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Comparison of chassis frame design of Go-Kart vehicle powered by internal combustion engine and electric motor

Naveen Kumar Chandramohan [a,*], Mohanraj Shanmugam [b], S. Sathiyamurthy [c], S. Tamil Prabakaran [d], S. Saravanakumar [c], V.S. Shaisundaram [e]

[a] *Department of Automobile Engineering, Kumaraguru College of Technology, Coimbatore, India*
[b] *Department of Materials Engineering and Nanotechnology, Politecnico di Milano, Milan, Italy*
[c] *Department of Automobile Engineering, Easwari Engineering College, Chennai, India*
[d] *Department of Mechanical Engineering, Government College of Engineering, Bargur, Tamilnadu, India*
[e] *Department of Automobile Engineering, Vels Institute of Science, Technology and Advanced Studies, Chennai, India*

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ABSTRACT

Go-Kart design and development helps in implying the theoretical knowledge into the practical aspect. It also helps to learn about various parameters that can be altered and implied to try to improve the performance of the kart. Go-kart is of various types namely internal combustion engine (IC) powered, Electric driven, solar powered and Hybrid. This project is aimed to convert an IC engine Go-kart into an Electric driven kart, the Frame of the IC engine kart requires a single mount as it needs only Engine and it is developed using SOLIDWORKS, whereas in Electric driven it is a combination of Battery, Motor and Controller and hence it requires a large number of mounts and cross members to support the components, the conversion of IC powered engine frame into an Electric driven needs some alteration to support the components and a new frame was developed using SOLIDWORKS. Both frames are analysed using ANSYS for different types of impacts namely front, side and rear in accordance with the load distribution that acts in the frame and the deformation results are compared.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science.

1. Introduction

Go-kart is a small racing vehicle with no suspension and rarely used with differential [1–4]. Karting is often used as a free time sport and it comes under Formula 9 category [5–8]. Go-kart is of various types such as Internal combustion engine, Electrical powered, Solar Go-kart and Hybrid Go-karts. Nowadays due to extinction of Hydrocarbons and increasing pollution Green concept is becoming popular and the world is expected to switch to completely Electric sourced vehicles [9–14].

This work aims to convert an existing IC engine Go-kart into an Electric powered by making changes in the frame to accommodate electrical components and to study the deformations that occurs during the conversion [15–20]. Both IC and Electric frames deformations are compared.

2. Frame

2.1. Frame material

The material used is AISI 1020 carbon steel for our frame because of its high tensile strength, best weld ability, machinability and high toughness [21,22]. The chemical composition of the material is as follows Table 1.

2.2. Design OF chassis frame for IC engine

Frame is designed using SOLIDWORKS 2016 to achieve best optimum geometry with less design errors Fig. 2.1.

2.3. Frame safety analysis

The structural integrity of the frame was verified by comparing the analysis results with the Standard values of the material. Analysis was conduct by use of finite element analysis FEA on ANSYS

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[*] Corresponding author.
E-mail addresses: cnaveenkumar27@gmail.com, naveenkumar.c.auto@kct.ac.in (N.K. Chandramohan).

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Table 1
Chemical composition of the frame material.

S. NO	PARAMETER	RESULT
1.	Carbon	0.18–0.23%
2.	Manganese	0.30–60%
3.	Phosphorus	0.045max
4.	Silicon	0.07–0.6%
5.	Sulphur	0.05max

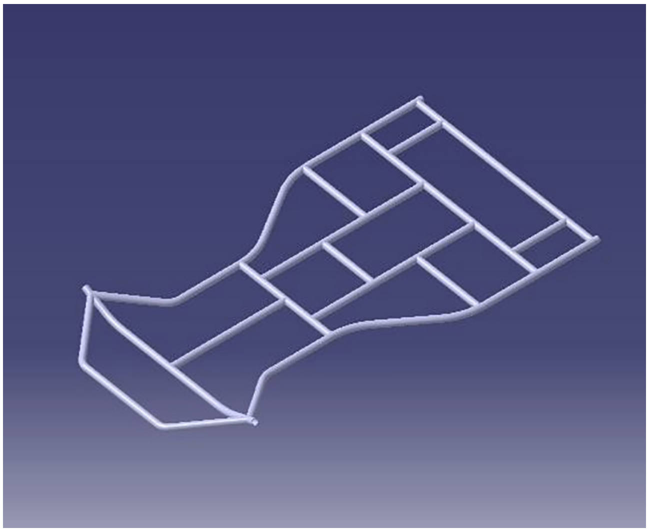

Fig. 1. Isometric view of frame.

