Appendix – PANUKL package brief description

Students who are strongly interested in problem of numerical aerodynamic calculations (CFD) can make this project utilizing the PANUKL software. Preparing model and analysis in the PANUKL is definitely more complicated and time consuming compared to the AVL software. The general procedure of calculation of the final aerodynamic characteristics is described in the project guide but read it very careful because some of calculations are not going to be needed if you are using PANUKL to model 3D aircraft. An example of pressure distribution computed for 3D aircraft by the PANUKL package is presented in Fig. 1.

PANUKL - Panel method software for aerodynamic analysis developed under supervision of prof. Tomasz Goetzendorf-Grabowski at Aircraft Design Department on the Faculty of Power and Aeronautical Engineering. The software is available free. It has user-friendly GUI for grid preparation, analysis and post processing. The software installation file, examples, and manual are available at: http://www.meil.pw.edu.pl/add/ADD/Teaching/Software/PANUKL

PANUKL first steps:

- Go to the software website and download one of the versions on Windows or Linux and install on your system. After opening it for the first time you will be asked to create work directory for the PANUKL. You must answer **YES** to all questions. It's an important step, because if the work directory won't be created program may not be able to make aerodynamic analysis.
- Manual for PANUKL may be opened from help menu. Remember to set English language.
- Open and compute examples attached to PANUKL.
- In case of computations failure logs can be found in "C:\Users\ComputerUser\.panukl" (Windows), "home\.panukl" (Linux).

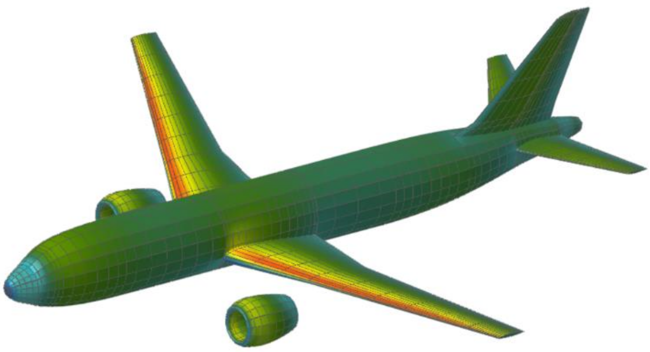

Fig. 1 Example of computations in PANUKL

PANUKL Tips & Tricks:

- It is recommended to generate geometry file with MS2 editor (**Fig. 2**);
- It is more efficient to add component one by one then make a pressure computation to cheek if the model is working rather than building the whole geometry first without making any test of pressure distribution computation in between.

- Using the geometry description by a superellipse is recommended to generate a fuselage geometry. To open the window to generate fuselage geometry definition follow the instruction: at fuselage section in MS2 editor mark *including fuselage*, next select *generate*, then click button *edit* (see Fig. 3). Detailed information about superellipse's parameters you can find in the PANUKL user manual (data, configuration and output files section) on page 11-12;
- To prepare fuselage for the PANUKL (see Fig. 4 and Fig. 5) you don't need CAD systems (such as Unigraphic) it **is unnecessary**, see the previous point and check in PANUKL user manual information *about wing-fuselage intersection type*;
- PANULK requires both left and right parts of an airplane, even when the symmetrical calculation case is considered. If your airplane is symmetrical about X-Z plane choose *symmetrical object* in MS2 editor then you need to define only a half of the model and program automatically makes the mirror of the geometry.
- Inside the fuselage, there can only be one wing's section - the root section, see Fig. 6. The same is going to apply for modeling a horizontal tail if the horizontal tail intersect with the fuselage.
- To get a good quality of results, the mesh distribution on the fuselage must match the distribution on the wing (in the area that both components intersect). This can be automatically done by the PANUKL by selecting the wing as a master component and ticking the "Compute wing-fuselage intersection" box. The same is going to apply for modeling a horizontal tail if the horizontal tail intersect with the fuselage.
- If you have a T-tail configuration you must add a connection between the vertical and horizontal tail - again it's a matter of making the mesh distribution on both components identical for the region where both components intersect.
- You can speed up the process of the necessary files preparation by using manage and compute sequence (see Fig. 7)
- You can use compute polar to compute all coefficients for a sequence of angles of attack (see Fig. 7), this is faster method than manually creating a files set for each AoA.
- Keep in mind that the final results (coefficients) can be found in the out file. The results are given in two axis systems (stability and body axis system).

