Vehicle Aerodynamics BMEGEÁTNW19
MID-TERM TEST – QUESTION TOPICs (2022)

See the sample mid-term tests from the previous years in separate files!

BASICS OF AERODYNAMICS / FLUID MECHANICS

- Aerodynamic force acting on a body in frictionless and in viscous flow. Force components. Definition of the pressure-based (form) drag and the friction-based (viscous) drag.
- Definition of the streamlined body and bluff body. Sketch the flow field (streamlines, zones). What is the physical quantity that dominates in the drag force acting on these bodies?
- Explain the influence of the vehicle's front body shape (concave/plane/convex front) on the average pressure (and on the drag) based on the contact angle (φ) between far-field velocity (v_∞) and the body surface tangent (t).
- Explain the influence of the vehicle's rear body shape (diverging / parallel / converging rear) on the average pressure (and on the drag) based on the contact angle (φ) between far-field velocity (v_∞) and the body surface tangent (t).
- Derive the equation for the aerodynamic force vector ($\underline{F}$) acting on a body in case of viscous fluid flow.
- Define and analyse the role of pressure coefficient (c_p) and the wall friction coefficient (c_f') in aerodynamics.
- Euler's equation in streamwise coordinate system (normal /$\underline{n}$/ component only). Connection between the parallel straight or curved streamlines and the pressure gradient in normal direction. Consequences of local pressure distribution on vehicle body surface based on the curved streamlines.
- Analysis of the underbody flow using Bernoulli's eq., Venturi-channel, continuity, total, static, dynamic pressure.
- How does "moving ground" effect on the aerodynamic parameters of a body placed close to the ground?
- Attached and separated flows around bodies. Laminar / turbulent boundary layer (BL), BL separation, reattachment. Conditions for BL separation. List some methods to favour and to inhibit or postpone BL separation.
- Laminar / turbulent flow: effect of Reynolds number on the boundary layer thickness, on the length of laminar BL.
- Evaluate the role of separation bubbles, reattachment zones, trailing vortices in vehicle aerodynamics.
- How and where does a passive separation bubble form? List the characteristics of a passive/2D separation bubble with the help of a sketch. What does the pressure inside the separation bubble depend on and how?
- How and where does an active separation bubble form? List the characteristics of an active separation bubble with the help of a sketch. What are its characteristics?
- Describe the formation of the drag force on a prismatic bluff body with sharp edges. Sketch the flow field and the pressure coefficient distribution! Estimate the magnitude of the components of the drag force (on the front, side and rear surfaces).
- Describe the formation of the drag force on a prismatic bluff body with rounded-up edges. Sketch the flow field and the pressure coefficient distribution! Estimate the magnitude of each component of the drag force (on the front, side and rear surfaces). How does the rounding-up of the leading edges reduce the drag force?
- What are the consequences of ground proximity in terms of pressure distribution on the vehicle body?
- List (with the help of sketches) some alternative methods besides rounding-up to reduce the drag force forming on the front face of a prismatic body.
- Sketch the coordinate system in vehicle aerodynamics with main (x;y;z) axes. Define the various aerodynamic forces and moments and their coefficients.
- What does it mean: side-wind condition? Sketch the vertical profile of the $\underline{v}=f(z)$ relative flow velocity vector for no-wind and for side-wind conditions! Effect of side-wind on stability in the function of yaw angle (side forces and moments in the function of yaw angle).

HISTORY OF VEHICLE AERODYNAMICS DEVELOPMENTS – FOUR MAIN PERIODS

- List the four main periods of the history of vehicle aerodynamics developments. Main characteristics of the periods, sketch example cars, list most famous people (aerodynamicists, car designers).
- Explain the main findings of period I. (borrowed shapes) with sketches of characteristic cars & vehicle examples.
- Explain the main findings of period II. (streamlining) with sketches of characteristic cars & vehicle examples.
- Explain the main findings of period III. (detail optimization) with sketches of characteristic cars & vehicle examples.
- Explain the main findings of period IV. (shape optimization) with sketches of characteristic cars & vehicle examples.
- Why weren't aerodynamically effective the ground vehicles having a borrowed body shapes?
- Why wasn't aerodynamically effective the Belgian electric vehicle named "La Jamais Contente" designed by Camille Jenatzy in 1899?
- Why wasn't aerodynamically effective the Zeppelin-shaped Alfa Romeo vehicle designed by coach-builder Castagna in 1914?
- Why wasn't aerodynamically effective the boat-tailed vehicle Audi Type C ("Alpensieger") designed by AUDI in 1912/1913?
- Why wasn't aerodynamically effective the "Rumpler Tropfenwagen" designed by Austrian car designer Edmund Rumpler in 1921?
- Explain and analyze the "combined form" (Kombinationsform") concept of Pál Járay! List famous vehicles using his idea!