WORKBENCH 16.2 software. To conduct finite element analysis of the chassis a CAD model of the designed chassis was uploaded from SOLIDWORKS 2016, the stress was calculated by simulating different induced load cases.

The load cases simulated were:

1. Front impact
2. Rear impact
3. Side impact

2.3.1. Pre-Processing

Meshing
Mesh quality: Fine mesh
No. of Nodes: 304,369
No. of Elements: 124,866
Fig. 2.2.

2.3.2. Calculations

The impacts are purely elastic collision and the velocities for the impact test were taken according to International Journal for Mechanical and Industrial technology.

$$F = M \times A$$

$$A = (V - U)/T$$

$$Factor\ of\ safety\ (FOS) = Yield\ stress/Working\ stress$$

Where,
F – Impact force applied on the vehicle
m – Mass of the vehicle with driver (120 kg + 60 kg = 180Kg)
a – deceleration (negative acceleration)
u – Initial velocity
v – Final velocity
t – Collision time

2.3.3. Front impact

The impact force at a speed of 60 km/hr for a collision time of 1.05secs in the front region of our frame by applying constraints at the rear end. Since,

$a = (60–0)/1.05$
$= (60 \times 1000)/(60 \times 60 \times 1.05)$
$= 15.87\ m/s2$
Therefore,
$F = 200 \times 15.87 = 3174\ N$

2.4. Result

Fig. 2.3, Fig. 2.4, Fig. 2.5, Fig. 2.6.

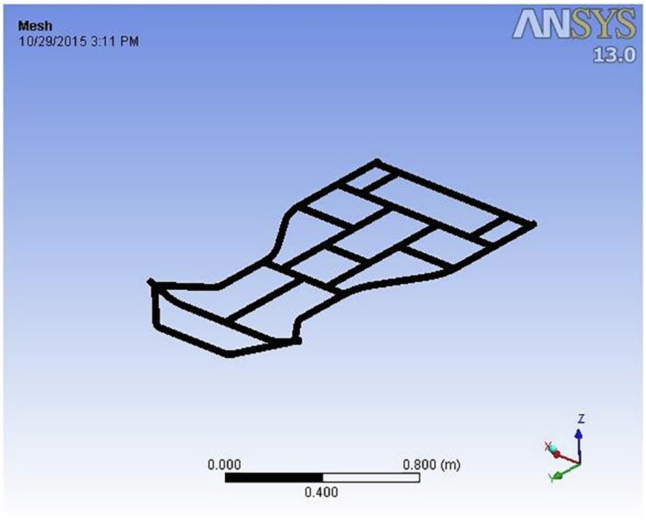

Fig. 2. Meshed view of frame.

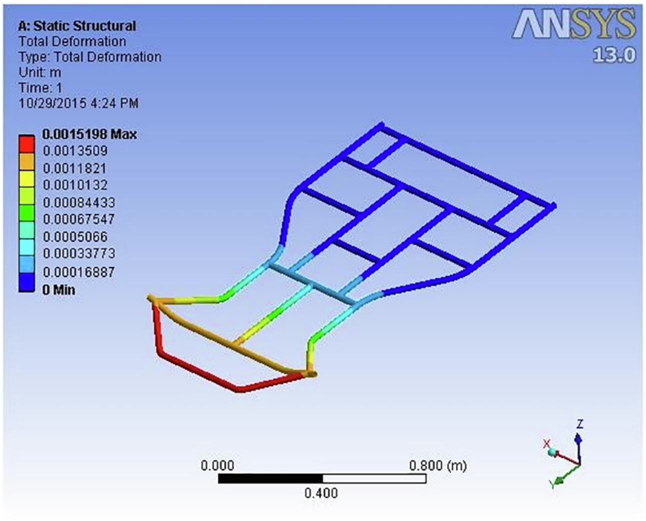

Fig. 3. Total deformation of front impact.

