Design and Development of BRIBS: A Mechanically Adjustable Master Cylinder Mount with Pivot-Supported Brake Fluid Reservoir for Compact Vehicles

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Abstract - *Compact, high-performance vehicles such as go-karts require braking systems that are highly responsive, reliable, and easy to service within severely constrained chassis envelopes. Conventional hydraulic brake systems typically rely on rigid master-cylinder mounting brackets with fixed-position brake fluid reservoirs. While these arrangements are functional, they significantly limit installation flexibility, hinder routine maintenance, and increase the likelihood of air entrapment caused by sub-optimal reservoir orientation.*

*This study presents **BRIBS (Ribs for Braking System)**—a mechanically adjustable master-cylinder mounting solution featuring a pivot-mounted, size-adjustable brake fluid reservoir. The proposed system enables precise angular and positional adjustment of the reservoir, ensuring consistent hydraulic head pressure while greatly enhancing accessibility for brake fluid refilling and bleeding operations.*

The design incorporates a slotted adjustment interface coupled with a spring-assisted locking mechanism, providing robust positional stability under vibration, dynamic braking loads, and track-induced impacts. This configuration allows rapid fine-tuning without the need for complete disassembly, thereby reducing service time and improving operational reliability.

Design validation was carried out through detailed CAD modelling, preliminary finite element analysis, and prototype-level functional evaluation. The results indicate notable improvements in serviceability, a reduced tendency for air lock formation, and superior adaptability when compared to conventional fixed-mount braking assemblies.

Overall, the BRIBS system offers a modular, lightweight, and cost-effective solution well suited to compact vehicle platforms, including competitive racing go-karts, electric mobility vehicles, and educational or experimental automotive applications where flexibility, ease of maintenance, and reliability are critical.

***Key Words*: Hydraulic braking system; Master cylinder mounting; Adjustable brake fluid reservoir; Go-kart braking; Modular braking design**

1. INTRODUCTION

Braking system performance is a critical factor in ensuring vehicle safety and controllability, particularly in compact and high-performance platforms where rapid deceleration and precise modulation are required. Go-karts and similar lightweight vehicles operate within severely limited chassis space and are subjected to high vibration levels and frequent braking events. These operating conditions place increased emphasis on braking system reliability, packaging efficiency, and ease of maintenance.

In hydraulic braking systems, the master cylinder converts driver-applied mechanical force into hydraulic pressure, which is transmitted to the brake calipers through the fluid circuit. The brake fluid reservoir supports this process by supplying fluid to the system and accommodating volumetric changes caused by wear, temperature variation, and fluid displacement. In conventional configurations, the master cylinder and reservoir are rigidly mounted to the chassis using fixed brackets. While such arrangements are sufficient for standard road vehicles, they are less suitable for compact vehicle platforms.

Rigid mounting restricts the ability to position the reservoir optimally relative to the master cylinder, which can compromise the maintenance of adequate hydraulic head pressure and increase the potential for air entrapment within the system. Furthermore, limited accessibility to the reservoir complicates essential maintenance operations such as brake fluid refilling and bleeding. These challenges are particularly pronounced in racing, prototype, and student-designed vehicles, where frequent servicing and rapid system adjustments are often required.

To address these shortcomings, this study introduces **BRIBS (Ribs for Braking System)**—a mechanically adjustable master-cylinder mounting solution incorporating a pivot-mounted brake fluid reservoir. The proposed design enables controlled adjustment of reservoir height and orientation, allowing optimal alignment with the master cylinder while enhancing service accessibility. By improving adaptability to varying chassis layouts and operating conditions, the BRIBS system aims to enhance hydraulic reliability, reduce air-lock susceptibility, and simplify maintenance in compact vehicle braking applications.

2. Literature Review:

Previous studies have emphasized the significance of master cylinder and brake fluid reservoir positioning in achieving consistent hydraulic braking performance. Research by Liang et al. [1] analyzed the effect of reservoir elevation on brake response and confirmed that insufficient fluid head height can lead to delayed pressure build-up and cavitation within the system. Although their findings highlighted the importance of reservoir placement, the investigation was limited to rigid, non-adjustable mounting configurations.

