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DIRECTIONAL DEFORMATION ANALYSIS OF SOLAR PANEL SUBJECTED TO WIND LOAD CONSIDERING DIFFERENT THICKNESSES OF LOW IRON TEMPERED GLASS

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Abstract- *Concerning about global environment, gradual decrease of conventional energy sources and expanding demand of energy, renewable energy has become indispensable. Photo-voltaic technology is one of the finest ways to harness the solar power as a great source of energy. Being an environment friendly source of energy the popularity of solar panel is increasing rapidly. Therefore the life cycle, maintenance and cost of solar panel has become important concerns throughout the world. The life cycle of encapsulated solar panel mostly depends on the change of mechanical properties. One of the main reasons of decreasing the life cycle is the stress developed on the solar panel. Environmental impact on solar panel enormously affect the life cycle while it is in operation. Wind load is most importantly one of them. In this study, a model is developed including all the layers practically used in solar panel considering the material properties of glass frame, crystalline silicon wafer with busbars, and aluminum frame. Total deformation and directional deformation under wind load is investigated using Finite Element Analysis (FEA). In the analysis, the solar panel is put under wind load in terms of pressure on the face of the panel. Finally for different thicknesses of low iron tempered glass, total deformation and directional deformation of solar panel is explored using constant load. The results show that, total deformation decreases with the increasing thickness of low iron tempered glass. Directional deformation along Y and Z axis is decreased with the increasing thickness of low iron tempered glass while the directional deformation is increased abruptly along X axis after crossing a certain thickness of low iron tempered glass.*

Keywords: FEA, Solar panel, Low iron tempered glass, Total deformation, Directional deformation

1. INTRODUCTION

As a means for solving the problem of energy production to growing energy demand, solar energy is currently playing a dynamic role as far as renewable energy is concerned in the world. In the last decades, energy related problems are becoming more and more important and involve the ideal use of resources, the environmental impact due to the emission of pollutants and the consumption of conventional energy resources [1]. Direct solar energy conversion to electricity is conventionally done using photovoltaic cells, which makes use of the photovoltaic (PV) effect. PV modules generate electricity directly from light without emissions, noise, or vibration.

Silicon solar cells are perhaps the simplest and most widely used for space and terrestrial applications. The PV system is promising source of electricity generation for energy resource saving and CO_2 emission reduction, even if current technologies are applied [2, 3]. As solar energy has low energy density i.e. PV modules require a large surface area for small amounts of energy generation [4]; further development in efficiency of solar cells, amount of material used in the solar cell and the system design for maximum use of recycled material are needed to reduce the energy requirement for generating energy and to enhance the life time of solar panel.

Encapsulated solar panel is the practical form that used to generate electricity. Life span of encapsulated solar panel is subjected to various factors such as- mechanical loading, thermal cycling, constant wind loading and stress on the panel etc. As wind loading and stress is major factor affecting the life span of the solar panel, for amendment of solar panel it must be considered to find the defects it causes.

A computational analysis has done on a complete solar panel module i.e. an encapsulated module including all the parts that is used in a solar panel for the investigation of mechanical properties under wind load. A model of solar panel was designed in solidworks & then by simulation software (ANSYS) wind load was put in terms of pressure on the surface face of the solar panel in a particular direction to analyze the total deformation and directional deformation.

2. SOLAR PANEL MODEL AND DIMENSION

The developed model in fig.1 consisted of six (3*2) semi square (152.5*152.5mm^2) silicon wafer with the thickness of 180 µm. Different model were considered by varying different thickness of glass frame. There were six busbars parallel to support attached with six wafer shown in fig.2. Above the wafer and busbars a low iron tempered glass (in fig.3) with changing thickness (2.8 mm to 4.2mm) was considered. Finite element analysis was done by changing the thickness of low iron tempered glass to analysis the deformation and directional deformation of solar panel. An aluminum frame was also considered .The whole model was rigidly supported by two fixed support bar of structural steel.

