International Journal of Future Generation Communication and Networking
Vol. 13, No. 2s, (2020), pp. 697–701

Optimization of Design of Solar Panel Ground Mounting Structure

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ABSTRACT

Generally we are using hydro energy, wind energy or minerals (coal) to produce electricity .As water has a major scarcity problem and as wind energy can't be used everywhere due to its prerequisite requirement. Sun is the only source of energy that is available mostly throughout the world, that's why we are using solar energy. Solar photo voltaic panels can be installed on roof of structure or on the ground. Normally we focus on the ground mounting structure, so in this paper by considering some design structure and analysis of solar panels support structure, structural loads and height of the structure can be done using different software, to determine its load calculation, total deformation, equivalent elastic strain, equivalent stress and reaction force on the structure. Identification of the structure critical points, it can be further extending up to different material.

Keywords— *Solar panel, three legs support structure, PosMAC, simonkolleite, structural analysis.*

I. INTRODUCTION

Solar energy is a renewable free source of energy that is sustainable and totally inexhaustible, unlike fossil fuels that are finite. It is also a non-polluting source of energy and it does not emit any greenhouse gases when producing electricity. Photo voltaic solar cells convert sunlight directly into electricity by the so-called photo voltaic effect, by which certain materials are able to absorb photons (light particles) and liberate electrons, generating an electric current.

The types of mounting structure to mount the solar panels are as follows:

Ground mounting structure, roof, top-of-pole, side of pole, tracking. The mounting structure is the supporting structure that holds the solar panels or arrays of solar panels to the ground. The solar panels, either on rooftops or on the ground, they are mounted on metallic structures. Mounting structures made of steel or aluminium support the panels on the ground, and also tilt them at an optimal angle to receive maximum sunlight. You might ask why solar panels cannot be directly attached to the ground. The following are the reasons panels need to be attached to the roof or to the ground. The panels themselves cannot be directly attached to the ground owing to their structure, and hence they need a separate mounting structure. Solar panels need a secure fastening to the roof or ground to protect against winds. Mounting structures do this function. Solar panels also require protection against water and other elements that gather on the ground or on the roof. In case of rooftop solar, the roof might not have a suitable inclination to get the maximum from sunlight. Having mounting structures at a suitable angle can tilt the solar panels at an optimal angle. You need some space between the solar panels and the ground for the cables etc. In addition to that there is of need space for repairs and maintenance of the panels. Typically, mounting structures cost about 10% of total system cost for large solar power plants and about 15% for smaller power plants. In this paper we are going to optimize the ground mounting structure design and by studying the material to get better strength, less cost and increase its longevity.

II. OBJECTIVE

1. To determine the optimized geometric configuration of the three legs support structure of a solar panel under a load when subjected to static load.
2. Studying the new coating and comparing it with conventionally use coatings.

ISSN: 2233-7857 IJFGCN

3.
III. LITERATURE SURVEY

Mihailidis et al[1] represented the analysis of two different design approaches of solar panel support structures.
1. Fixed support structure design.
2. Adjustable support structure design.
They did analysis according to the following steps.
1. Load calculation.
2. Analysis of the structure, which includes the creation of a Finite element model using ANSA as pre-processor. Loads calculated in the first step are applied to the model. As solver MSC Nastran is used.
3. Identification of the structure critical points. According to the results weak points are redesigned in order to increase the end.
Chih-Kuang Lin et al[2] use FEA approach to find the effects of self-weight and wind loads on structural deformation and misalignment of solar radiation. They consider distribution of stress and deformation with wind speed 7m/s and 12m/s with various blowing directions including gravity. The result shows that this CAE technique is applicable for designing a reliable. Highly stressed regions are located at bushing and ball bearing & according to von-mises criterion there is no structural failure for given photovoltaic system. The result also indicate displacement and angular displacement increase with an elevation angle for wind directions at, 0^o, 30^o and 60^o but it will started decrease with wind direction of 120^o, 150^o and 180^o.
Alex Mathew et al[3] worked on design and stability analysis of solar panel support structure made out from mild steel. They conducted this work as a part of project of Mahindra Reva Ltd. Named as “solar 2 car”. The result shows that the solar panel support structure can able to sustain a wind load with velocity 55m/s. They calculated required amount of weight to withstand wind load for different wind zones without any holding arrangements and then after optimization can be done for easy assembly, dismantle and transportation.

IV. METHODOLOGY

Type of structural material: Some common materials used in the manufacture of structures are Galvalume, PosMAC[4], and hot dip galvanized metallic structures. The material must allow for the structure to be sturdy so as to withstand the load of the module and the wind load. The solar mounting structure can be made up of many materials as mentioned in the previous paragraph. It can be made with the help of welding and with the use of nuts and bolts. The mounting is made up of legs, rafter, outline, base plate which are joined together with the help of u-clamps-clamps and spring bolts. Software used to make the mounting is solid works for creating 3D model. ANSYS software is used for analysing the load analysis on the mounting.

