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A revolutionary step towards green transport system

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ABSTRACT

The fuel for today's I.C engine cars is obtained from one of the most crucial sources of energy, Fossil Fuels. But being used at such an extensive rate will result at the end of it within just a few years so the need of the hour is to shift from non-renewable source of energy to Renewable source of energy. The fuel used by cars is not just limited but also a major cause of global warming and ozone layer depletion. Moving to solar energy which is available to us in abundant and as a never-ending source, it will not only reduce carbon emissions but also reduce the use of fossil fuels to power our vehicles. The software used for designing of this car is Solidworks, Lotus, Ansys, etc.

Keywords*— Solar car, Green energy, Conventional vehicles*

1. INTRODUCTION

A solar vehicle can be mainly used for land transportation. A solar car draws energy from the sun to operate, as the sun is the main source of power for solar vehicle and it is available to us in abundance, it can be a great way to extract energy. To reduce pollution and deterioration of our environment and ecosystem electric vehicles are our best bet. Solar technology combined with the domestic electric supply can boost the overall scope in solar vehicle. Conventional I.C Engine vehicles tend to have problems such as air pollution, noise pollution, etc. maintenance of conventional I.C engines is quite high as compared to solar vehicles. All this positive aspect makes solar vehicles a wise choice in comparison to conventional I.C engine vehicles.

1.1 Research Survey

For any vehicle to be successful a market survey is necessary. We should understand the market and crowd which we are going to cater to our vehicle. Doing all the research we got to know that electric vehicles are the need of current market as they are reliable, cheap to maintain and usability. By doing market research we found out that, electric cars are the future of mobility and transport. We have found out the flaws and misfits in the previous researchers and made an optimum design which is agile, reliable as well as usable in the urban terrain. By using modern technological tools and solutions we can remove all the flaws from the previous designs and research.

2. DESIGN AND CALCULATIONS

2.1 Chassis

The chassis of the vehicle is the skeleton made from a hollow section of pipes on which different components would be mounted. The design of the chassis was done on the emphasis of weight reduction. The design was made in such a way that the car will be a single-seater vehicle and would be in a tadpole design i.e 3-wheel design with 2 on front and 1 rear. Following table depicts the parameters and details of the chassis made and few sketches.

Fig. 1: Isometric view

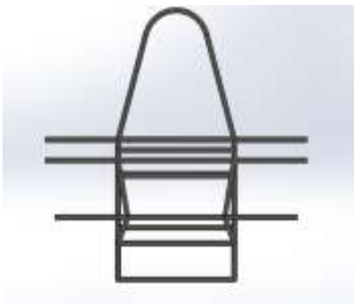

Fig. 2: Front view

Table 1: Vehicle specifications

Length of vehicle	2362mm
Width of vehicle	1424mm
Height of vehicle	1346mm
Wheelbase	1778mm
Track width	1320mm
Ground clearance	203.2mm
Tyre size	304.8mm
Chassis material	AISI 4130

The above table depicts the basic dimensions of the vehicle and the type of chassis material used. We used seamless pipes of 25.4mm O.D and 1mm wall thickness. The reason behind using seamless pipes was higher strength, lower weight, low cost, and high machinability.

We performed a static impact on the chassis with a load of 10000N and following results were obtained. The following figure shows test results.

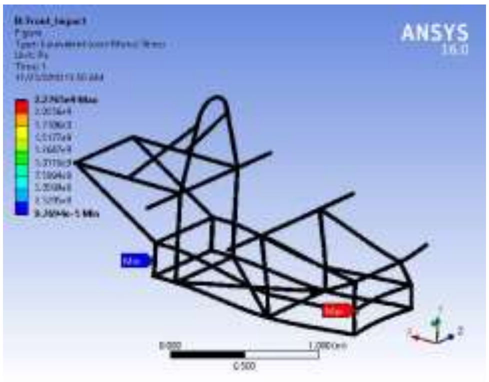

Fig. 3: strain results

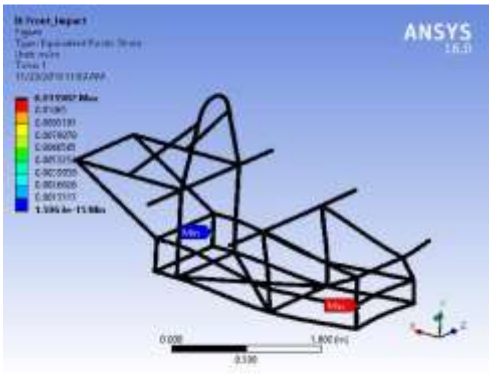

Fig. 4: stress results

Table 2: Impact analysis

Front Analysis	
Parameters	**Maximum Values**
Stress Results	2.276E+9 N/m^2
Strain Results	11.982 mm/mm
Total Deflection Results	26.53 mm
The factor of Safety (F.O.S.)	8.3

2.2 Motor Calculations

BLDC (Brushless Dc) Motors are also known as electronically commutated motors due to their dependence on semiconductor switches for precise switching of stator windings. They are synchronous motors powered by DC supply via an inverter or switching power supply which produces an AC electric current to drive each phase of the motor via a closed-loop controller. In this vehicle rear-wheel drive is used driven by electric motor. We decided to use hub motor due to its high efficiency of about >83%.