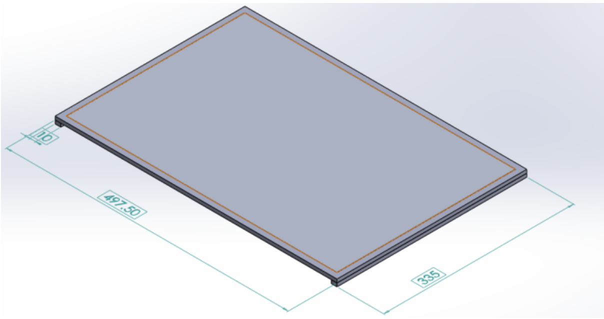

Fig.1: Solar panel with fixed support

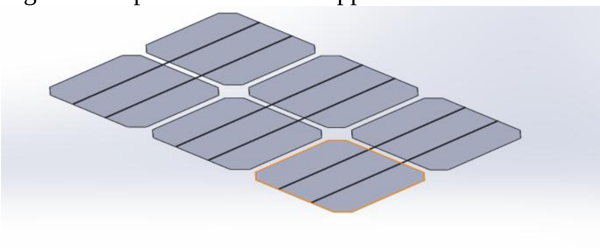

Fig.2: 3*2 wafer with 6 busbars

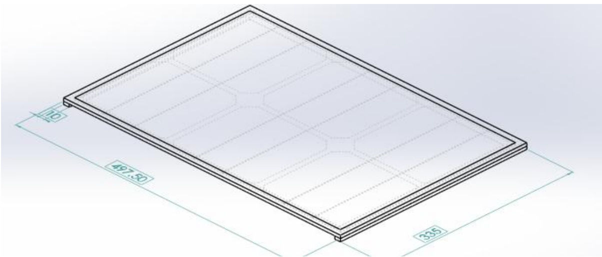

Fig.3: Solar panel with fixed support

3. SIMULATION MODEL

The Finite Element Analysis was carried out by a simulation software. The wind load was converted into pressure and applied on the face (along negative Y axis) of the solar panel. Two fixed rigid structural steel rigid bar was used as fixed support shown in fig.4.

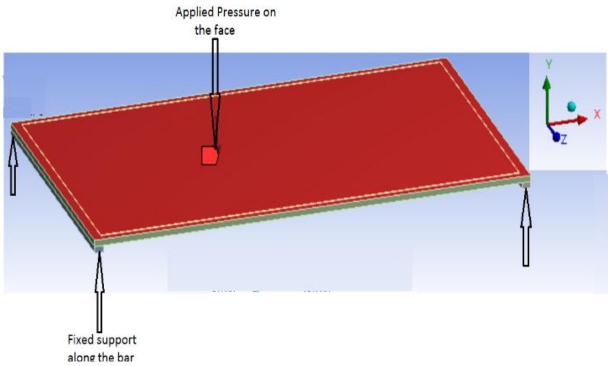

Fig.4: Simulation model showing applied pressure and fixed support

The material properties for different layer of solar panel also considered .The properties was considered based on the practical model of solar model available on the market. The dimensions also selected based on availability in local market. The wind was considered laminar and the wind flow was also considered for one direction only. The temperature of the environment was considered 297k and the one directional applied pressure was 45 Pa. The applied pressure was uniform and not varied with time.

4. RESULT AND DISCUSSION

Since solar panels are expensive so people can't afford to change the solar panels on a regular basis that's why it's longevity should be increased by taking into consideration the various stresses on it like the stress due to wind, thermal stress etc. In our experiment we tried to determine the effect of wind on solar panels. In our simulation we observed the stresses due to wind for 6 wafer and 4 basbars and two fixed support at both end shown in fig.5.

4.1 Total deformation

In Table 1 We have seen that for 6 wafer and 6 basbars the total deformation is decreasing with the increasing thickness of glass frame.

Table 1. Total deformation for different thickness of glass.

Thickness of glass frame in mm	Total deformation In nm
2.8	2023.4
3.0	1962.6
3.2	1903.2
3.4	1844.9
3.6	1787.7
3.8	1731.8
4.0	1677.8
4.2	1623.9

The changes were significant with the variation of thickness of glass shown in fig.6 and it is a normal characteristic for any material.

