VELOCITIES DETERMINATION AROUND AN AERODYNAMIC PROFILE

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Abstract. *In this paper are presented the experimental results obtained for the velocities determination around an aerodynamic profile consisting of a biplane configuration. The experimental results are obtain through laser Doppler method, the results consisting from the flow velocities around the profile and the determination errors.*

Key words*: velocities determination, laser Doppler Method, aerodynamic profile.*

1. The laser Doppler method uses a source the monochromatic laser light. The intersection of two laser beams reflected on the detector where they are forming a fringe net. The information regarding the velocities of the diffraction centers are contained in the diffraction field through the laser Doppler effect. The laser Doppler method is an indirect measuring method.

The basic principle of the laser Doppler method is presented in the figure bellow. The laser Doppler effect appears twice, once when the laser beam is incident on the moving particle, beam characterized by the wavelength λ_b and the frequency f_b and one when the reflected beam, with the frequency f_p, is received by a stationary detector having the frequency f_r.

$$f_r = f_p \frac{1}{1-\frac{e_{pr}\cdot v_p}{c}} = f_p \frac{\frac{e_b \cdot v_p}{c}}{1-\frac{e_{pr}\cdot v_p}{c}} \qquad (1)$$

$$\approx f_b + f_b \frac{v_p(e_{pr}-e_b)}{c} = f_b + \frac{v_p(e_{pr}-e_b)}{\lambda_b} \quad (|v_p| << c, \mathrm{c} = \mathrm{f_b}\lambda_b)$$

c is the sped of light in the specific environment.

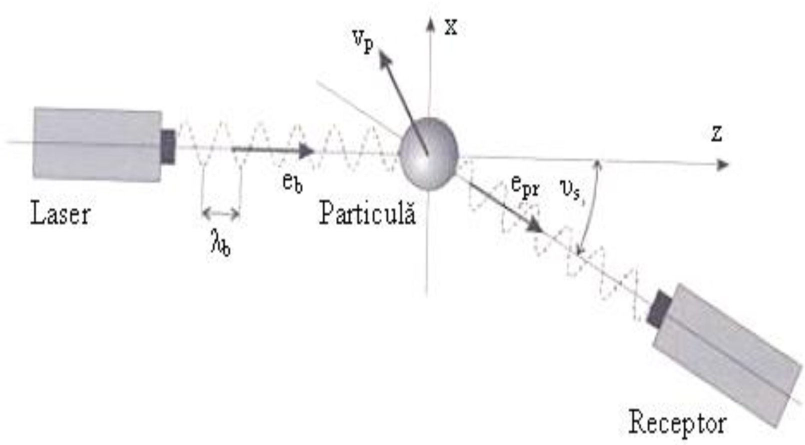
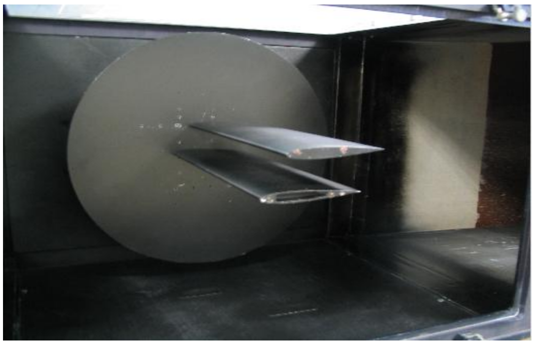


Fig. 1 – Laser Doppler effect

2. The configuration



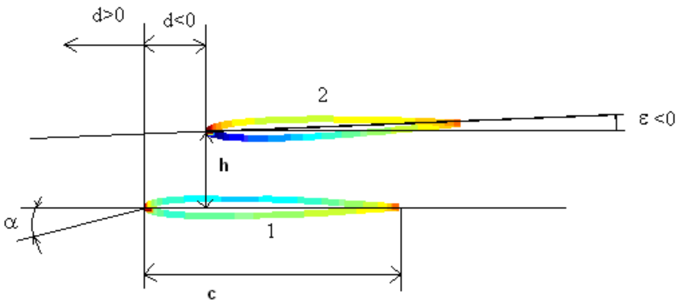


Fig. 2 – The measuring configuration

Notations:

- c – the profile chord
- d – the horizontal distance between the front of the two wings
- h – the vertical distance between the front of the two wings
- ε - the angle between the two wings
- α – the incidence angle (measured form the wing 1)

The configuration is made form two identical and rectangular wings, naca0012 profile, in biplane configuration.

