CZ.1.05/1.1.00/02.0060: Flow visualization techniques in the Climatic Wind Tunnel

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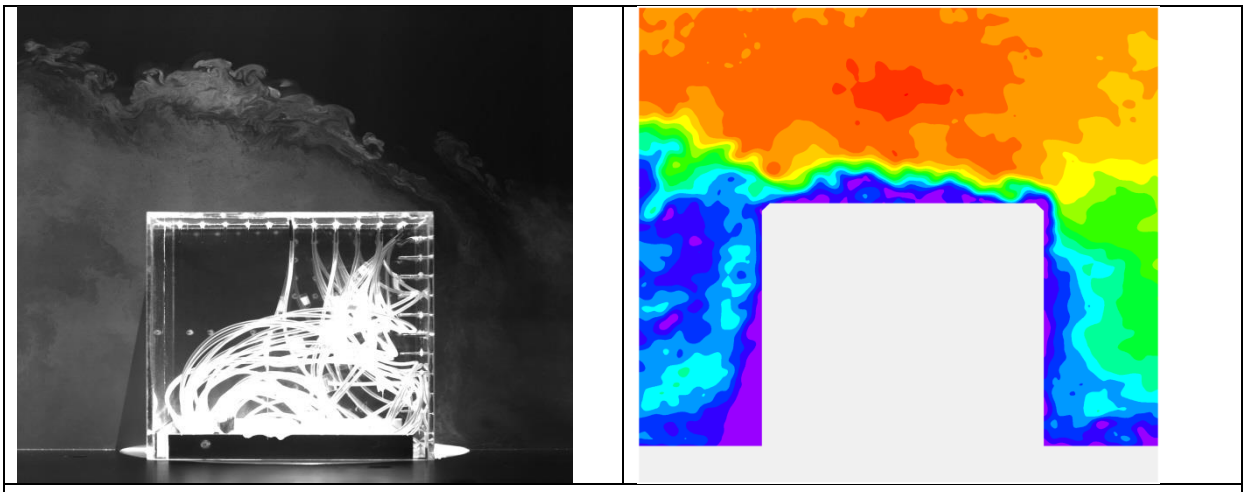
Investigation of the fluid flow is still an important research discipline. The areas in which fluid flow plays a role are numerous. Gaseous flows are studied for the development of cars, aircraft and spacecraft, and also for the design of machines such as turbines and combustion engines. Liquid flow research is necessary for naval applications, such as ship design and is widely used in civil engineering projects, chemistry, medicine and so on.

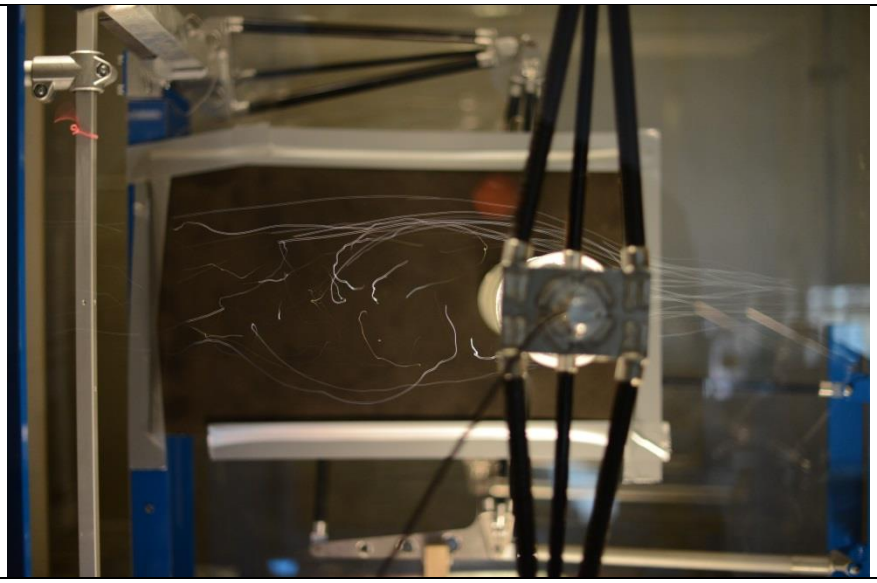
If the flow could be made visible by some kind of flow visualization technique, it would be possible to observe flow phenomena which are essentially inviscid (e.g., vortex flows, flows distant from surfaces). In addition to qualitative observations, under certain conditions it would be possible to make quantitative measurements from flow visualization.

Flow visualization provides information on the whole flow field immediately understandable without the need for data processing. Since air is transparent, the flow field can be made visible only indirectly and therefore one of the following techniques is needed: light scattering by gaseous, solid or liquid particles seeded in the stream; behaviour of materials deposited on the surface of the body immersed in the flow; changes of the refractive index produced by changes in density (optical methods).



Exampe of the results of Particle Image Velocimetry technique describing the flow around a benchmark object (cube)

Visualization of the external field is particularly interesting when there is separation of the boundary layer or in general when the flow is three-dimensional. If the flow is unsteady, it can be defined: lines tangent to the direction of the instantaneous speed; all points crossed in time by each particle, these can be visualized with long exposure photography; instantaneous positions of all the particles that have passed through given points, these can be visualized with low exposure photography.
In three-dimensional flows, streamlines near a solid surface can be very different from those of the external stream. Surface streamlines can also be very complicated in the zone of the boundary layer, separation and near obstacles on the surface and below a vortex.



Helium bubbles tracking around a circular cylinder

To visualize the streamlines in a plane orthogonal to the direction of the asymptotic velocity, flakes of wool or silk linked to screens are placed across the stream or smoke or vapor illuminated by a light sheet normal to the direction of motion is used.

Flow on a model visualized with silk tufts