

Multicopter UAV propeller development using Mecaflux Heliciel

Sale rates of multicopter unmanned aerial vehicles, for both private and commercial uses, are growing very rapidly these days. Even though there are still legal restrictions in some countries, demand for multicopters with long flight times is significant. Only a few propellers available off the shelf are optimized for multicopter use. They are often designed for small unmanned aircrafts and don't provide high efficiency at hover.

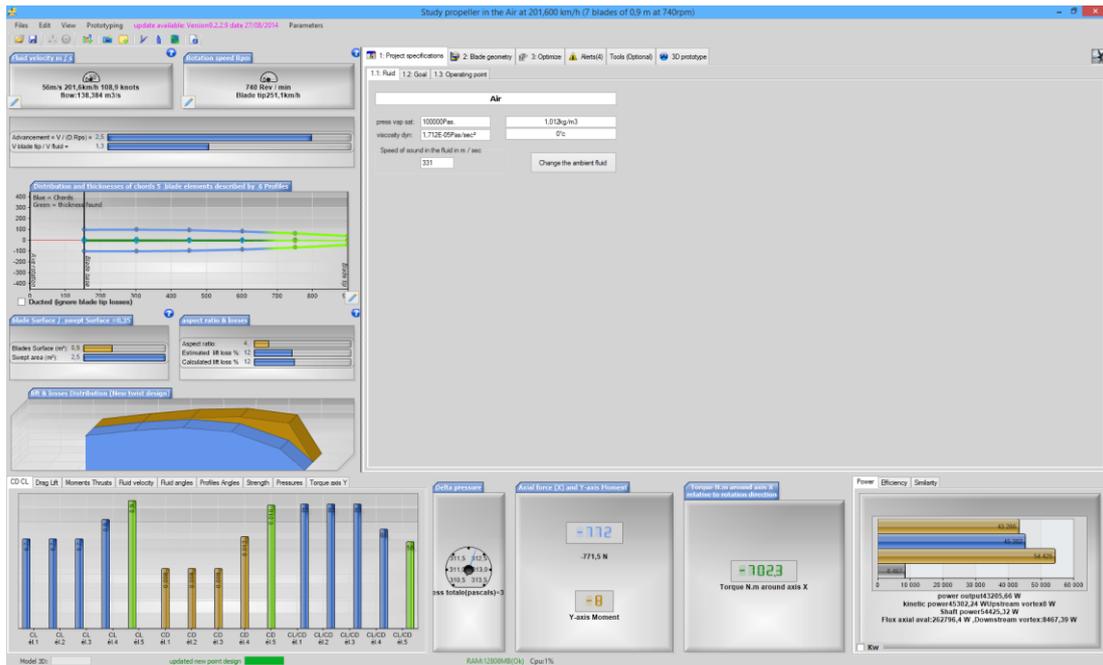
Many companies are facing the challenge of designing their own propellers to increase flight times of their products. Mecaflux Heliciel is very well suited for this task. It doesn't require many years of engineering experience to design the propeller. The process is very easy and all you have to do is to understand conditions in which propeller is going to work.

This tutorial describe the process of propeller design for multicopter aircraft step by step.