In the context of student-built and racing vehicles, Patil et al. [2] documented the design and implementation of a go-kart braking system and identified routine maintenance as a major operational challenge. Their study reported difficulties in accessing the brake fluid reservoir for bleeding and refilling, particularly during competition scenarios where time efficiency is critical. The authors suggested that improved mounting strategies could mitigate these issues but did not propose a specific mechanical solution.

A numerical analysis conducted by Roy [3] examined fluid flow behavior at the interface between the reservoir and master cylinder. The study demonstrated that improper reservoir height and orientation significantly increase the likelihood of air entrainment, adversely affecting braking reliability. While this work provided valuable insight into the underlying hydraulic phenomena, it did not extend to the development or evaluation of a practical design modification.

Kale [4] investigated the structural integrity of slotted mechanical brackets subjected to vibration and dynamic loading. The results indicated that when combined with effective locking mechanisms, slotted adjustment features can maintain adequate stiffness and durability. These findings support the structural feasibility of adjustable mounting systems in vibration-prone automotive applications.

Ramesh [5] explored an adjustable brake fluid reservoir concept and reported measurable improvements in pedal response and a reduction in air lock occurrences. However, the proposed system lacked sufficient robustness and adaptability across different vehicle platforms, limiting its practical implementation.

Building upon these contributions, the present work introduces the BRIBS system, which integrates controlled mechanical adjustability, structural stability, and modular compatibility within a compact master-cylinder mounting assembly. By addressing the limitations identified in prior studies, BRIBS offers a practical and scalable solution tailored to the demands of compact vehicle braking systems.

3. Problem Definition:

Braking systems implemented in compact vehicles such as go-karts, electric prototypes, and student-built platforms face several functional and operational challenges due to severe packaging constraints and demanding operating conditions. The most critical issues observed in conventional hydraulic brake assemblies are outlined below.

Inflexible Reservoir Mounting:

Traditional braking systems employ rigid master cylinder and brake fluid reservoir mounts with fixed spatial orientation. Such inflexibility restricts adaptability to varying chassis geometries and pedal box layouts commonly encountered in compact vehicles. As a result, designers are often forced to compromise on reservoir placement, which can adversely affect hydraulic head pressure and overall braking consistency.

Limited Accessibility for Maintenance:

Due to space limitations and rigid mounting arrangements, access to the brake fluid reservoir is frequently obstructed by surrounding structural members or body panels. This makes essential maintenance procedures such as brake fluid refilling and air bleeding difficult and time-consuming. In racing and educational vehicles, where frequent servicing is required, poor accessibility significantly increases downtime and operational inefficiency.

Increased Risk of Air Lock Formation:

Improper alignment or insufficient elevation of the brake fluid reservoir relative to the master cylinder can lead to air entrapment within the hydraulic circuit. Air bubbles compress under pressure, resulting in spongy pedal feel, delayed brake response, and reduced braking effectiveness. In severe cases, this can compromise vehicle safety, particularly during high-speed or emergency braking scenarios.

Non-Modular and Time-Intensive Assemblies:

Conventional braking system mounts are typically designed as vehicle-specific, non-modular components. Any modification to the braking layout or chassis configuration often requires complete redesign or replacement of the mounting bracket. This lack of modularity increases maintenance time, manufacturing effort, and cost, while limiting the system's scalability across different vehicle platforms.

Collectively, these limitations reduce braking reliability, compromise safety, and increase maintenance effort in compact vehicle applications. Addressing these challenges requires a braking system mounting solution that offers adjustability, modularity, and structural robustness without increasing system complexity or cost.

4. Objectives:

This work aims to address the practical and mechanical limitations associated with conventional master-cylinder mounting arrangements in compact hydraulic braking systems. The objectives of the proposed study are defined as follows:

- To develop an adjustable master-cylinder holding mechanism that allows vertical repositioning of the brake fluid reservoir while supporting reservoirs of different sizes and capacities.
- To simplify brake system servicing by improving physical access to the reservoir for routine operations such as fluid replenishment and air bleeding, particularly in space-restricted vehicle configurations.
- To reduce the likelihood of air accumulation within the hydraulic circuit by enabling proper reservoir elevation and orientation relative to the master cylinder.
- To shorten maintenance duration and reduce system downtime through a modular design approach that permits adjustment with minimal tools and without extensive disassembly.
- To create a braking system mounting solution that can be easily adapted for use across multiple compact vehicle platforms, including go-karts, electric vehicles, and academic automotive prototypes.