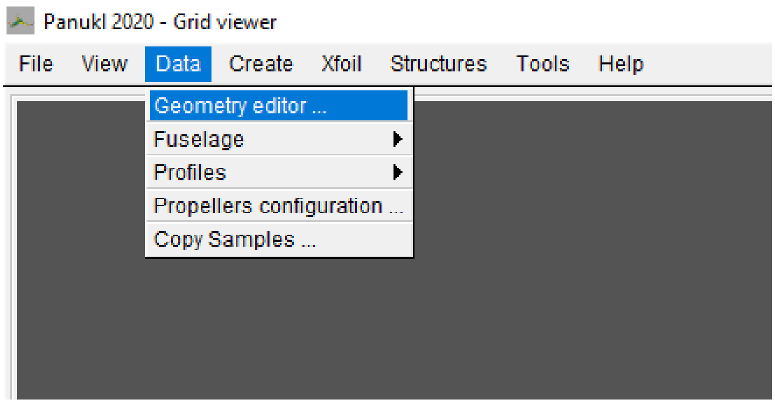

Fig. 2 Opening MS2 editor

Fig. 3 MS2 editor

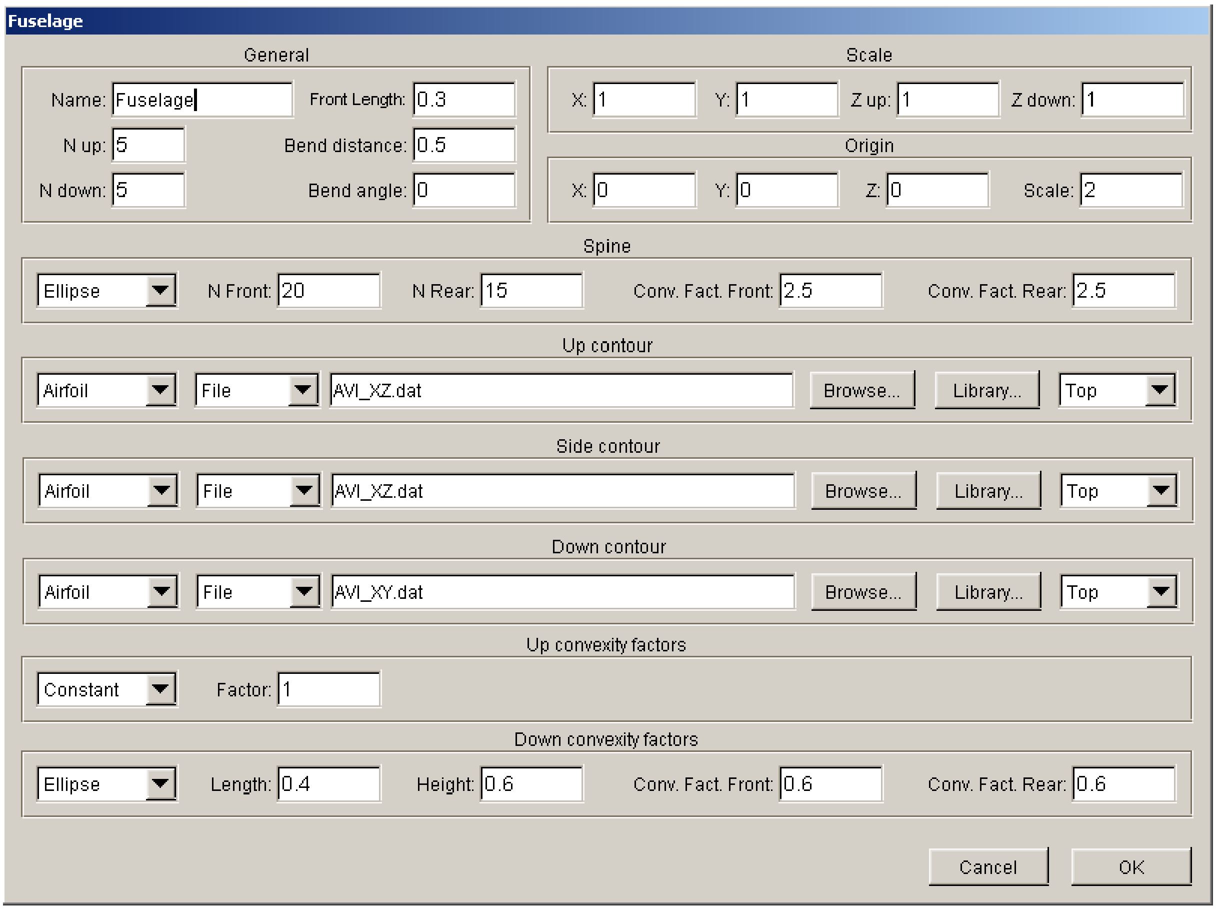

Fig. 4 MS2 editor – fuselage generator

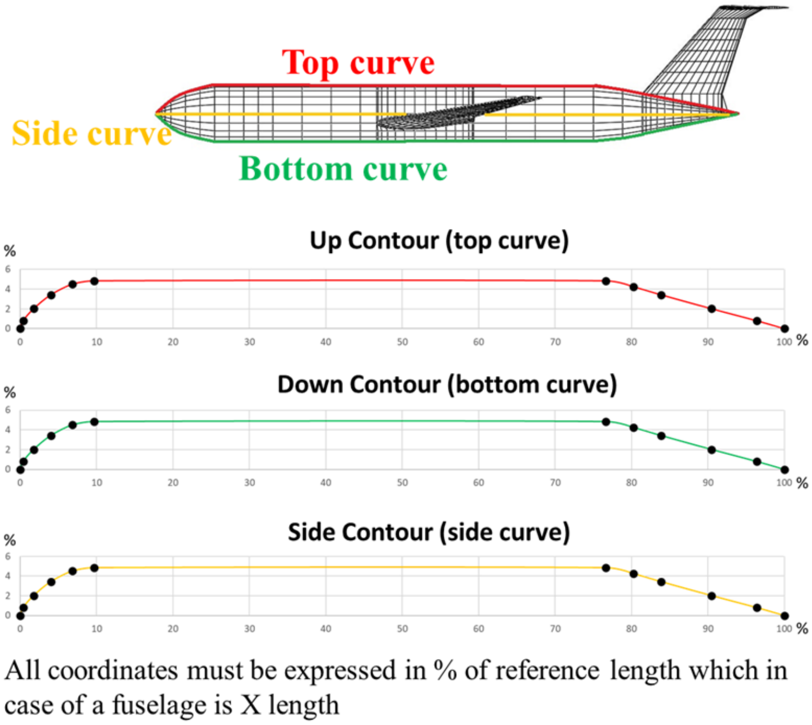

