IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 6, Issue 9, March 2026

Impact Factor: 8.2

A Numerical Investigation of Go-Kart Chassis Design and Structural Integrity

Reeti Mukherjee[1], Manikanta Kalumuri[2], Kanneboina Rishi Chandra[3], Nitin Kumar Mamidi[4]
Assistant Professor, ACE Engineering College, Ghatkesar, India[1,5]
Students, ACE Engineering College, Ghatkesar, India[2,3,4]
ritu1433@gmail.com, kalumuri.manikanta18@gmail.com
rishithandrakanneboina@gmail.com, nitz246@gmail.com
Correspondence: ritu1433@gmail.com

Abstract: *The go-kart chassis is the primary load-bearing structure responsible for ensuring driver safety, durability, and overall vehicle performance under dynamic racing conditions. It must withstand severe impact, torsional, and vibrational loads while maintaining minimal weight and high rigidity. In this study, a rulebook-compliant go-kart chassis was designed using AISI 4130 steel tubing due to its excellent strength-to-weight ratio, weldability, and suitability for lightweight vehicle structures. A complete three-dimensional model of the chassis was developed based on ergonomic considerations, steering geometry, wheelbase, ground clearance, and component packaging requirements. The structural behaviour of the chassis was evaluated using the Finite Element Method in SolidWorks simulation. Frontal, side, rear, torsional, and bump load cases were applied with appropriate constraints at the wheel contact points to replicate real racing conditions. Static structural analysis was carried out to obtain Von Mises stress, total deformation and factor of safety. The simulation results showed that the maximum stresses in all loading scenarios were well below the yield strength of AISI 4130, and the corresponding deformations were minimal, indicating sufficient stiffness and structural stability of the chassis for competitive go-kart applications*

Keywords: AISI 4130 Steel, Finite Element Method (FEM), Structural Analysis, Impact Load Analysis, Torsional Stiffness, Static Structural Analysis, Von Mises Stress, Factor of Safety, Lightweight Vehicle Structures

I. INTRODUCTION

The chassis is the primary structural element of a go-kart, responsible for ensuring structural integrity, driver safety, and vehicle stability during high-speed operation. Since go-karts are typically manufactured without a suspension system, all dynamic loads, vibrations, and impact forces arising from braking, cornering, and track irregularities are transmitted directly to the chassis. Therefore, the frame must be capable of withstanding frontal, lateral, rear, and torsional loads while maintaining minimal weight to enhance acceleration, handling characteristics, and overall racing performance.

II. METHODOLOGY AND MATERIAL

The design and structural evaluation of the go-kart chassis were carried out using a systematic approach involving computer-aided design, analytical calculations, and finite element analysis. Initially, the chassis geometry was developed using **SolidWorks CAD software**, where a space-frame structure was created using circular AISI 4130 steel tubes. The design followed motorsport safety guidelines and aimed to achieve an optimal balance between lightweight construction and structural strength. Proper placement of structural members and triangulation was incorporated to improve rigidity and load distribution.

DOI: 10.48175/IJARSCT-32719

After completing the CAD model, the chassis was imported into the SolidWorks Simulation environment for finite element analysis. Material properties corresponding to AISI 4130 steel were assigned to accurately represent real structural behaviour. Boundary conditions and loading scenarios representing realistic racing conditions were then applied. Three major structural tests were performed: torsional stiffness analysis, vertical bending analysis, and impact analysis (front, side, and rear).

For torsional analysis, an equivalent load representing vehicle weight was applied diagonally to simulate chassis twisting during cornering. Vertical loads were applied to evaluate bending deformation caused by the driver and vehicle components. Impact loads were applied to assess crash safety and structural resistance. Mesh generation was performed to discretize the model, and simulation results were obtained in terms of deformation, von Mises stress, and factor of safety to evaluate chassis performance.