The two wings were put in configuration by the help of a disc, resulting a bidirectional flow. An assembly between walls was chosen.

3. The measuring system

The measurements were made to determine one component of the velocity (horizontal). To determine two components of the velocity, two pairs of laser beams are necessary. For every component a different wavelength is used.

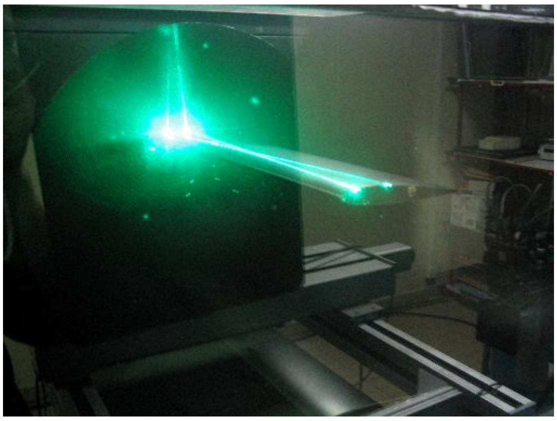


Fig. 3 – The measuring system

The measurements were made for different configurations and for two incidence angles 0 and 5^o. These configurations are:

1) h/c=1.5, d/c=0 and ε =0
2) h/c=0.5, d/c=0 and ε =0
3) h/c=0.5, d/c=0.5 and ε =-3.

The measurements were made in an cross plane at the half of wings length. For the measurements, a net of measuring points was defined.

4. Results for the velocities measurements

1) h/c=1.5, d/c=0, ε =0, zero incidence configuration

In the image form bellow is presented the velocities distributions around a biplane configuration. The velocities configuration is the same as for a monoplane. The flow around the two wings is the same and it is symmetrical in rapport of the profile chord. The results are similar from the one in aerodynamics. The stopping phenomenon can be seen in fort and in the back part of the wing. Also, it can be seen that the velocity increases between the two wings because of the decreasing of the cross section.

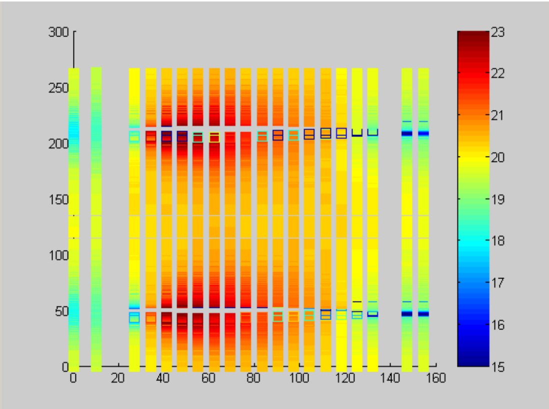


Fig. 4 – Flow field for h/c=1.5 d/c=0 and ε =0

2) h/c=1.5, d/c=0, ε =0, 5 degree incidence configuration

As in the image above, the flow field is similar with the aerodynamics theory. The interaction of the two wings can be seen. The low is no longer symmetrical. In this configuration the stopping phenomenon can be seen more easily, especially for the wing bellow. It can be seen that the velocities in the above part of the wings are greater then the ones bellow, resulting in a lifting force. The difference between the velocities from the above and the bellow part of the wings is higher for the wing above.

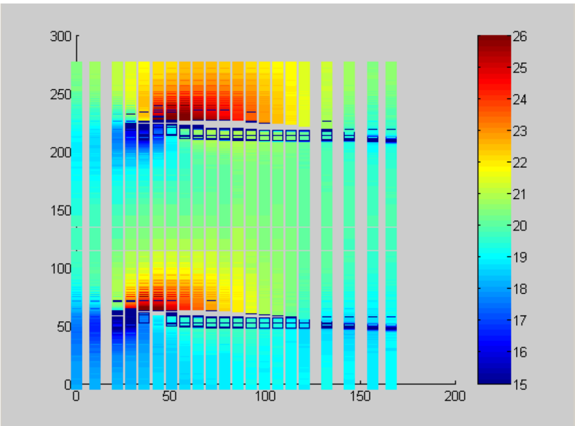


Fig. 5 – Flow field for h/c=1.5, d/c=0, ε =0, α =5

3) h/c=0.5, d/c=0, ε =0, zero incidence configuration

In the image bellow it can be seen that the velocities between the two wings is greater than the firs configuration, so the influence of the wings on each other is greater. The maximum velocity in the first configuration is 23 m/s, while in this configuration the maximum velocity is 26 m/s. The flow is no longer symmetrical in rapport of the profiles chord, but is symmetrical in rapport of a line between the two wings. The lower wing has a positive lift force and the higher wing has a negative lift force.