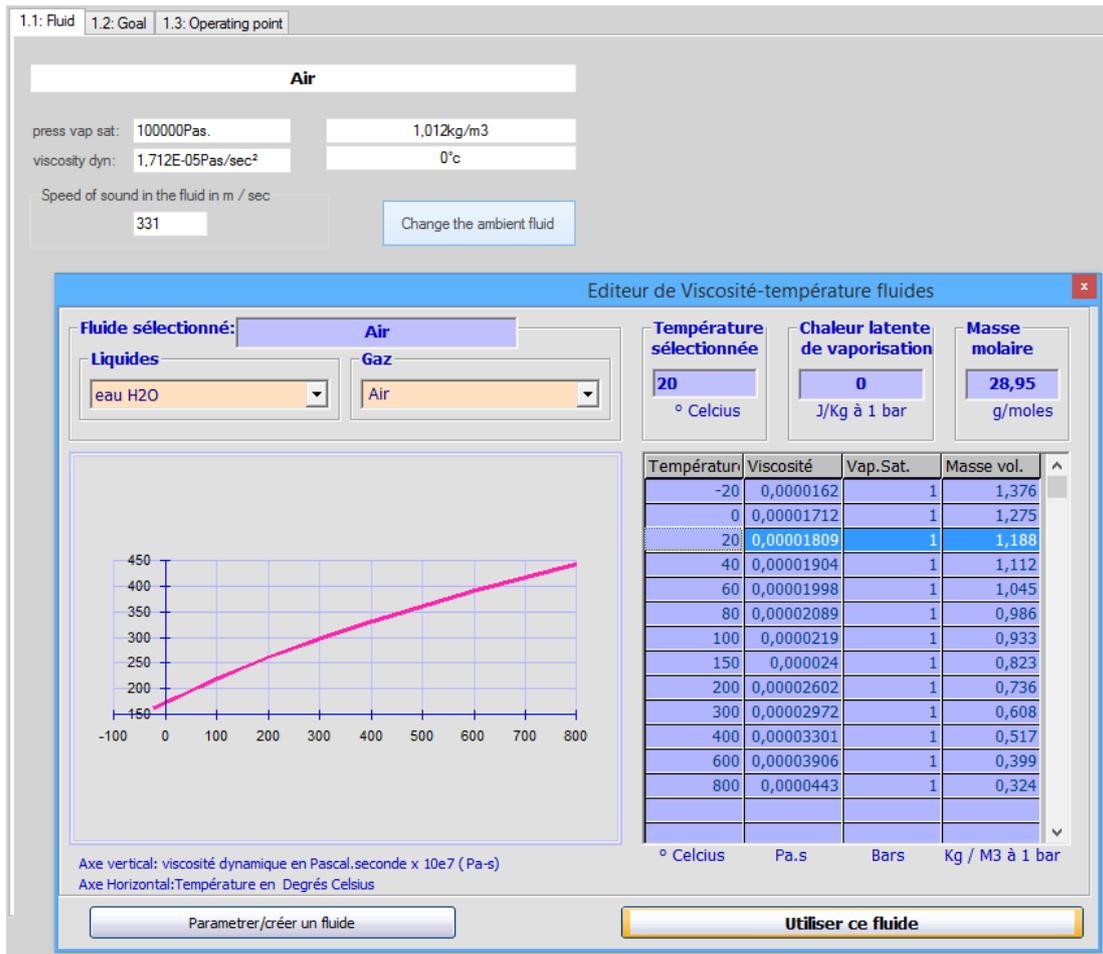
1. The first step is to start a new project simply by clicking:

Files → New project (from model) → New propeller (thrust generation)

2. Now let's take a look under the tab **Project specifications** → **Fluid** and click on the button **Change ambient fluid**. In **Gaz** tab choose **Air**. Then decide in which temperature your propeller is going to operate. If you develop a multicopter for inspecting oil pipes in Alaska the design could vary from the design for filming tropical forest. When you choose temperature go to the next step. You will be asked to enter an altitude. Both parameters of temperature and altitude can influence angles of attack in different parts of a propeller therefore they could change the efficiency.

