NPL Wind tunnel

N2. Race car wheel: Drag force acting on the front wheel of a Forma1 race car, and its reduction by means of shear layer conditioning

A significant portion of aerodynamic drag acting on Forma 1 race cars is the force acting on the two front wheels. The boundary layer is separated from the plate being normal to the flow and located upstream of the wheel near the ground. Downstream of the plate, a separation bubble develops, in which depression occurs. This depression moderates the overpressure on the lower part of the wheel, and thus, the force acting on the wheel decreases (shear layer conditioning).

Assignment: Investigation on the possibilities of modification of flow field, serving as basis for drag reduction. In order to model the ground (impermeable boundary), two symmetrically arranged wheel models are available. Deflector plates of various size and position can be tested.

In the 45 min of the measurement,

1. The balance is to be calibrated (by means of weights, in 2 or 3 points),
2. The drag force acting on the balance arm is to be determined,
3. The flow characteristics are to be examined by oil smoke flow visualization,
4. For 3 different velocities, the drag force acting on the models is to be determined,
5. The drag force is to be measured again when installing plates,
6. For a given velocity, the static pressure about the wheel is to be measured without and with plate.

Availabilities:

- Balance protruding into the measurement section of the wind tunnel, by means of which the drag force being parallel to the flow direction can be measured,
- 2 F1 wheel models,
- Deflector plate, attachable on the wheels, interchangeable, adjustable
- Oil smoke generator,
- Pipe and probe for introduction of the oil smoke,
- Manometer.

A camera is to be provided by the measurement group.

Expected background information (chapters from Lajos, T.: Fundamentals of Fluid Mechanics, 2004, 3rd Edition):
2.1.1. Pathline, streakline, streamline, 2.1.3. Flow visualization, 3.3.3. Static, dynamic, total pressure, 3.4.1. Euler component equations in the natural coordinate system, 3.4.2. Applications, 6.2.4. Instruments based on the deformation of a flexible body, 6.2.5. Practical pressure measurement problems, 6.3.1. Determination of velocity based on the measurement of dynamic pressure, 8.5.2. Preconditions for similarity of flows, 9.1.1. Characteristics of boundary layers, 9.2.2. Development of the boundary layer in streamwise direction, 9.3.1. Development of shear stresses in the boundary layer, 9.3.2. Boundary layer separation, 9.3.3. Flow past a cylinder, 9.3.5. Control and elimination of boundary layer separation, 10.1.2. Dimensional analysis, 10.1.3. Application of dimensional analysis, 11.1.1. Development of aerodynamic forces, 11.1.2. Aerodynamic force acting on a cylinder, 11.2.2. Aerodynamic force acting on bluff bodies.
Further recommendations: From 4th Edition: 6.4.1. The aim of application of wind tunnels, 6.4.2. Types of wind tunnels, considering velocity and layout, 6.4.3. Structural elements of wind tunnels, layouts for measurement sections, 6.4.4. Practice of wind tunnel measurements, and/or Bradshaw, P., Mehta, R.: Wind tunnel design www-htgl.stanford.edu/bradshaw/tunnel/

Expected further background information –
For measurements regarding vehicle models:
3rd Edition, CD appendix: M.11.2.4. Vehicle aerodynamics PP presentation (**4th Edition**: DVD appendix M.11.3.1 presentation).
Further recommendations: 4th Edition:
11.3.1. Aims and approaches in vehicle aerodynamics, 11.3.2. Structure of the flow field past vehicles, the front wall drag and its reduction, 11.3.3. Rear wall, under-chassis and side-wall drag, 11.3.4. Flow past buses and trucks