AME 70634 Flow Control

Fall, 2024

Homework No. 1

Problems

1. Considering a Constant Current Anemometer (CCA),

1. Derive the static sensitivity in terms of the overheat parameter.
2. What is the static sensitivity at the velocity limits 0 and ∞? What does this say about the operation range?
3. How can the static sensitivity be increased?

2. Considering a Constant Current Anemometer (CCA),

1. Derive the 1st order time constant given in Equation 2.44.
2. How can the dynamic response be increased?
3. Can the static and dynamic responses be *simultaneously* maximized?

3. Because a hot-wire sensor does not directly measure velocity only heat transfer, it is sensitive to changes in the ambient temperature.

1. Determine the error in the hot-wire anemometer output voltage as a function of its overheat ratio in the range $1.3 \leq r \leq 1.8$ if the static temperature varies by 10°C. Assume the wire sensor is Tungsten.

4. Because of its easy ability to vary the overheat ratio of a Constant Current Anemometer (CCA) , it is advantageous for use in mass-flux measurements in supersonic flows. However the frequency response of the CCA is at best 2kHz where the frequencies of interest range up to 100kHz.

1. Design a frequency compensation circuit that will increase the frequency response of the CCA (a 1st order system) to 100kHz. Plot the uncompensated CCA response. the response of the compensation circuit, and the compensated CCA response.
2. The compensated CCA output will be acquired digitally. As a result, to avoid aliasing, the output will need to be low-pass filtered at 100kHz. Therefore using the same relation used in the design of the frequency compensation circuit, design a low-pass filter that will pass frequencies up to 100kHz and then reduce the amplitude at a rate of 20dB per decade of frequency.

5. An LDV is proposed to be used to document the basic flow (mean velocity profile) of a laminar boundary layer to compare it to a Blasius profile.

1. What are the issues regarding signal-to-noise and bias error of the measurements that may come up?
2. How can these issues be resolved?

6. Given the parameters that govern a synthetic jet actuator,

1. How might the actuator frequency and jet amplitude be simultaneously increased?
2. How would this affect the Stokes number which is attributed to causing the jet vortex rollup tp occur?
3. If multiple synthetic jet actuators are placed side-by-side, what characteristics might be used to determine their spacing?

7. Fluidic oscillating wall jets have been quite successful in maintaining attached boundary layer flows. Separated flows are sensitive to unsteady disturbances at frequencies that scale with the length of the separated region and free-stream speed.

1. In the design of a fluidic oscillator, list the parameters that affect the jet oscillation frequency.
2. How might the frequency be varied to match the optimum for separation control under varying conditions?
3. Could fluidic oscillators also be used as a mass flow meter?