AerE 344X: Undergraduate Aerodynamics and Propulsion Laboratory

Lab Instructions

Lab # 9: Set up of a Schlieren/Shadowgraph System to Visualize the Flow Field of a Thermal Plume

Objectives:

1. To get "hands-on" experiences about Schlieren/shadowgraph techniques for flow visualization.

2. To learn how to do the optics alignment and experimental setup of a Schlieren/shadowgraph system.

3. To visualize the flow structure around a thermal plume by using a Schlieren/shadowgraph system.

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Technical Background:

- Schlieren technique is one of the most commonly used flow diagnostic techniques for the flow visualization of shock waves and flame phenomena, in which the index of refraction would change due to the variations of the flow density, pressure or temperature in the measurement domain.
- While Schierem technique is mostly used for qualitative flow visualization, it can be used to conduct quantitative pressure, density or temperature measurements theoretically.
- The contrast seen in the Schlieren images is closely related to the variation of the first directive of the index of refraction
- The Schlieren system used in the present laboratory is a z-type system which consists of a focused light source, two field mirrors, a display screen/board and a knife edge. The experimental setup of the system is shown in the following figures.

In this lab you will set up a Schlieren/shadowgraph system to visualize various airflows. The system will be of the z-type consisting of a focused light source, two field mirrors, a display screen/board and a knife edge. Each group should be able to complete the tasks in approximately 20 minutes.

Primary Task:

Obtain a focused image of a convective airflow (i.e. flow past a heat source); which will require some percentage of knife edge cut-off.

Secondary Task:

Determination of the focal lengths of the two field mirrors.

The steps to set up a schliren system are listed as follows:

1) Use a blank sheet of white paper to construct a “test screen” by drawing a circle with the same diameter as the field mirrors onto the paper. Tracing of the mirror covers is satisfactory.
2) Determine the focal length of the field mirrors (the focal length for both mirrors is the same). Shine the light source onto the first field mirror and adjust the mirror’s position until the collimated light beam just fills the circle on the test

sheet, held some distance away. Measure the distance from the light source to the center of the field mirror and determine the focal length.

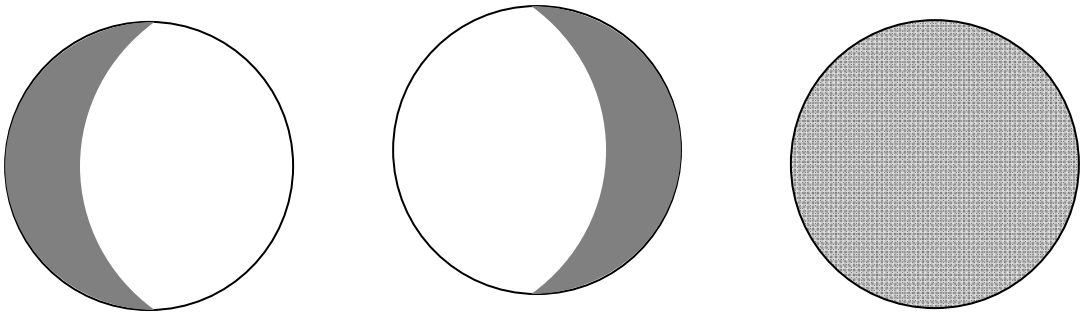
3) Setup the first of the field mirrors so that the light source is at its focus and the collimated light beam shines through the test area. The angle between the illuminating beam and the collimated beam should be kept to the minimum.

4) Setup the second field mirror so that the collimated beam from the first mirror just fills the second mirror. The axis controls on the first mirror may need to be adjusted in order to do this. The second mirror should project a nearly circular light beam on to the viewing screen. Place a threaded bolt in the test section in order to confirm that the image on the screen is in focus.

5) Obtain a shadowgraph image of a convective airflow by placing a candle or other source of heat in the test section.

6) Setup the knife edge position. Begin by obtaining a focused image of the light source (you should see a coil shaped lamp) on the knife edge. The light source is mounted vertically, so the knife edge should be mounted vertically also. Move the knife edge slightly so that it is cutting the focused light source in half. Next, move the knife edge either toward or away from the second field mirror until a uniform darkening of the source image is observed.

7) Obtain a Schlieren image of a convective airflow by placing a candle or other source of heat in the test section.



a. Knife edge too close to the second field mirror

b. Knife edge too far away from the second field mirror

c. Uniform darkening

Fig. 1. Effects of the knife edge position on the Schlieren image

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Writeup Guidelines

There is no lab report required for this lab!