In this configuration the interaction of the two wings is more pronounced. The difference between the lower and the higher part of each wing being 3,5 – 4 m/s.

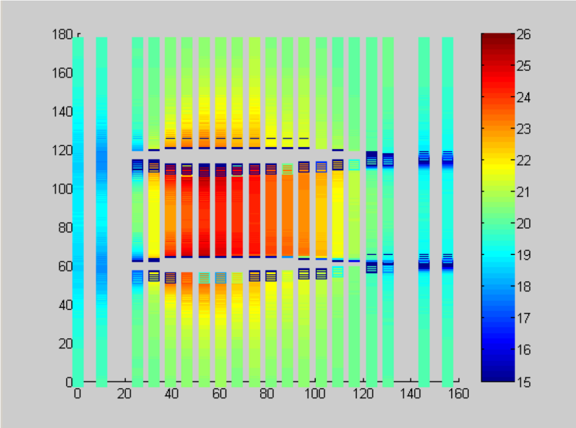


Fig. 6 – Flow field for h/c=0.5, d/c=0, ε =0, α =0

4) h/c=0.5, d/c=0, ε =0, 5 degree incidence configuration

In this configuration both wings have a positive lift force, but the one of the lower wing is greater. The velocities difference for the two parts of the lower wing is 7 m/s. In this configuration the velocities between the two wings increases.

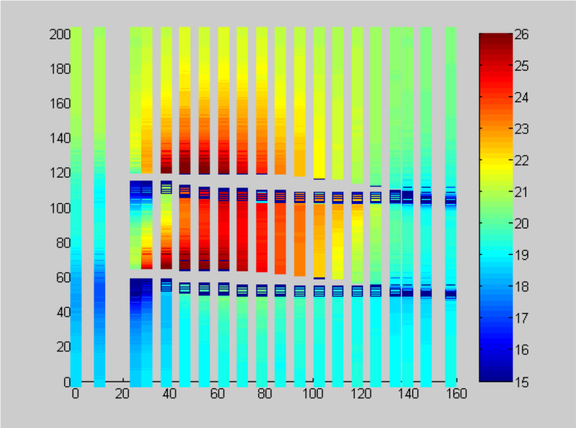


Fig. 7 – Flow field for h/c=0.5, d/c=0, ε =0, α =5

5) h/c=0.5, d/c=0,5, ε =3^o, zero incidence configuration

In this configuration the higher wing is in front of the lower wing with a half of the chord and it is rotated with 3^o form horizontal. In this case the stopping phenomenon is more pronounced for the higher wing. The velocities difference is grater for the higher wing. This configuration has a negative lift force although the lower wing has a positive lift force.

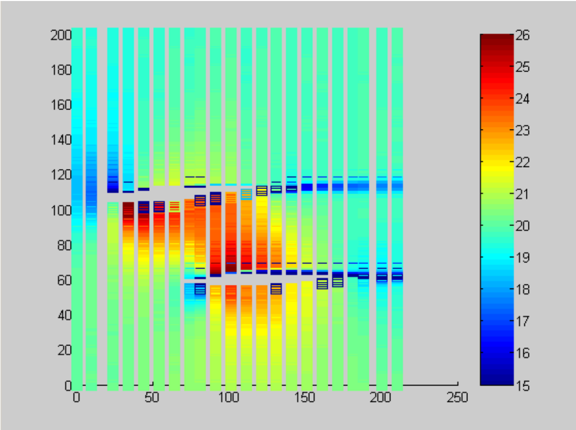


Fig. 8 – Flow field for h/c=0.5, d/c=0.5, ε =-3, α =0

6) h/c=0.5, d/c=0.5, ε =-3^o, 5 degree incidence configuration

In this configuration the stopping phenomenon is more pronounced for the lower wing. The velocities differences is higher for the lower wing, which is the same as in reality.