2.1 Design of the chassis

The vehicle chassis is constructed using thick metal tubing arranged in a space frame structure. The tubes are positioned in a triangulated pattern with intersecting nodes, which improves structural rigidity and distributes loads effectively, reducing deformation under operating conditions. The chassis material used is AISI 4130 steel (chromoly), known for its high strength-to-weight ratio, toughness, and durability, making it suitable for high-performance automotive applications. This material also offers good fatigue resistance, ensuring long-term reliability. The tubes are joined using Metal Inert Gas (MIG) welding, a process that uses a continuous wire electrode and shielding gas to produce strong, clean welds, ensuring stable joints and maintaining overall chassis strength and safety.

2.2 Chassis Thickness

Chassis thickness is a fundamental design parameter that directly impacts the performance, safety, and durability of a go-kart. It must balance rigidity to maintain structural integrity under loads and flexibility for improved handling. Key factors influencing thickness include material properties (yield strength, fatigue resistance), load types (static, dynamic, impact), and safety requirements.

2.3 Calculation of the Chassis

The Calculation of the Chassis of the Go kart was done in the MATLAB by preparing the required code.
By the MATLAB code we have found the value of the d, t which has been given in the section below.

Calculations

Total weight of kart =200Kg
Dynamic weight balance of kart
Front axle supports 30% of the total weight
= 60Kg = 686.48N
Rear axle supports 70% of the total weight =140Kg =1373.4N
Longest straight segment in chassis=1525 mm
Suppose External diameter =D=25.4mm Inner diameter =d=?

Code 1: MATLAB code to find d & t

```
% Input parameters
rear_axial = 686.48;    % Rear axial load (N)
l = 1000;               % Shaft length (mm)
Ultimate = 670;         % Ultimate stress (MPa)
FOS = 1.7;              % Factor of safety
D = 25.4;               % Outer diameter (mm)
```

```
% Bending moment calculation (simply supported beam, max at center)
M = (rear_axial * l) / 2;
% Material and geometry calculations
sigma = Ultimate / FOS;
Y = D / 2;
I_req = (Y * M) / sigma;
k = 3.141 / 64;            % π/64 for moment of inertia
% Solve nonlinear equation: I = k*(D^4 - d^4)
d = fzero(@(d) I_req - k*(D^4 - d^4), 10);
t = (D - d) / 2;           % Pipe thickness (mm)
% Display complete results
fprintf('Bending Moment M = %.0f N-mm\n', M);
fprintf('Allowable Stress σ = %.2f MPa\n', sigma);
fprintf('Required I = %.2f mm^4\n', I_req);
fprintf('Core Diameter d = %.2f mm\n', d);
fprintf('Thickness of the pipe t = %.2f mm\n', t);
```

Output of the Code

```
Bending Moment M = 343240 N-mm
Allowable Stress σ = 394.12 MPa
Required I = 11060.52 mm^4
Core Diameter d = 20.90 mm
Thickness of the pipe t = 2.25 mm
```

The standard pipe thickness of 2.25 mm is not available, so a pipe with a thickness of 2.00 mm has been selected instead.

The pipe size of the selected was
D = 24.5mm,
d= 20.90mm,
t= 2.00mm

2.4 Material Selection

High Strength-to-WeightRatio:

AISI 4130 offers high yield and tensile strength while remaining lightweight, which is critical for improving acceleration, handling, and overall kart performance.

Excellent Fatigue Resistance:

Go-kart chassis experience repeated cyclic loads due to vibrations, cornering, and impacts. AISI 4130 has superior fatigue strength, ensuring long service life without failure.

GoodWeldability:

The material can be easily welded using MIG welding with minimal risk of cracking, ensuring strong and reliable joints throughout the chassis.

High Toughness and Impact Resistance:

It absorbs impact energy effectively during frontal, side, and rear collisions, improving driver safety.

Dimensional Stability Under Load:

AISI 4130 maintains structural integrity under high torsional and bending loads, which helps preserve steering geometry and handling characteristics.

Industry Proven Material:
Widely used in aerospace structures, racing frames, roll cages, and motorsport applications due to its reliable mechanical performance.

