Impact Analysis of a Go-Kart Chassis: An ANSYS Study

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Abstract - This research paper presents the design, analysis, and optimization of a go-kart chassis constructed from low-carbon steel AISI 1018. The chassis was subjected to three types of impact simulations: frontal, rear, and side. The simulations were conducted using finite element analysis (FEA) in ANSYS to evaluate the chassis's structural integrity and performance under various loading conditions.

Key findings from the simulations include: Frontal Impact: The chassis demonstrated adequate performance, with a factor of safety of 3.7 and maximum equivalent stress well below the material's yield strength. Rear Impact: The chassis exhibited a higher factor of safety (5.35) but experienced significantly higher maximum equivalent stress, suggesting potential areas for reinforcement. Side Impact: The chassis performed well, with a factor of safety of 5.68 and minimal deformation.

Keywords: Chassis Design, ANSYS, impact forces, analysis

1. INTRODUCTION

Go-kart racing, a popular and exhilarating motorsport, has gained significant traction worldwide. The design of a go-kart chassis plays a crucial role in determining its performance, safety, and handling characteristics. A well-designed chassis ensures optimal weight distribution, structural integrity, and driver comfort, ultimately contributing to a competitive and enjoyable racing experience.

This research paper focuses on the design, analysis, and optimization of a go-kart chassis. The objective is to develop a robust and safe chassis that meets the specific requirements of go-kart racing, while also considering factors such as cost-effectiveness and manufacturability. By employing finite element analysis (FEA) and incorporating design principles from existing research, this study aims to provide valuable insights into the development of high-performance go-kart chassis.

Objectives-

The objectives of paper are as follows:

1) The selection of material for chassis.
2) To construct the appropriate chassis for go- kart .
3) To determine the maximum stress concentration areas.

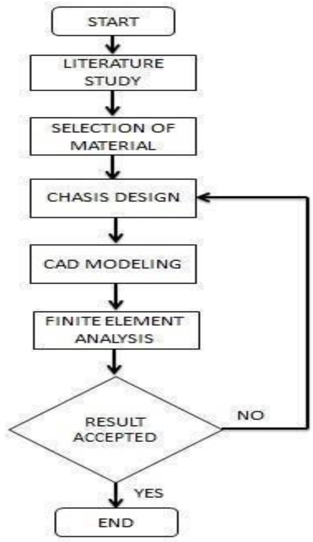


FIG.1 FLOW CHART : PROCESS METHODOLOGY

2. LITREATURE REVIEW

1.Kartik Kelkar et al.: This research paper investigates the modeling and static analysis of go-kart chassis constructed from circular beams, emphasizing their unique structural properties compared to conventional car chassis. Using advanced 3D modeling software, specifically CATIA, the authors create detailed models of the chassis. They then conduct static analysis using ANSYS 14.5 to evaluate the mechanical performance of the chassis under various load conditions. The study focuses on determining the maximum deflection experienced by the chassis when subjected to these loads, highlighting the importance of material selection and structural integrity in achieving an optimal design for racing applications.

2.Virendra S. Pattanshetti: In this paper, the author delves into the critical role of the roll cage in go-kart design, as it serves as the main structural framework that supports key components such as the engine, steering mechanism, and transmission. By employing CATIA V5 to develop a 3D model of the go-kart and its roll cage, the author explores the various forces that act on the vehicle during operation. These forces can lead to significant stress and deformation, making it essential to conduct a Finite Element Analysis (FEA) to identify areas prone to maximum stress concentrations. The paper also includes crash analysis simulations for both front and side impacts, alongside torsion analysis, all performed in Hyper Works 11.0. The design process strictly adheres to the regulatory guidelines established by the NKRC Rule Book, ensuring safety and performance compliance.

3.Sannake Aniket et al.: This study focuses on the modeling and dynamic analysis of a go-kart chassis, specifically designed using circular beams. The authors utilize CREO Parametric for the modeling phase, followed by dynamic analysis in ANSYS. The paper emphasizes the lightweight yet robust nature of the chassis, which is engineered to endure the specific loads encountered in racing conditions. AISI 1018 steel is identified as the optimal material due to its favorable mechanical properties, including high tensile strength and excellent machinability, along with a good balance of toughness and ductility. The authors discuss the implications of these material choices on overall chassis performance and safety.

4.Kiral Lal and Abhishek O. S.: This paper presents an overview of go-karting, describing it as a small, four-wheeled vehicle characterized by the absence of suspension and differential systems. The authors highlight karting as a foundational step in motorsport, accessible to a broad demographic, from children to adults. They discuss the skill development aspects of karting, including enhanced reflexes, precision control, and strategic decision-making, which are vital for competitive racing. Furthermore, the paper reflects on how karting serves as a cost-effective and relatively safe introduction to the world of motor racing, nurturing future drivers for higher levels of competition.

