

Sail2D

Vers. 2.4

User's Manual

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1. INTRODUCTION

The program Sail2D is not a commercial product. The software should only be used for research work. It comes without any warranty. The software is protected by copyright and intellectual property laws. The author reserves all rights. The software is licensed free of charge but not sold. You may install it on your computer for your own personal use, but you may not distribute or sell the software or copies of it.

Sail2D.exe was compiled with the Intel® Fortran compiler for Windows. When you start it for the first time, some OS can block the execution and display a message that Sail2D might contain a risk to your computer. The reason for this message is the fact, that Sail2D comes without a certificate and Microsoft tries to enforce its own certification process. Since Sail2D is free software, it is impossible to buy every year an expensive new certificate. You can click on the information button in the message, “accept the risk” and run the program.

Sail2D is a small program that computes the aerodynamic characteristics of 2D sail sections. It interpolates in a database of discrete values that were created with XFOIL [1] for sails with optimum camber. The theoretical background is explained in [2]. The program can calculate the values for headsails as well as for the mainsail behind a mast. Changes in version 2.2 are the use of spline interpolation, the correction of a bug in the calculation of CD at large angles and the extension of the range of mast diameters D/c to 50%, to get proper predictions also at the head of the sail. In version 2.4 additional datasets for fixed camber were added. It is helpful on reaching courses, when sheeting angle and camber are predetermined [2]. The results will later be used in a VPP, when the forces created by the complete rig will be calculated using classical wing theory.

2. INSTALLING AND RUNNING THE PROGRAM

The zipped file that you downloaded contains the executable file Sail2D.exe and an example of the output file Sail2D.txt. You should extract these files into a folder of your choice. Nothing else will be installed on your computer. You can run the program within its folder.

When you open Sail2D.exe the command prompt window will appear and the software will walk you through the required input parameters. If you chose the path for the prediction of the headsail-parameters, the screen might look like figure 1 (depending on the setting of your command prompt options, the background color might be black). There are four options for the profile of the sail. One shape follows the NACA mean-line $a = 0.1$. The other option is the shape of a parabola, either with optimum camber or with a camber that is prescribed by the user in the next step. Details are explained in [2]. If you chose the mainsail with mast, the window might look like figure 2. The input for the letters is not case sensitive. The geometric definitions are depicted in figure 3. The chord is measured from luff to leech of the sail; the mast is not included. The camber is defined as f/c . The relative mast diameter is D/c . If the mast has the form of an ellipse, D is the length of the larger axis. γ is the sheeting angle. The Reynolds-number is based on the chord-length, without the mast. Alpha is the angle of attack. All angles are measured in degrees.

```
C:\Users\Uli\Desktop\Sail2D\Sail2D\Sail2D.exe
*****
*          Sail2D version 2.4      *
*  Copyright (C) 2022 Ulrich Remmlinger   *
*  Commercial usage not allowed       *
*  There is absolutely no warranty and no   *
*  liability can be accepted by the author   *
*  for more details see www.remmlinger.com   *
*****


Sail2D calculates the aerodynamic characteristics
of 2D sail sections by interpolating XFOIL-results

type "H" for headsails or "M" for the mainsail, press enter
h
For a sail profile equal to naca a=0.1 and optimized camber enter "N"
For a sail profile equal to a parabola and optimized camber enter "P"
For a sail profile equal to naca a=0.1 and fixed camber enter "NX"
For a sail profile equal to a parabola and fixed camber enter "PX"
nx
enter camber in percent
10
enter the Reynolds-number based on chordlength
2000000

define a sequence of angles of attack alpha
enter first alpha value (deg)
0
enter last alpha value (deg)
30
enter alpha increment (deg)
1
results in file Sail2D.txt
press enter to exit
```

Figure 1: input for
headsail

```
C:\Users\Uli\Desktop\Sail2D\Sail2D\Sail2D.exe
*****
*          Sail2D version 1.0      *
*  Copyright (C) 2021 Ulrich Remmlinger   *
*  Commercial usage not allowed       *
*  There is absolutely no warranty and no   *
*  liability can be accepted by the author   *
*  for more details see www.remmlinger.com   *
*****


Sail2D calculates the aerodynamic characteristics
of 2D sail sections by interpolating XFOIL-results

type "H" for headsails or "M" for the mainsail, press enter
m
enter relative mast diameter D/c in percent
12
enter sheeting angle in degrees
15
enter the Reynolds-number based on chordlength
600000

define a sequence of angles of attack alpha
enter first alpha value (deg)
0
enter last alpha value (deg)
20
enter alpha increment (deg)
0.5
results in file Sail2D.txt
press enter to exit
```

Figure 2: input
for mainsail

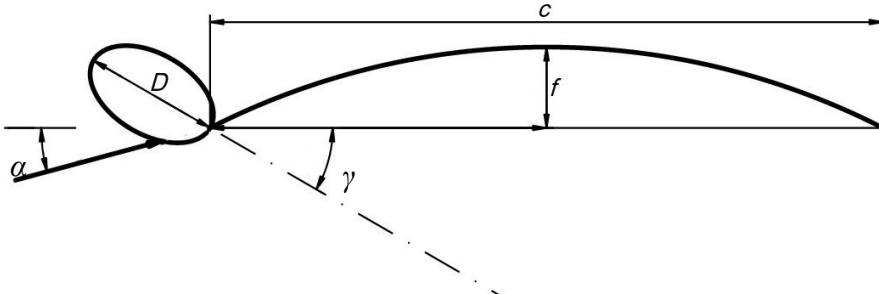


Figure 3. Definition of the geometric parameters

3. THE OUTPUT FILE

The output file is called Sail2D.txt. It contains a table of the aerodynamic characteristics as a function of the angle of attack. These parameters are the dimensionless coefficients for lift and drag based on chord-length, the optimal camber f/c in percent and the relative position of the aerodynamic center x_{AC}/c . The vector of the resultant aerodynamic force is acting at this center. x_{AC} is the distance of the center from the luff of the sail. The allowed camber is limited to 18% for mainsail and jib (NACA-profile) and to 31% for the parabolic headsail with optimal camber. The module in version 2.4 for fixed camber can predict a parabolic headsail up to 36% camber. For a larger camber, the program XFOIL will fail to arrive at a converged solution. The output for fixed camber will also indicate the source of the database. For angles of attack close to zero or even negative, the camber of the sail cannot be maintained and the sail will come aback. This is also indicated in the source-column.

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4. REFERENCES

- 1 Drela, M., Youngren, H., XFOIL Computer Program, [Online], Available: <http://web.mit.edu/drela/Public/web/xfoil/>
- 2 Remmlinger, U. "Aerodynamic Characteristics of 2D Sail sections", [Online], Available: <http://www.remmlinger.com/2D%20aerodynamics.pdf>