iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: I Month of publication: January 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Design and Fabrication of Solar Vehicle using Composite Materials and Tilting Mechanism

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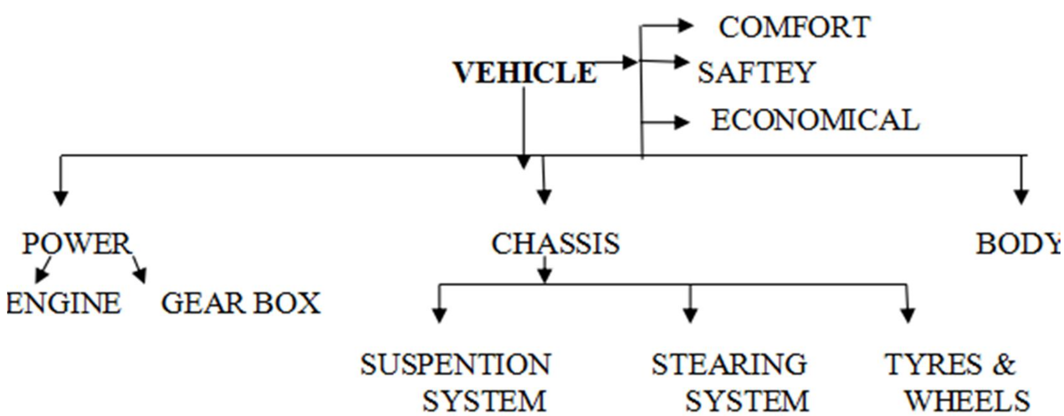
Abstract: The solar powered car, one of the oldest alternative energy vehicles, has many applications to the emerging electric vehicle market. This paper surveys the history and future of solar and electric vehicles and provides an overview of a typical solar car with the help of tilting mechanism i.e the solar panels are tilted at an angle which is inclined to the sun maximum energy,the efficiency of the single axis tracking & dual axis tracking system over that of the static panel is calculated to be 32.17% & 81.68% respectively. And also a detailed explanation is given on the usage of composite materials to reduce the weight of the chassis and to improve the electrical resistivity. It is anticipated that the body-mass reductions that can be achieved in the near term vary from 10% (with mostly conventional and high-strength steels) to 40% (with a mostly aluminum structure) and up to 75% (with mostly magnesium structure).

Key words: Solar vehicle,Components of solar vehicle,Composite materials,Solar trackers.

I. INTRODUCTION

A solar vehicle is an electric vehicle powered completely or significantly by direct solar energy. Usually, photovoltaic (PV) cells contained in solar panels convert the sun's energy directly into electric energy. The term "solar vehicle" usually implies that solar energy is used to power all or part of a vehicle's propulsion. Solar power may be also used to provide power for communications or controls or other auxiliary functions. To increase the power generation on these solar panels, the panels should be oriented in the direction normal to the sun's position. By increasing the efficiency of the panel to a certain range we can attain an increase in the power of vehicle by means of speed, increase in the rpm of the motor.This tilting mechanism is of two type based on the purpose, one is active solar tracker and the second one is passive solar tracker. Another important aspect of this solar vehicle is reduction in weight component with an increase in the strength. This can be achieved by the usage of composite materials. Types of materials that are explained in this paper are high strength steel, aluminum, magnesium. The usage of these materials in making of car chassis will gives a good weight to strength ratio ultimately there will be an increase in the out put power of the vehicle. Since if a small amount of load is applied onto the motor it can revolve at a high speed producing high torque and efficiency.Whereas if an heavy load is applied onto the motor it will decreases the life time of the battery which ultimately cause a decrease in speed of the motor and its efficiency.

II. DESIGN AND FABRICATION OF SOLAR



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III. DESIGN AND MODELING

Design may be done in two ways one way is the component design which is done by improving the existing ones. The other is conceptual design where there is no reference and creation of new machines. A new or better machine is one which is more economical in the overall cost of production and operation. From the study of existing ideas, a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape and form in the form of drawings. Generally the design of a component involves various steps in it. Initially, the drawings must be drawn in user friendly software and they must be converted into a 3D model. This 3D model must be imported into an analyzing medium where it is structurally or thermally analyzed to sustain the need.