PosMAC (POSCO Magnesium Aluminium alloy Coating product) is a ternary alloy coated steel (Zn-3%Mg- 2.5%Al) with high corrosion resistance developed with POSCO’s own technology. PosMAC is the registered trademark of POSCO.

Following are PosMAC characteristics:
PosMAC is a corrosion resistant product that is 5 to 10 time’s stronger resistance than that of a normal hot-dip galvanized steel sheet (GI, GI (Hot Dip)) with the same coating weight. PosMAC has an excellent cross-section corrosion resistance; normal thick plating products can be replaced with this product. The same processing, assembly and painting process can be applied to PosMAC as one would apply to GI.

This paper focuses on analysis of different types of design of ground mounting structure. By performing FEA analysis on different types of design structure of solar ground mounting which was design in SOLIDWORKS (V2016) and analysed in ANSYS software using static structural.

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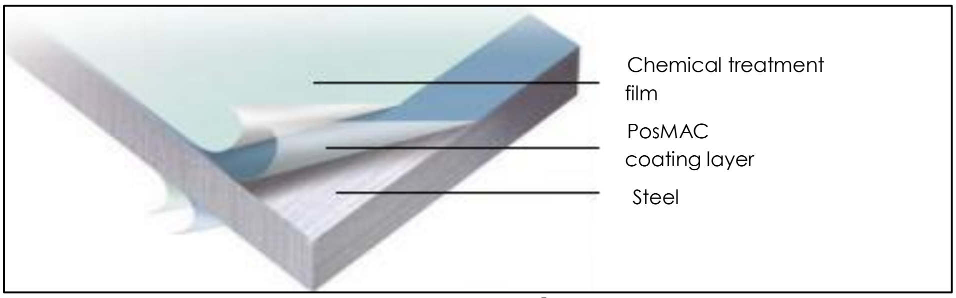
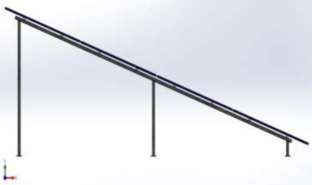
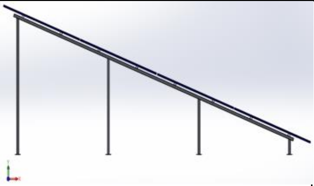
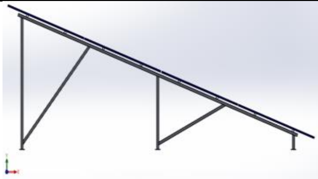
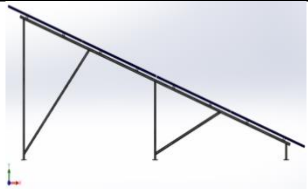


Fig. 1 PosMAC coating layer

TABLE I
COMPARISON BETWEEN
DIFFERENT DESIGNS OF GROUND MOUNTING STRUCTURE

HDG Strut Channel: ₹ 86 /Kg; PosMAC: ₹ 76 /Kg[5]

Three Legs (50x50 mm)	**Four Legs (50x50 mm)**	**Three Legs support (50x50 mm)**	**Three Legs support (40x40 mm)**
			
Mass = 131.0570 kilograms	Mass = 140.1699 kilograms	Mass = 156.7295 kilograms	Mass = 137.1179 kilograms
Total Cost : ₹ 9,960.332	Total Cost : ₹ 10,652.912	Total Cost : ₹ 11,911.442	Total Cost : ₹ 10,420.960
Purline TD(mm) = 4.5538 Rafter TD(mm) = 4.8991	Purline TD(mm) = 1.0743 Rafter TD(mm) = 0.8701	Purline TD(mm) = 0.5674 Rafter TD(mm) = 0.3810	Purline TD(mm) = 0.8898 Rafter TD(mm) = 0.6859

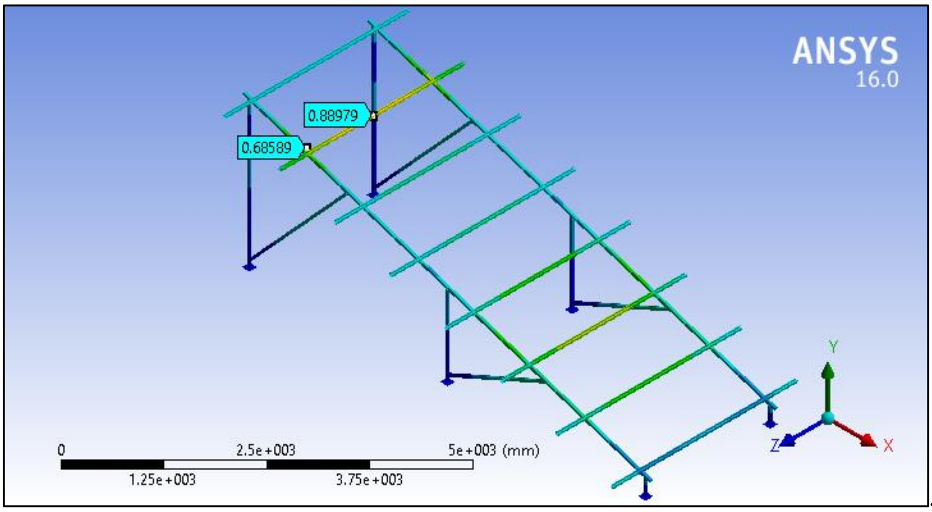


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Fig. 2 Static structure Analysis of Three Legs support (40x40 mm)