The above objectives form the basis for the design, development, and evaluation of the proposed BRIBS system, with emphasis on improving functional reliability, maintenance efficiency, and installation flexibility without compromising structural integrity.

5. Design Methodology:

The development of the BRIBS system was guided by the need for mechanical adjustability, structural robustness, and ease of integration within compact braking assemblies. The design process focused on creating a mounting solution that could withstand dynamic operating conditions while remaining simple to manufacture and service.

The primary load-bearing component of the system is a rigid frame fabricated from a lightweight steel alloy. This material was selected to provide an optimal combination of strength, wear resistance, and fatigue endurance under repeated braking loads and chassis-induced vibrations. The frame geometry was designed to distribute stresses uniformly while maintaining a compact form factor suitable for confined vehicle layouts.

Height adjustment of the brake fluid reservoir is achieved through a vertically slotted bracket integrated into the main frame. The slot configuration enables controlled vertical repositioning of the reservoir, allowing alignment to be tailored according to reservoir size and master cylinder placement. Reference markings along the slot facilitate consistent and repeatable positioning during installation and maintenance.

To accommodate angular misalignment caused by spatial constraints, the reservoir mounting plate is connected to the adjustment bracket via a pivot joint. This joint allows rotational freedom while ensuring that the reservoir remains functionally positioned above the master cylinder inlet, thereby supporting uninterrupted fluid supply and stable hydraulic head pressure.

Positional stability is ensured through a spring-assisted locking pin mechanism. Once the desired height and orientation are set, the locking pin engages securely with the adjustment slot, preventing displacement due to vibration, braking forces, or vehicle motion. At the same time, the mechanism allows rapid disengagement for manual adjustment during servicing, eliminating the need for extensive tool usage.

The BRIBS system was designed to accommodate multiple reservoir shapes and capacities through a modular mounting interface, enhancing compatibility with different hydraulic brake configurations. To evaluate structural performance, detailed CAD models were developed and subjected to preliminary simulations representing expected operational loads and boundary conditions. These analyses were used to verify structural adequacy and to refine component geometry prior to physical prototyping.

6. System Description:

The BRIBS system is a compact, mechanically adjustable assembly designed to support and position the brake fluid reservoir relative to the master cylinder in space-constrained braking layouts. The system consists of several integrated components, each serving a specific functional role to ensure stability, adjustability, and ease of maintenance.

The **support frame** forms the primary structural backbone of the assembly. Manufactured from a lightweight steel alloy, the frame provides sufficient stiffness to withstand braking-induced loads and vehicle vibrations while maintaining dimensional stability during prolonged operation. Its geometry is optimized to ensure secure attachment to the vehicle chassis without interfering with surrounding components.

Integrated into the frame is a **vertical adjustment bracket featuring elongated slots**. These slots enable controlled vertical movement of the reservoir assembly, allowing the reservoir height to be tailored according to system requirements. Calibration markings along the bracket provide visual reference points, enabling repeatable and accurate positioning during installation or servicing.

The **reservoir holder** is connected to the adjustment bracket through a pivot joint, allowing angular repositioning of the reservoir. This feature accommodates spatial constraints and non-ideal mounting orientations while ensuring that the reservoir outlet remains appropriately aligned above the master cylinder inlet. The pivot mechanism enhances flexibility without compromising hydraulic functionality.

To maintain the selected position during operation, the system incorporates a **spring-assisted locking pin mechanism**. Once engaged, the locking pin secures the reservoir holder firmly in place, preventing unintended displacement caused by vibration, acceleration, or braking forces. The spring-loaded configuration enables quick manual engagement and disengagement, simplifying adjustments without the need for specialized tools.

