NPL Wind tunnel

N1. Car front surface: Investigation on the flow past a simplified, mirrored car front surface model, with special regard to the drag force, for various chassis geometries

No drag force acts on bodies exposed to flow of ideal fluids. In the case of accelerating flow, e.g. developing in the vicinity of the front wall of a personal car, the boundary layer is thin. For this reason, the flow in the vicinity of the front wall is similar to the ideal, inviscid flow. As a result, the front wall drag coefficient of the car (being nearly equal to the mean pressure coefficient) is nearly zero. The total pressure slightly away from the front wall is nearly constant.

Assignment: justification of the above assumptions and gathering experiences about the flow in the vicinity of the car front wall. In order to model the ground (impermeable boundary), two symmetrically arranged front wall models are available. Pressure taps are installed inside the model as well as in the symmetry plane related to one of the two part-models. By this means, the pressure distribution can be measured on the front wall and in the separation bubble. The drag force can also be measured by means of a balance. The depression inside the model (i.e. in the separation bubble), multiplied by the maximum cross-section of the model, is to be subtracted from the drag force. By this means, the front wall drag can be estimated.

In the 45 min of the measurement,

a) The balance is to be calibrated (by means of weights, in 2 or 3 points),
b) The flow characteristics are to be examined by oil smoke flow visualization,
c) The drag force acting on the balance arm w/o the model is to be determined,
d) For 3 different velocities, the drag force acting on the models as well as the static pressure inside the models (relative to the pressure in the measurement section) is to be determined, when the models are equipped with wheels,
e) Repetition of the measurements w/o wheels with open and closed wheelhouse, and with modification of front wall geometry: e.g. sharp inlet edge above the windscreen, spoiler below the front wall.

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, and by means of which the static pressure inside the model can be tapped,
- 2 symmetrical car front wall models, one is equipped with static pressure taps,
- 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/

Further information –
Vehicle model measurements:

CD appendix for 3rd edition: M.11.2.4. Vehicle aerodynamics PP presentation (in 4th edition: DVD appendix, M.11.3.1 presentation). From 4th edition: 11.3.1. Aims and approximations of vehicle aerodynamics, 11.3.2. Classification of flow domain past car bodies, the front surface drag and its moderation, 11.3.3. Rear surface, under-chassis and sidewall drag, 11.3.4. Flow past buses and trucks