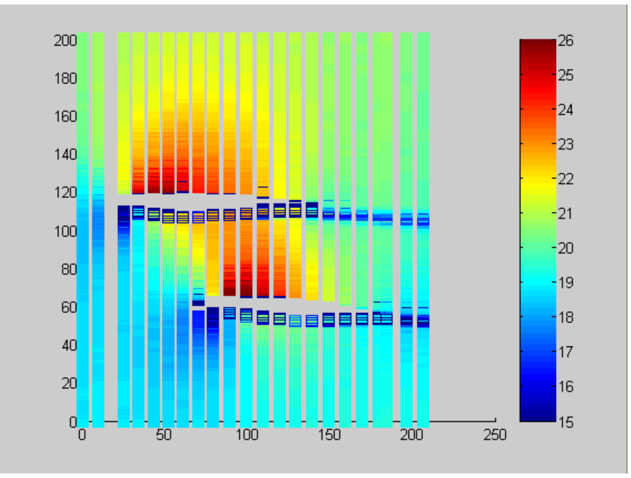
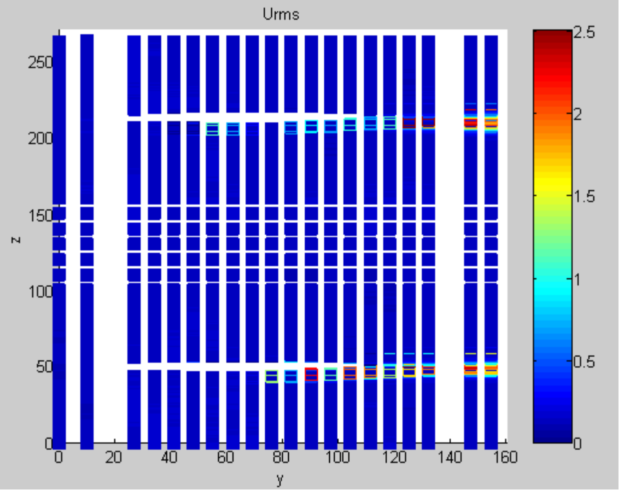


Fig. 9 – Flow field for h/c=0.5, d/c=0.5, ε =-3, α =5

5. Measuring errors



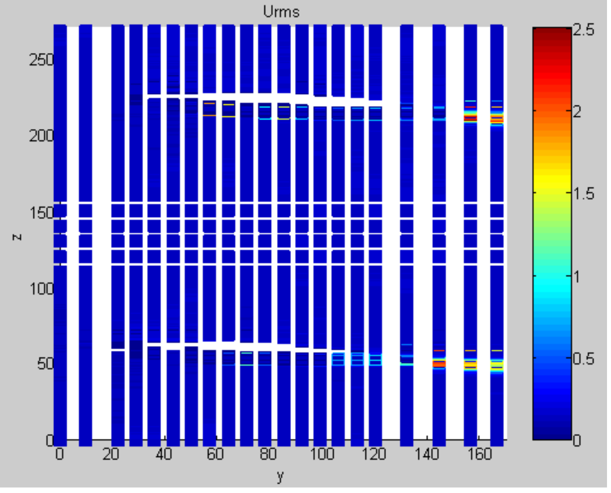
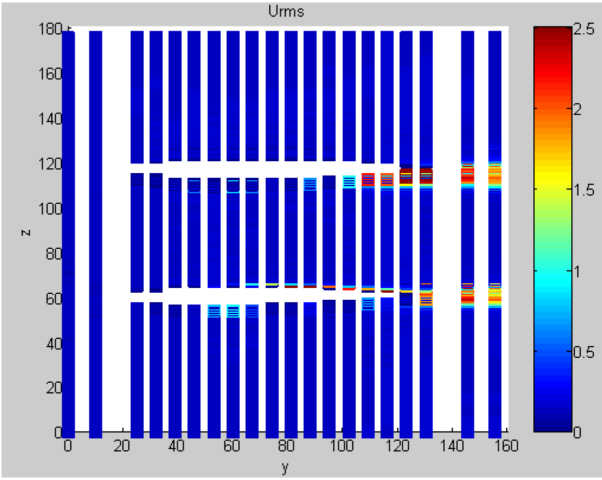


