

AAE 334L

Spring 2020 Final Project Experimental Paper Review

Paper 1

Shock-Wave/Boundary-Layer Interactions at Compression

Ramps Studied by High-Speed Schlieren

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Part 1: Summary (20 points)**Score: ____ / XX***Give a brief summary (300 words or less) of the work and the main findings discussed in the paper.*

The main purpose lies in scrutinizing the shockwave/boundary-layer interaction (SWBLI) and the change in shockwave unsteadiness effected by different ramp angles and Reynolds numbers. This research paper postulates the results and the analysis conducted from a compression wave generated by a supersonic air flow over a ramp with an angle ranging from 20 to 30 degrees. Meanwhile, the Reynolds number is also treated as a dependent variable which alters the shockwave behavior examined by the airflow; and the 2 different Reynolds numbers applied for the experiment were the following: $Re_1 = 18,600$ and $Re_2 = 35,600$. The Mach number for this experiment is treated as a constant with a value of Mach 2.

By capturing an instant moment of the supersonic flow with high quality schlieren/shadowgraph photography at the ramp, the research team were able to obtain results that were required to figure out how the ramp angles and Reynolds number influenced the SWBLI. Incrementing the ramp angles from 20 to 30 degrees, the results showed that the higher the angle of the ramp was the longer the interaction length of the shockwave grew and also the turbulent region became thicker as well as the magnitude of the Schlieren intensity. When the Reynolds number was increased the turbulent boundary layer thickness increased as well as the interaction region. For the ramp case, the separation and reattachment of the shockwave was only visible for conditions of high angles (above 24 degrees); however, with a higher Reynolds number the shockwave portrayed separation and reattachment for all ramp angles.

For the last part of the research, the team implemented their original algorithm that allowed the schlieren intensity magnitudes to map the shockwave spectra over frequency distributions. Then observing the fluctuations of intensity and spectrum transitions over the frequencies they have investigated the stability, or in other words, the unsteadiness of the shockwave related to the ramp angle and Reynolds number. From analysis, the research team found out the correlation of the unsteadiness with the thickness of the turbulent boundary layer.

Part 2: Overall Review (5 points)**Score: ____ / XX**

Summarize your overall opinion of the work in 1-3 sentences.

The paper was well organized by dividing the sections systematically and provided clear explanations of how the experiment was conducted. Meanwhile, there were some mathematical and statistical terms and theories that were unheard of (personally) and was difficult to understand what kind of approach they have took to analyze the acquired data. The paper provides an ample amount of references to fortify their theory and explanation, and the conclusions were clearly laid out while being neatly backup by quantitative evidence.

Part 3: Introduction (20 points)

Score: ____ / XX

Give a brief review (300 words or less) of the Introduction section of the paper. Some questions to consider are: Is the Introduction easy to follow? Does it cite the appropriate papers? Does it provide a hypothesis or aim of the study? Does it clearly discuss the originality and impact of the research?

The introduction of this paper is somewhat lengthy in my opinion. What I thought is that, the paper tries to emphasize the importance of investigating shockwave/boundary-layer interaction (SWBLI) at relatively low Mach numbers such as Mach 2 by including many sources that have done research with larger Mach numbers but introduces less numbers of sources concerning low Mach numbers. This was for the first half of the introduction. The last half was dedicated to explaining the core concepts and overview of the research that the team has done. This second half was somewhat difficult to follow since they do not sufficiently explain what the data they are referencing mean but only, in some sense, throws the numerical data at you. However, the sources are related to the topic and do seem to be supplementing their objectives; thus, I would say that they are citing appropriate sources but not leveraging them sufficiently.

At the last paragraph of the introduction, they successfully summarize their primary aim of the experiment, and owing to this last paragraph was I able to fully understand what their main objective was. As aforementioned above, they do underscore the importance and benefits of conducting the research with the posed aerodynamic conditions such as ramp angles and Reynolds number.

One factor that I am concerned with the introduction is that it lacks information of the original experiment they have done to analyze the unsteadiness of the shockwave. They do devote a long paragraph to explain the characteristics of the unsteadiness in shockwaves but do not go much in detail of how unique their experiment was. Personally, the experiment they have done using the schlieren intensities were very enticing and would have been more worth mentioning in the introduction to lure attention.

