Title: Low-cost Schlieren system for flow visualization in transparent media in the wind sector

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Introduction

The purpose of this research is to apply a qualitative technique that helps us to visualize the flows formed in the blade of a wind turbine. The Schlieren technique will be applied. This is an optical technique of visualization of a flow with density changes, from which information is obtained about the variables of this flow, such as the different densities along a section. To form the system, a light source, two parabolic mirrors, a blade, and a screen or image sensor are needed. The system has a "Z" configuration, with the test area in the center.
Methodology

Mechanical Design

First, in order to build the Schlieren System, it had to be designed in the SolidWorks® program (Dassault Systèmes, 2023). The objective of the mechanical design is that the system should be as aligned as possible because the focal point must coincide with the two mirrors, camera and lamp; the result is a image of the visualization of the flows.

Figure 4. Schematic of Schlieren System Z-array: (a) isometric view, (b) top view, (c) front view.
Physical assembly of the Schlieren System

In this way, the whole system was assembled with the obtained materials, as show in Figure 5. At this stage, adjustments are made to the alignment of the main elements.

Figure 5. Assembly of the Schlieren System: (a) lateral view, (b) top view.
Modification and improvements to the Schlieren System

The first results obtained were not entirely satisfactory, so it was decided to make various adjustments and implementations to the Schlieren system: adding a condenser lens, to concentrate the light of the lamp, and directed towards the mirror. In the same way the arrangement was modified, as shown in Figure 9. The adjusted distribution considers the condenser lens.

Figure 7. Schlieren system with condenser lens, (a) isometric view, (b) front view. Source: Own elaboration.
**Schlieren system**

The final Schlieren System is shown in Figure 8.
Results

As can be seen in the images captured from the test performed with the solid alcohol, the visualization of the flows is clearer; this is because the solid alcohol reaches a higher temperature than the hot air gun and this makes the phenomenon can be better appreciated, unlike the air gun that reaches a maximum temperature of 60°C.
Figure 15 shows the sequence of images displayed on the Schlieren system for the solid alcohol test. Figure 16 shows the image sequences with the hot air gun.
Figure 16. Sequence of Schlieren images captured with air gun tests. Source: Own elaboration.
Conclusions

The objective of this project was to develop a prototype for flow observation in transparent media. Among the different Schlieren configurations available, the Schlieren Z-array technique was selected. This technique was the most efficient for the observation of the phenomenon since it has a wider space to perform the tests and due to the refraction of the light it can reduce one of the optical aberrations that occur in this type of systems, in this case astigmatism.
References


