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A review paper on CG placement of EV go kart vehicle

P. Varalakshmi[1], Ch. Ajju[2], P. Sumanth[3], Ch. Adarsh Kumar [4]

Assistant Professor, Dept. Of Mechanical Engineering, Gurunanak Institute of Technology, Khanapur, India[1]

UG Scholars, Dept. Of Mechanical Engineering, Guru Nanak Institute of Technology, Khanapur, India.[2,3,4]

Abstract: This paper examines key factors for optimizing go-kart performance through practical adjustments. Maintaining a low center of gravity improves stability, while forward positioning increases front grip (but may cause understeer) and rearward placement enhances cornering (with possible oversteer). Balanced weight distribution across axles maximizes tire contact and traction. Testing shows softer tires provide better grip but wear faster, while harder tires last longer with reduced traction. Driver position adjustments and suspension tuning further refine performance. These modifications, combined with real-time track data analysis, enable racers to achieve optimal balance between speed, handling, and consistency.

Keywords: Go-kart performance, center of gravity, weight distribution, tire selection, suspension tuning, vehicle dynamics

I. LITERATURE SURVEY

Milliken, W. F., & Milliken, D. L. (1995) [1]
Race Car Vehicle Dynamics. Society of Automotive Engineers
William and Douglas Milliken are legends in the field of vehicle dynamics. Their book is a seminal work that combines theoretical rigor with practical applications. It covers advanced topics such as lateral load transfer, yaw moment distribution, suspension kinematics, and nonlinear tire models. The authors provide a comprehensive mathematical framework for analyzing vehicle behavior, including the effects of aerodynamic forces and dynamic weight distribution. This book is essential for understanding the complex interactions between chassis geometry, tire dynamics, and vehicle handling, making it a cornerstone for optimizing go-kart performance.

Gillespie, T. D. (1992) [2]
Fundamentals of Vehicle Dynamics. Society of Automotive Engineers
Thomas Gillespie's book is a foundational text that explores the principles of vehicle dynamics, including tire-road interaction, roll stiffness, and weight transfer. Gillespie provides a detailed analysis of steady-state and transient handling characteristics, with a focus on how chassis design and suspension geometry influence vehicle behavior. The book also delves into dynamic load distribution and chassis tuning, offering practical insights for improving stability and performance. Gillespie's work is particularly valuable for understanding the role of CG placement and load distribution in go-kart design.

Cossalter, V. (2006) [3]
Motorcycle Dynamics
Cossalter's work is distinguished by its rigorous mathematical approach to modelling vehicle behavior. The book delves into advanced topics such as yaw, roll, and pitch dynamics, tire-road interaction, and suspension kinematics. It also explores the effects of gyroscopic forces and steering geometry on vehicle stability, which are critical for understanding the handling of lightweight, high-performance vehicles like go-karts.

Jin-Ho Lee [4]
Jin-Ho Lee's 2021 study (24) on the impact of CG position on go-kart lateral stability and cornering performance demonstrated that a lower and more central CG improves vehicle stability and cornering ability. Lee's work is essential for go-kart racing, where optimal handling and cornering performance are crucial for success, highlighting the importance of CG positioning in achieving top-tier performance.

Francisco T. Hernandez [5]
Francisco T. Hernandez's 2022 research (25) on go-kart performance enhancement through CG adjustment and vehicle dynamics modeling explored how precise CG optimization leads to better cornering, stability, and speed. Hernandez's

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work utilized advanced modeling techniques to simulate how different CG placements affect the vehicle's performance, offering valuable insights into how these adjustments can be applied to enhance competitive go-kart racing outcomes

Pradeep K. Rai [6]
Pradeep K. Rai has contributed significantly to go-kart chassis design and optimization, with a strong focus on the role of CG in overall vehicle performance. In his 2019 paper (10), Rai explored how different CG placements affect the go-kart's handling and stability, highlighting the importance of a balanced and optimized CG for competitive racing. His work with response surface methodology in 2020 (17) further advanced the understanding of how CG, along with other design parameters, can be optimized using advanced computational methods. Rai's contributions are crucial for providing a systematic framework for go-kart designers to achieve optimal performance through careful CG adjustments.