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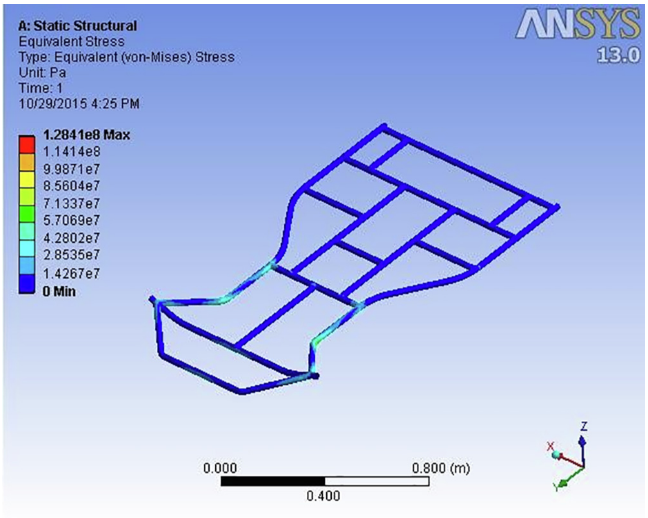

Fig. 4. Equivalent stress of front impact.

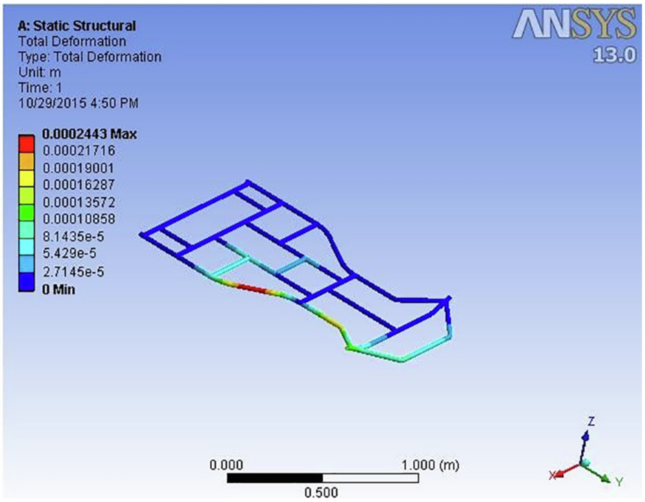

Fig. 5. Total deformation of side impact.

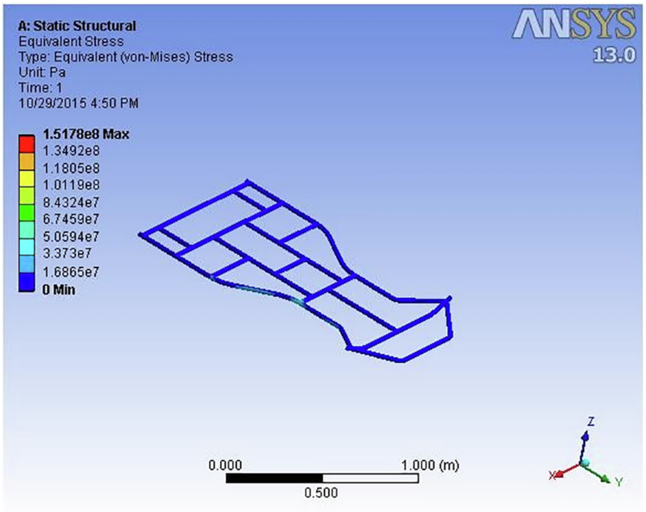

Fig. 6. Equivalent stress of side impact.

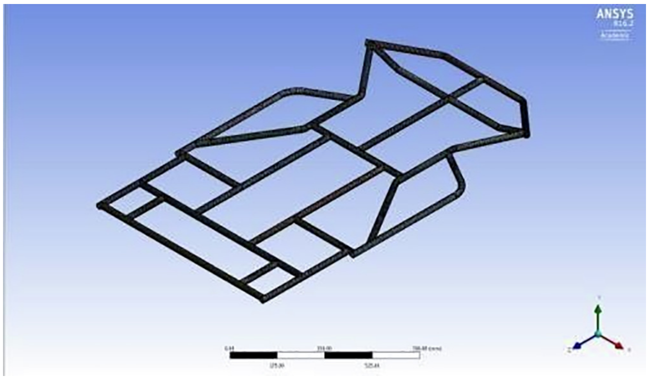

Fig. 7. Meshed view of frame.

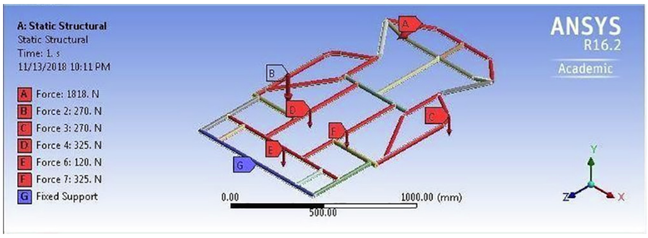

Fig. 8. Load acting on the frame in front impact.