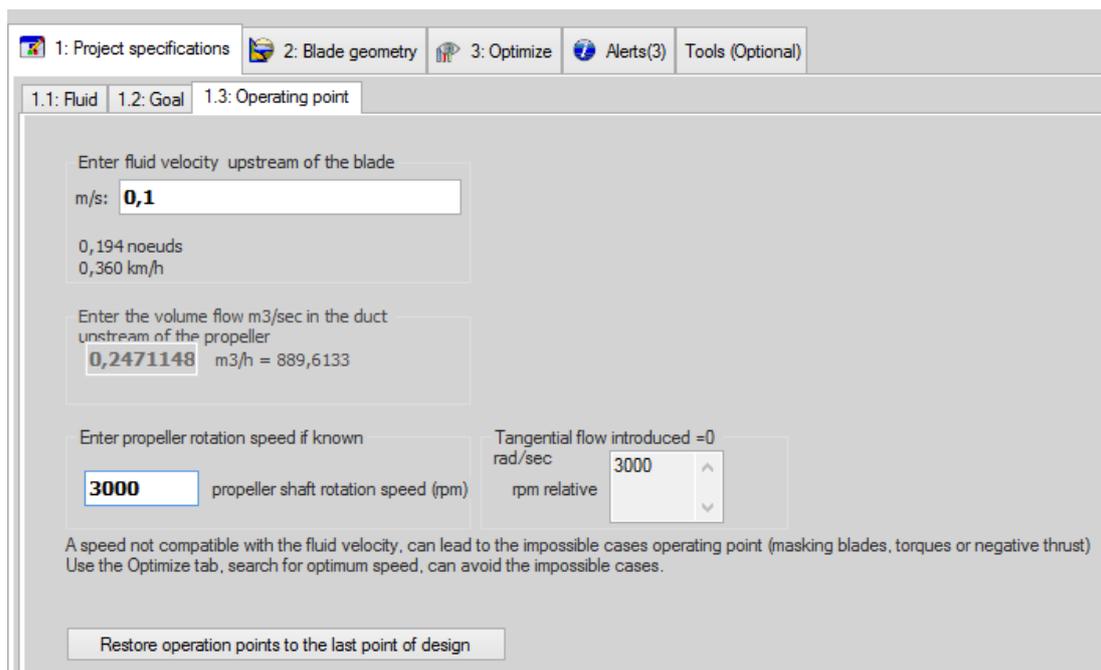


The basic window after creating a new project



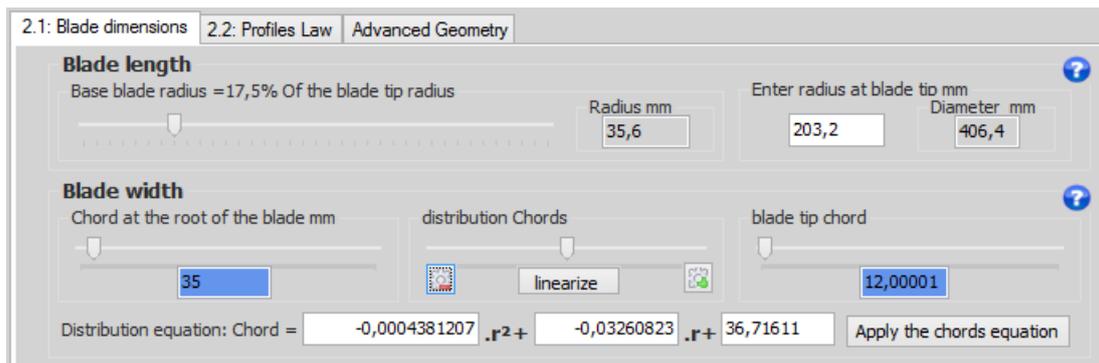
Ambient fluid tab

3. Right after that go to the **Goal** tab and choose **Propeller**.
4. In the next step go to the **Operating point** tab. **Air velocity** is probably the most important parameter in terms of propeller efficiency in a multirotor. If we would develop a propeller for a model aircraft we would enter high air velocity value. In multirotors we want to achieve the maximum efficiency at hover. It means that you have to enter low value like 0.1 m/s. You can't enter 0 because program uses this value for some calculations and it would cause errors. Number a little higher than 0 is fine – there is always some wind. If you want to develop multirotor for continuous forward flight feel free to enter high velocity. Just keep in mind that this isn't speed of the flight but speed of air in propellers axis (which isn't horizontal in multirotors) .
5. The next parameter under the same tab is **propeller rotation speed**. If you already chose an electric motor find what is the rotational speed at maximum efficiency and enter that speed. You will adjust this parameter later either way.



