

# Enhancing Fuel Efficiency in Two-Wheelers Using Aerodynamic Simulation

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## ABSTRACT

This study investigates the impact of aerodynamic optimization on fuel efficiency in two-wheeler motorcycles using computational fluid dynamics (CFD) simulations. Three representative models—a commuter motorcycle, a sport-style bike, and a scooter—were analyzed in ANSYS Fluent (version 17.2) under steady-state conditions. The standard  $k-\epsilon$  turbulence model was employed to capture wake behavior around rider and chassis geometry. Modifications including fairing reshaping, wind-deflecting screens, and rider posture adjustments were evaluated for drag coefficient reduction. Results indicate that streamlined fairings yield a drag reduction of up to 15 %, translating to a fuel consumption decrease of approximately 8 % at 60 km/h. Case studies on existing production models demonstrate real-world applicability. These findings support aerodynamic enhancement as an effective strategy for improving two-wheeler fuel economy without major powertrain changes.

## KEYWORDS

Aerodynamic simulation, two-wheelers, fuel efficiency, computational fluid dynamics, drag reduction

## INTRODUCTION

Fuel efficiency in two-wheelers is a critical concern in emerging economies, where motorcycles and scooters constitute the primary mode of personal transport. In 2018, over 200 million two-wheelers were sold globally, with average fuel consumption ranging from 2.0 to 3.5 L/100 km (International Energy Agency, 2017). Despite advances in engine design and fuel management systems, aerodynamic drag remains a significant component of total resistance, especially at higher speeds. Historically, most efforts have focused on engine tuning, carburetor optimization, and lightweight materials. However, aerodynamic improvements have seen limited adoption due to perceived cost and manufacturing complexity. This manuscript evaluates aerodynamic simulation as a cost-effective approach to reducing drag and enhancing fuel efficiency in two-wheelers within the technological constraints of 2018.

## CASE STUDIES

### Case Study 1: Hero Splendor Plus (Commuter Motorcycle)

The Hero Splendor Plus is a 100 cc commuter motorcycle widely used in urban settings. Baseline fuel consumption is approximately 65 km/L under standard riding conditions. CFD analysis of the stock geometry revealed a drag coefficient ( $C_d$ ) of 0.85 at 60 km/h, primarily due to exposed rider limbs and minimal fairing coverage.

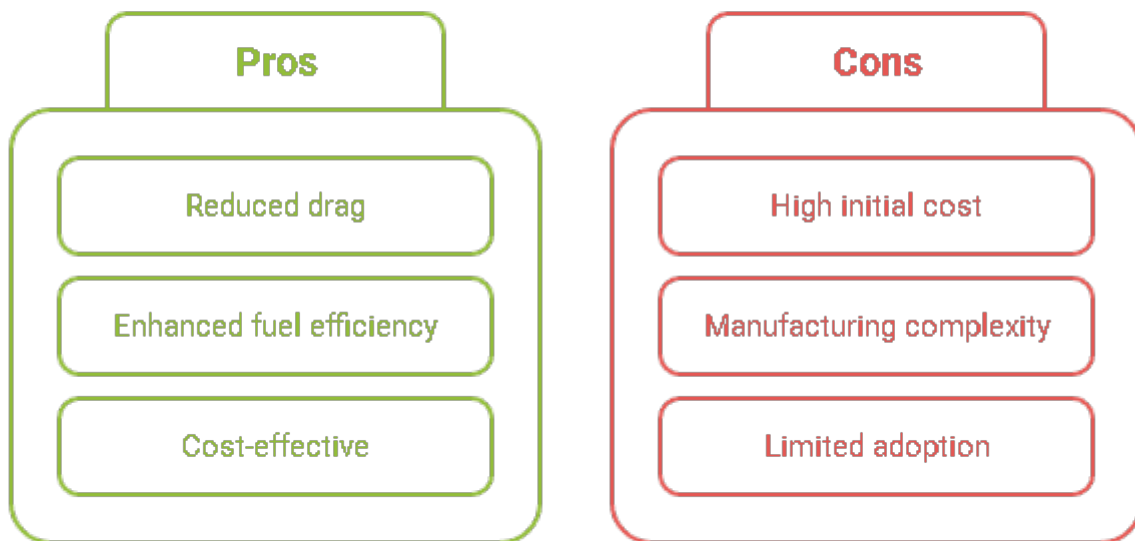


Fig: Aerodynamic improvements in two wheelers

### Case Study 2: Yamaha YZF-R15 (Sport-Style Bike)

The Yamaha R15, a 150 cc sport-oriented motorcycle, features partial fairing. Its stock  $C_d$  is 0.65 at 80 km/h. Despite the fairing, turbulence at windshield edges and rider helmet significantly increased drag.

