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Design Optimization of Go-Kart Chassis

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Abstract*—A go-kart, often referred to as a kart, is a type of open-wheel car. It is a small four wheel vehicle used for traditional motorsport racing. They resemble formula cars but are not as swift as they are. Moreover, go-karts are cheaper than any other racing vehicle. The design of a go-kart chassis plays a critical role in its overall performance, including handling, safety, and speed. The goal is to reduce weight while maintaining structural integrity and ensuring safety standards, ultimately enhancing the performance of the go-kart. The approach combines material selection, geometry optimization, and stress analysis to create a high-performance, cost-effective chassis design. The objective is to develop an optimized go-kart chassis that balances performance with safety, manufacturability, and cost. Given that go-karts operate at high speeds and navigate sharp turns, optimizing the chassis for load distribution, weight reduction, and material resilience is critical. The research applies Finite Element Analysis (FEA) to simulate various design iterations, evaluating stress points and deformation under different load scenarios. Through this optimization, the aim is to design a chassis that minimizes weight while maintaining structural integrity, thus improving speed, handling, and safety. The major portion of the design process is to do modelling and perform analysis of the go-kart chassis by using 3D simulation software, SOLIDWORKS. This software helps in the conceptualisation of the design until the final manufacturing of the product. It also lends several benefits like shortened design cycle and increased productivity. The results from this material were taken into consideration as the frame made up of AISI 4130 could yield better results based on the parameters like strength to weight ratio, high tensile strength and machinability, price and availability.

Keywords: **Go-Kart, Chassis Design, Finite Element Analysis, AISI 4130, CAD, Optimization**

1. INTRODUCTION

Go-kart is a simple four-wheeled, small engine, single seater racing car. They were initially created in the 1950s, post-war period by airmen as a way to pass spare time. A go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks, but are sometimes driven as entertainment or as a hobby by non-professionals. Karting is commonly perceived as the stepping stone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available.

Since its inception, go-kart racing has undergone significant change, growing in popularity and serving as a springboard for professional motorsports. A go-kart's chassis is an essential part that has a direct impact on the vehicle's safety, handling, and stability. It determines the kart's overall rigidity as well as its adaptability during turns and under various loads, and it provides the structural support for important parts like the engine, axles, and seat. A go-kart's performance characteristics, such as its speed, handling, and cornering, can be significantly enhanced by an optimized chassis design. A strong yet lightweight chassis can also increase the vehicle's power-to-weight ratio, essential for setting competitive lap times in racing settings.

Weight, structural strength, durability, and manufacturability are some of the factors that must be balanced when designing a go-kart chassis. Conventional go-kart chassis are frequently made of steel tubing, which adds weight but offers the required strength. New avenues for optimizing these designs have been made possible by developments in Computer-Aided Design (CAD) tools and materials science, providing ways to create frames that are both strong and lightweight. Engineers can now dynamically test design modifications and simulate real-world stresses without the need for physical prototypes in the early stages thanks to Finite Element Analysis (FEA) software. An optimized go-kart chassis that satisfies performance and safety standards can be produced by experimenting with various design variations, materials, and stress-relieving techniques.

The main goal of this research is to create a go-kart chassis that is optimized for handling and safety while simultaneously minimizing weight. The analysis focuses on design configurations that improve overall performance, examines load distribution, and compares various materials. This project will find and apply design solutions that satisfy the exacting requirements of go-kart racing all while being economical for possible manufacturing
by using FEA and CAD tools to perform iterative design modifications.

2. METHODOLOGY

The design optimization process for the go-kart chassis is systematic and comprehensive, incorporating both theoretical analysis and practical simulation techniques. The process begins with an extensive literature review of existing go-kart chassis designs, analyzing their structural and material properties, common failure points, and design limitations. This review informs the initial design concept, helping to identify critical design parameters such as chassis dimensions, load-bearing capacity, and ideal material types. With these specifications, a preliminary CAD model of the chassis is created, forming the foundation for subsequent testing and modifications. Parameters such as weight distribution, structural rigidity, and resilience to impact are measured and analyzed. Any discrepancies in the simulated performance are noted for further refinement, ensuring that the final chassis design is reliable, lightweight, and suitable for high-performance racing conditions. The designing process was done by building a 3D sketch on SOLIDWORKS, following which structural members were created using weldments. It experiences torsion, buckling, and axial force. The dimensions used are 29.2x1.65mm (outer diameter x thickness). In this design, there is stress drastically at corners and the manufacturing complex is high. Crash testing simulations included frontal, side, rear, and torsional loads. Assumptions included a 120 kg chassis mass and impact speed of 50 km/h. The FEA revealed AISI 4130 to be the most effective material based on factor of safety and weight considerations.

The go-kart chassis design underwent seven iterations to achieve an optimal balance between structural integrity, weight reduction, and crashworthiness. The first iteration served as the baseline, revealing critical stress points at horizontal joints. The second iteration removed redundant members but compromised safety (FoS < 1). The third and fourth variations explored member removal and repositioning, showing minor improvements but introducing new failure zones. The fifth combined elements from previous versions but remained unsafe under side impact. The sixth iteration, which introduced dual diagonal members in place of a central one, significantly improved load distribution, reduced weight, and achieved the highest factor of safety (1.4), marking it as
the optimal configuration. The seventh provided a viable alternative with slight structural rearrangements but was less efficient than the sixth in handling dynamic loads.