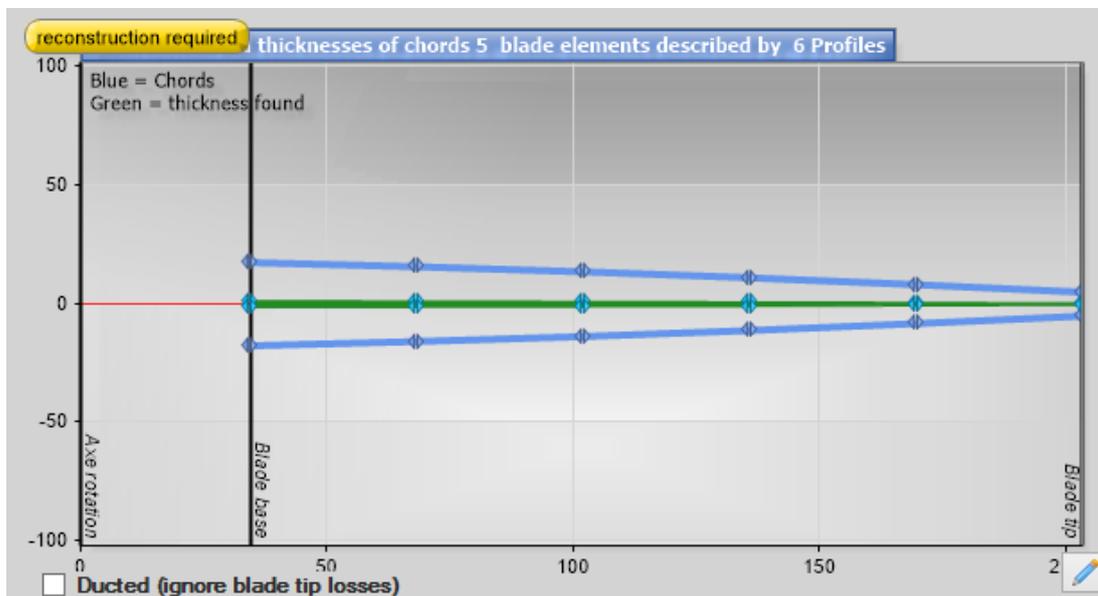
Tab with air velocity and propeller rotation speed

6. At this point it's time to go to the next tab named **Blade geometry** and under that **Blade dimensions**. The first parameter you should adjust is **radius at blade tip**. This is basically radius of the propeller. As an example enter radius of 16" propeller which is 203.2 mm. You can also change **Base blade radius**. This is a radius of center part of the propeller, most likely defined by diameter of the motor.



Blade dimensions tab

7. Now let's move to the **Blade width**. These parameters are going to influence thrust, torque and therefore efficiency of propeller. You have to experiment with values to achieve the highest efficiency at thrust you need. Adjusting width of the blade also help to prepare propeller to manufacturing process. If you develop very small propeller you may want to use high width values to make sure that cross sections aren't too thin. At the beginning adjust **Chord at the root**, **Blade tip chord** and **distribution Chords** to make your blade look like this:



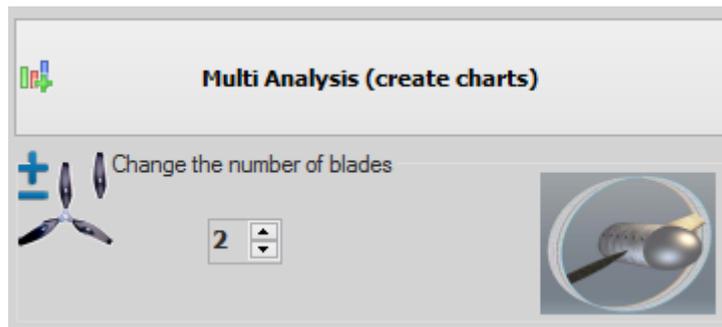
This is how blades of most modern multirotor propellers are shaped.

8. In the next tab named **Profiles Law** try to find most efficient airfoils. If you are not an aerodynamics engineer you have to know a few things. There isn't only one best airfoil. Airfoils tend to perform different under different conditions. It depends on

airfoil length, air velocity, temperature and pressure of air. That's why you shouldn't use an airfoil from full sized helicopter in small multicopter.

