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Research Paper

Design and Performance Optimization of a Go-Kart Chassis Using Finite Element Analysis (FEA)

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ABSTRACT

A go-kart is a small, lightweight four-wheeled vehicle designed for recreational, educational and competitive driving. This project deals with the design and fabrication of a go-kart powered by an internal combustion (IC) engine. The main objective is to develop a simple, strong, economical and serviceable vehicle using commonly available mechanical components and workshop processes.

The project covers the selection of the IC engine, chassis design, steering system, braking system, power transmission, wheels and tyres, accelerator and control mechanism. The frame is designed to support the engine, driver and other components while maintaining adequate rigidity and stability. The engine converts the chemical energy of fuel into mechanical power, which is transmitted to the driving axle through a suitable transmission arrangement.

The methodology includes requirement identification, conceptual design, component selection, basic engineering calculations, CAD/drawing preparation, material procurement, fabrication, assembly and testing. The report also discusses important safety aspects such as braking performance, steering response, chain guarding, fastener tightening and driver protection.

The project provides practical understanding of automobile engineering, IC engines, manufacturing processes, machine design, welding, power transmission and vehicle testing. The final design can be further improved by reducing weight, improving ergonomics, optimizing power transmission and introducing additional safety and instrumentation.

1. INTRODUCTION

1.1 Background

A go-kart is a compact four-wheel vehicle with a simple chassis and a low seating position. It is widely used in kart racing, recreational activities, driver training and engineering student projects. Because the construction is comparatively simple, a go-kart is an excellent platform for learning the practical application of mechanical engineering principles.

1.2 Project Need

A student-built go-kart combines several engineering systems in one machine. It requires understanding of the IC engine, torque transmission, chassis strength, steering geometry, braking, wheel selection and manufacturing. Building the vehicle helps bridge the gap between theoretical classroom knowledge and practical engineering.

1.3 Problem Statement

To design and fabricate a compact, economical and mechanically reliable go-kart using an IC engine, while ensuring adequate chassis strength, controllable steering, effective braking and safe power transmission.

1.4 Objectives

- To design a simple and rigid go-kart chassis suitable for a single driver.
- To select a suitable IC engine and transmission arrangement.
- To design and integrate steering and braking systems.
- To fabricate the chassis using commonly available workshop processes.
- To assemble and test the vehicle for basic performance and safety.
- To understand the practical application of automobile and manufacturing engineering.

1.5 Scope of Project

The project includes conceptual design, basic calculations, component selection, fabrication, assembly and testing of a small IC-engine go-kart. Detailed road certification, mass production and high-speed racing optimization are outside the scope of this academic prototype.

2. LITERATURE REVIEW

2.1 Go-Kart Chassis

The chassis acts as the main structural member. A tubular steel frame is commonly used because it is relatively easy to fabricate by cutting, bending and welding. A good chassis should have adequate stiffness without unnecessary mass.

2.2 IC Engine

A small four-stroke petrol engine is commonly selected for an academic go-kart because it provides useful torque, is comparatively simple to operate and has commercially available spare parts. The engine produces rotary power at the crankshaft.

2.3 Power Transmission

Power may be transmitted from the engine to the rear axle using a centrifugal clutch or torque-converter type system followed by a chain and sprocket drive. The transmission ratio affects wheel torque, acceleration and maximum speed.

2.4 Steering

Go-kart steering normally uses a steering wheel, steering shaft, steering arms and tie rods. Ackermann-type geometry may be used so that the inner and outer front wheels follow suitable turning paths.

2.5 Braking

A mechanical or hydraulic disc brake can be mounted on the rear axle. The brake must be capable of bringing the vehicle to rest in a controlled manner under the expected operating conditions.

2.6 Safety

Important safety provisions include a strong seat mounting, secure fasteners, protected rotating parts, reliable brakes, positive steering, an accessible engine shut-off arrangement and suitable personal protective equipment during testing.

3. METHODOLOGY

3.1 Overall Method

The project was planned in a sequence so that design decisions could be checked before fabrication. The major steps are requirement identification, conceptual design, calculations, component selection, CAD/drawing preparation, fabrication, assembly, testing and documentation.

Step	Activity	Output
1	Requirement study	Design requirements
2	Concept design	Initial layout
3	Engineering calculations	Dimensions and selected ratios
4	Component selection	Engine and component list
5	Detailed design	Fabrication drawings
6	Fabrication	Chassis and mounting
7	Assembly	Complete go-kart
8	Testing	Performance and safety observations

3.2 Functional Block Diagram

[IC ENGINE] → [CLUTCH / TORQUE CONVERTER] → [CHAIN & SPROCKET] → [REAR AXLE] → [REAR WHEELS]

Control systems operate independently: steering controls vehicle direction, while the accelerator controls engine power and the brake reduces vehicle speed.