Good Corrosion Resistance (with coating):
When properly coated or painted, it provides long-term resistance to corrosion in outdoor racing conditions.

Table 1: Material Properties of AISI 41030

S.No	Property	Values In Metric
1	Density	7.85 g/cc
2	Tensile strength, ultimate	560–700 MPa (annealed)
3	Tensile strength, yield	435 MPa (annealed)
4	Bulk modulus	140 GPa
5	Shear modulus	80 GPa
6	Modulus of elasticity	205 GPa
7	Poisson's ratio	0.29
8	Hardness, Brinell	197 HB
9	Hardness, Rockwell B	92 HRB
10	Hardness, Rockwell C	23–25 HRC

Table 2: Composition of AISI 4130 Steel

S.No	Element	Content %
1	Iron, Fe	97.0–98.5
2	Chromium, Cr	0.8–1.1
3	Manganese, Mn	0.8–1.0
4	Carbon, C	0.28–0.33
5	Silicon, Si	0.15–0.30
6	Molybdenum, Mo	0.15–0.25
7	Sulphur, S	0.04 max
8	Phosphorus, P	0.035 max

III. DESIGN OF THE GO KART CHASSIS

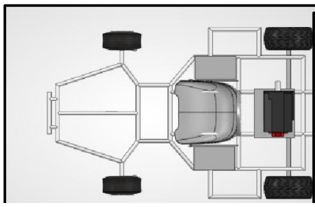


Figure 1: Top view

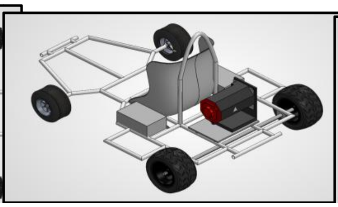


Figure 2: Isometric view

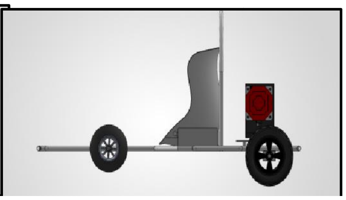


Figure 3: Side view

Figure 1 shows the Top view of the Chassis,Figure 2 show the Isometric view of the Chassis&Figure 3 show the Side view of the Chassis

The wheelbase is specified as to be **1025 mm** and the front track width is **1000 mm**, and the rear track width is **1300mm**.

The total length of the chassis is **1700 mm**. The total width of the chassis is **1300 mm**. The total height of the chassis is **700 mm**.

3.1 Analysis of the chassis

The analysis of the chassis involves evaluating the forces and moments acting on its structural components, along with the corresponding reactions induced under various loading conditions. This evaluation is classified as a static structural analysis, where the primary objective is to assess the stress distribution, deformation, and overall structural integrity of the chassis During vehicle operation, the chassis is subjected to various external and internal forces. These forces, including gravitational loads from the vehicle's weight, dynamic forces from acceleration and braking, lateral loads during cornering, and vertical loads caused by road undulations, are collectively analysed as the loads acting on the chassis. This analysis ensures the structural integrity, stability, and load-bearing capacity of the chassis under real-world operating conditions.

3.2 Load Calculations

3.2.1 Force acting during the torsional test

The force acting upon the chassis during the torsional test is torque. The torque applied is the product of the amount of load applied during the dynamic bump condition times the horizontal length from the point of application.

Torque applied = load applied × perpendicular distance

$T= P \times L$

$T= Mg \times L$

$T = 200 \times 9.81 \times 1.1$(total mass X perpendicular length)

$T= 2158$ N-m

3.2.2 Static stability factor

The static stability factor is the factor through which the stability of the vehicle is determined. The lower the value of factor, the higher the risk of rolling it over when turned at higher speeds. The roll factor determines the handling and dynamic characteristics of the vehicle. It is determined by the formula,

SSF = track width / 2 X height of C.G from the ground.