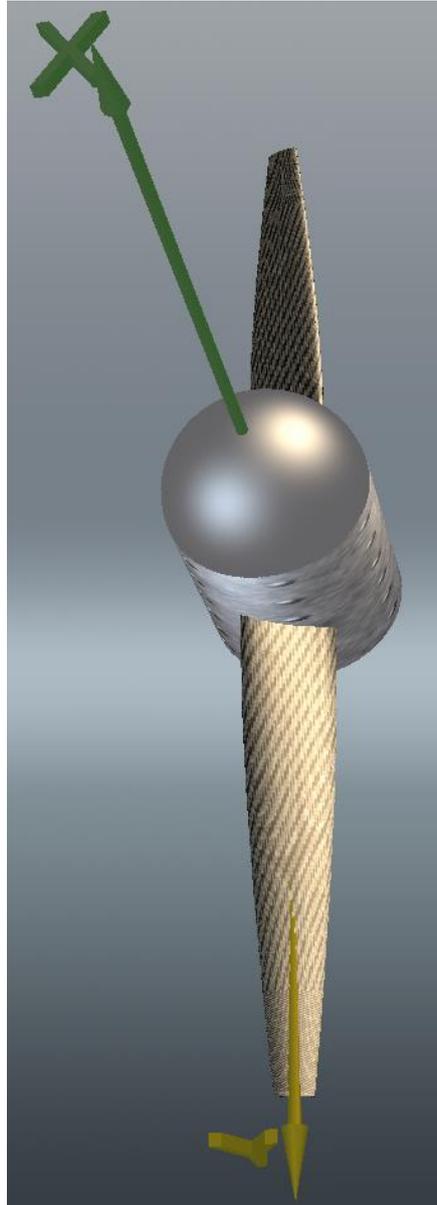
Click on the button named **select the default profile**. It opens another window where you can find a table with data of all airfoils in database. To choose probably the best one click to sort the table in a way that airfoils with the highest **f_max** parameter will be on top. Then click on the profile on top. After that all you have to do is to click the button named **Default profile (profile law)**

9. The last step before seeing some results is to go to **Optimize** tab where you can adjust blade number. Most propellers for multicopters have 2 blades because it gives the best efficiency in most cases. Unless you want to achieve higher thrust without changing other parameters like radius of the blade you should choose 2 blades. Now only click on an icon right to the save icon .



Part of an optimize tab

Congratulations! You just designed your first propeller. On the bottom part of Heliciel window there are all important parameters like thrust, torque and efficiency. You will probably notice that propulsive efficiency is very low. That's because this number depends on air velocity which is very low in case of multicopters (we entered 0.1 m/s). Just compare kinetic efficiency with an improved design.



3D prototype of propeller

There is still a lot to adjust to make a propeller perform better.

10. Open Editor calculation notes by clicking on an appropriate icon . Scroll table to the right until a column named **Reynolds** appears. It's the most important number in search for the best airfoil for your propeller. For multicopter purposes Reynolds numbers will be under 100000. Heliciel database of airfoils is limited to NACA profiles but many other airfoils were invented. You can search for them in databases in the internet. If you decide to do that Reynolds number will be helpful. In search engines of the internet databases you can choose Reynolds number that your propeller will

operate in. Choose an appropriate Reynolds number and look for airfoils with the highest drag to lift ratio. Take under considerations that very thin profiles can be impossible to manufacture and not stiff enough to work properly. When you find an interesting profile you can download .dat file, import it in Heliciel and test if it improves you propellers performance.

11. After finding a better profile you can go back to adjusting blade width. Try many combinations to find the most efficient one. Changing blade width is going to have an influence on Reynolds number. After significant changes in blade dimensions you may have to go back to search of the best airfoil.

Heliciel is a powerfull tool for everyone from hobbyists to professional propeller design companies. Ease of use will be appreciated by every user because it simply save time during the process. It also helps to focus on perfecting propeller parameters which is the key to efficient design.