

EFFECT OF TRUCK BED ON DRAG FORCE

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Introduction

- Kei trucks are used in Japan to haul cargo throughout the country due to their small size and maneuverability.
- In the automotive industry, trucks are known for their relatively higher drag coefficients. [1]
- By reducing the drag, more gas can be saved and trucks can travel farther distances.



Figure 1. Japanese Kei Truck

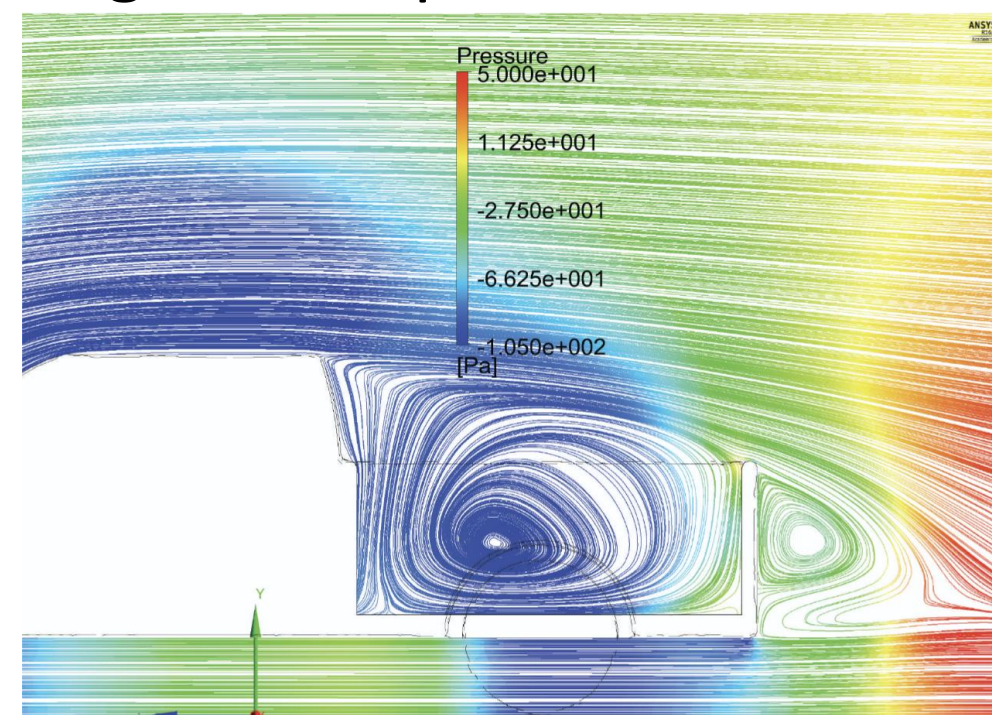


Figure 2. Pressure streamlines for the truck without bed covers [1]

Fabrication

Truck Base

- Two 1/10th scale RC Kei truck models were used for testing.

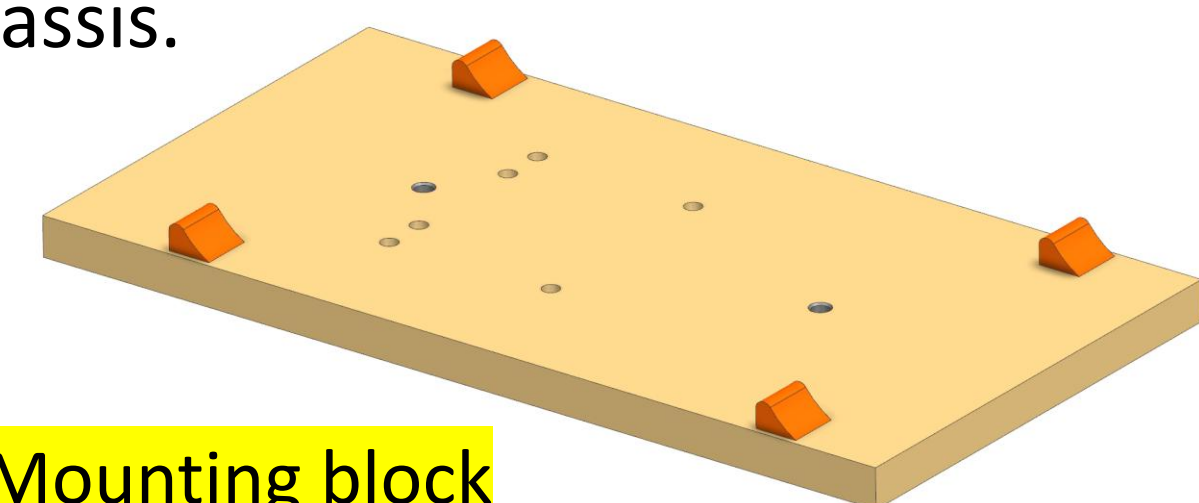
Bed Covers

- Three bed cover configurations have been 3D printed and attached to the RC models. The three configurations include:

- Open bed (control)
- Flat tonneau cover
- Sloped bed cover

Mounting Apparatus

- A custom mounting block was fabricated out of wood and attached to the underside of the RC Kei truck chassis.



Mounting block

Open bed



Flat bed cover



Sloped bed cover



Hypothesis

The presence of a bed cover will decrease the drag on a Kei truck compared to the truck configuration with an open bed.

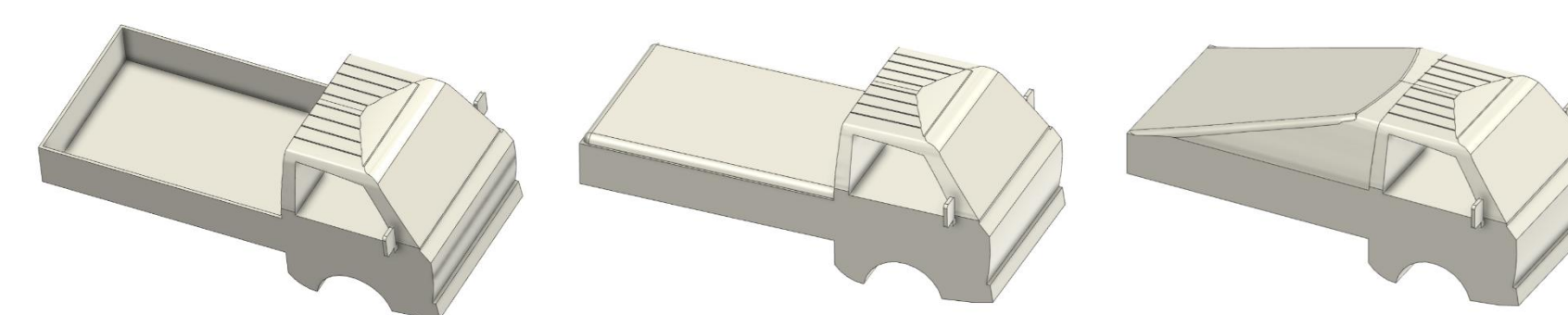


Figure 3. Truck CAD models used for CFD. Open-bed(left), flat (middle), and sloped(right) covered.

Results

Wind Tunnel Test:

- Strain vs. Time data were converted to Drag vs. Time using calibration curves.
- Mean drag over time with 95% confidence intervals was calculated from 4 trials.
- Mounting apparatus had mean drag $F = 4.512 \text{ N}$. It was subtracted from each configuration.
- Net drag were then obtained:

Configuration	Net Drag (N)	95% C.I.	%lower vs Open
Open-bed	8.789	± 0.342	0
Flat Cover	7.931	± 0.288	9.80%
Sloped Cover	8.481	± 0.116	3.51%

NX CFD Simulation:

- 3D CAD models were developed based on measured dimensions of the 1/10th truck model.
- Boundary conditions were set to match the wind tunnel conditions.
- NX CFD simulation results were compared with experimental data.