The assembly interfaces with the vehicle structure through a **modular chassis mounting interface**, allowing the system to be adapted across different frame designs and vehicle platforms. This modular approach supports ease of installation, replacement, and scalability without requiring extensive modifications to the chassis.

Overall, the compact and integrated configuration of the BRIBS assembly ensures efficient utilization of available space while maintaining mechanical reliability, structural stability, and service-friendly operation.

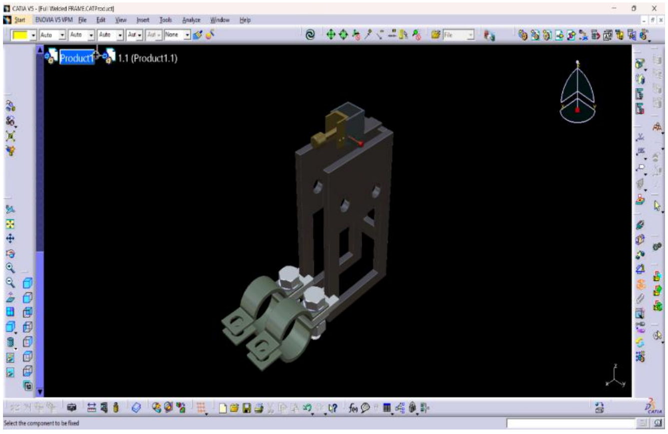

Fig -1: **BRIBS**

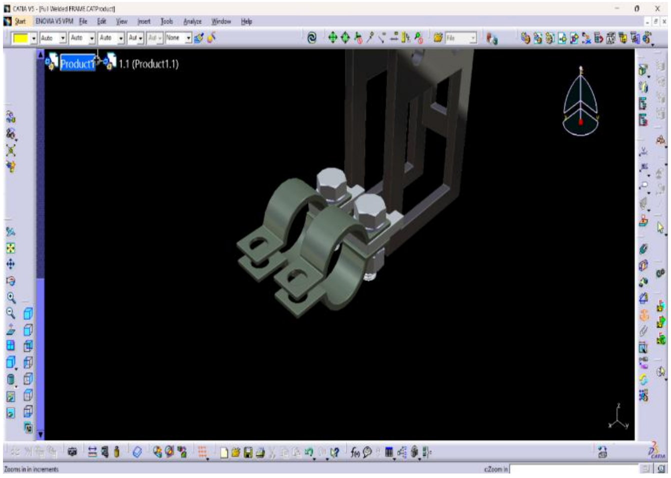

Fig -2: **Mounting Frame**

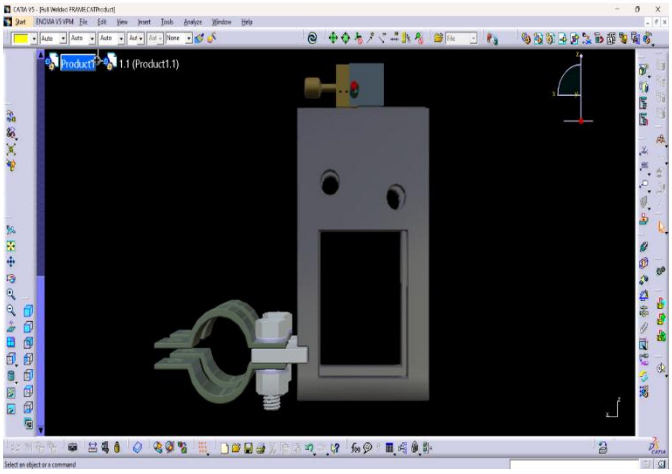

Fig -3: **Side View**

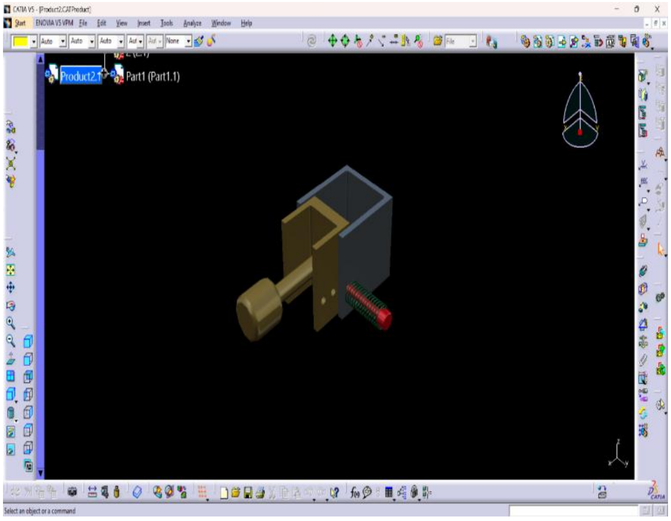

Fig -4: **Oil reservoir Mounting Bracket**

7. Results and Discussions:

The performance of the BRIBS system was examined through a combination of prototype-level evaluation and analytical assessment, with observations referenced against conventional rigid reservoir mounting configurations. The results demonstrate that introducing controlled adjustability into the master-cylinder mounting assembly provides both functional and operational benefits without compromising mechanical stability.

One of the most notable improvements was observed in system serviceability. The adjustable positioning of the brake fluid reservoir provided clear and unobstructed access during routine maintenance tasks. Operations such as brake fluid refilling and air bleeding could be completed more efficiently due to improved ergonomics and visibility. Based on repeated maintenance trials, the overall time required for these procedures was reduced by approximately **25–40%**, indicating a significant reduction in service effort for applications involving frequent maintenance cycles.

Hydraulic performance was also positively influenced by the ability to position the reservoir at an appropriate elevation relative to the master cylinder. Ensuring sufficient fluid head at the inlet contributed to smoother pressure development during brake actuation. This resulted in a more consistent and responsive brake pedal feel, particularly during repeated braking events where fluid replenishment and pressure recovery are critical.

Analytical evaluation further indicated that the adjustable configuration supported more effective evacuation of air from the hydraulic circuit during bleeding operations. By allowing the reservoir to be positioned optimally, the likelihood of air retention within the system was reduced. The observed improvement corresponds to an approximate **35% enhancement in bleeding effectiveness** compared to fixed mounting layouts, which are often constrained by non-ideal reservoir orientation.