Calculations:
Weight (W) = 260 KG
Rim dia = 12 inch
R = 0.1524 m
u = 0.017 = 0.02
f_t = umg = 51.02 N
T = f_t* R =7.775 N-m   Torque Required: 7.775 N-m.

Based upon these calculations we selected a motor of 1500W capacity. The following table shows motor specifications.

Table 3: Motor specifications

Type	**BLDC Hub motor**
Rated capacity	1500W
Rated Voltage	48V
Rated Current	20-40A
Rated RPM	742
Rated Torque	15 n.m – 45 n.m
Weight	9 Kgs
Continuous Discharge Current	10-15A

Peak Current Calculation

Peak Power: P = 1500 watt
Voltage: V = 48 volt

Peak current: I = power consumption/voltage
= 1500 / 48
= 31.2 Ampere

2.3 Battery calculations

Lithium-ion battery pack is less in weight as that of lead acid battery pack. So, to keep our vehicle under the weight, lithium ion is better. BMS comes with lithium ion pack. Hence, it is safer than lead acid pack.

Fig. 5: Discharge curve

Table 4: Battery specifications

Nominal Voltage	48V
Battery Capacity	80Ah
Low Voltage cut-off	41.6V
High Voltage cut-off	57.6V
Operating Temp	55 degrees
IP Rating	64
C rating	0.5C

2.3.1 Selection criteria

Size Availability: The standard size in voltage form is multiple of 12volt. i.e., 12V, 24V, 36V, 48V, 60V

Cost: As the number of cells in battery pack increases, the overall price of the pack will increase. So, to keep our vehicle within the minimum budget we are going with 48-volt battery pack.

Weight: With each number of cells, the weight of the battery pack increases, so, to satisfy the weight limitation of our vehicle. We are opting for minimum required pack. I.e., 48-volt battery pack.

Power Consumption:

P = VOLTAGE × CAPACITY
= 48 × 80=3840 Watt.

2.3.2 Continuous run time of battery pack

Capacity: C= 80 AH
Operating Voltage: V = 48 volt
Average current consumption by motor: I = 25 Amps
Total run time: T = C / I
= 80 / 25
= 3.2 Hours (approx.)

2.3.3 Distance Calculation

If we consider average speed of 40kmph,

Total distance = speed*time = 40*3.2 =128km (approx.)

2.4 Solar Panel Calculation

The power to charge this battery is produced using solar panels, which convert photoelectric energy in electric energy. The panels used in our cars were manufactured from WAAREE industries and under merlin technology. The table shows the specifications for a single cell, further, the calculations show the arrangement of cells to achieve required voltage and current.

Table 5: Solar cell specifications

Voltage	0.5V
Short circuit current	6.75A
Size	175.25x142.2mm
IP Rating	64
Bend angle	45 degrees

To charge our battery pack, we required the potential difference at the end of solar panels to be >57V. Using basic rules of voltage and current i.e- voltage adds in series and currently remains same and current adds in parallel and voltage remains constant. So we connected all the cells in series and at the end we obtained a peak voltage short circuit voltage of 58.5V and short circuit current of 6.75A. Different modules were made as per area available to us and were connected in series to obtain desired results.

Table 6: Solar modules

Dimensions	No. of cells to be fit	Voltage	Current
355x1422	2x10	11	6.75
355x1422	2x10	11	6.75
355x724	2x5	5	6.75
355x724	2x5	5	6.75
355x965	2x7	7	6.75
355x965	2x7	7	6.75
625x965	5x5	12.5	6.75
TOTAL	**113**	**58.5V**	**6.75A**

2.5 Wiring Diagram

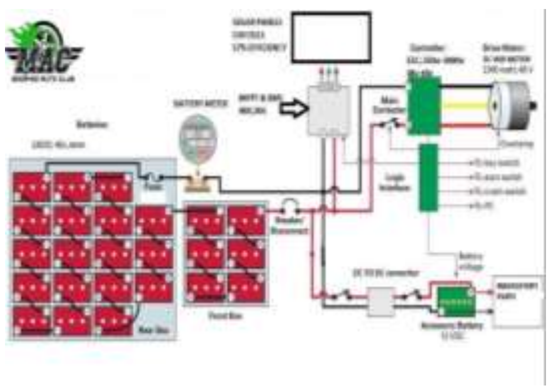

Fig. 6: Wiring diagram

The various aspects of electrical wiring and interfacing of different electrical components and accessories used in our solar vehicle. To run a solar vehicle with maximum safety the wiring plays the most important role. So we have taken care of all the safety measures and design. Consideration to formulate the final wiring design using electrical software's such eagle and multisim.

