

Calculating the Wing Lift Distribution with the Diederich Method in Microsoft Excel

The lift distribution on the wing is essential for the induced drag, the loads on the wing, and therefore, for the stall behavior, the maximum lift coefficient of the wing, and the wing mass.

The Diederich method is a semi-empirical method to determine the lift distribution of wings. The method is described in DIEDERICH, Franklin W., 1952. *A Simple Approximate Method for Calculating Spanwise Lift Distributions and Aerodynamic Influence Coefficients at Subsonic Speeds* [1]. For better didactics, see TORENBEEK, Egbert, 1988. *Synthesis of Subsonic Airplane Design* [2]. TORENBEEK's work is based on that of Diederich and combines it with the findings of ANDERSON, Raymond F., 1936. *Determination of the Characteristics of Tapered Wings* [3].

PURPOSE

Aim of this project is to provide the Diederich Method for calculating the lift distribution of a wing in a Microsoft Excel spreadsheet based on didactic considerations (Figure 1).

METHODOLOGY

The Diederich Method is described based on primary and secondary literature. Diagrams are digitized so that the method can run automatically. To optimize the lift distribution of the wing, the elliptical and triangular lift distribution as well as Mason's lift distribution are offered for comparison. A method for calculating the maximum lift coefficient of the wing is integrated into the Diederich Method. To do this, the maximum lift coefficients of the airfoils at the wing root and at the wing tip must be entered in the program.

FINDINGS

The calculation assumes a trapezoidal wing. Both wing sweep and linear wing twist can be taken into account.

RESEARCH LIMITATIONS

The aspect ratio must not assume values that are too small. Subsonic flow and unseparated flow are assumed. Since only the wing is described, all other influences such as from the fuselage or from the engines are not taken into account.

PRACTICAL IMPLICATIONS

The Excel workbook was created for teaching in aircraft preliminary design.

ORIGINALITY

At the moment, the Diederich Method is apparently nowhere offered as a spreadsheet. With this work, this gap can be closed.

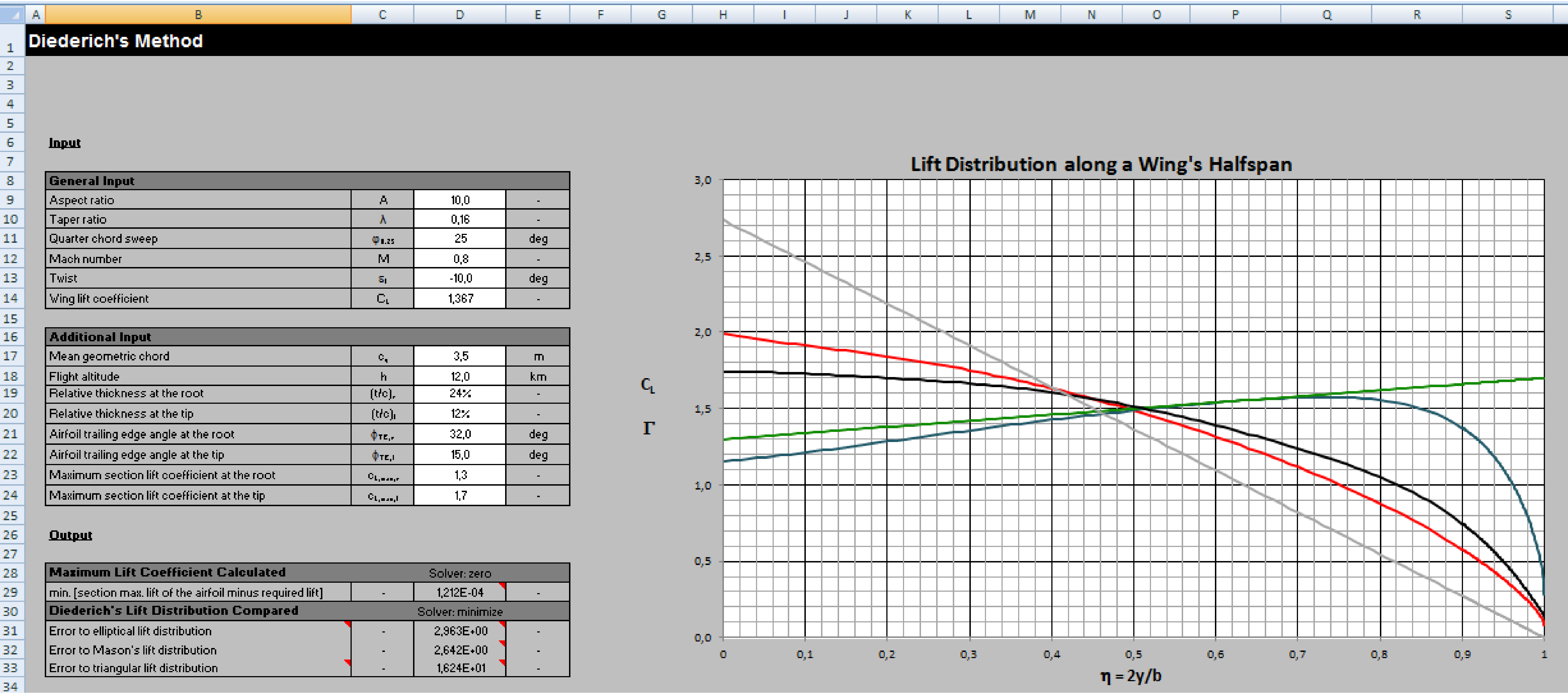


Figure 1: Input data in white fields. The graph to the right shows (depending on the curve) circulation, Γ or local lift coefficient, C_L , plotted against relative half span (from root, 0 to tip, 1). Various curves exist: The lift distribution or circulation, Γ (Gamma) (red) should be between the elliptical lift distribution (black) and the triangle lift distribution (light gray). The distribution of the lift coefficient (blue) may at no point along the span be above the maximum lift coefficient of the airfoil (green) - a straight line between root and tip values. If this condition is violated, a smaller wing lift coefficient, C_L , may be selected under "General Input". A lift coefficient (blue) above the lift coefficient of the airfoil (green) indicates that the wing will be stalled (flow is separated from the surface) in this region of the wing.

References

- [1] <https://ntrs.nasa.gov/citations/19930083506>
[2] <https://resolver.tudelft.nl/uuid:229f2817-9be9-49b6-959a-d653b5bac054>
[3] <https://ntrs.nasa.gov/citations/19930091647>

All details in the Bachelor Project of Arslan (2023) and the User Guide:

<https://nbn-resolving.org/urn:nbn:de:gbv:18302-aero2023-04-13.012>

Software in Harvard Dataverse:

<https://doi.org/10.7910/DVN/UK2SIV>