IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

‘‘A Review Of Intake Manifold Design, Modeling, And Materials For Small Spark-Ignition Two-Wheeler Engines (Case Context: Honda Activa)”

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Abstract: This review synthesizes literature on intake manifold geometry, acoustic tuning, computational modeling, injector placement, and materials relevant to small spark-ignition (SI) engines used in Indian two-wheelers, with the Honda Activa (110–125 cc) as contextual reference. Prior work demonstrates that runner length, plenum volume, elbow curvature, and surface finish influence volumetric efficiency, pressure losses, and mixture preparation; CFD using RANS (e.g., k–ω SST) is frequently employed for design iteration and validation. The review collates reported design strategies—including bellmouth entries, diffuser–converger shaping, variable-length runners, and polymer manifolds (PA6-GF30)—and summarizes their measured or simulated impacts on pressure drop, charge uniformity, and torque. It also highlights injector orientation to mitigate wall wetting. Gaps for two-wheeler-specific validation (transient intake events, fuel–air multiphase modeling, chassis-dyno correlation) are identified to guide future research.

Keywords: Intake manifold, two-wheelers, Honda Activa, CFD, k–ω SST, runner tuning, minor-loss coefficients, PA6-GF30, wall wetting

I. Introduction

Scooters like Honda Activa (≈109.51 cc SI, CVT) dominate Indian urban mobility; packaging constraints force a compact intake path with sharp elbows and short runners, which can raise local losses and reduce volumetric efficiency in mid-range speeds used most in city riding. Manufacturer specifications indicate the operating torque peak near ~5500 rpm, with fuel-injected variants and under-bone frame packaging. In such layouts, minimizing entrance and bend losses, conditioning the flow for attached behavior, and tuning runner lengths for desired torque are key to improving charge delivery without hardware changes to the cylinder head.
In naturally aspirated SI engines typical of scooters (109–125 cc), the intake manifold governs cylinder filling, transient response, and emissions. Popular Indian models like Honda Activa provide a practical context where compact packaging and cost constraints challenge manifold performance.
This review paper aims to:

(i) consolidate theory and evidence on manifold geometry and flow losses;
(ii) summarize modeling best practices (CFD and 1D wave dynamics);
(iii) examine material choices and manufacturing; and
(iv) discuss injector placement and mixture preparation issues in port-fuel injection (PFI).

Where applicable, the implications for a Honda Activa-class engine are noted.

II. Previous Research

Geometry & Losses: Engineering references tabulate minor-loss coefficients (K) for elbows/entries and show substantial reductions with long-radius bends and rounded inlets; diffuser half-angles of ~3–5° are repeatedly recommended to avoid separation in curved ducts.
Plenum and entry: Bellmouth inlets and mild tapers reduce entrance losses and condition the flow for attached behavior through the throat; short diffusers with low half-angles mitigate separation in curved passages.

Acoustic Runner Tuning: Studies employing 1D/3D models (Helmholtz/wave propagation) demonstrate that runner length and diameter strongly affect rpm of peak torque; variable-length concepts broaden torque curves.

CFD Modeling: For separation-prone ducts, RANS k–ω SST is widely validated for adverse pressure gradients and near-wall fidelity; two-wheeler and small-engine papers use steady/unsteady CFD with coupled 1D boundaries to evaluate Δp, velocity fields, and TI.

Injector Positioning & Wall Wetting (PFI): Experimental and modeling works quantify spray-wall film formation, show injector angle/targeting effects, and propose compensators to stabilize AFR during transients/cold start.

Materials: Polymer manifolds (PA6-GF30) are reported with higher stiffness/strength, thermal resistance, and moldability (integral bell mouth/fillets), enabling manufacturable aerodynamic features.

III. Gap Identified

- Two-wheeler-specific transient intake events (cycle-resolved valve motion, CVT load profiles) are under-reported relative to automotive multi-cylinder studies.
- Limited multiphase CFD for wall wetting in small PFI scooters under Indian ambient conditions; most studies focus on lab engines or automotive platforms.
- Sparse chassis dynamometer correlation linking manifold geometric changes to torque/η_v improvements for scooters; gains often reported in bench/CFD terms.
- Manufacturing/aging evidence for polymer manifolds (dimensional stability, heat soak, NVH) specific to scooter layouts needs expansion; datasheets exist but long-term in-service data is limited.

IV. Future Directions

Based on the above, our study targets practical, manufacturable improvements for an Activa-class manifold:

- bell mouth entry and mild plenum taper to reduce entrance losses.
- increased elbow radius with inner-wall filleting plus short diffuser before converger to suppress separation.
- runner length tuning to 1st/2nd harmonic for 4,500–5,500 rpm torque band.
- PA6-GF30 material to integrate aerodynamic features and mitigate heat soak; and
- injector orientation aligned with mainstream to minimize wall wetting. We validate with steady CFD (k–ω SST) and first-principles loss accounting, with recommended next steps in transient CFD and chassis dyno to close literature gaps.
- Transient CFD with moving valves and cycle-resolved boundary conditions for scooters.
- Multiphase fuel–air modeling for PFI, including film dynamics and evaporation under Indian ambient conditions.
- System-level validation: chassis dyno torque curves, emissions, and AFR control with injector timing/angle sweeps.

- Manufacturing studies: dimensional stability, heat soak, and NVH for polymer manifolds; long-term aging effects.

V. Selected Literature Summary

Study	Application/Method	Key Variables	Findings
Fontana et al., SAE 2003-01-3134	Small SI engine; 3-D CFD + theoretical analysis	Intake port geometry; turbulence	Higher turbulence accelerates combustion; efficiency gains with port modifications
Narwade et al., IJMPERD 2015	KTM 390; 1D+3D CFD	Restrictor, plenum, runner	Optimized diffuser/plenum improves velocity and reduces losses
Mahadik & Sontakke, IJSRD 2017	Two-wheeler review	Tuning, plenum volume	Simulation reduces cycle; dual intake concepts improve torque
Khaje Zade Roodi et al., JACM 2021	Experimental + numerical	Double intake manifold	Brake power/torque ↑ ≈6.8% vs baseline
Menter (SST model)	RANS turbulence closure	Near-wall + freestream blending	Improved separation prediction for adverse gradients
PA6-GF30 datasheet (PLASTUM)	Material properties	GF30 reinforcement	Higher stiffness/strength; HB flammability; service temp up to ~120°C long-term

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