2.6 Braking calculations

We have decided to incorporate an all-wheel disc brake system considering its various advantages and ease of installation/maintenance and keeping in mind the various problems we could encounter. The factors and parameters which were considered while designing all-wheel disc brake system are listed below:

Table 7: Braking system

S no.	Parameters	Values
1.	Front Disc diameter	9 inches
2.	Rear Disc diameter	9 inches
3.	Front Caliper piston diameter	2.5 inches
4.	Rear Caliper piston diameter	2.5 inches
5.	Coefficient of friction (μ_r)	0.7
6.	Coefficient of friction (μ_p)	0.6
7.	Wheelbase (L)	70
8.	Track Width	52
9.	Master Cylinder Bore Diameter	5 inches
10.	Initial Velocity	40 km/h
11.	Maximum Weight of vehicle considered	280 kg

Our hydraulic brake system is controlled by a single pedal in line with two separate master cylinders. The use of two separate master cylinders is a safety interlock, in case one fails, the other will still be operable. Another advantage of using dual master cylinders is the ability to adjust brake bias. The brake circuit we have used is of the horizontal split type. This was used due to the fact that the tires have a positive scrub radius. Hence, one cylinder will control the front braking system and the other the rear system.

2.6.1 Braking calculations

Force/Pressure exerted on MC Bore = FM.C/PM.C
Force/Pressure developed on calipers=F_C/P_C
Clamping force on each wheel =F_{CF}/F_{CR}
Effective rotor radius = r_e
Max. Retardation = a
MC Bore area = A_{MC}
Caliper piston area = A_C

Calculations

Mechanical leverage (m) = **6:1**

Force acting on the master

$$F_{mc} = m*F_p$$

Cylinder = 12000cos (43) = **8776.2444 N.**

Area of master cylinder (piston/bore)

$$A_{mc}= \pi*b^2/4 = \mathbf{3.94\ inch^2}.$$

Pressure generated

$$F_{mc}/A_{mc}= 87764.2444/3.94 = \mathbf{2227.47\ N/inch^2}.$$

Area of calliper

$$A_{cp} = \pi * d^2cp/4 = \mathbf{3.94\ inch^2}$$

Force on caliper

$$F_{cp} = p*A_{cp} = 2227.47*3.94 = \mathbf{8776.244\ N.}$$

By two calliper piston

$$F_c = 2*F_{cp} = 2*8776.2444 = \mathbf{17552.48\ N}$$

Force on disc

$$F_d = u*F_{cp}$$

$$= 17552.48*0.6 = \mathbf{10531.488\ N.}$$

$$T_b \text{ (braking torque)} = F_d*(D_d/2)$$

$$=10531.488*4 = \mathbf{42125.952\ N\text{-}inch}$$

$$F_b \text{ (braking force)} = T_b/(D_w/2)$$

$$= 42125.952/9$$

$$F_b = \mathbf{4680.661\ N}$$

On two tyres = **9361.322 N**

CALCULATIONS FOR STOPPING DISTANCE

CASE 1:

S = 5 m

Initial velocity (u) = 40 km/hr = 11.11 m/s

$$v^2-u^2 = 2as$$

$$0 - (11.11)^2 = 2*a*5$$

$$\mathbf{A = -12.3432\ m/s^2}$$

Inertia force = F = ma

$$F = 260*12.3432 = \mathbf{3209.2346\ N}$$

Energy generated

$$F*s=3209.2346*5 = \mathbf{15146.173\ J}$$

CASE 2:

S = 2 m

Initial velocity (u) = 40 km/hr = 11.11m/s

$$v^2 - u^2 = 2as=0 - (11.11)^2 = 2*a*2$$

$$\mathbf{a = -30.858\ m/s^2}$$

Inertia force = F = ma

$$F = 260*30.858 = \mathbf{8023.08\ N}$$

Energy generated

$$F*s=8023.08*2 = \mathbf{16046.16\ J}$$

$$F_b > ma$$

Therefore braking is effective.

3. RESULTS

As we all know, within a few years ic engines will not only be reduced but might completely eliminate, hence we require for an alternate source of energy to fulfill our needs. Electric Solar cars have the following advantages:

(a) Zero-emission.
(b) Low maintenance
(c) Subsidized
(d) High efficiency
(e) Smooth drive
(f) Instant torque
(g) Unlimited energy source, greener technology.

4. CONCLUSION

The electric vehicle can play a vital role in the upcoming automotive industry. The solar technology can be implemented in the betterment of industry and people. Although solar vehicles have a few disadvantages like small range, low speed, high initial cost, slow energy conversion rate, etc. but all drawbacks can be overcome by further research in this field and can be implemented successfully. Solar cars have a great scope in the coming future.

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