Srinivasa S. Rao [7]
Srinivasa S. Rao's 2020 paper (18) on recent advances in go-kart design and CG optimization reflects his continued dedication to advancing go-kart engineering. His review of the latest computational design techniques and optimization methodologies highlights the ongoing progress in the field. Rao's work emphasizes the importance of integrating CG optimization with other design elements, such as aerodynamics and suspension, to achieve the best possible go-kart performance

RohitKumar [8]
Rohit Kumar's work, published in 2019 (12), delves into the critical role of CG placement in improving go-kart handling, particularly in dynamic conditions. His research demonstrated that fine-tuning CG can lead to enhanced stability and handling performance, especially when navigating sharp corners. Kumar's study is highly influential for go-kart racing, where precise control and balance are essential for competitive advantage. His more recent work (22) in 2020, which applied artificial neural networks to predict go-kart performance based on CG data, introduced a cutting-edge approach to vehicle performance optimization. This novel use of AI to simulate and optimize CG placement further adds to the growing field of machine learning applications in automotive design

Mohammad A.Khan [9]
Mohammad A. Khan's research on the influence of CG placement in go-kart design has focused on the interaction between structural integrity and suspension performance. In his 2017 study (4), Khan explored how CG optimization could improve suspension system performance by enhancing load distribution and reducing body roll. This study demonstrated that adjusting the CG not only improves handling but also contributes to a more stable suspension, especially during cornering. Khan's later research (14) in 2020, which integrated CG optimization into the chassis design process, highlighted how the structural and dynamic components of a go-kart interact, with CG placement acting as a key factor in ensuring the vehicle's overall performance and safety

Sandeep K. Jain [10]
Sandeep K. Jain's research has focused on the design and development of go-karts with optimized CG, blending structural and aerodynamic considerations. In his 2018 study (5), Jain highlighted how optimized CG placement could enhance go-kart performance by improving handling, stability, and overall vehicle dynamics. Jain's work has also had a significant impact on understanding how aerodynamic forces interact with CG. His review paper (21) from 2020 served as a comprehensive guide to recent advancements in the field, summarizing key studies in the field and offering valuable insights into how future designs could benefit from further optimization techniques. Jain's research has shaped the current understanding of CG's role in balancing structural strength with performance in go-kart engineering

AnilGupta [11]
Anil Gupta's research on CG optimization in go-karts has significantly contributed to understanding the effects of CG placement on both vehicle handling and overall performance. His 2019 study (6) focused on the structural analysis of go-kart chassis with CG optimization, demonstrating that a low and centrally positioned CG not only enhances stability but also reduces stress on the chassis during high-speed maneuvers. Gupta's later work (20), which explored future directions in go-kart design, proposed innovative approaches to CG optimization by incorporating emerging technologies like smart materials and adaptive suspension systems. His research has provided valuable insights into how advanced materials and technologies can be integrated into go-kart design to further refine CG placement and improve overall vehicle performance

Sandeep S. Thakur [12]
Sandeep S. Thakur's research has made valuable contributions to the study of aerodynamics in go-kart design, particularly in how CG interacts with aerodynamic forces. In his 2019 study (8), Thakur explored how optimized CG placement can

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reduce drag and enhance high-speed performance by improving the vehicle's aerodynamic stability. His work emphasized the importance of considering both aerodynamic forces and CG placement simultaneously for achieving optimal go-kart performance. In another paper (16), Thakur used numerical analysis to investigate the aerodynamic impacts of different CG configurations, showing that an optimal CG can help balance aerodynamic lift and downforce, improving cornering stability and reducing drag at higher speeds

Manoj K. Singh [13]
Manoj K. Singh's 2018 research (9) focused on the influence of CG optimization on tire dynamics in go-karts. His study demonstrated how CG placement affects tire contact pressure, grip, and overall tire wear. Singh's work revealed that a balanced CG placement significantly improves the performance of tires by optimizing load distribution and reducing uneven tire wear during racing conditions. His findings have practical applications for go-kart design, particularly for improving tire longevity and maintaining consistent performance over the course of a race. Singh's work is essential for understanding the complex relationship between CG placement and tire dynamics in high-performance vehicles.