5.Koustubh Hajare et al.: This research focuses on the design and static analysis of a go-kart chassis, highlighting its distinctive features compared to regular vehicle chassis. The authors employ sophisticated 3D modeling software, including SOLIDWORKS and ANSYS, to accurately model the chassis and conduct thorough analyses under various load conditions. The study aims to assess maximum deflection and evaluate the structural integrity of the chassis, with discussions on material strength, rigidity, and energy absorption characteristics. By examining these factors, the authors aim to optimize the chassis design for enhanced performance and safety.

6.Harshal D. Patil et al.: This paper explores the realm of affordable motor sports, focusing on go-karting as an accessible and economical option for racing enthusiasts. The authors detail the design and fabrication of a go-kart that prioritizes high fuel efficiency, driver comfort, and compactness without sacrificing performance. The design process is governed by compliance with the NKRC 2015 rulebook, which influences many of the design parameters. The study encompasses a comprehensive approach, including theoretical calculations, simulations, and analyses of all major components, aimed at optimizing strength, improving vehicle performance, and minimizing manufacturing costs while ensuring serviceability and ease of maintenance.

7.Abhijit Padhi et al.: This project centers on enhancing the safety factor of a go-kart chassis designed in accordance with the regulations of the Go-Kart Design Challenge 2015. Through rigorous theoretical calculations and multiple analyses, the authors present a redesigned chassis that offers improved performance and safety features. The study emphasizes the importance of meeting required safety standards during front impact scenarios, with modifications made to the computer-aided design model to enhance safety without significantly increasing the chassis's overall weight. The paper discusses innovative design optimization methods that maintain the integrity and competitiveness of the go-kart while adhering to regulatory requirements.

3. CHASSIS

The go-kart chassis is a skeletal frame constructed from pipes and other materials in various cross-sections. This frame must be stable, torsionally rigid, and yet flexible due to the lack of suspension. It should also be strong enough to support the weight of the operator and any additional accessories. The chassis design prioritizes both operator convenience and safety. The chassis is designed to ensure a safe ride while withstanding applied loads without compromising structural integrity. A balance between strength and weight is essential, and we recommend using 2mm thick tubing, which can be square, round, or a combination based on your preference. The chosen material should be easily bendable. To enhance frame strength, filler material can be added to notched areas during the welding process.

4. MATERIAL

OPTIONS:- AISI 1018/1020, AISI 4130, AISI 1141 On the basis of required mechanical properties, market availability, price and mechanical engineering practices we selected the following: Material–Grade:AISI1018

Specification of AISI 1018

Table No 1: Specification of AISI 1018

Yield stress	370 N/mm²
Ultimate stress	440 N/mm²
Densit	7800 kgm-3
Poisson's ratio	0.29
Tube specifications	OD= 1.25" (31.75 mm),Thickness = 0.0787" (2 mm)

5. DESING

The chassis design incorporates factors such as safety margins, maximum load capacity, force absorption, required space for accessories and the driver, and specific dimensions. Design software like AutoCAD, SolidWorks, and CREO is used to create the chassis, ensuring uniform load distribution. The structural design provides insights into the chassis's overall structure, while the design process determines the optimal size and shape.

6. MODELING

The 3-D modeling of chassis:

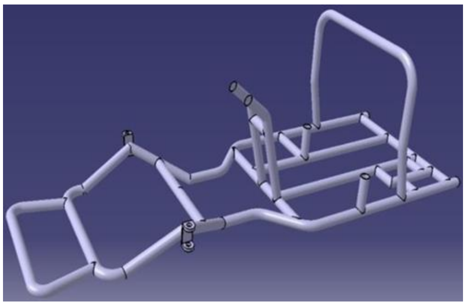


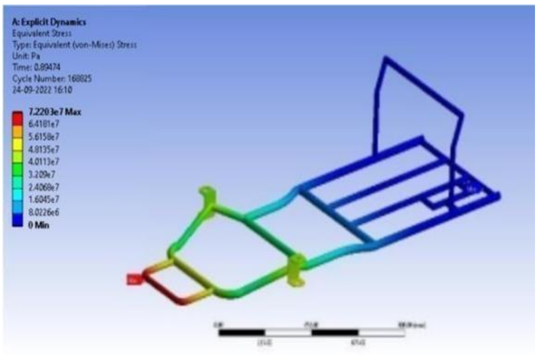
Fig -2: Chassis Model

7. – ANALYSIS

Finite element Analysis:

The structural analysis assesses the impact force's effect on the chassis. Extreme condition impact force testing determines maximum deformation. The driver cabin frame must resist impact forces for driver protection. Analysis can evaluate and improve driver safety.