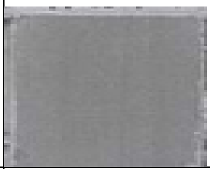
1. Three legs (50x50 mm):- This design includes 6 legs (w.r.t base plate), 8 purline and 12 panels. By applying the boundary conditions as, density for structure is 7850 kg/m^3, density for panels is 416.67 kg/m^3, applying the standard gravity 9.81 m/s^2, maximum deformation of 4.89 mm for rafter and 4.55 mm for Purline. Total mass of structure excluding solar panels is 131.057 kg. By applying the material cost of ₹ 76 /kg, the total cost of the structure is ₹ 9,960.332. As the deformation of this structure exceeds the allowed range there is the need for design modification to optimize the structure.

2. Four legs (50x50 mm):- In this design there is an addition of extra two legs in an attempt to reduce the total deformation of purline and rafter. Thus total no of legs adds up to 8. This increases the material and thus increasing the total mass of the structure. Applying similar boundary conditions as for three legs structure we get total mass of the structure as 140.16 kg. The total cost is ₹ 10,652.912. The total deformation for Purline reduced to 1.074 mm and for rafter 0.870 mm. Due to the extra pair of legs the total deformation of structure reduces considerably but due to increase in material cost also increases. It also increases the foundation cost for the extra pair of legs thus there is a need for optimization.

3. Three legs support (50x50 mm):- This design is similar to the three legs but with slight changes in the design. Instead of using the 4th legs for reducing the deformation a support is added to structure. Total four supports are provided to the structure, the supports are connected from the middle of the rafter to the base of the legs. Applying the similar boundary conditions the total weight of the structure is 156.72 kg and total deformation is 0.567 mm, 0.3810 mm for purline and rafter respectively. The total cost of the structure adds up to ₹ 11,911.44. Deformation is within the allowed limits but cost is comparatively high. Thus there is need for optimization.

4. Three legs support (40x40 mm):- The main problem with three legs support structure (50x50 mm) was the cost compared to other structures. Also the deformation was way more within the allowable limits. So to reduce the cost of the structure there is a need for reduction in material. As the design is optimum with added support, so instead of changing the design the cross-sectional dimension of the legs are reduced to 40x40 mm. Thus for this design by applying the boundary conditions we get analysis result as total mass is 137.117 kg, the total deformation is 0.88 mm and 0.68 mm for purline and rafter respectively. The cost optimizes up to ₹ 10,420.96. Because of its three legs the foundation cost is reduced compared to four legs structures. By this results we conclude that this is the optimum design for the mounting structure as deformation is within the acceptable limits and the total cost of the structure is also comparatively less than any other structure.
PosMAC shows 5 to 10 times corrosion resistance compared to galvanised sheet steel on flat surfaces. In addition PosMAC shows equal or greater corrosion resistance than Galvalume on flat surface. The magnesium (Mg) in PosMAC's coating layer will accelerate the formation of a dense corrosion product called "Simonkolleite (Zn5(OH)8Cl2·H2O)" which is extremely stable. When simonkolleite is formed on the surface of the coating layer in a film-like-form, it plays a role as a corrosion inhibitor for the base metal. In addition, the upper coating layer can be dissolved to cover the cross-section and accelerate the growth of a stable corrosion product. However red-rust can be found in the already exposed steel plate, but fortunately, the film of the corrosion products covers the cross-section and serves to prevent corrosion.
PosMAC has particularly excellent galling & scratch resistance compared to that of GI due to its high surface hardness. Consequently, PosMAC excretes less dust-like compound than a GI, so our customers can keep their press machines clean during the forming process.
Test Method:
Surface inspection after salt spray test (5% NaCl, 350C) every 24Hr.

TABLE II
COMPARISON TO (GI (H))/GALVALUME
IN CORROSION RESISTANCE ON FLAT SURFACES

SST	**GI(H)**	**Galvalume**	**PosMAC**	
he coating weight on both sides	**600 g/m^2**	**100 g/m^2**	**200 g/m^2**	**350 g/m^2**
480 hrs.				
720 hrs.				
1440 hrs.				

V. CONCLUSION

1. Solar panel ground mounting structure experiences the loads under gravity due to weight of the panels.
2. This three leg (40x40 mm) support structure which is designed can successfully withstand this load. FEA is a good tool to reduce the time consuming theoretical work and also reduce costly experimental work.
3. Depending on the analysis of the corrosion test, it has been concluded that PosMAC is the optimum coating material as compared to conventionally used coating materials.

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ISSN: 2233-7857 IJFGCN