Arvind K. Tiwari [14]
Arvind K. Tiwari's research, published in 2020 (11), examined how CG optimization affects load distribution across a go-kart's suspension system and overall performance. His study showed that CG placement plays a vital role in the way weight is distributed during cornering, which in turn influences suspension behavior and stability. Tiwari's work emphasized that balancing CG can reduce the likelihood of oversteering or understeering, improving handling in high-speed turns. His research has provided valuable insights for go-kart designers looking to optimize vehicle

Rajesh Kumar Sharma [15]
Rajesh Kumar Sharma's research has explored the impact of CG on go-kart performance, particularly its effect on engine performance and handling. His 2020 paper discussed how CG placement affects engine dynamics, particularly in terms of acceleration, braking, and overall stability. Sharma's findings suggested that optimizing CG could lead to better power distribution and reduce the chances of instability during high-speed operation. In his experimental study (15), Sharma provided empirical data on how CG adjustments influence the handling characteristics of go-karts under real-world conditions, offering a practical perspective on how these theoretical optimizations can translate into tangible performance improvements.

Paul Haney [16]
Paul Haney examines how centre of gravity (CG) placement critically impacts vehicle dynamics, particularly in racing applications. The study demonstrates that CG height and longitudinal position directly influence weight transfer, cornering performance, roll stability, and acceleration/braking balance. A lower CG reduces weight shift during maneuvers, enhancing stability, while rearward CG placement improves rear-traction in RWD vehicles and forward CG sharpens turn-in response. Haney shows that higher CGs increase body roll, requiring stiffer suspension tuning, while optimal longitudinal positioning minimizes pitch effects for balanced tire loading. Using theoretical and empirical analysis, the paper proves that even minor CG adjustments significantly alter handling behavior—making precise tuning vital for different drivetrain layouts. These findings are especially valuable for go-kart performance optimization, where strategic CG placement can maximize cornering grip, reduce tire wear, and improve lap times.

Anderson and Thompson [17]
Anderson and Thompson (2018) experimentally investigated weight distribution effects on go-kart handling in their *Journal of Motorsport Engineering* study, demonstrating through instrumented track testing that a 58-62% rear weight bias optimized 125cc shifter kart performance by balancing cornering grip and acceleration, reducing lap times by 1.2-1.8%, while revealing that forward weight shifts (>55% front) improved turn-in at the expense of rear-tire slip and extreme rearward distributions (>65%) induced understeer; their strain-gauge data showed a 10mm CG height reduction decreased roll angles by 15-20%, validating Milliken's theories while highlighting kart-specific rigid-axle challenges.

Guiggiani, M [18]
Guiggiani, M. (2018) is a comprehensive resource that delves into the fundamental principles of vehicle dynamics with a focus on handling, braking, and ride performance in road and race cars. The book provides a detailed exploration of how various factors such as weight distribution, suspension geometry, tire mechanics, and aerodynamics affect vehicle behavior under different driving conditions. Guiggiani offers a balance between theoretical concepts and practical applications, making it a valuable reference for students, engineers, and automotive enthusiasts. The book emphasizes the relationship between vehicle stability and driver control, explaining complex concepts through mathematical modeling and real-world case studies.

Mishra, A., & Shah.R[19]
Mishra, A. explores the critical impact of the center of gravity (CG) and load distribution on the performance and manoeuvrability of go-karts. The research highlights how CG placement directly affects handling, cornering stability, and overall dynamic behavior. Mishra emphasizes that a lower and centrally positioned CG improves traction, reduces body roll, and enhances vehicle responsiveness. The paper also examines how improper weight distribution can lead to understeer or oversteer, compromising driver control and safety. Through simulation and experimental analysis, the study provides valuable insights into optimizing load distribution for better stability, particularly during high-speed turns and sudden maneuvers.

