airflow to control the speed or sequence of operations. One method of classifying directional-control valves is by the flow paths under various operating conditions

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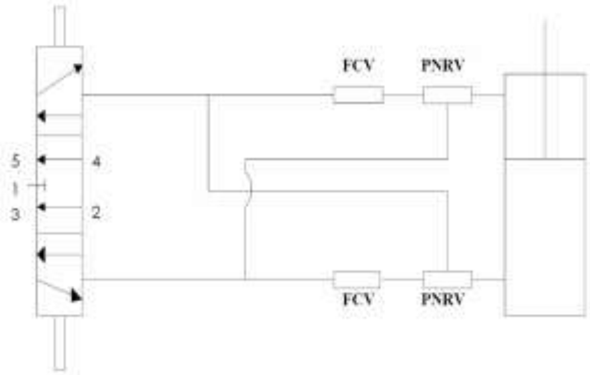


**Fig -1**: Pneumatic Circuit

## 2.3 DESIGN CONSIDERATION

The frame of solar panel will consist of a pivot point on which the panel will be attached. The base of frame will hold the cylinder. The entire load from panel will be transferred to pivot and cylinder mounting point. Different calculations are done to verify the load on cylinder.

## 3 CALCULATIONS

## 3.1 DOUBLE ACTING CYLINDER, OUT STROKE

The force exerted by double acting pneumatic cylinder on outstroke can be expressed as:

F= p*A

F= p*π*d2/4

Where

F= Force Exerted (N)= 68.67 N

P= Gauge Pressure (N/m2, Pa)

A= Full Bore Area (m2)=1.96* 10-3 m2

d= Full Bore Piston Diameter (m)= 0.05 m

Therefore, the Required Air Pressure for Out Stroke is: **p= 35 kPa**

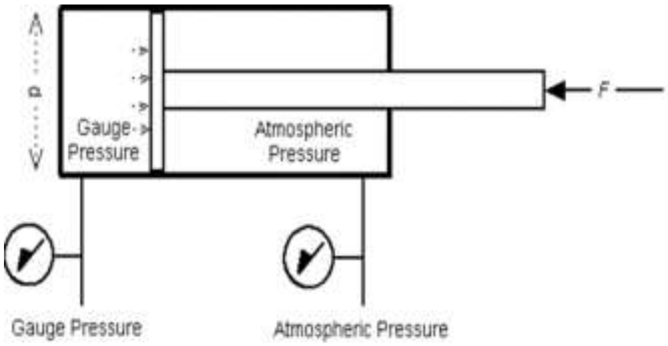


**Fig -2**: Out Stroke

### 3.3 DOUBLE ACTING CYLINDER, IN STROKE

The force exerted on in stroke can be expressed as:
F= p*π*(d12-d22)/4
Where
d1= Full Bore Piston Diameter (m)=0.05 m
d2= Rod Diameter= 0.02m
Therefore, the Required Air Pressure for in stroke is: **p= 41 kPa.**

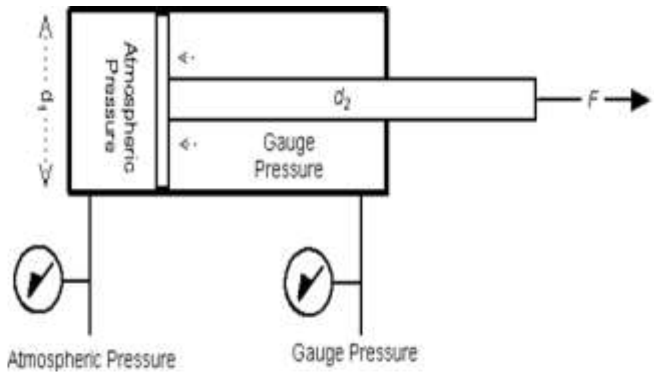


**Fig -3**: In Stroke

## 4. PROCEDURE

### 4.1 VOLTAGE MEASUREMENT

For efficiency calculations open circuit voltage is required. Open-circuit voltage (abbreviated as OCV or VOC) is the difference of electrical potential between two terminals of a device when disconnected from any circuit. There is no external load connected. No external electric current flows between the terminals. It is sometimes given the symbol Voc.

### 4.2 CURRENT MEASUREMENT

For efficiency calculations closed circuit current is required. A short circuit (sometimes abbreviated to short or s/c) is an electrical circuit that allows a current to travel along an unintended path with no or very low electrical impedance. The electrical opposite of a short circuit is an "open circuit", which is an infinite resistance between two nodes.

## 5 OBSERVATION & RESULTS

**Table -1:** Rotary Mechanism 9 hour readings

| Time | Voltage (V) | Current (A) | Power (W) |
|---|---|---|---|
| 8.45 AM | 21.6 | 1.74 | 37.584 |
| 9.45 AM | 21.3 | 1.78 | 37.914 |
| 10.45 AM | 21 | 2.4 | 50.4 |
| 11.45 AM | 20.9 | 2.49 | 52.041 |
| 12.45 PM | 19.57 | 2.49 | 48.729 |
| 01.45 PM | 20.4 | 2.44 | 48.776 |
| 02.45 PM | 19.4 | 1.89 | 36.666 |
| 03.45 PM | 20.8 | 1.65 | 34.32 |
| 04.45 PM | 19.66 | 1.45 | 28.507 |

**Table -2:** Stationary Mechanism 9 hour readings

| Time | Voltage (V) | Current (A) | Power (W) |
|---|---|---|---|
| 8.45 AM | 21.6 | 1.84 | 39.744 |
| 9.45 AM | 21.3 | 2.26 | 48.138 |
| 10.45 AM | 21 | 2.49 | 52.29 |
| 11.45 AM | 20.9 | 2.48 | 51.832 |
| 12.45 PM | 19.66 | 2.35 | 46.201 |
| 01.45 PM | 20.5 | 1.98 | 40.59 |
| 02.45 PM | 19.33 | 0.99 | 19.137 |
| 03.45 PM | 20.4 | 0.66 | 16.464 |
| 04.45 PM | 18.94 | 0.36 | 6.8184 |

Total power produced by Rotary system: 375.9 W

Total power produced by Stationery system: 321.21 W

Area of the Solar Panel = (0.628 x 0.476) m2

Average power produced by Stationery Panel = 35.69 W

Average power produced by Rotary Panel = 41.77 W

$$\text{Efficiency} = \frac{\text{Average Power Produced (kW)} \times 100}{\text{Area of Panel}}$$

Efficiency of Stationery Panel = 11.97%

Efficiency of Rotary Panel = 14.02%

**Fig -4**: Actual Prototype

## 6 CONCLUSIONS

From this project, this is evident that efficiency of a photovoltaic cell can be improved by using a rotary system which can track the solar radiations. There are multiple system which are available currently but they are expensive than this system, this is why solar radiation tracking system for photovoltaic cells by using pneumatic system should be preferred.

This project is successful in increasing efficiency of photovoltaic cell by around 3% which is an improvement in current system of stationery panels and it is must for future.

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