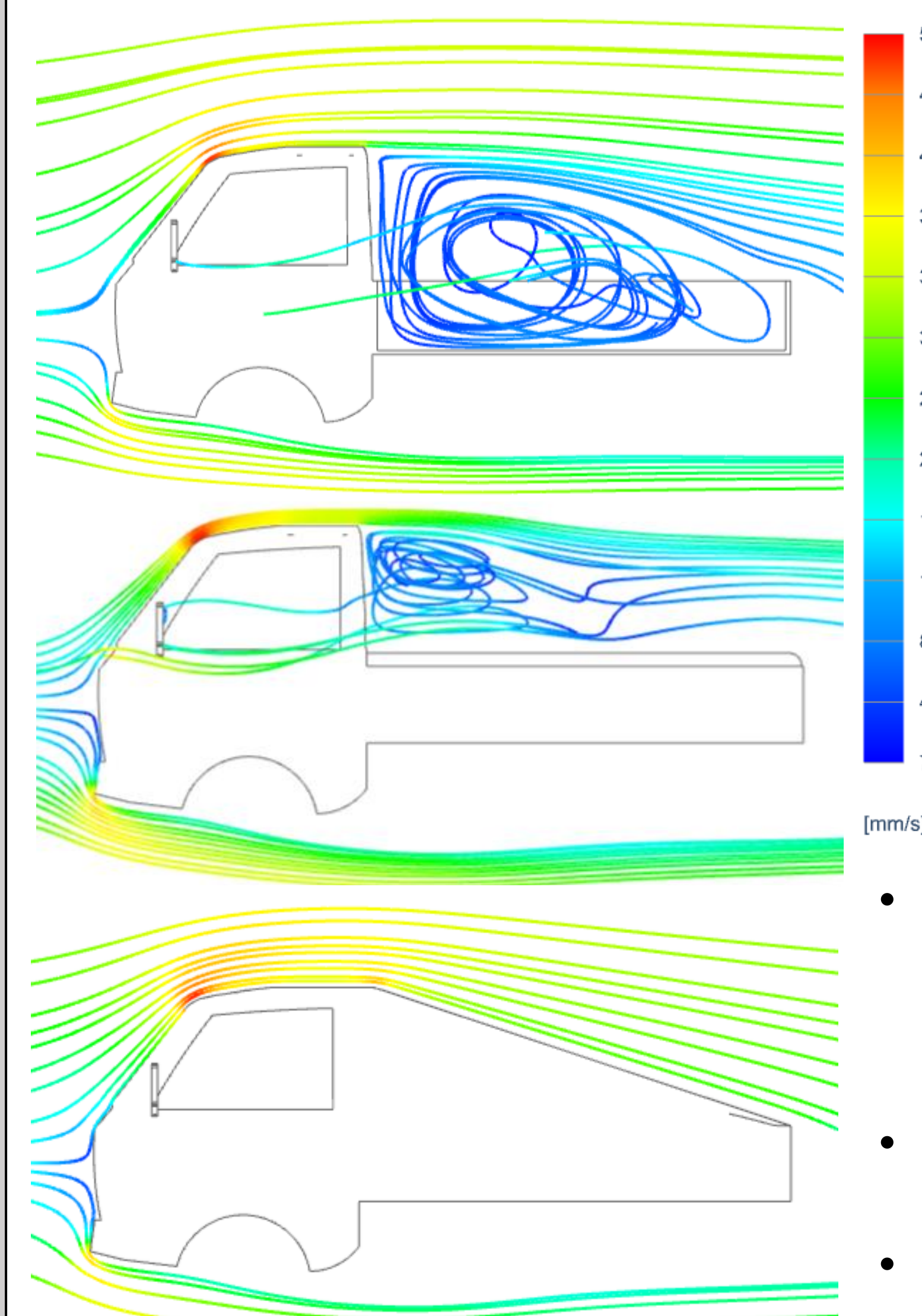


Figure 4. Flow velocity streamlines from NX CFD simulations

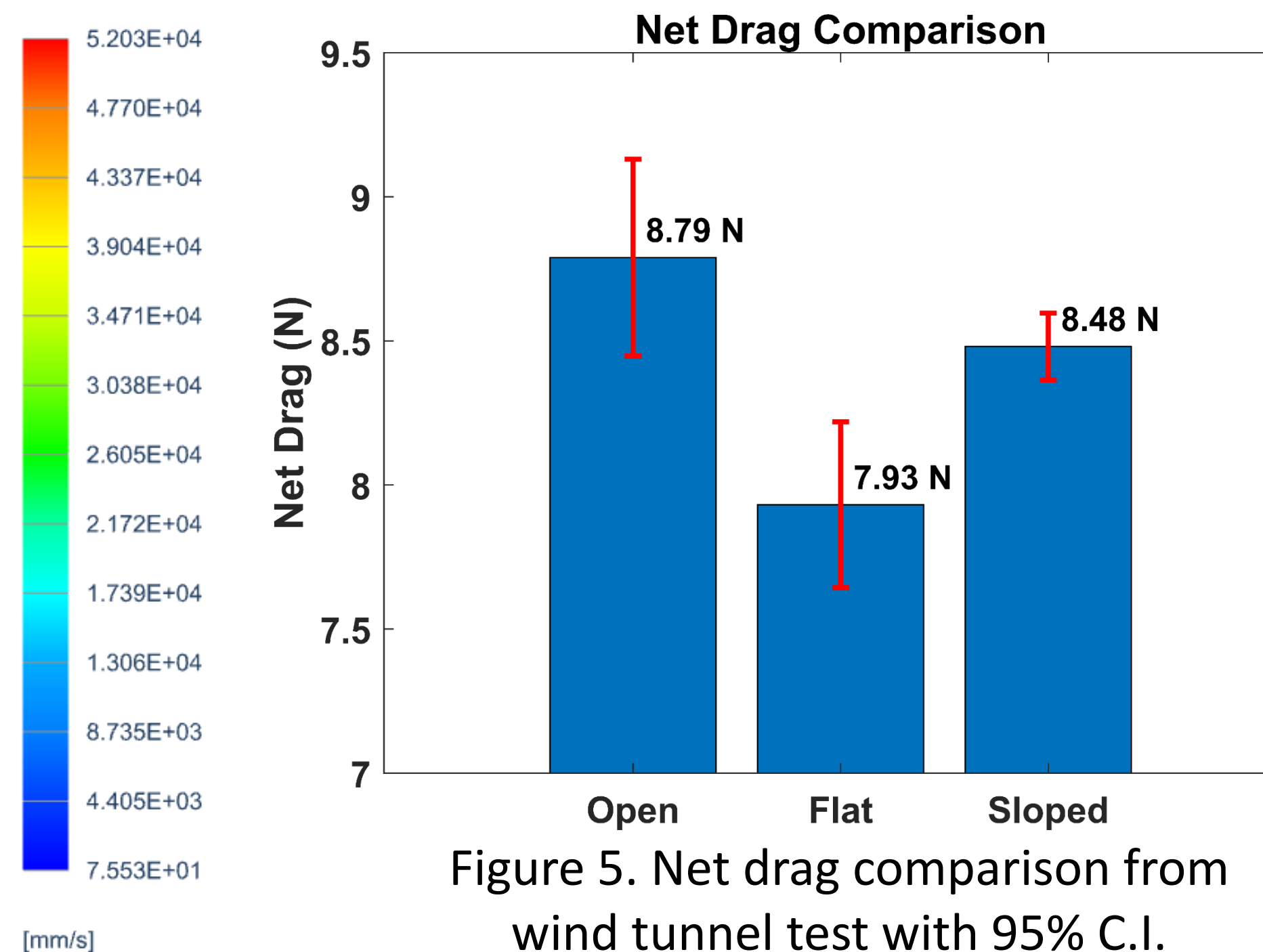


Figure 5. Net drag comparison from wind tunnel test with 95% C.I.

- From the wind tunnel test, the open bed produced the highest net drag: **8.789 N**, the flat cover produced the lowest net drag: **7.93 N (9.80% reduction)**, and the sloped-bed provided a modest benefit (**3.51%**).
- From CFD simulation, same trend was observed:
Flat-bed < Sloped-bed < Open-bed
- We concluded that, adding a bed cover **reduces aerodynamic drag**, and flat-bed is the **most effective design** among those tested.

Methodology

Wind Tunnel Test

- 31 m/s to match the Reynolds number.
- 3 trials for mounting apparatus.
- 4 trials for each bed configurations.
- Calibration to convert strain to drag.



Figure 6. Truck model in the wind tunnel

CFD Simulation

- Laser scanning to get rough CAD model.
- CAD model refinement in NX.
- NX CFD simulation results compared to experimental results.



Figure 7. Faro laser scanning

Discussion

Results support the hypothesis that adding a bed cover reduces drag, with the flat-bed being the most effective configuration. Non-overlapping 95% confidence intervals indicate the drag reduction is statistically significant at least at the 95% confidence level.

However, CFD simulations were idealized and laser scanning failed to capture dark regions of the model, leading to missing geometry (e.g., wheels). Future work can use a larger-scale model and higher wind speeds to better match Reynolds number. Improving CFD models with more realistic geometry and material properties can better represent real-world conditions.

References

- [1] Ait Moussa, A., Fischer, J., & Yadav, R. (2015). Aerodynamic Drag Reduction for a Generic Truck Using Geometrically Optimized Rear Cabin Bumps. *Journal of Engineering*, 2015, 1–14.
- [2] Abed Alrzaq Alshqirate, Dastan Zrar Ghafoor, & Sachin L. Borse. (2021). CFD Analysis of Flow Over Pickup Truck with And Without Covering Cargo Area Using OpenFOAM. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, 90(1), 40–51.

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