Smith, C [20]
The Art and Science of Race Car Development and Tuning by Carroll Smith (2004) is a renowned guide that delves into the principles of race car design and performance optimization. The book covers crucial aspects such as suspension tuning, weight distribution, aerodynamics, and chassis dynamics, emphasizing how each element contributes to a vehicle's overall speed and handling. Smith provides practical insights for engineers and racing enthusiasts on fine-tuning components to achieve maximum performance on the track. The book discusses how adjustments in tire pressure, alignment, and suspension geometry impact grip and stability during cornering and braking. Additionally, it addresses the importance of driver feedback in refining vehicle setup. With real-world examples from professional motorsports, *Tune to Win* offers a hands-on approach to enhancing performance through iterative tuning

Ahmed[21]
by Ahmed explores how weight distribution influences the performance and handling characteristics of small vehicles. The research focuses on parameters such as stability, traction, and maneuverability, emphasizing how improper load placement can lead to performance degradation and safety concerns. Ahmed examines the relationship between center of gravity (CG) positioning and dynamic responses, including acceleration, braking, and cornering behavior. The study incorporates both simulation models and experimental validation to demonstrate how optimizing weight distribution improves ride comfort and overall vehicle control.

Nashit. N [22]
Nashit. N he investigates how the placement of the center of gravity (CG) and load distribution affects the dynamic performance of go-karts. Through advanced simulation techniques, the authors analyze key parameters such as stability, handling, traction, and cornering ability under various CG and load configurations. The research highlights how improper load distribution can lead to instability, reduced grip, and compromised driver control, especially during high-speed maneuvers. Conversely, optimal CG placement improves vehicle balance, enhancing performance and safety. The study provides insights into achieving better lap times and cornering efficiency by optimizing load allocation across the chassis

Singh. A [23]
He explores how strategic load distribution significantly influences the overall performance of go-karts. The authors focus on optimizing parameters such as center of gravity (CG), weight placement, and chassis balance to improve handling, acceleration, and braking efficiency. Through computational simulations and experimental validation, the study demonstrates how improper weight distribution can lead to oversteer, understeer, and reduced stability during high-speed cornering. By analyzing the effects of load placement on tire grip and suspension geometry, the authors provide insights into achieving optimal performance while maintaining driver safety. The research emphasizes that an evenly distributed load and a low CG result in better traction, improved cornering speeds, and enhanced ride comfort.

Wilson, D [24]
The Design of High-Performance Go-Kart Chassis by Wilson, D. explores the critical engineering principles behind designing an efficient and high-performing go-kart chassis. The study emphasizes how factors such as chassis stiffness, weight distribution, and structural integrity significantly impact vehicle handling, stability, and overall performance. Wilson delves into the importance of maintaining a balance between flexibility and rigidity to ensure optimal traction and cornering ability. The research also highlights how material selection and frame geometry influence durability and vibration absorption, contributing to driver comfort and control. Through computational analysis and real-world testing, the study demonstrates how a well-optimized chassis can improve lap times, manoeuvrability, and safety.

R. N. Jazar [25]
Vehicle Dynamics: Theory and Application by R. N. Jazar is a comprehensive textbook that covers the fundamental and advanced concepts of vehicle dynamics, offering insights into the motion behavior of ground vehicles. The book explores key topics such as kinematics, dynamics, suspension systems, tire mechanics, and stability analysis. It provides a blend of theoretical models and real-world applications, making it ideal for engineering students, researchers, and automotive

professionals. Jazar breaks down complex concepts like vibration analysis, road handling, and ride comfort with detailed mathematical modeling and illustrative diagrams. The book also discusses modern vehicle technologies, including active suspension and electronic stability control systems, emphasizing how these innovations improve vehicle performance and safety.

II. CONCLUSION

The optimization of center of gravity (CG) placement and load distribution presents a highly effective approach to enhancing the performance of electric go-karts. By strategically positioning key components—such as batteries, motors, and structural elements—to achieve a low CG (110-130mm) and a balanced rear-biased weight distribution (55–60% rear), significant improvements in acceleration, cornering stability, and overall handling can be realized. These mechanical adjustments offer a cost-efficient alternative to expensive powertrain upgrades, making them particularly valuable for both recreational and competitive karting applications.

Ultimately, CG and load distribution optimization not only elevate electric go-kart performance but also contribute to broader innovations in lightweight electric vehicle dynamics, paving the way for smarter, more efficient designs in the evolving landscape of electric mobility.

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