3.3 Major Components

Sr.	Component	Function
1	IC engine	Produces mechanical power
2	Chassis	Supports driver and components
3	Clutch / CVT	Engages engine power with drive system
4	Chain and sprockets	Transmits power to axle

5	Rear axle	Transfers torque to driving wheels
6	Steering system	Changes direction
7	Brake system	Reduces speed and stops vehicle
8	Wheels and tyres	Provide contact with ground
9	Seat	Supports driver
10	Accelerator	Controls engine speed
11	Kill switch	Stops engine quickly

4. DESIGN AND ENGINEERING ANALYSIS

4.1 Design Requirements

The design should be compact, sufficiently rigid, easy to manufacture and easy to maintain. The centre of gravity should be kept low, and heavy components should be positioned to provide suitable weight distribution.

4.2 Chassis Design

A tubular frame is selected because it offers a good balance between strength, fabrication simplicity and weight. Mild steel is commonly used for student prototypes because it is readily available and can be welded using conventional workshop equipment.

4.3 Basic Weight Calculation

Total vehicle weight is the sum of the chassis, engine, transmission, steering, braking system, wheels, seat and other components. For design purposes, the expected driver mass should also be considered.

Total mass, m = mass of vehicle + mass of driver

Weight, $W = m \times g$, where $g \approx 9.81 \text{ m/s}^2$.

4.4 Engine Power and Torque

Engine power is related to torque and angular speed by:

$$P = 2\pi NT / 60$$

where P is power in watts, N is engine speed in rpm and T is torque in $\text{N}\cdot\text{m}$. This relationship is useful for understanding how engine torque changes with speed and how transmission ratio affects wheel torque.

4.5 Drive Ratio

For a simple chain drive, the approximate speed ratio can be estimated from sprocket tooth counts:

$$\text{Speed ratio} = \text{Teeth on driven sprocket} / \text{Teeth on driving sprocket}$$

A higher reduction ratio increases wheel torque and improves starting/low-speed pulling ability, but reduces theoretical maximum wheel speed.

4.6 Wheel Speed

For a wheel of diameter D , the approximate vehicle speed can be related to wheel rpm by:

$$V = \pi DN / 60$$

where V is in m/s, D is wheel diameter in metres and N is wheel rpm.

5. IC ENGINE AND POWER TRANSMISSION

5.1 IC Engine

An internal combustion engine produces power by burning a fuel-air mixture inside the engine cylinder. In a typical four-stroke petrol engine, one complete cycle consists of suction (intake), compression, power and exhaust strokes.

5.2 Four-Stroke Cycle

Stroke	Piston movement	Main action
1. Suction	TDC to BDC	Air-fuel mixture enters cylinder
2. Compression	BDC to TDC	Mixture is compressed
3. Power	TDC to BDC	Spark ignites mixture and gases push piston
4. Exhaust	BDC to TDC	Burnt gases leave cylinder

5.3 Main Engine Components

- Cylinder and cylinder head
- Piston and piston rings
- Connecting rod
- Crankshaft
- Camshaft and valve mechanism
- Spark plug
- Carburettor or fuel-injection system
- Lubrication and cooling system
- Air filter and exhaust system

5.4 Engine Selection Criteria

- Required power and torque
- Engine mass and mounting arrangement
- Fuel availability
- Cooling requirement
- Spare-part availability
- Ease of starting and maintenance
- Compatibility with the selected transmission

5.5 Power Transmission

The engine crankshaft drives the clutch or torque converter. After engagement, power passes through the chain and sprocket arrangement to the rear axle. The axle then rotates the driving wheels.

5.6 Chain Drive

Chain drive is useful because it can transmit relatively high torque with good efficiency and is simple to inspect. Correct chain alignment, lubrication and tension are important for reliable operation. A suitable guard should cover exposed moving parts.

6. STEERING, BRAKING AND OTHER SYSTEMS

6.1 Steering System

The steering system consists of a steering wheel, steering shaft, steering arms, tie rods and front steering knuckles. When the steering wheel is rotated, the steering shaft transfers motion to the steering mechanism, which turns the front wheels.

6.2 Ackermann Steering Principle

During a turn, the inner front wheel follows a smaller radius than the outer wheel. Ackermann-type steering provides different steering angles for the two front wheels so that the wheel paths are better matched and tyre scrubbing is reduced.

6.3 Braking System

A disc brake is suitable for a small go-kart. The brake disc is mounted on the axle or wheel hub and a caliper applies friction to the disc. The brake pedal is connected to the brake mechanism through a mechanical or hydraulic linkage.

6.4 Brake Force

The braking system must provide sufficient braking torque at the wheel. The required performance depends on total mass, speed, tyre-ground grip, brake dimensions and weight transfer. Braking should always be verified experimentally at low speed before higher-speed testing.

6.5 Wheels and Tyres

Tyre selection depends on wheel size, load, surface condition and intended use. Proper inflation and secure wheel fastening are necessary for predictable handling.

6.6 Seat and Driver Ergonomics

The seat position should allow comfortable access to the steering wheel and pedals while keeping the driver securely supported. Pedal travel should be sufficient and controls should not interfere with each other.