$SSF= T/2H$

$SSF= 1 / 2\times0.3$

$SSF = 1.66$ (Good Stability)

3.2.3 Crash testing

Crash testing is an integral process in evaluating the safety performance of go-karts, ensuring effective occupant protection during collision events. These simulations replicate real-world impact scenarios, allowing engineers to assess dynamic forces, energy dissipation, and structural integrity under various load conditions. Key tests, such as frontal, lateral, and rear end collisions, assess distinct safety parameters to ensure the driver's protection across multiple collision modes. These evaluations are conducted in alignment with the stringent protocols outlined by the Japan New Car Assessment Program (JNCAP). The simulations are executed using advanced finite element analysis (FEA) techniques in SolidWorks software, which enables detailed Modeling of the go-kart's response to impact loading.

Based on the **(JNCAP)**standards, the impact velocities are set at 62 km/h for frontal impact, 55 km/h for side impact , and 32 km/h for rear-impact.

3.2.4 Frontal Impact

Calculate Kinetic Energy (KE)

$KE= 1/2\ mV^2$

Mass (m): 200 kg (go-kart + driver)

Initial velocity (v): 17.236 m/s (approximately 64 km/h)

Final velocity (vf): 0 m/s (post-impact, the go-kart comes to rest)

Impact time (t): 1 s (time taken to stop during the crash)

$KE= 1/2\times(200\times(17.22)^2) = 29652.84$ J

The force experienced during the font impact is calculated Using the impulse-momentum equation

DOI: 10.48175/IJARSCT-32719

F ×t= Δp

Where: Δp = change in momentum $(pi - pf)$ where p=m×v = is momentum (mass times velocity)

m× v=200×17.77 = 3554 k/g ×m/s

F= 3554/1 =3554N

3.2.5 Side Impact

KE= 1/2 mV^2

KE= ½×200× $(15.27)^2$ =23317.29 J

The force experienced during the font impact is calculated Using the impulse-momentum equation F ×t= Δp

Where: Δp = change in momentum m× v=200×15.27 = 3054 k/g ×m/s

F= 3054/1 =3054N

3.2.6 Rear Impact

KE= 1/2 mV^2

KE= ½×200×$(8.88)^2$ =7885.44 J

The force experienced during the font impact is calculated Using the impulse-momentum equation

F ×t= Δp

Where: Δp = change in momentum

m× v=200×8.88 = 1776 k/g ×m/s

F= 1776/1 =**1776N**

3.3 Calculating kinetic energy (KE)

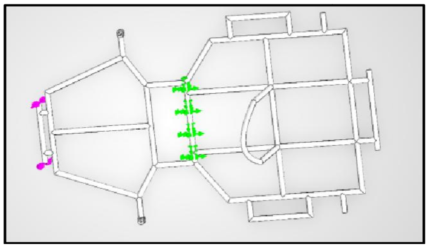
Crash testing is essential for assessing a vehicle's safety performance. Kinetic energy represents the energy a vehicle possesses due to its motion, and during a collision, this energy is transferred to the vehicle's structure and occupants. Understanding how this energy behaves during a crash helps engineers design vehicles that minimize injury risks. In crash testing, KE is a critical factor in evaluating the severity of an impact. It allows engineers to determine the amount of energy that needs to be dissipated during a collision. By using energy-absorbing features like crumple zones, seat belts, and airbags, engineers aim to reduce the forces transferred to the occupants. Calculating KE helps assess the effectiveness of these features in mitigating injury risks. Furthermore, calculating KE during various impact tests (front, side, and rear) allows for the optimization of vehicle designs. It helps identify areas requiring reinforcement and ensures that the structure absorbs the right amount of energy to protect the driver. All structural analyses of the chassis are performed through simulations in SolidWorks software.

Torsional test
Bending test
Frontal impact test
Side impact test
Rear impact test

3.3.1 Torsional Test

The torsional stiffness of the chassis is analysed using advanced finite element analysis (FEA) to simulate real-world conditions with precision, in this test, a torsional load is applied as a couple on the front members of the chassis, replicating the forces experienced during cornering or uneven loading. The applied force is equivalent to the total weight of the vehicle, assumed to be **200 kg**, translating to a force of **2158 N-m**.