7.1 Front impact 3G force implemented:
F.O.S = 3.7



Weight of the vehicle(kg)	170	Time of impacts(s)	1.5
MaximumForce (kN)	4.4	Maximum Force(g)	5
Maximum EquivalentStress (MPa)	7.2		
Maximum Deformation(mm)	0.717		

7.2 Rear impact 3G force implemented :
F.O.S = 5.35

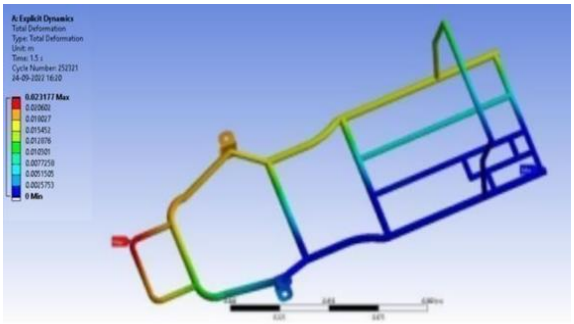


Fig -4: Rear impact

Weight of the vehicle(kg)	170	Time ofimpacts (s)	0.2
Maximum Force (kN)	8.12	Maximum Force(g)	5
Maximum Equivalent		66	

Stress (MPa)	
Maximum Deformation (mm)	0.0519

7.3 Side Impact 2G Force Implemented:
F.O.S = 5.68

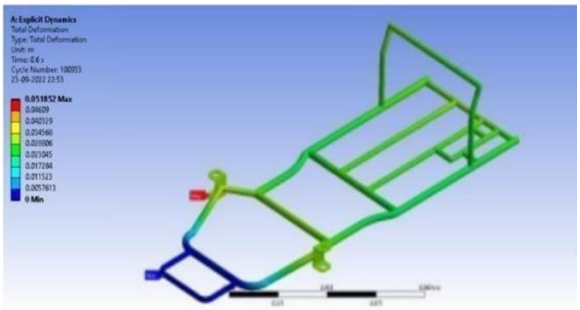


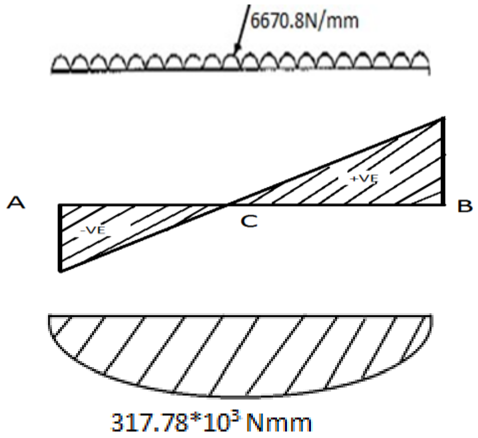
Fig -5: Side impact

Weight of the vehicle(kg)	170	Time ofimpacts (s)	0.2
Maximum Force (kN)	4.06	Maximum Force(g)	2.5
Maximum Equivalent Stress (MPa)		70	
Maximum Deformation(mm)		0.023	

Theoretical Calculations of Chassis

For O.D. =31.75 mm and I.D = 29.75mm, thickness 2mm. Mass of chassis =22.914 kg.
Volume =0.003 mm^2
C.G. of chassis - G_x =24.308 mm, G_y = -910.497 mm, G_z =53.41mmIf consider
Chassis = 30 kg, Driver = 60 kg, Steering = 10 kg, Rear axle & brake = 30 kg, Engine = 30 kg, Fuel tank & battery =10kg

Total weight=170 kg.
Now take total weight of vehicle=170 kg.Front impact=170*4*9.81= 6670.80 N
$R_A + R_B - 6670.8 = 0$
$M_A = 0$
$-R_B*381+6670.8*381/2=0$
R_B=3335.4 N
R_A=3335.4 N
F_{BR} = 0 N
F_{BL}= 3335.4 N
F_{AR}= 3335.4 - 6670.8 = -335.4N
F_{AL}= 0



M_C = 0
M_C=-3335*381/2+17.5*381/2*381/4=0 M_C = -635317. 5+317539.69
M_C = -317.78*10^3N.mm
Now by taking σ_{yield} and calculate,
σ_{yield} =370 N/mm^2
σ_b = M *b* y / I
370 = (317.78*10^3 *15.875)/ (π/64[26.4^4-d_i^4]
18.16 = 4.21*10^6/ (26.5^4-$d_i^{4)}$
D_i=21.355 mm

Thickness=31.75-21.355=5.1975
Check the design for dimensions of pipes available in market that are as follows…
Now for thickness =2mm and d_i=21.355mm,
d_o=31.75mm
d_o=31.75mm
σ_b=317.78*10^3*15.875/ (π/64*[31.75^4-21.355^4])
σ_b=127.156N/mm^2
Working ⍰b < $\sigma_{b\,yield}$.
FOS =370/127.156=2.90

CONCLUSION

The Finite Element Analysis (FEA) shows that the vehicle can sustain 3G force from both the front and rear, and 2G from the sides, with deformation and stress levels remaining within acceptable limits. The roll cage design successfully meets the essential requirements for a go-kart, achieving a low weight-to-strength ratio and reduced ground clearance. Additionally, I have focused on manufacturability to ensure the design is both efficient and straightforward. In conclusion, the roll cage demonstrates strong resilience against frontal, rear, and lateral impacts. The factor of safety is well within a secure range, affirming its suitability for go-kart construction.

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