Fig. 10 – h/c=1.5 d/c=0 and ε =0 configuration

Fig. 11 – h/c=1.5, d/c=0, ε =0, α =5 configuration



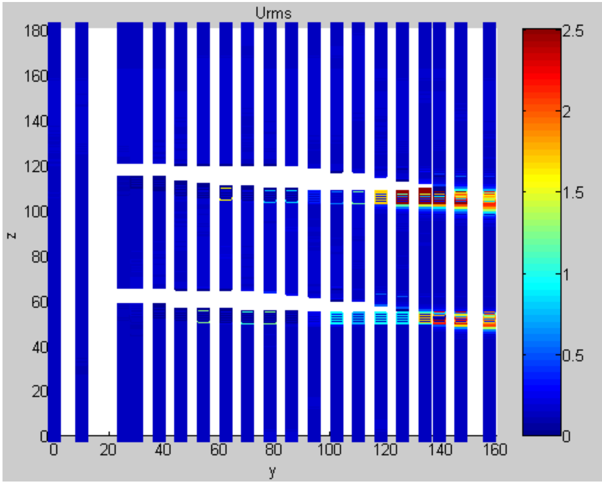
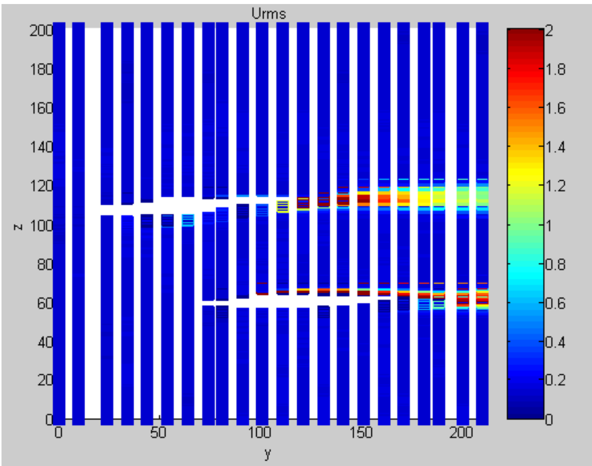


Fig. 12 – h/c=0.5, d/c=0, ε =0, α =0 configuration

Fig. 13 – h/c=0.5, d/c=0, ε =0, α =5 configuration



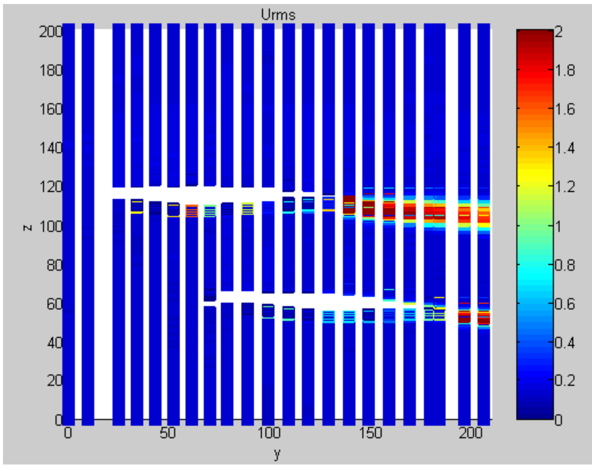


Fig. 14 – h/c=0.5, d/c=0.5, ε =-3, α =0 configuration

Fig. 15 – h/c=0.5, d/c=0.5, ε =-3, α =5 configuration

6. Conclusions

The chosen system configuration was a biplane for which the relative positions of the wings were modified. This modification were made in such a way to study as much cases as possible (a total of 6 configurations were studied), each with its own particularities.

For each point velocity measurement, a total of 1024 measurements have been made. The resulting velocity was an average of these 1024 results.

According to these multiple measurements for each configuration, the measurement errors were determined, the errors being negligible in rapport of the velocity measured (environ 0,1-0,2 m/s for velocities of 20 – 24 m/s). Higher values for the measurement errors appeared in points in which the system configuration influenced the measurements. Because of the system vibrations due to the flow around the profiles, close to the wings, the lasers beams were interrupted, resulting higher measurements errors.

The laser Doppler method is a non-intrusive one (the phenomenon is not influenced by the measures) and its precision is at the order of the laser wavelength used.

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7. Bibliography

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