Methods of flow visualization

Eng. Ionut BRINZA
INCAS, Experimental Aerodynamics Laboratory, ibrinza@incas.ro
Eng. Mihai-Victor PRICOP
INCAS, Numerical Simulation Laboratory, vpricop@incas.ro
DOI: 10.13111/2066-8201.2009.1.1.18

Abstract

Flow visualization is an important topic in scientific visualization and has been the subject of active research for many years. Typically, data originates from numerical simulations, such as those of computational fluid dynamics, and needs to be analyzed by means of visualization to gain an understanding of the flow. With the rapid increase of computational power for simulations, the demand for more advanced visualization methods has grown.

Tuft flow visualization

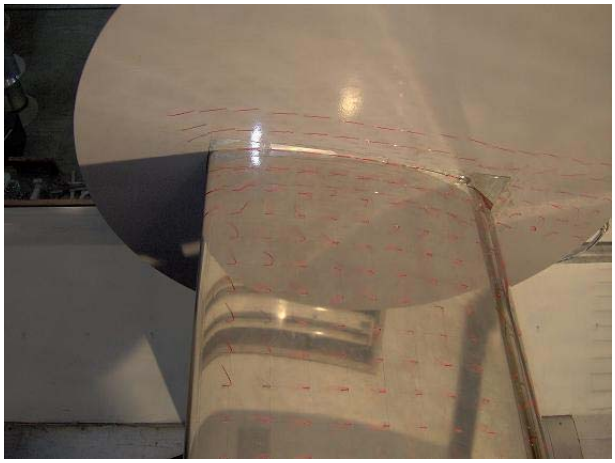
For this experiment, cotton threads segments have been attached on the upper part of the right wing. The length of the threads was of 45 mm each, the active length being of 35 and the rest of 10 mm used for fixing on the wing. The attachment was made with small rectangular pieces 10x14 mm of adhesive tape. On the chord direction, the tufts were distributed with a fixed step of 10% of chord length and span wise, the threads were placed with a 45 mm distance between them. This placing of the tufts generated a rectangular distribution matrix. As a future work, we intend to use two other configurations for this matrix: the double column and zigzag distribution.

Angle of attack=0°; Flap angle=49°; v=30m/s

The same method was used for the attachment of the threads to the flap; the only difference is that the step was increased to 20% of the chord length.
The experiment was performed at incidence angles from 0° to 10° and the steering angle of the flap at 49°. The air speed in the wind tunnel had a gradual value 20, 30 and 50 m/s.

It was noticed the presence of a massive detachment bubble and minor side effect, difficult to observe.

Conclusion: to identify the problem of the detachment bubble, the other two geometries shall be implemented by the addition or displacement of the transition tape to the leading edge. It is a fact that at an air velocity of 50 m/s the detachment bubble on the main element can not be observed.

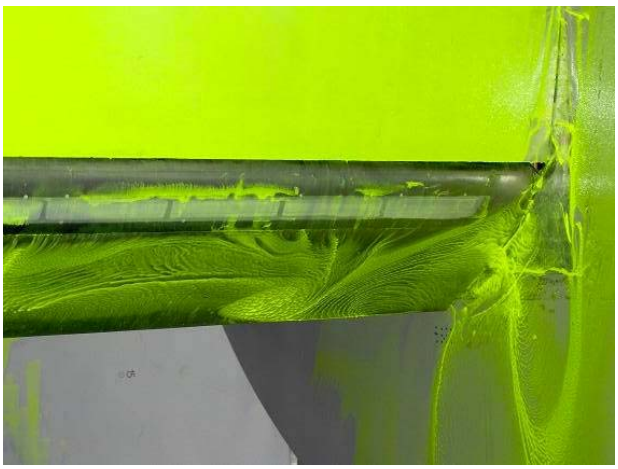


An inverted flow is noticed coincident with a massive detachment bubble

Oil flow visualization

In this case, the same wing was used at a setting angle from 0 to 15 degrees. The air velocity had a gradual value from 30 to 50 m/s. For the main configuration pictures and movies were taken at wing incidence of 0°, flap at 49° and the air velocity 50 m/s.
Further more the incidence was progressively increased at 5, 8 and 11 degrees, respectively. Picture and movies were also taken at every step.

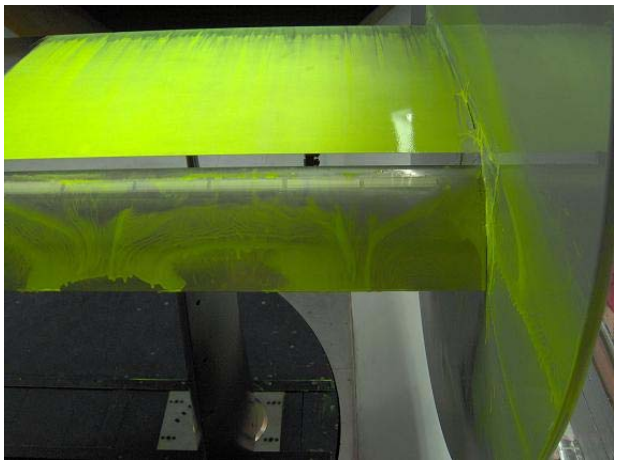
The visualization was made using a lighting unit. The light was directed to the ceiling of the tunnel, for a better quality of the pictures.



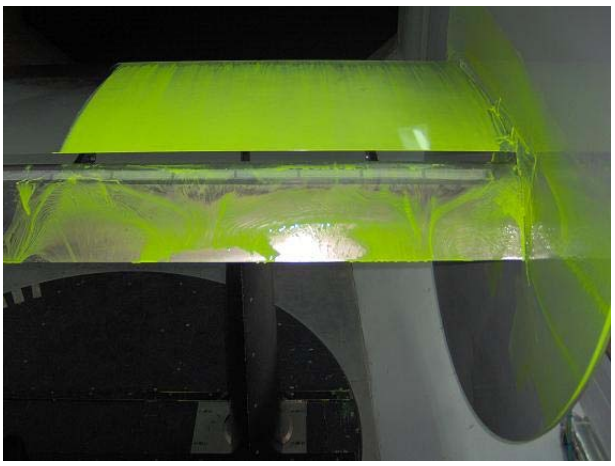
The flow detachment on the flap

Incipient phase of the vortex on the side plane

Conclusion: the detached vortex caused an imprint on the side plane. We also observed a possible periodical structure on the flap.



Possible/probable periodical structure on the flap



Final view of the experiment- air velocity v=0

Recommendations: to identify the structure's periodicity and dimension on the flap, it is necessary that the entire surface of the wing to be spread on with a liquid solution.

REFERENCES

[1] ***Low-Speed Wind Tunnel Testing,*** *ALAN POPE, JOHN J. HARPER*

[2] ***Flow Visualization Overview,*** *DANIEL WEISKOPF AND GORDON ERLEBACHER*