DOI: 10.48175/IJARSCT-32719



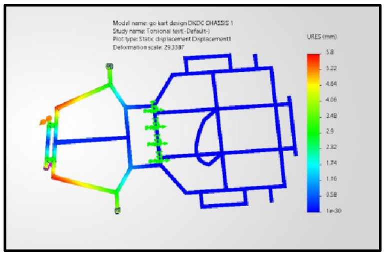


Figure 5: Fixed support and Couple Figure 6: Deformation during force for torsional torsional test

Figure 5 shows the fixed support and the couple of forces for torsional &Figure 6 show the deformation of the chassis during the torsional test.

3.3.2 Bending test

Vertical bending strength assesses the chassis ability to sustain gravitational loads from components like the engine, body, drivetrain, and driver. It evaluates the frame's capability to endure the vehicle's total weight without structural failure. Finite Element Analysis (FEA) is commonly used for this assessment. In the FEA setup, the chassis is modelled as a supported beam, with wheel mounting points as fixed supports, and component weights applied as vertical forces. The simulation measures key parameters such as Von Mises stress and safety factors. These insights ensure the chassis can withstand operational loads, maintaining structural integrity and safety under real-world conditions.

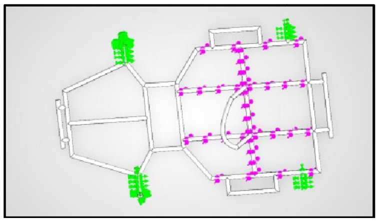


Figure 7: Fixed support Force applied for bending moment

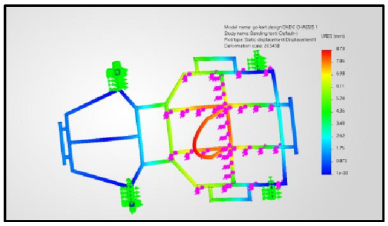


Figure 8: Deformation during bending test

Fix 7 shows the Fixed support and the forces applied for the Bending Moment & Fix 8 shows the Deformation of the chassis during the bending moment.

3.3.3 Front impact test

In the frontal impact test, the rear of the chassis is constrained, and a force equivalent to a collision at 62 km/h is applied to the frontmost structural member. This corresponds to an impact load of approximately 1.756 G of the vehicle's weight, calculated as 3554 N. The analysis provides insight into the structural integrity and deformation behavior of the chassis under frontal impact conditions, ensuring its capability to withstand such forces while maintaining occupant safety.

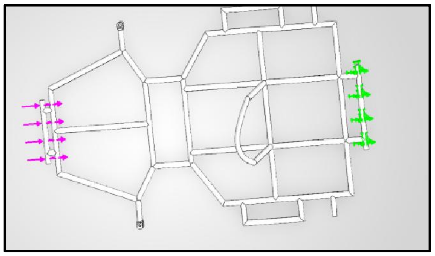


Figure 9: Fixed support and Force acting from front

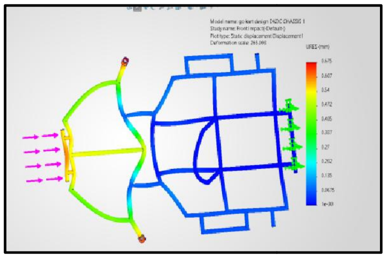


Figure 10: Front Impact – Total Deformation

DOI: 10.48175/IJARSCT-32719

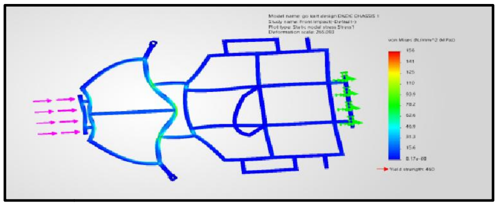


Figure 11: Equivalent Stress

Fix 9 shows the fixed support and the forces acting in the front Impact, Figure 10 shows the Deformation in the Front Impact & Fix 11 Equivalent Stress during the Front Impact.