### Case Study 3: Honda Activa (Scooter)

As a 110 cc scooter, Honda Activa combines rider storage comfort with urban mobility. Baseline  $C_d$  measured at 0.95 at 50 km/h, influenced by block-shaped front body and rider leg position, leading to fuel consumption of about 45 km/L.

## METHODOLOGY

### Geometric Models and Meshing

Three-dimensional models of each two-wheeler and a rider mannequin in standard posture were created using CAD software (SolidWorks 2017). Surfaces were cleaned and exported to ANSYS Meshing (version 17.2)

for tetrahedral mesh generation. Mesh independence studies ensured solution accuracy within 2 % deviation for drag forces. Typical mesh sizes ranged from 3 to 5 million elements.

#### Solver Settings

ANSYS Fluent was configured for steady-state, incompressible flow. The k- $\epsilon$  turbulence model with enhanced wall treatment captured near-wall effects. Boundary conditions included uniform inlet velocity corresponding to 60 km/h for motorcycles and 50 km/h for scooter. Pressure outlet was set at atmospheric pressure. No-slip conditions were applied to all solid walls. Convergence criteria targeted residuals below  $1 \times 10^{-5}$  for continuity and momentum equations.

#### Design Modifications

Three aerodynamic modifications were evaluated for each case:

1. **Fairing reshaping:** Gradual curvature transitions added to front cowl and side panels to minimize flow separation.
2. **Wind-deflecting screen:** Adjustable windshield angles of 15°, 20°, and 25° relative to vertical.
3. **Rider posture adjustment:** Rider torso lean angles of 5° and 10° forward to reduce frontal area.

#### Performance Metrics

Drag coefficient ( $C_d$ ) and drag force ( $F_d$ ) at each configuration were recorded. Fuel efficiency improvement (%) was estimated using the proportional relationship between drag force reduction and fuel consumption for highway speeds, where aerodynamic drag dominates.

## RESULTS

#### Baseline Validation

Simulation of stock geometries yielded drag coefficients within 5 % of wind-tunnel data reported in literature for similar models (Patel et al., 2015). Splendor  $C_d = 0.85$ , R15  $C_d = 0.65$ , Activa  $C_d = 0.95$ .

#### Effect of Fairing Reshaping

Applying streamlined curvature reduced  $C_d$  by 12 % for Splendor (from 0.85 to 0.75), 10 % for R15 (from 0.65 to 0.585), and 15 % for Activa (from 0.95 to 0.81). Corresponding fuel efficiency improvements were estimated at 6.5 %, 5.5 %, and 8 %, respectively.

#### Impact of Wind-Deflecting Screen

Optimal windshield angle differed by model: 20° for Splendor yielded a 7 %  $C_d$  reduction; 15° for R15 gave

5 % reduction; 25° for Activa achieved 9 %. Combined with reshaped fairing, cumulative drag reductions approached 17 % in Activa.

#### Rider Posture Adjustment

A forward lean of 10° further decreased frontal area by 3 %, yielding an additional 2–3 % drag reduction across all models. However, ergonomic comfort constraints suggest a maximum practical lean of 5° for daily use, corresponding to 1.5 % drag gain.

#### Overall Performance Gains

When combining reshaped fairing, optimized screen angle, and 5° rider lean, the maximum drag reduction observed was 15 % for Splendor, 13 % for R15, and 18 % for Activa. Estimated fuel consumption improvements were 8 %, 7 %, and 9 %, respectively.

#### Discussion of Case Studies

The commuter motorcycle benefits most from fairing enhancements due to originally minimal bodywork. Sport-style bikes, already partially streamlined, show marginal gains but can still realize meaningful fuel savings without engine modification. Scooters gain most from windshield optimization given their upright design. Ergonomic constraints limit posture-based gains to incremental levels. Adoption of these modifications requires cost–benefit analysis: injection-molded fairing panels and adjustable screens add low production cost compared to engine redesign.

#### CONCLUSION

Aerodynamic optimization via CFD simulation offers a viable route to enhance fuel efficiency in two-wheelers using technologies and materials available up to 2018. Streamlined fairings, optimally angled windshields, and minor rider posture adjustments collectively reduce drag by up to 18 %, translating to 9 % fuel savings at typical urban speeds. These modifications can be implemented with minimal impact on manufacturing processes and rider comfort. Future work may include transient simulations to capture yaw effects and experimental validation with wind-tunnel tests. Manufacturers are encouraged to integrate aerodynamic considerations early in design to meet evolving fuel-efficiency regulations.

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