Part 4: Assessment of the Experimental Methods and Analysis (30 points)

Score: ____ / XX

Provide a critical review of the experimental methods used and the analysis methods applied to the experimental data. Some questions to consider are: Are the experimental methods described in enough detail such that you could go and repeat the experiments? Is the amount and variety of data sufficient to draw statistically-significant conclusions? Is there adequate discussion on sources of error and uncertainty in the experiments and analysis? Are there any measurements and/or analyses that seem appropriate that were not performed?

The experimental methods are explained sufficiently enough that as long as we have the required facility we are able to duplicate the experiment. This is because all the dimensions of the test models are given along with a detailed 3D and 2D cross-sectional sketch of the model. Moreover, the type of wind tunnel and setup of the testing section inside the wind tunnel is explained meticulously with a 3D sketched diagram. The ramp, velocity, Reynolds number and other conditions are organized in a table and very clear to see. Thus, the experiment is described sufficiently.

For the first two tests investigating the effects of the ramp angle and Reynolds number the most pivotal data analyzed all come from the visual data provided by the Schlieren photographs. From the photographs, numerical data such as the Schlieren intensity and the turbulent boundary layer thickness are derived as well as the interaction region. The amount of numerical data seems somewhat few but from the fact that the experiment is somewhat open-ended and only experimental output is the Schlieren photograph it seems to be an adequate amount of data. Not only do the research paper provide the actual Schlieren photographs but they also provide the Schlieren photographs in a contour view of the Schlieren intensity to support the conclusion and this visual evidence makes it easier for the reader to understand the turbulent thickness change as well as the shockwave separation and reattachment. From the data they draw conclusions that they have only observed for their experiment, confirmed visually, and what is congruent with numerical data. They do not go overboard with concluding things they have not observed. For the unsteadiness analysis they take 1000 to 9000 position sample points of the Schlieren image and for the separation spectra they processed the data "though the Welch method using blocks of 512 samples and the Hamming window function with 50% overlap." The terms do not ring a bell, so it is hard to tell if they are a sufficient number of data processed to draw statistically significant conclusions. However, by observing the spectral contours and non-linear graphs we can examine some distinct differences for different Reynolds numbers and ramp angles in terms of Schlieren intensities. Thus, overall, I would say they do provide enough data to draw a conclusion.

One downside of this paper is that there is no section discussing possible sources of error and conducting uncertainty calculations to support their theory.

For the unsteadiness/instability analysis they should have collected data for several more trials and plot them on the same plot (fig.9 and fig.10). For stability analyses it seems insufficient with only 1 trial. Additionally, they could have verified their unique Schlieren intensity experiment using a much larger range of Reynolds number in some sense to validate its accuracy.

Part 5: Results and Discussion (25 points)

Score: ____ / XX

Provide a critical review of the presentation and discussion of the results and the conclusions drawn based on the results. Some questions to consider are: Does the Discussion address the main findings of the research? Are the conclusions drawn consistent with the evidence and arguments presented? Do they address the main question posed? If the paper includes tables or figures, what do they add to the paper? Do they aid understanding or are they superfluous?

The conclusion of the research paper properly organizes each conclusion that they have rehearsed in the sections A, B, and C in part II. They do not add anything excessive that they do not mention in the analysis section of the paper. This also means that data analysis and their conclusions are all consistent and do not pose any unverified theory inside the conclusion.

The main objective of this experiment was to examine the effects of ramp and Reynolds number on the shockwave/boundary-layer interaction (SWBLI) at low Mach numbers. They do leave some room for further analysis but do fulfill the main objective by finding out how the turbulent boundary layers, interaction region, and shockwave separation and reattachment correlate with the Reynolds number and ramp angle that they are experimenting.

The paper mainly and only includes the Schlieren photographs and their contour representations and the Schlieren intensity plots over frequencies. All of them are very important in terms representing the numerical analysis and visual analysis that they have done. From my perspective, all the figures were needed for the readers to follow the analysis they have done and none of them were superfluous.