A. Existing Model

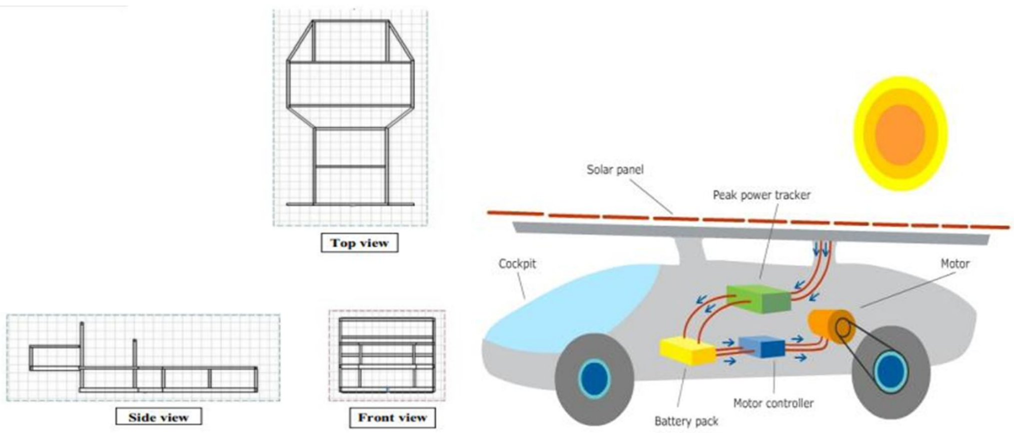

Fig:1 Different views of solar car

B. Proposed Model

Tab:1 SPECIFICATIONS OF VEHICLE

SL NO	DESCRIPTION	DIMENSIONS (mm)
1	WHEEL BASE	3600
2	FRONT TRACK	1800
3	RARE TRACK	1690
4	MAX WIDTH	2270
5	FRAME LENGTH	5620

Different steps involved in designing a component are

1) Part drawing
2) Modeling
3) Structural analysis

The present frame is divided in to individual components and each component is drawn, modeled and structurally analyzed by using software and its procedure is explained as below.

C. Part Drawing

It is a document that includes the specifications for a part's production. Generally the part drawings are drawn to have a clear idea of the model to be produced. The part drawing of the entire frame is drawn with all the views in CATIA V5 R20.

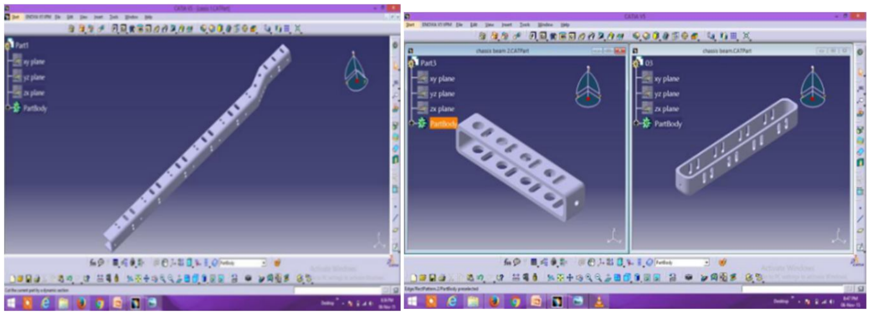

Fig: 2 part modeling of components in catia v5

D. Assembly

The components that are generated in part module are imported to assembly module and by using 'insert components' command and all these components are mated together to form the required assembly. The different views of assembly and the drawing generated in CATIA V5 R20 are as shown below Fig 3 and Fig 4.

E. Developed Model

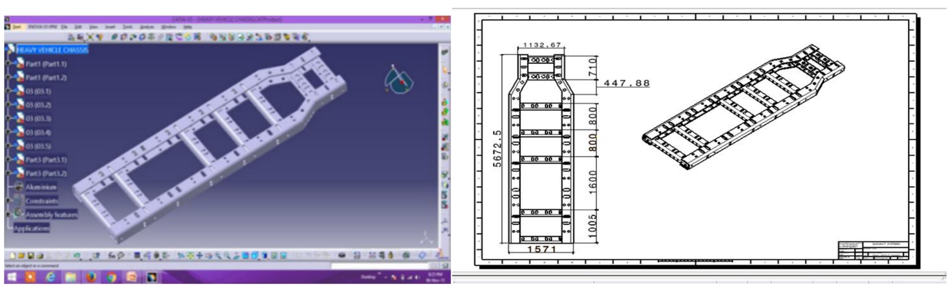

Fig: 3 Different views of drawing

Fig: 4 The frame assembly in catia v5

IV. LIGHTWEIGHT COMPOSITE MATERIALS USED IN THE FAABRICATION OF SOLAR CAR CHASSIS

The utilization of composites in automotive sector has historically been limited to secondary structures such as appearance panels and dash boards. The major obstacles to automotive industry will be due to undeveloped high production rate processes, lack of knowledge about material responses to automotive environments. By weight, about 8% of today's automobile parts are made of composites including bumpers, body panels, and doors.