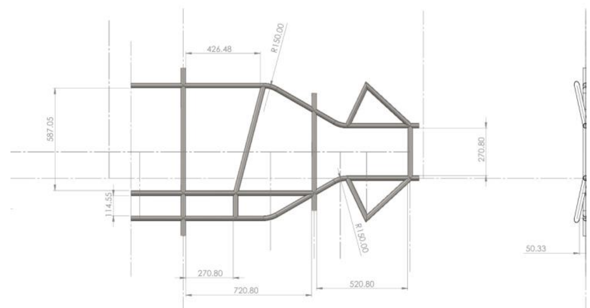

Figure 1 - Base Design

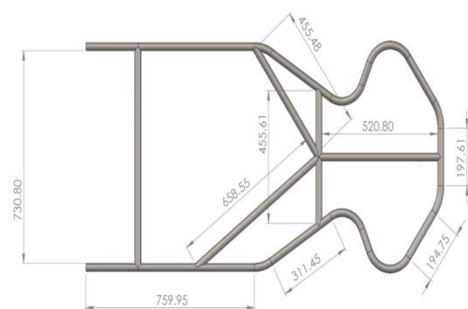

Figure 2 – Optimized Design

Iteration	Max Stress (MPa)	FOS	Failure Point Location	Comment
1	450	1.2	Joint at horizontal members	Baseline configuration.
2	520	0.9	Diagonal member	Unsafe. FOS < 1. This design will not be continued.
3	470	1.1	Near diagonal support zone	Improvement in safety. May be used for structural support ideas.
4	490	1.05	Side impact zone	Slight decrease in safety. Will not be continued.
5	530	0.85	First member (frontal stress)	Unsafe on the left side. Discarded due to FOS < 1.
6	410	1.4	No major failure zone	Safe and optimized. This design will be continued.
7	440	1.3	Rear diagonal junction	Still safe. Alternative candidate; less optimal.

Table 1 - Design Iteration Comparison Table

3. RESULTS AND DISCUSSION

Multiple frame designs were developed and tested. The sixth frame design, which used diagonal members to redistribute stresses, showed the best performance. FEA results confirmed reduced stress concentrations and improved safety margins. Compared to the initial design, the final version showed a mass reduction of ~100g and increased surface area uniformity, leading to better load distribution.

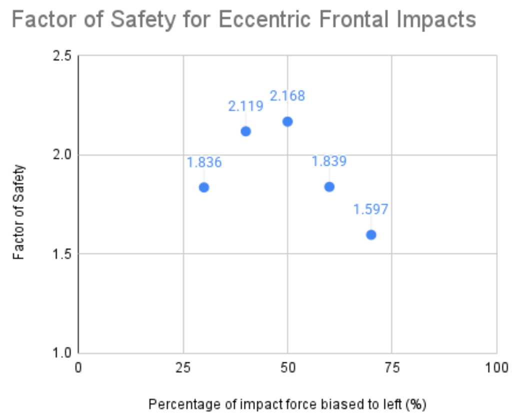

Figure 9.1- FOS before for Eccentric Frontal Impact

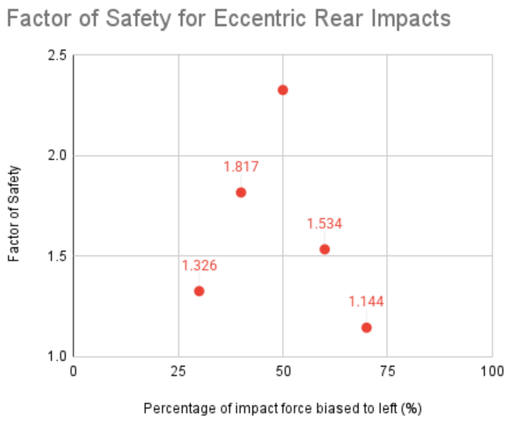

Figure 9.2 - FOS before for Eccentric Rear Impact

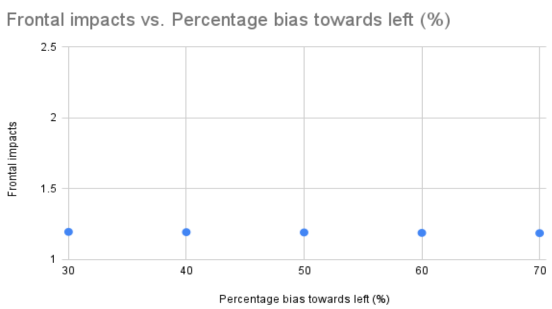

Figure 9.3- FOS now for Eccentric Frontal Impact

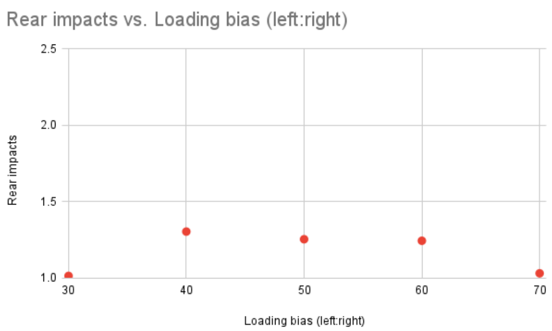

Figure 9.4 - FOS now for Eccentric Rear Impact

4. CONCLUSION

This research demonstrates the significance of iterative optimization in go-kart chassis design. Through FEA-based simulations, an effective design was achieved that enhances safety, performance, and cost-efficiency. AISI 4130 emerged as the most viable material. The designed go-kart is able to withstand against any adverse condition on road as each component is designed specifically considering all types of failures and safety issues; it is the best vehicle for racing on circuit as there is no suspension used in kart roll cage is designed in such a way that it having maximum flexibility in slight twisting motion to accommodate the role of suspension while turning and other twisting motions. Future work may involve the use of composite materials, integration of sensor technologies, and application to electric go-karts.

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