AIR FLOW THROUGH A BUS WITH OPEN WINDOWS

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Part support: VREF

Busworld India webinar on air ventilation, air purification and cleaning systems
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Open window bus

- Mainstay of public transport systems
- Vast majority of bus fleet in India and many countries
- Open windows (and doors)
- Hot and/or humid climate
- More eco-friendly than AC bus
- Economical
Studies at TRIPP, IIT Delhi: Bus ventilation

• Experimental studies
  • Scaled model – visualization in water channel
  • Scaled model – measurements in wind tunnel
  • Full-scale bus – visualization in motion

• Computational studies
  • Numerical studies: CFD of full-scale bus

• Innovations
  • Effects of static interventions
    slots (front, rear) and/or roof vents

6 May 2021
Busworld (Kale)
Single floor bus, no interiors

Scaled model – visualization in water channel
Full-scale bus – visualization in motion

Numerical simulation (CFD)
Velocity vectors: Single floor, no interiors, all windows open

Horizontal plane through window mid-height

Vertical plane normal to window, through window mid-span (transverse plane)
Validation. Findings.

- Drag and side forces: Numerical simulations vs. Wind tunnel measurements
- Flow field
  - Inflows and outflows through windows
  - Flow over passengers
  - Effects of modifications

- Air flow through the bus (empty, or seated passengers)
Bus with no passengers, or all seated passengers

- Base design    OR    Modifications
  - Single floor
  - Low floor
  - Selectively closed windows
  - Slots in front, rear
  - Roof-mounted deflector
  - Roof vents

Air velocity : 40 km/h (steady)
Model : LES

Ground effect
Windows, Roof vents, and Front & rear slots
Velocity vectors: Open all windows, two top slots, two rear slots

- Vertical center plane.
- Horizontal plane at mid-plane of windows.

Through flow: 8 to 17 kg/s
400 - 800 Nm³/min

Aerodynamic drag force:
Up to 28% less

- More studies in progress
- Low-floor bus
- Enhanced thermal comfort; convection only, no radiation
- Extendable to particle (dust) and virus dispersion.
Concluding remarks

- Considerable experience in bus ventilation with open windows.
- Potential for enhanced thermal comfort, and drag reduction.
- Considerably enhanced ventilation:
  - can disperse virus
  - can develop seating plan that minimizes exposure to virus
- No major changes to bus body structure.
- Further studies are needed.
- Extendable to railway coaches.

Public Transport for Sustainability

Thank you.