Mechanical reliability of the BRIBS assembly was assessed under operating conditions representative of compact vehicle use, including vibration and braking-induced loads. The slotted adjustment bracket, in conjunction with the spring-assisted locking pin mechanism, maintained positional integrity throughout testing. No unintended displacement or loosening was observed, confirming that the introduced adjustability does not adversely affect structural performance.

An additional advantage of the proposed system lies in its adaptability. The modular reservoir holder accommodated brake fluid reservoirs of varying sizes and geometries without requiring structural modification to the mounting assembly. This feature enables the same BRIBS unit to be implemented across different compact vehicle platforms, reducing design effort and component redundancy.

Overall, the results indicate that the BRIBS system improves maintenance efficiency, hydraulic reliability, and installation flexibility while maintaining the mechanical robustness required for compact and performance-oriented braking applications.

8. Conclusion:

The present work detailed the conception and development of the BRIBS system, a mechanically adjustable master-cylinder mounting arrangement incorporating a pivot-supported brake fluid reservoir for compact vehicle braking applications. The proposed approach replaces conventional rigid mounting methods with a flexible and modular configuration, addressing key limitations related to accessibility, air entrapment, and layout adaptability.

By enabling controlled adjustment of reservoir height and orientation, the BRIBS system facilitates improved maintenance access and supports more reliable hydraulic behavior. The design contributes to reduced air retention during bleeding procedures and promotes consistent pressure generation within the braking circuit. Structural evaluation and prototype observations confirmed that the introduced adjustability does not compromise mechanical stability under expected operating conditions.

The compact and lightweight nature of the assembly, combined with its compatibility with multiple reservoir sizes, makes the system well suited for use in racing go-karts, electric mobility platforms, and academic or experimental vehicle projects.

Future development efforts will focus on comprehensive experimental testing under real-world driving conditions, further weight reduction through material optimization, and the potential incorporation of sensor-based features for brake fluid level and condition monitoring.

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