A. High Strength Steel

HIGH strength steel (HSS) is based on alloy that are categorized on the basis of yield strength. Standard HSS has a yield strength between 210 M pa and 550 M pa, ultra-high strength steel (UHSS) has a yield strength higher than 550Mpa. High-strength steels can cost as much as 50% more than regular mild steels, but they allow use of lower thickness than milder steels the brittleness whilst maintaining most of the strength and hardness as shown in Tab 2.

SL.NO	ULTIMATE STRENGTH (N/m^2)	WEIGHT (Kg/m^2)	FACTOR OF SAFTEY	STRENGTH TO WEIGTH RATIO	MODULUS OF ELASTICITY (G Pa)	DOMESTIC PRODUCTION ($/Kg)	TENSILE STRENGTH (M Pa)	SPECIFIC STRENGTH (N m/Kg)
HIGH STRENGTH STEEL	550	31.61	2.64	38	200	0.47	1300	167
ALUMINUM	240	31.73	2.04	130	73	2.00	350	124
MAGNESIUM	185	10.62	1.81	158	45	3.31	270	150

TabLE: 2 Comparison of HSS, ALUMINUM, MAGNESIUM

B. Aluminum In Chassis Application

Weight saving in the chassis can also achieve 40% in comparison to the conventional steel chassis.5000 alloys like AA5049(AlMg2Mn0.8) and AA5454 (AlMg3Mn) are used comprising good formability and weldability. They have high strength after forming, and outstanding corrosion resistance, also in uncoated condition. For certain parts, that experience long-term thermal loads the Mg content is limited to 3% of the mass to avoid the potential danger of inter granular corrosion (IGC), due to possible micro-structural changes by Mg precipitation along grain boundaries (known as sensitization) at elevated temperatures (>70℃) with an exposure to aggressive environment.

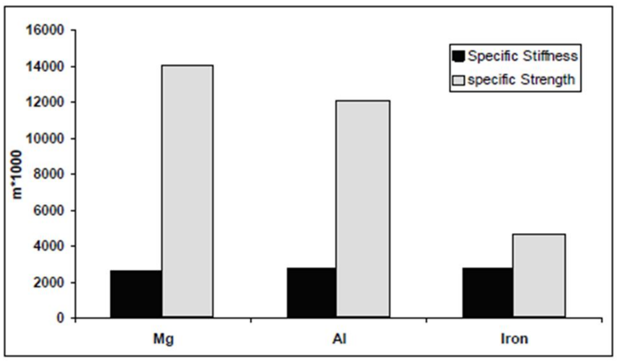

Fig: 5 Comparison of specific stiffness & strength of MG, AL AND FE

C. Magnesium

Magnesium is 33% lighter than aluminium and 75% lighter than steel/cast-iron components. The corrosion resistance of modern, high-purity magnesium alloy is better than that of conventional aluminium die-cast alloys. As well, porosity-free die-cast AM501 AM60 can achieve 20% elongation, over three times that of AL A380, leading to higher impact strength; but magnesium components have many disadvantages that require unique design for application to chassis components. Strength , and creep strength is higher compared to aluminium. The hardness of magnesium alloys is lower than aluminium and the thermal expansion coefficient is greater.

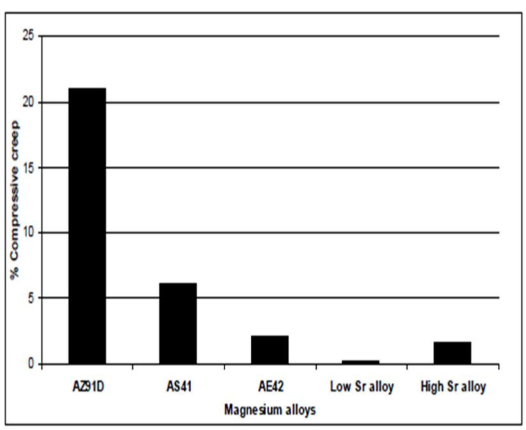

Fig: 6 Compressive creep of the Magnesium alloys at 70 MPA, 150^0C .