3.3.4 Side Impact

In the side impact test, one side of the kart chassis is constrained, and a force equivalent to a collision at 55 km/h is applied to the opposite side. This load corresponds to an impact force of approximately 1.55 G of the vehicle's weight, calculated as 3817.5 N. This analysis is essential for evaluating the crashworthiness of the chassis, understanding force distribution during side impacts, and ensuring the structure's ability to reduce injury risk by limiting deformation while effectively absorbing impact energy.

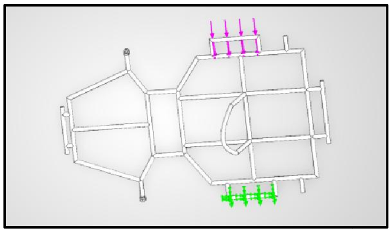


Figure 12: Fixed support and Force acting from side

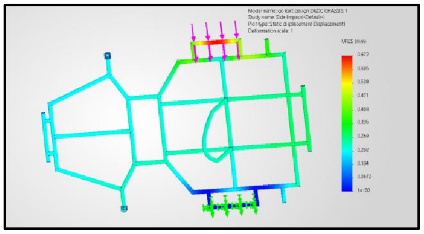


Figure 13: Side Impact – Total Deformation

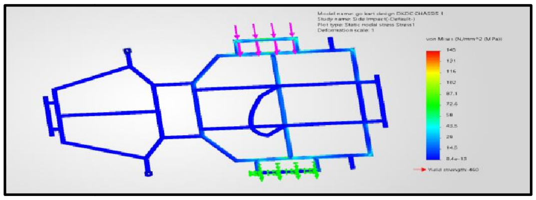


Figure 14: Side Impact-Equivalent stress

Fix 12 shows the fixed support and the forces acting in the Side Impact , Figure 13 shows the Deformation in the Side Impact &Figure 14 Equivalent Stress during the side Impact.

3.3.5 Rear Impact

In the rear impact test, the front end of the kart chassis is constrained, and a force equivalent to a collision at **32 km/h** is applied to the rear structural members. This load corresponds to an impact force of approximately **0.90 G of the vehicle's weight**, calculated as **1776 N**. The simulation evaluates the chassis's ability to absorb and dissipate impact energy, ensuring effective protection for the driver during rear-end collisions. This assessment is crucial for determining the overall crashworthiness of the vehicle and its capability to safeguard the occupant in such impact events.

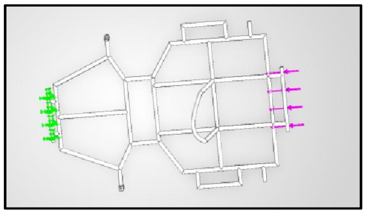


Figure 15: Force acting and Fixed support for rear impact

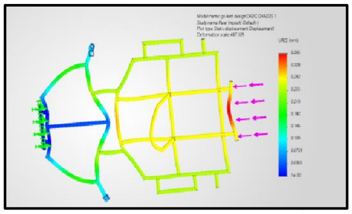


Figure 16: Rear Impact – Total Deformation

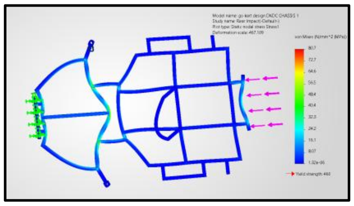


Figure 17: Rear Impact-Equivalent stress

Figure 15 shows the Force acting and the fixed support for the rear impact, Figure 16 shows the Total Deformation for the Rear Impact &Figure 17 Shows the Equivalent stress acting for the rear impact.

IV. RESULTS AND DISCUSSION

The structural performance of the go-kart chassis was evaluated using finite element analysis to examine its ability to withstand torsional, bending, and impact loads experienced during racing conditions. Since go-karts do not have a conventional suspension system, the chassis itself must absorb and distribute dynamic loads, making structural strength and stiffness critical design requirements.