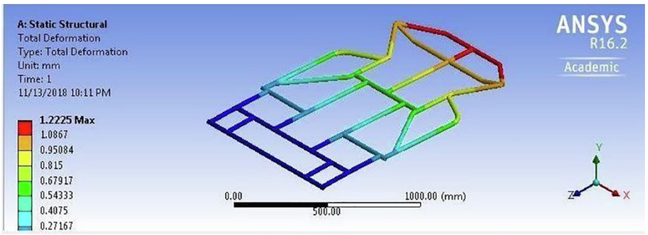

Fig. 9. Deformation due to front impact.

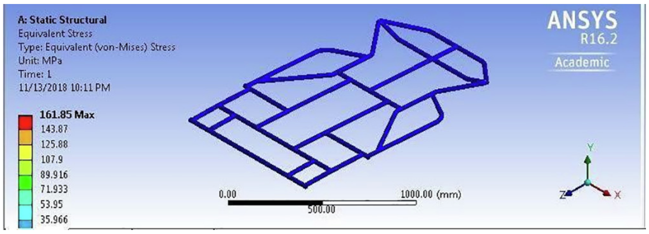

Fig. 10. Equivalent stress due to front impact.

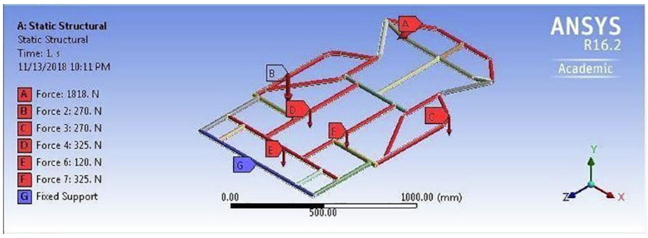

Fig. 11. Load acting on the frame at rear impact.

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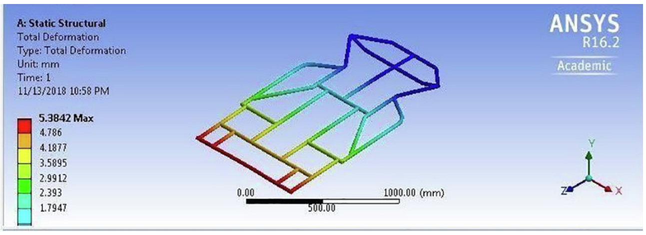

Fig. 12. Deformation due to rear impact.

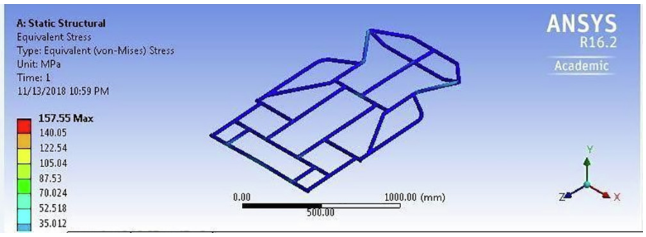

Fig. 13. Equivalent stress of rear impact.

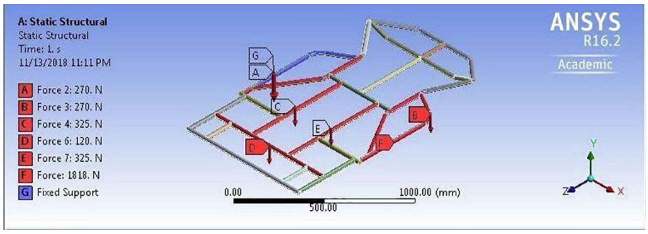

Fig. 14. Load acting during side impact.

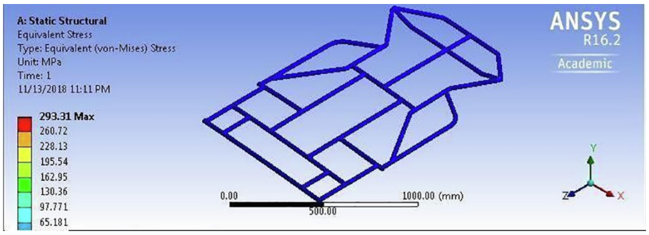

Fig. 15. Equivalent stress due to side impact.

