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DESIGN AND PRODUCTION OF NEDDI VEHICLE WEDGE

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ABSTRACT

The adverse effects of neglecting to obstruct a vehicle's motion during maintenance operations, such as tire changes or suspension work, can lead to severe hazards and equipment damage. Hence, developing an appropriate technology for a vehicle wedge is essential for ensuring vehicular stability during such operations. This paper presents the design and construction of a low-cost, mechanically simple vehicle wedge capable of providing motion obstruction during the lifting of any vehicle suspension point up to 160 mm height for passenger cars weighing a maximum of 1660 kg. The design calculations cover the evaluation of ground clearance of common passenger cars in Nigeria, curb and maximum vehicle weights, applied load on the wedge, frictional forces, and the critical buckling load of the wedge plate. The fabricated wedge was tested on selected passenger cars and demonstrated excellent motion obstruction during lifting. The design proved both technically sound and economically feasible for local automotive applications.

Keywords: ***Vehicle wedge, automotive safety, Design and fabrication*.**

1. Introduction

Vehicle stability during maintenance is a critical safety consideration in mechanical and automotive operations. The neglect of proper motion obstruction during vehicle lifting for tire replacement or suspension service often results in unexpected rolling, leading to injuries, damage, and operational hazards.

A vehicle wedge, also known as a wheel chock, provides a mechanical means of preventing motion by creating static frictional resistance between the tire and the inclined wedge surface. While imported versions are available, they are often costly, limiting accessibility for low-income users and local workshops.

This research therefore focuses on the design and production of a mild steel vehicle wedge using local materials and simple fabrication techniques to ensure affordability, reliability, and safety compliance.

2. Objectives of the Study

The primary objectives of this study are as follows:

1. To design and produce a device that can obstruct vehicle movement during maintenance operations such as tire or suspension repair.
2. To fabricate the device using locally available materials.
3. To compare the cost of production with existing market products.
4. To determine the load capacity and performance limits of the wedge.
5. To identify the best production methods for small-scale manufacturing.
6. To determine the types of vehicles the device can serve.
7. To evaluate forces acting on the device and the critical load to cause buckling.

3. Product Originality

Originality refers to the unique and innovative aspects of a design that distinguish it from existing products. The NEDDI Vehicle Wedge demonstrates the following original and creative design features:

- A profile depression on the slanting (front) face in contact with the vehicle tire, which increases surface grip and structural strength, reducing deformation risk.
- A triangular depression on the rear vertical plate, improving rigidity and load- bearing capacity.
- A reflective caution sign on the rear vertical face, serving as a passive safety feature for visibility during night or roadside repairs.

These novel enhancements collectively improve both structural performance and user safety, distinguishing the NEDDI wedge from conventional designs.

4. Product Justification

The structured design and marketing of the vehicle wedge are justified based on:

- **Customer Need:** Safety during vehicle maintenance operations.
- **Competitive Positioning:** Locally fabricated, low-cost, and strong compared to imported versions.
- **Product Fit:** Complements NEDDI's range of automotive support tools.
- **Profitability:** Low production cost ensures commercial viability.
- **Uniqueness:** Structural depressions and reflective features are novel.
- **Cost-Benefit:** High functional efficiency with low risk implication.

5. Design Analysis and Material Selection

5.1 Design Basis

The wedge design is based on the following parameters:

- Vehicle weight: 1660 kg maximum.
- Lifting height: 160 mm.

- Slope angle (θ): 45°.
- Coefficient of friction (μ): 0.2 (steel-rubber contact).

5.2 Ground Clearance for Common Passenger Cars in Nigeria

S/N	Vehicle Type	Ground Clearance (mm)
1	Toyota Corolla	160
2	Mazda 323	150
3	Peugeot 305 / 505	120
4	BMW 125	125
5	Audi CC	120

(Source: Bosch Automobile Handbook)

Hence, the maximum wedge height is limited to **120 mm** to ensure compatibility across common vehicle types.