In the torsional stiffness analysis, an equivalent vehicle load of 200 kg producing a torsional moment of 2158 N·m was applied. The simulation showed a maximum deformation of 5.8 mm, indicating adequate torsional rigidity. This level of stiffness helps maintain stable handling, reduces chassis twist during cornering, and ensures proper load transfer between wheels.

For bending analysis, vertical loads representing the motor, battery, drivetrain, and driver were applied. The chassis showed a maximum deformation of 8.73 mm, which is within acceptable limits for a lightweight racing structure, confirming sufficient bending strength.

Impact analyses were performed for frontal, side, and rear loading conditions. The frontal impact produced a stress of 89.8 MPa with a factor of safety (FOS) of 5.122. The side impact showed the highest stress of 167 MPa with an FOS of 2.75, while the rear impact produced 52.8 MPa with an FOS of 2.712. All stresses remained below the material yield strength, confirming that the chassis design is structurally safe and capable of withstanding expected racing loads.

V. CONCLUSION

The work presented here shows the structural design and finite element evaluation of a go-kart chassis intended for competitive racing applications. The absence of a suspension system necessitated careful consideration of impact and dynamic loading conditions, which were addressed through frontal, side, and rear impact analyses using SolidWorks simulation tools.

The results demonstrated that the chassis is capable of sustaining all evaluated load cases with acceptable stress levels and minimal deformation. The calculated factors of safety for frontal, side, and rear impacts were found to be within or above the recommended SAE limits for go-kart chassis design, confirming adequate strength and stiffness of the structure. The rear impact condition exhibited the highest safety margin, while frontal and side impacts remained well within safe operating limits.

DOI: 10.48175/IJARSCT-32719

Overall, the analysis verifies that the proposed chassis design meets structural safety requirements and is suitable for durable and reliable go-kart operation. Future work may include experimental validation, fatigue analysis, and dynamic testing to further enhance the design and correlate simulation results with real-world performance.

REFERENCES

[1] D. Planchard, "SolidWorks 3D CAD," SDC Publications, 2018.

[2] J. Reimpell, H. Stoll, and J. Betzler, "The Automotive Chassis," SAE International, 2011.

[3] S. S. Rao, "The Finite Element Method in Engineering," Butterworth-Heinemann,, 2017.

[4] W. T. Thomson, "Theory of Vibration with Applications," Pearson, 2015.

[5] Rajput, R. K., S. Chand, Strength of Materials, 2010.

[6] X. K. Zhu and J. A. Joyce, " Review of fracture toughness (G, K, J, CTOD, CTOA) testing and standardization," in Engineering Fracture Mechanics, 2012, p. 1–46.

[7] S. A. English, N. K. Arakere, and P. A. Allen, "J–Q characterized stress fields of surface-cracked metallic liners," in Engineering Fracture Mechanics, 2011, p. pp. 2097–2114.

[8] G. V. Guinea, J. Planas, and M. Elices, "KI evaluation by the displacement extrapolation technique," in Engineering Fracture Mechanics, 2000, p. pp. 243–255.

[9] C. Kishen and K. D. Singh,, "Stress intensity factors and fracture criteria for mixed-mode interface cracks," in Engineering Fracture Mechanics, 2001, p. pp. 201–219.

[10] T. Belytschko and T. Black, "Elastic crack growth in finite elements with minimal remeshing," in Int. J. Numer. Meth. Eng., vol. 45, no. 5, 1999, p. pp. 601–620.

[11] R. S. Sharp and D. J. N. Limebeer, "Vehicle dynamics of racing karts,," SAE Technical Paper 2001-01-3555, no. doi: 10.4271/2001-01-3555., 2001.

[12] A. C. Mitra, A. Bhattacharya, and S. Das, "Structural analysis and optimization of go-kart chassis using finite element method,," SAE Technical Paper 2016-28-0205, no. doi: 10.4271/2016-28-0205., 2016.