7. FABRICATION AND ASSEMBLY

7.1 Material Selection

Mild steel is selected for the main frame because it is economical, easily available and suitable for welding and machining. Other components may be selected according to their required strength, wear resistance and availability.

Component	Typical material	Manufacturing process	Purpose
Chassis tubes	Mild steel	Cutting + welding	Main structure
Mounting plates	Mild steel	Cutting + drilling	Engine/component support
Steering shaft	Steel	Machining	Steering input
Tie rods	Steel	Cutting + threading	Steering linkage
Brake disc	Steel	Machining / purchased	Braking
Axle	Steel	Machining / purchased	Power transmission
Seat bracket	Mild steel	Cutting + welding	Seat support
Guards	Sheet/mesh steel	Cutting + forming	Safety protection

7.2 Fabrication Sequence

- Prepare the final chassis layout and dimensions.
- Cut the frame tubes according to the drawing.
- Arrange and tack-weld the frame on a flat surface.
- Check squareness and symmetry before final welding.
- Weld the frame joints and add required brackets.
- Fabricate and mount engine and axle supports.
- Install steering components and verify free movement.
- Install brake components and adjust pedal travel.
- Mount engine, clutch/drive system, chain and guards.
- Install seat, accelerator and engine shut-off control.
- Fit wheels and check alignment and fasteners.

7.3 Welding and Workshop Safety

Welding should be carried out by trained personnel using appropriate PPE. The frame should be supported securely during fabrication. Grinding, drilling and cutting should be performed with suitable eye and hand protection. Fuel and flammable materials must be kept away from hot work.

8. ASSEMBLY, INSPECTION AND MAINTENANCE

8.1 Assembly Checks

- Check chassis dimensions and weld quality.
- Confirm engine mounting is rigid.
- Check chain/sprocket alignment and tension.
- Check steering for free movement and excessive play.
- Check brake operation before starting the engine.
- Check wheel nuts and all critical fasteners.
- Ensure rotating and hot components are guarded where practical.
- Check fuel system for leakage before engine operation.
- Confirm engine shut-off control is accessible.

8.2 Maintenance Schedule

Item	Inspection	Action
Engine oil	Before/regular use	Maintain correct level and replace as specified
Air filter	Regularly	Clean/replace as required
Chain	Regularly	Lubricate and adjust tension
Brake	Before every test	Check pad/disc and pedal response
Tyres	Before every test	Check condition and inflation
Fasteners	Regularly	Inspect and tighten
Steering	Before every test	Check joints, alignment and free movement

8.3 Troubleshooting

Problem	Possible cause	Corrective action
Engine does not start	Fuel/ignition/air issue	Check fuel, spark and air supply
Poor acceleration	Transmission or engine issue	Check clutch, chain and engine condition
Chain noise	Misalignment or loose chain	Align sprockets and adjust tension
Vehicle pulls to one side	Wheel/steering misalignment	Inspect and align
Weak braking	Adjustment/wear	Inspect brake and adjust/replace worn parts

9. RESULTS AND DISCUSSION

The fabricated prototype should be evaluated systematically rather than only by subjective driving feel. Testing should begin with static inspection, followed by low-speed controlled testing in a safe, closed area. The measured values should be entered in the tables below after actual testing.

CONCLUSION

The project “Design and Fabrication of a Go-Kart with IC Engine” demonstrates the integration of several mechanical engineering concepts into a working vehicle system. The project includes chassis design, IC-engine operation, power transmission, steering, braking, wheel selection, fabrication and testing.

The IC engine provides the required mechanical power, while the clutch or transmission and chain drive transfer this power to the rear axle. The chassis supports the complete system and must provide adequate strength and stiffness. Steering and braking systems are essential for vehicle control and safety.

The project also provides practical experience in material selection, cutting, drilling, welding, assembly, inspection and troubleshooting. It demonstrates that a relatively simple vehicle can serve as an effective learning platform for automobile and mechanical engineering.

Final performance values should be reported only from actual prototype measurements. The design can be improved further through weight reduction, improved ergonomics, optimized transmission and additional safety features.

FUTURE SCOPE

- Use CAD/FEA analysis to optimize chassis strength and reduce unnecessary weight.
- Improve the steering geometry and driver ergonomics.
- Optimize sprocket ratios for the desired acceleration and operating speed.
- Use improved braking components and provide a more consistent brake feel.
- Add instrumentation for engine rpm, vehicle speed and temperature.
- Study fuel economy and engine operating efficiency.
- Develop improved engine mounting and vibration isolation.
- Add suitable protective guards around rotating components.

- Investigate electric or hybrid powertrains as an alternative to the IC engine.
- Perform structured endurance testing to identify fatigue and maintenance issues.

REFERENCES

The references below are examples of sources suitable for an academic report. The final submitted report should also include the exact manuals, textbooks, standards and papers actually consulted by the project team.

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