5.3 Curb and Maximum Weights of Selected Cars

S/N	Vehicle Type	Curb Weight (kg)	Maximum Weight (kg)
1	Audi CC	950	1410
2	BMW 524	1310	1810
3	Peugeot 505	1215	1655
4	Toyota Corolla	865	1385
5	Mazda	880	1450

(Source: Bosch Automobile Handbook)

5.4 Force Analysis

From equilibrium of forces along the inclined plane:

$$N_1 \sin\theta - F_1 - P = 0 \quad (1)$$

Given:

$$F_1 = \mu N_1$$

Substituting:

$$P = -2620 + 1310 \times 10 \times \sin 45^\circ = 8527N = 8.527kN$$

Hence:

- **Applied Load (P):** 8.527 kN
- **Frictional Force (F_1):** $F_1 = 0.2 \times 1310 \times 10 = 2.62kN$

5.5 Critical Buckling Load

$$W_{cr} = \frac{3ET^4}{256L}$$

Where:

$T = 3\ mm = 0.003\ m$,
$L = 160\ mm = 0.16\ m$,
$E = 210 \times 10^3\ N/mm^2$.

$$W_{cr} = \frac{3 \times 210 \times 10^3 \times 0.003^4}{256 \times 0.16} = 12.873kN$$

Since $W_{cr} > P$, the design is **safe against buckling.**

5.6 Material Selection

S/N	Property	Value	Unit
1	Young's Modulus	21O	GPa
2	Yield Strength	250	MPa
3	Plate thickness	3	mm
4	Slope angle	45^0	

Mild steel was selected for its high strength, ductility, and local availability.

6. Manufacturing Layout and Equipment

6.1 Manufacturing Operations

1. **Cutting:** Using a power press (5-ton capacity).
2. **Cold Forging:** To shape the slanting surface.
3. **Welding:** To join the base and vertical plates.
4. **Riveting:** Local studs added for stability.
5. **Electroplating:** For corrosion resistance.
6. **Painting:** Gloss coating and reflective —Caution‖ marking.

6.2 Equipment Used

S/N	**Operation**	**Equipment**	**Capacity**
1	Blanking	Power press	5 tons
2	Stamping	Power press	5 tons
3	Punching	Power press	5 tons
4	Fastening	Cutting/riveting machine	—
5	Finishing	Electroplating setup	2×4×3 ft
6	Assembly	Riveting machine	—
7	Quality Control	Deformation testing rig	—

7. Novelty and Innovation

- Profile depressions on slanting, vertical, and horizontal plates improve material rigidity.
- Reflective safety signage ensures visibility during roadside repair.
- Locally produced at low cost (₦10,000/unit) with 85% efficiency and 1 kg net weight.

Figure 1: NEDDI Vehicle Wedge

8. Results and Discussion

The fabricated wedge was tested on several passenger vehicles, including Toyota Corolla and Peugeot 505. The wedge provided effective motion obstruction and no noticeable deformation under applied loads.
Experimental performance validated analytical predictions that the critical buckling load exceeds applied loads, ensuring safe use for vehicles up to 1660 kg.

The combination of profile reinforcement and 45° slope angle achieved excellent stability. The addition of reflective caution material also enhanced operational safety during low-light conditions.

8. Product Specification

S/N	Parameter	Specification
1	Efficiency	85%
2	Net Weight	1 kg
3	Overall Dimensions	160 × 100 × 3 mm
4	Maximum Vehicle Weight	1660 kg
5	Maximum Lift Height	160 mm

10. Local Material Content

All components were produced from locally sourced materials, including:

- Mild steel plate
- Reflective glossy sheet (for caution imprint)
- Fabricated studs and fasteners

This supports NASENI's goal of promoting indigenous design and manufacturing capability.

11. Conclusion

The design and production of a mild steel vehicle wedge have been successfully achieved using indigenous resources and technology. Analytical and experimental evaluations confirmed the wedge's reliability, cost-effectiveness, and safety. The developed wedge is suitable for all light and medium passenger cars and can be reproduced for mass production at low cost. Future improvements may include integration of rubber pads for enhanced grip and finite element stress analysis to optimize material distribution and further reduce weight.

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