ASE 162M
Fall 2024

Laboratory 1
Supersonic Flow over a Sphere

Assignment

Provide answers to the questions below. Assignments are to be turned in on an individual basis. All assignments must be typed, including equations and diagrams. If you use equations from anywhere, you must cite the source. For all quantities stated in the report, you must show uncertainties and the derivation of uncertainty propagation formulas where applicable. You may attach these derivations in a separate document if easier. Where applicable, describe the methodology used in the measurement or calculation.

1) Describe the experimental setup. This should include a description of the wind tunnel used in the experiments, a description of the data acquisition system, a detailed schematic of the Schlieren system (with a description of the function of each part), and descriptions (preferably diagrams) of the models tested. (10 pts)

2) Calculate the unit Reynolds numbers and diametric Reynolds numbers (Re_D) for all runs, as well as the Mach numbers. Make a plot of Mach number vs. Re_D. For calculating viscosity, use Sutherland's law. (15 points)

3) Present the schlieren images for highest and lowest Mach number. Label the flow features on the images. Discuss the features found throughout the flowfield for the sphere, including shocks and the viscous structures as well. Pay specific attention to changes that occur to the viscous structure as a result of a change in Mach number. Correlate these changes to the Reynolds number and Mach number. Finally present the shadowgraph image and compare with Mach 3 schlieren image. Discuss the differences. (20 points)

4) Calculate the non-dimensional standoff distance of the bow shock for each case. Present these as plots of δ/D vs M. (25 points)

5) Perform a curve fit on the plots from question 4. You will be fitting three different scaling relationships for each geometry:

   a) Qualitative scaling dependence

$$\frac{\delta}{D} = c\,\frac{\sqrt{\left(1 + \frac{\gamma - 1}{2} M_\infty^2\right)}}{M_\infty - 1}$$

b) Basic

$$\frac{\delta}{D} = c\gamma^{\alpha} M^{\beta}$$

c) Offset

$$\frac{\delta}{D} = c\gamma^{\alpha} (M-1)^{\beta}$$

Present these results as both plots including the data and the fit curve and as a table indicating the values of the different constants obtained through the fitting procedure. (45 points)

6) For the fits obtained in problem 5, discuss how well your data agrees with the relation. In particular, discuss the physical nature of each of these fits, and why your data agrees or disagrees with each. For the basic and offset fits, discuss whether or not you would expect the dependence on composition and Mach number and the consistency of your data with these expectations. (15 points)