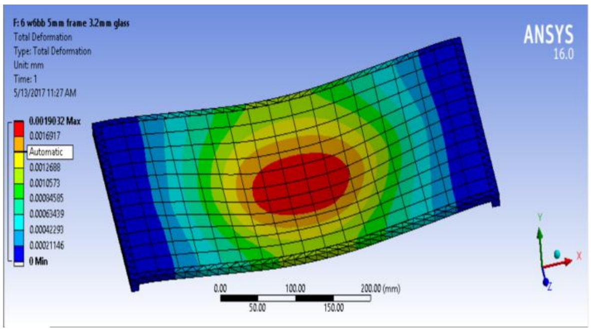

Fig.5: Wind load in terms of pressure on Solar Panel

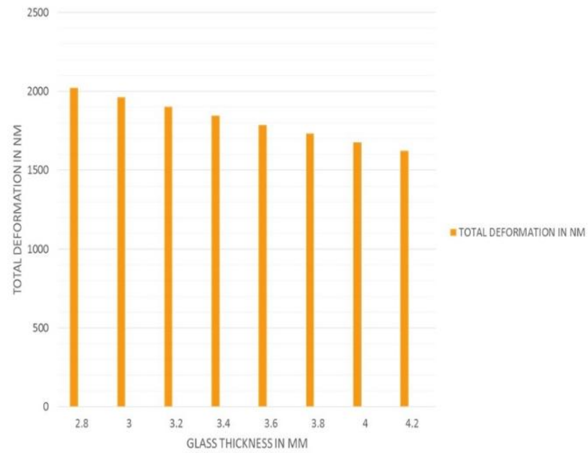

Fig.6: Total deformation vs Glass thickness

4.2 Directional Deformation

From Table 2. It was observed that the directional deformation along the Y and Z axis (shown in fig.7 (a) & fig.7 (b)) was satisfactory since the directional deformation was decreasing with the increasing thickness.

The change of the directional deformation along Y axis was too small to consider but the change in Z axis was significant.

Table 2. Directional deformation for different thickness of glass.

Thickness of glass frame in mm	Deformation in x axis in nm	Deformation in y axis in nm	Deformation in z axis in nm
2.8	24.186	0.78800	15.504
3.0	24.146	0.77300	15.151
3.2	24.120	0.75941	14.744
3.4	24.103	0.74500	14.293
3.6	24.291	0.73130	13.807
3.8	24.512	0.71760	13.296
4.0	24.698	0.70425	12.776
4.2	24.852	0.69113	12.354

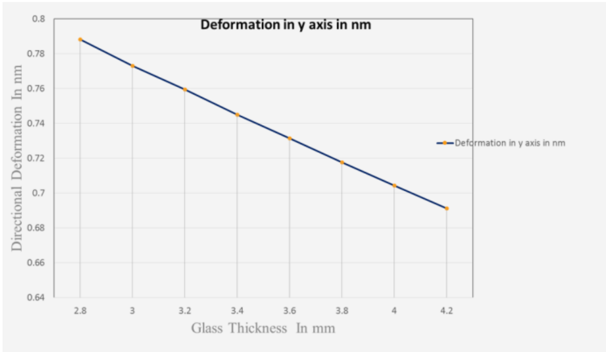

Fig.7 (a): Directional deformation along Y and Z axis vs Glass thickness

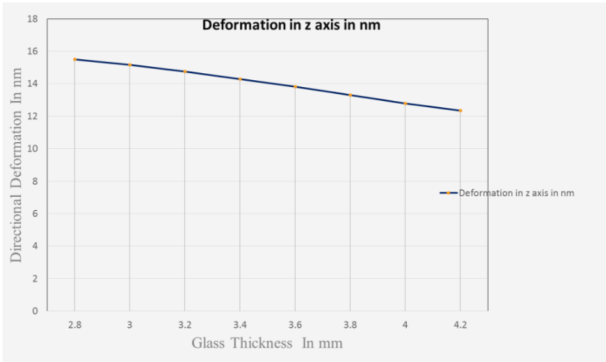

Fig.7 (b): Directional deformation along Y and Z axis vs Glass thickness

Although for Y and Z axis the directional deformation was conventional but the directional deformation along the X axis showed some absurdity. It was decreasing with the increasing thickness of the glass frame till certain thickness. But after crossing certain thickness the directional deformation along X axis increased absurdly. From fig.8 it is clear that directional deformation along X axis will be minimum for glass thickness 3.5 mm. From 3.6mm it was increasing abruptly. For 3.4mm and 3.6mm glass thickness the simulation models are shown in fig.9 (a) and fig.9 (b).