- Why wasn't successful Karl Schlör's "Schlörwagen", the German experimental vehicle from 1939?
- Usually, streamlined vehicles were equipped later with attachments e.g. vertical rear fins. Why?
- Explain the main findings of the detail optimization! (based on example image-pairs: aerodynamic developments resulted in the same (=0,41) drag coefficient for VW Scirocco in 1974 as it was for the Opel GT in 1969.)
- Why the drag area is more important than the drag coefficient as far as fuel consumption is concerned?
- Notwithstanding that shape and detail optimization resulted in better and better drag coefficients, the today vehicle's average drag coefficient is still approx. ~0,32. Why is it difficult to reach the 0,15 drag coefficient of e.g. Schlörwagen?
- Notwithstanding that shape and detail optimization resulted in better and better lift coefficients, the today passenger cars' average lift coefficient is still a high positive value of 0,15÷0,30. Why is it challenging to reach a negative lift for passenger cars without additional spoilers?

PASSENGER CARS' AERODYNAMICS (topics in blue are not presented during the lectures)

- Describe the formation of the drag/lift force for a passenger car body! List methods to decrease the drag/lift.
- List and explain (with a sketch) methods to decrease the front drag/lift.
- List and explain (with a sketch) methods to decrease the rear drag/lift.
- Sketch and explain typical pressure coefficient distribution in the symmetry (vertical) mid-plane (upper and lower part) of the vehicle contour body-line.
- Rounding-up of the edges. How does it effect the drag/lift? Explain its mechanism with the help of a sketch.
- Effect of closed / open front grille. How does it effect the drag/lift? Explain its mechanism with the help of a sketch.
- Boat-tailing / truncated rear: How does it effect the drag/lift? Explain its mechanism with the help of a sketch.
- Changing inclination angles (front, hood, windows, roof, sides, rear, underbody etc). How does it effect the drag/lift? Explain its mechanism with the help of a sketch.
- Spoiler (front, rear). How does it effect the drag/lift? Explain its mechanism with the help of a sketch.
- Methods for changing the position of the front stagnation point. How does it effect the drag/lift? Explain its mechanism with the help of a sketch.
- Rear diffuser. How does it effect on the drag/lift? Explain its mechanism with the help of a sketch.
- Underbody coverings. How does it effect on the drag/lift? Explain its mechanism with the help of a sketch.
- Optimum ground clearance and smallest skirt gap: are these the solutions for better aerodynamics of passenger cars?
- Stationary / rotating wheels with partially open rim in wheel housing. How does it effect on the drag/lift? Explain its mechanism with the help of a sketch.
- List and explain methods for aerodynamic optimisation of flow field around rotating wheels.
- Describe the flow field forming at the rear of a fastback / squareback / notchback type vehicle, and show the lift force acting on it in function of the angle relative to the horizontal plane of the rear windshield.
- With the help of a sketch, show the working mechanism of the front and rear spoilers / wings placed on a passenger car. How do they affect the drag and lift coefficients?
- How does interact the front spoiler and the rounding up of the top leading edge of a passenger car? How does this interaction influence on the drag force? (separation, reattachment on the hood)
- Hood and front windshield inclination: separated zone size vs. transition angle.
- How does roof camber and side camber influence on the drag and drag area?
- Explain the working mechanism of wind deflector (for cabriolet).
- Compare hatchback(squareback), fastback and notchback vehicles.
- List - without explanation - at least eight solutions/methods to reduce the drag force acting on a passenger car.
- List - without explanation - at least eight solutions/methods to increase the negative lift force (=downforce) acting on a passenger car.
- Describe how a selected the add-on device (excrescence) influence on the drag / lift forces and moments.
- Compare various types of side mirrors. (analysis: form drag, flow interaction, upstream/downstream position, soiling, insert, etc.)
- How do wheels and wheel housings affect the drag and lift coefficient acting on a car? Explain the mechanism with the help of a sketch of the pressure distribution around the stationary / rotating wheel.
- How does wheel width influence drag and lift?
- Calculation examples: calculate basic parameters, e.g. pressure coefficient, wall friction coefficient, drag & lift coefficients, aerodynamic forces, aerodynamic power loss, drag area, top speed, etc.