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V. TILTING MECHANISM FOR SOLAR PANELS

To increase the power generation on the panels, the panel should be oriented in the direction normal to the sun's position.The sun's position on various times are noted. According to the sun's position the program to tilt the solar panel is fed on the PLC. Tilting mechanism is classified as active solar tracker and passive solar tracker.

A. Tracking system

1) *Passive Tracking :*difference in gas pressure is created, moving the tracker until it gets to an equilibrium position. The advantage of passive tracker is that the tracking system does not require a controller. But passive trackers are slow in response and are vulnerable to wind gusts.

B. Active tracking

Active tracking uses motors, gears, and actuators to position the solar tracker so that it is perpendicular to the sunlight. Trackers that use sensors to track the sun position inputs data into the controller, which in turns drives the motors and actuators to position the tracker. Active tracking is again classified as single axis tracker and dual axis tracker. The major component used in active tracking is slewing drive.

C. Slewing Drive

The slewing drive makes sure of the worm drive mechanism to produce torque for rotating. It can be found in many types of machinery such as wind turbines, cranes, and telescopes. But they are also widely used in solar trackers to provide rotational movement, mainly in vertical direction. These are known as single axis slewing drive. Because slewing drive uses a worn drive system, it is self-locking or irreversible. A slewing drive is made by combining the gearing, bearings, seals, housing and other components into one single unit as shown in fig 8.

D. Single Axis Tracker

A Single axis tracking system is a method where the solar panel tracks the sun from east to west using a single pivot point to rotate. Under this system there are three types: Horizontal single axis tracking system, Vertical single axis tracking system and Tilted single axis tracking system. In the Horizontal system the axis of rotation is horizontal with respect to the ground. In the Vertical system the axis of rotation is vertical with respect to the ground . In the Tilted tracking system the axes of rotation is between horizontal and vertical axes and this also has the face of the module oriented parallel to the axis of rotation as shown in fig 7 .

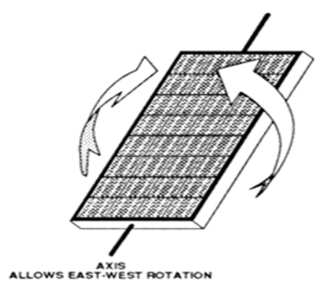

Fig: 7 Single axis tracker

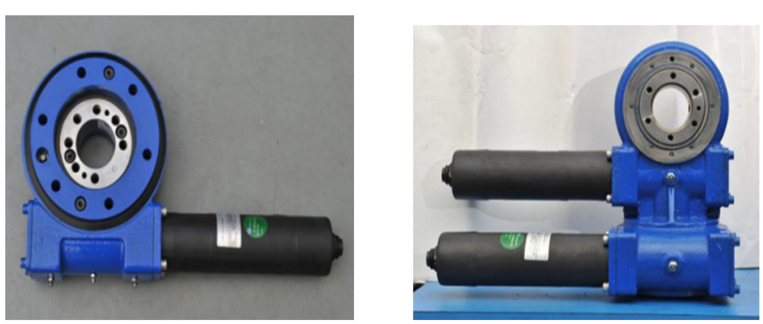

Fig: 8 slewing drives

VI. EFFICIENCY OF SINGLE-AXIS TRACKING SYSTEM OVER FIXED MOUNT

The readings for both the static panel and single-axis tracker are taken for a single day from morning 8 am to evening 6 pm for every one hour.

The efficiency for single axis tracker is shown in Tab 3 and graph is shown in fig 9.

Tab: 3 Comparison of fixed amount with single axis tracking system

HOURS	STATIC PANEL			SOLAR TRACKING (SINGLE AXIS)		
	V	mA	mW	V	mA	mW
08.00AM	08.4	0.60	05.04	09.15	1.70	15.60
09.00AM	08.5	1.17	09.94	09.45	1.78	16.86
10.00AM	08.6	1.25	10.75	09.70	1.99	19.30
11.00AM	09.7	1.82	17.65	09.85	2.38	23.44
12.00PM	09.9	2.22	21.97	10.20	2.70	27.54
01.00PM	10.3	2.56	26.36	10.80	3.20	34.29
02.00PM	10.5	2.97	31.18	10.70	3.05	32.68
03.00PM	09.7	2.71	26.28	10.25	2.93	30.08
04.00PM	08.6	2.50	21.5	09.80	2.63	25.77
05.00PM	08.3	22.14	17.76	09.25	2.43	22.47
06.00PM	08.1	1.43	11.58	08.75	1.87	16.40
AVERAGE POWER	18.18			24.03		

