Design, aerodynamic optimisation and testing of a Touring Car Racing rear wing

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Industrial research and relevance

Dive into the world of Touring Car Racing aerodynamics with the groundbraking research on rear wing design following recent regulatory changes. Given its novelty and niche engineering interest, this topic remains unexplored in scientific literature. The change of regulations was introduced to minimise costs and allow closer racing by simplifying key aerodynamic elements such as the diffuser and rear wing. Validating numerical data with experimental testing in a wind tunnel stands as a hallmark of this research. To achieve this, the baseline rear wing model was manufactured involving in-house and external production.

Overall aim and objectives

The aim of this Engineering project is to optimise the rear wing aerodynamic efficiency of the TCR race cars under the FIA 2022 technical regulations.

The specific objectives include:

1. Designing a 3D CAD model of the rear wing in SolidWorks, adhering to existing regulations regarding dimensions and design geometries.
2. Carrying out CFD analysis in Star-CCM+ to investigate the effect of aerodynamic parameters such as wing profiles, angles of attack (AoA) and end plate geometry.
3. Manufacturing the rear wing using a 3D printer and incorporating pressure tubes.
4. Conducting an experimental test campaign with the university's wind tunnel facility.
5. Analysing and correlating numerical and experimental data to validate the findings.

Aerodynamic fundamentals and simulation setup

Drag force

$$F_D = \frac{1}{2}\rho v^2 C_D A$$

Lift force

$$F_L = \frac{1}{2}\rho v^2 C_L A$$

The two categories of aerodynamic forces acting on an automotive vehicle are pressure and shear force. They contribute for side, lift and drag loads.

Mesh continuum

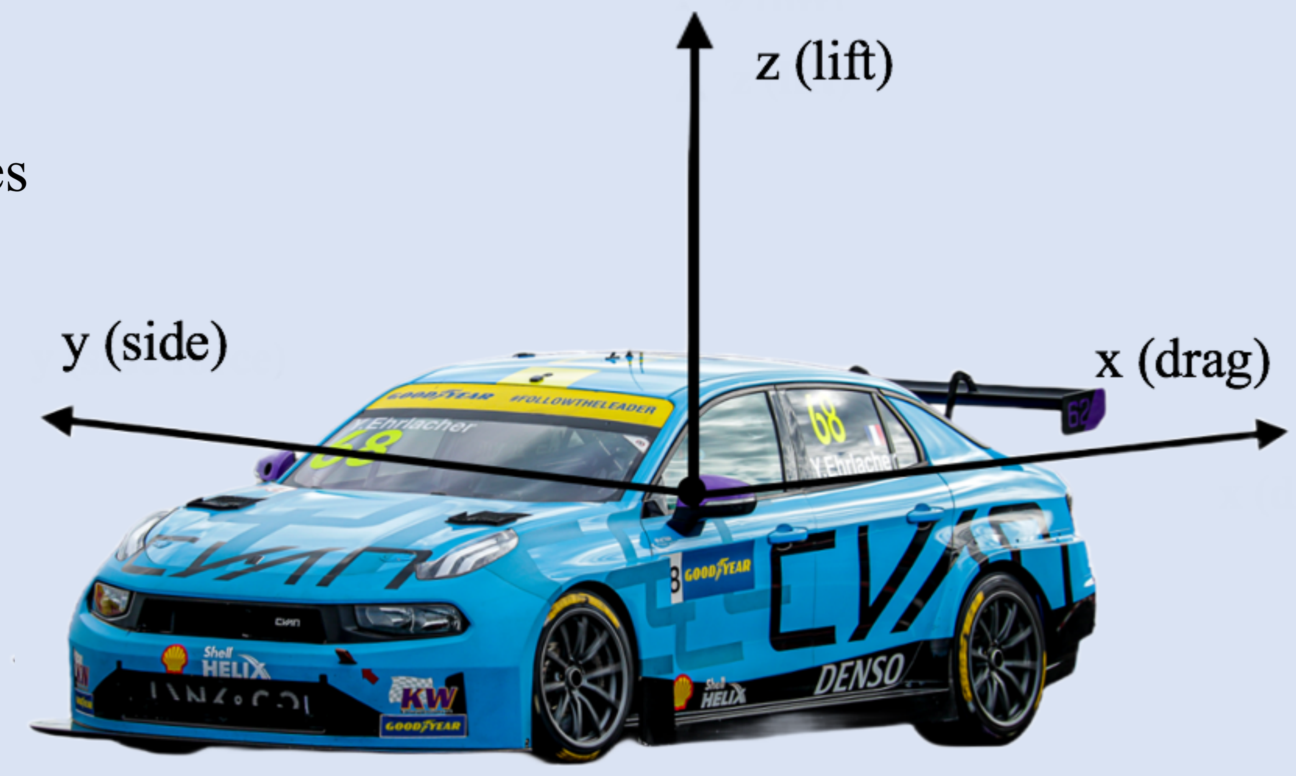
- Trimmer volume mesh
- Car and wake refinement boxes
- Sensitivity analysis