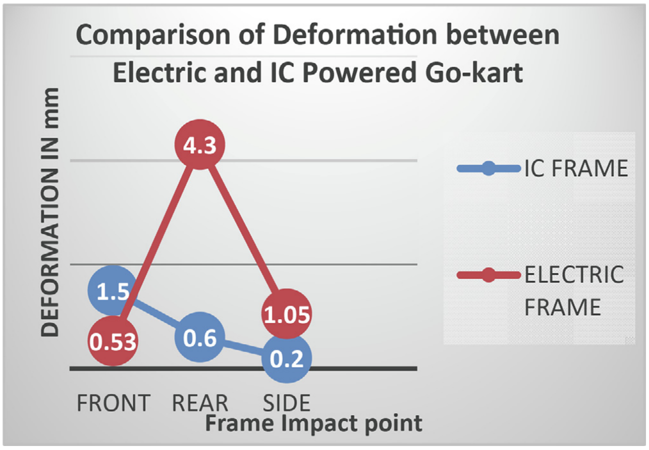

Fig. 16. Graph of deformation of IC and electric Go-Kart frame.

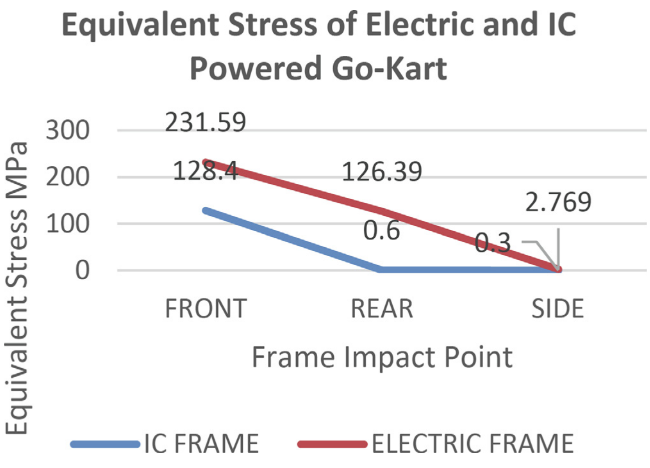

Fig. 17. Graph of equivalent stress of IC and electric frame.

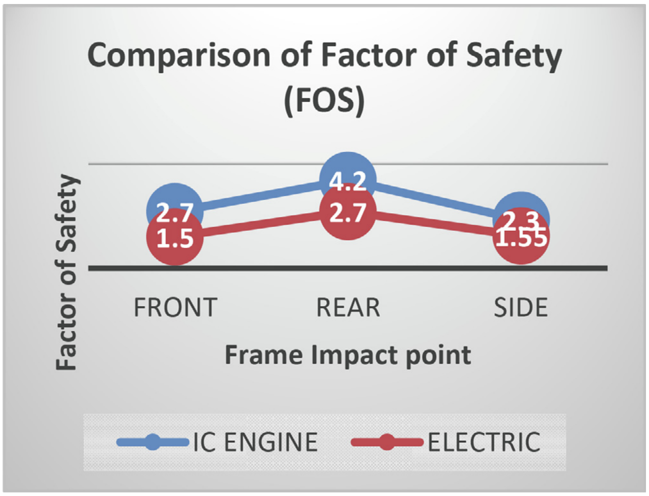

Fig. 18. Graph for FOS of IC and electric vehicle.

2.4.1. Results for Electric vehicle frames

Fig. 2.7, Fig. 2.8, Fig. 2.9, Fig. 2.10, Fig. 2.11, Fig. 2.12, Fig. 2.13, Fig. 2.14, Fig. 2.15.

3. Conclusion

To convert an IC engine powered Go-Kart into Electric powered Go-Kart there are a lot of parameters to be considered like in this case the battery chosen is Lead acid battery where the load of the battery is to be considered along with Electric motor which increases the vehicle load as well, so the frame is bit heavier in this case. When the deformation of the vehicle is compared due to less weight the Conventional IC powered has shown less deformation, which decreases linearly from Front, rear and then on to the side. But the deformation on the front is less for the Electric than the IC powered Fig. 3.1, also the equivalent stress is less for IC powered by considering all the three impacts Fig. 3.2. Even though the Electric go-kart has been heavier compared to the IC the frame design is proved to be safe with a factor of safety nearly equal to 2 which is shown in the graph Fig. 3.3.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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