Fig. 5 How the fuselage geometry must be define by 3 contours

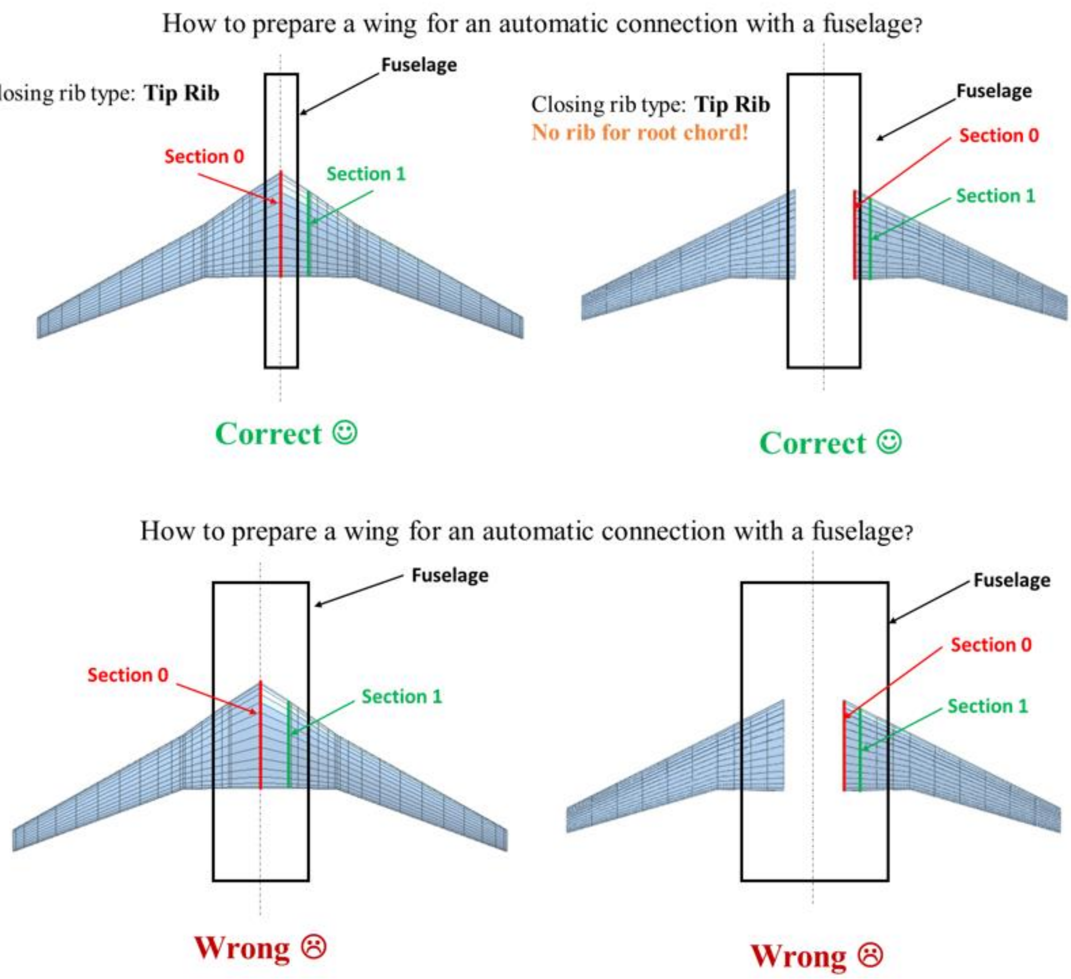

Fig. 6 How to correctly model the wing in the PANUKL package

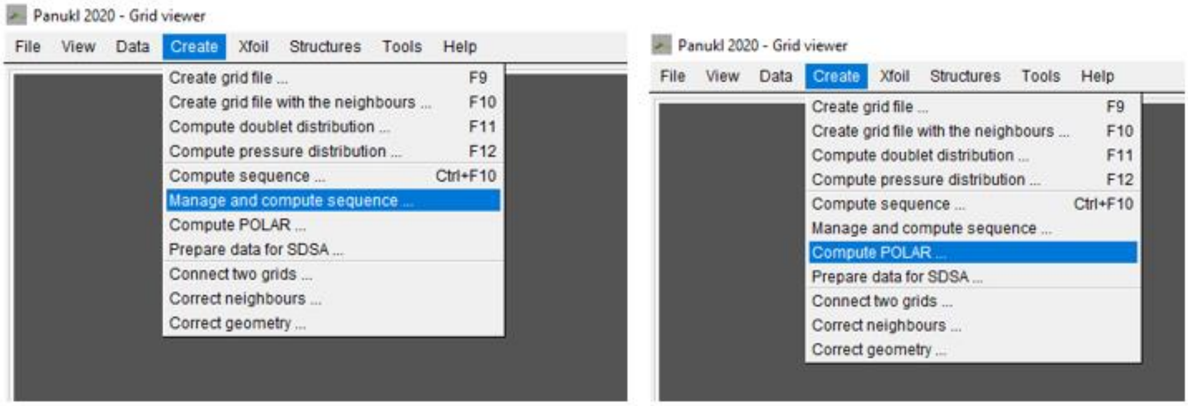

Fig. 7 To speed up the process of files preparation use the Manage and compute sequence feature while to speed up process of computation for a sequence of angles of attack use Compute POLAR feature