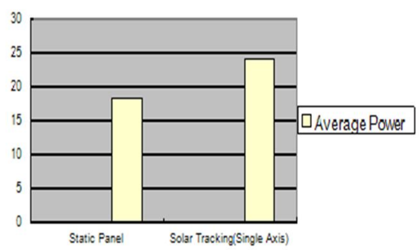

Fig: 9 Graph for single axis tracking system

The efficiency of the single axis tracking system over that of the static panel is calculated to be 32.17%.The main disadvantage of the single axis tracker is that it can only track the daily movement of the sun and not the yearly movement.

A. Dual Axis Solar Tracking System

Dual axis tracking system uses the solar panel to track the sun from east to west and north to south using two pivot points to rotate. The dual axis tracking system uses four LDR’s, two motors and a controller. The four LDR’s are placed at four different directions. One set of sensors and one motor is used to tilt the tracker in sun’s east - west direction and the other set of sensors and the other motor which is fixed at the bottom of the tracker is used to tilt the tracker in the sun’s north-south direction. The controller detects the signal from the LDR’s and commands the motor to rotate the panel in respective direction as shown in fig 10.

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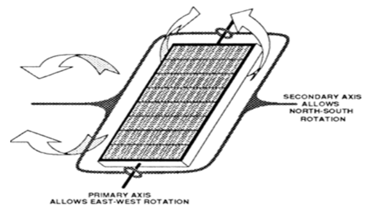

Fig: 10 Dual axis tracker

VII. EFFICIENCY OF DUAL-AXIS TRACKING SYSTEM OVER FIXED MOUNT

The following readings are tabulated and a graph was generated using MATLAB as follows.

The efficiency for dual axis tracker is shown in Tab 4 and graph is shown in fig 11.

Tab: 4 Comparison of fixed amount with dual axis tracking system

HOURS	STATIC PANELS			SOLAR TRACKING (DUAL TRACKING)		
	V	mA	mW	V	mA	mW
0.800AM	08.4	0.60	05.04	10.20	2.93	29.88
09.00AM	08.5	1.17	09.94	10.35	3.02	31.25
10.00AM	08.6	1.24	10.75	10.42	3.00	31.26
11.00AM	09.7	1.82	17.65	10.51	3.23	33.94
12.00PM	09.9	2.22	21.97	10.60	3.20	33.92
01.00PM	10.3	2.56	26.36	10.80	3.35	36.18
02.00PM	10.5	2.97	31.18	10.73	3.41	36.58
03.00PM	09.7	2.71	26.28	10.40	3.29	34.21
04.00PM	08.6	2.50	21.5	10.55	3.30	34.81
05.00PM	08.3	2.14	17.76	10.36	3.12	32.32
06.00PM	08.1	1.43	11.58	10.29	2.82	29.01
AVERAGE POWER			18.18			33.03

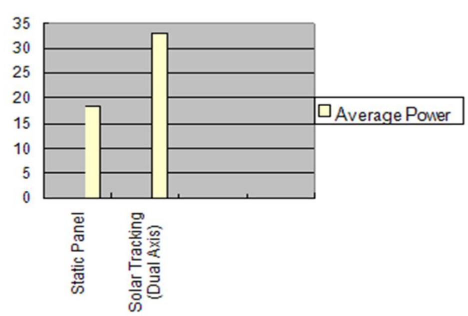

Fig:11 Graph for single axis tracking system

The efficiency of the dual axis tracking system over that of the static panel is calculated to be 81.68%.

VIII. CONCLUSION

Light weight materials such as aluminum, and magnesium have been proved for having high potential to increase the fuel economy of vehicle, making it feasible for the manufactures to increase their average fuel economy even in passenger and larger vehicles. And also by using tilting mechanism for solar power based vehicles the efficiency can be improved .The efficiency of the single axis tracking system over that of the static panel is calculated to be **32.17%.** The efficiency of the dual axis tracking system over that of the static panel is calculated to be **81.68%.** These materials has proven to be the ideal light-weighting material allowing weight saving and increase in fuel efficiency and without compromising safety.

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