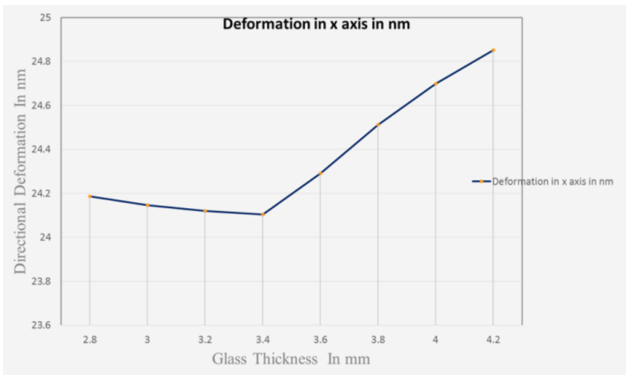

Fig.8: Directional deformation along X axis vs Glass thickness

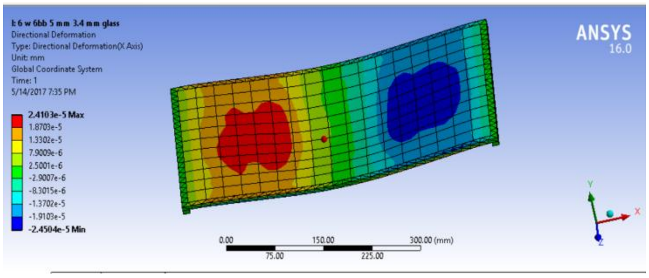

Fig.9 (a):3.4 mm thick glass

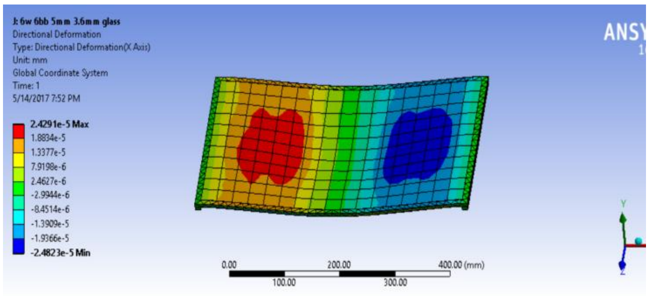

Fig.9 (b):3.6 mm thick glass

6. CONCLUSION

For the stability of solar panel there are various factors which are responsible. The effect of wind load only considered here for different thickness of low iron tempered glass.

From the study it may be concluded that, the thickness of glass can't be much for considering stability .From the simulation it was found that for increasing glass thickness the directional deformation along X axis is not conventional.

Though the directional deformation along Y and Z axis was conventional and for Y axis the deformation variation was not significant as for Z axis.

So for 6wafers and 6 basbars that means if the busbars are parallel to support the glass thickness should be below 3.4mm .From the fig.8 it is clear that 3.4mm could be a good limit if the directional deformation along X axis is the main concern which will also increase the life span of solar panel.

It is also found that the total deformation for different glass thickness was conventional as it was decreasing with increasing thickness of low iron tempered glass.

7. ACKOWLEDGEMENT

8. REFERENCES

[1] Stoppato A. Life cycle assessment of photovoltaic electricity generation. Energy 2008; 33:224–32.

[2] Sakamoto Y, Zhou W. Energy analysis of a CO_2 recycling system. International Journal of Energy Research 2000; 24(6):549–59.

[3] Sakamoto Y, Zhou W, Kawabe T. Performance analysis of a CO_2 recycling system which utilizes solar energy. International Journal of Energy Research 2001; 25(3):275–80.

[4] Topcu YI, Ulengin F. Energy for the future: an integrated decision aid for the case of Turkey. Energy 2004; 29:137–54.