Optimisation methods

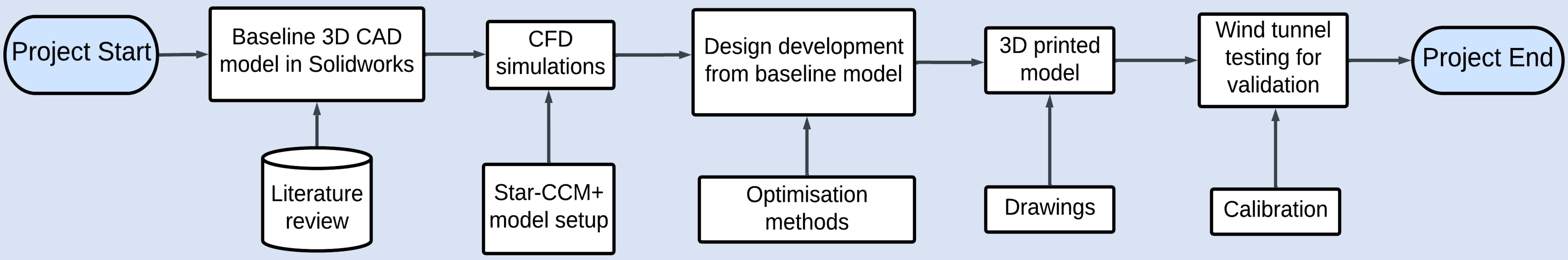
- Parametric
- Adjoint shape

RANS Turbulence models

- k-ϵ



Methodology flowchart: phases of production – research, design, optimisation, manufacturing, testing and analysis.



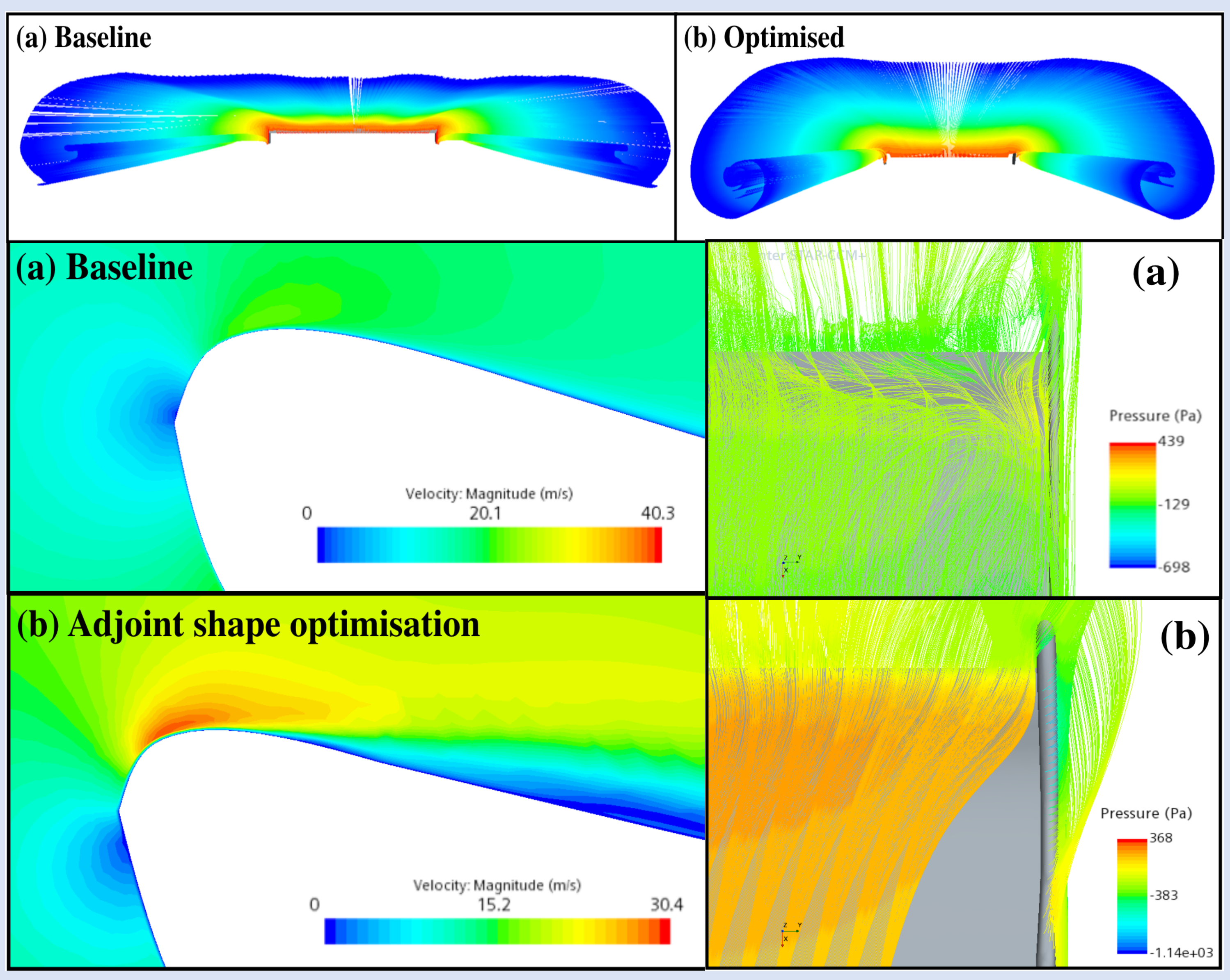
Results

· Both designs produce counter rotating vortices.

· Optimised rear wing vortices are significantly stronger.

· Parametric modelling on end plate and shape deformation on main plane

· Vortices produce a low-pressure zone over the upper surface of the optimised end plate, opposing performance and producing vortex lift.



Despite the experimental results may not precisely align with those from CFD, similar trends are evident.