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Computational Review Of One Dimensional Shock Tube Problem

Deepak Kumar
Assistant Professor, Dept of Mechanical Engineering, Amity University, Haryana
Deepak209476@gmail.com

Abstract

In this paper analysis of shock tube problem has been done. The analysis has been carried out computationally. The variation of density has been exercised. Also the variation of pressure, velocity and the temperature difference has been studied classically. The results absorb a sincere agreement with the actual results. The Eulerian form of equations of gas dynamics has taken on a very prime contribution in the study and analysis.
Keywords: *Eulerian, Shock, Density, Numerical, Compressible, Flow.*

1. Introduction

There are mainly three reasons which are responsible for a problem interesting in case of shock tube. Firstly it gives a basic idea about the partial differential equations of not linear and hyperbolic nature. Secondly numerical thought of view and finally real life situations. In the case of shock tube basically we consider a tube which is long enough. It is closed from the ends. The tube is divided in two parts equally. Each part is having the gas which is same in both the regions. But the properties are different in two different parts. The properties may be pressure, temperature etc.

Greenough,J.A et al.2004 studied the Euler equations numerically with the help of a modern method for the compressible flow. The modern method was linear and piecewise as compared to the old version of the numerical method. This was examined with the help of various test problems. The various problems wer related with the problems of linear nature and classical as well as complex problems related to interactions of shock. For these different problems rate of convergance and the density error was reported. The difference in errors was showing some variation from problem to problem. There was a large variation in the two methods in case of error levels in linear problems.

Jorick, N.2005 reported the development of simulation solver for the Euler equations. The solver was a shock tube solver. For this one dimensional flow problem was considered. The problem was Riemann initial problem. The two separated states initially resulted in the advancement of flow. The two states were separated with the help of a membrane. When the membrane was removed the pattern of waves was consisting of three forms of waves. First is a wave in the form of shock, secondly an expansion fan and third contact discontinuity. The theory of gas dynamics can solve the problem of Riemann. With the help of use of this theory in a device resulted into solver of exact Riemann. After that time axis region can be determined. For determination algorithm known as elegant algorithm was used. Solver was tested with the help of tests performed. For the complex problems a numerical approach was found to be effective. Euler's equations were discretized with the help of FVM. Complex wave pattern was observed. And it was found due to the discontinuities at the initial level in the pressure.

Rajmohan, T.et.al. 2015 Introduced a scheme which was compact and of order higher. The scheme was used for Euler equations in one dimension in gas dynamics. The effectiveness and accuracy of this scheme was tested by applying them on different types of problems. These problems include shock tube, nozzle problem. The nozzle used was convergent and divergent. It was observed that these schemes are having different order of accuracy in case of time and space parameters. In the former case the accuracy was observed to be of the order of 2^{nd} or lower. But in the latter case the accuracy was found to be of the order four. And finally the simulation results had been compared with the results that are already available or exact solutions. In a concise form the schemes has been found to be effective and of higher accuracy.

Rainald Löhner et.al. 1987 used examples in a state which was steady to show the effectiveness of the algorithm. After this examples based on transient state were solve to test the efficiency of algorithm. In this study flow was taken for steady who was at high speed. Finite element method was used to solve this type of high speed compressible problem. The concept which was used for the problem was based on corrected transport of flux. Later on it was presented in different forms. This lead to the development of a concept which was applicable to different meshes. These meshes may be triangular or tetrahedral and also unstructured.

Fernandez,G. & Larrouturou,B Explored the way in which Euler's equations were used. In this study the main focus was on the simulation of flow which was multi species. Reactive flow was given more importance for study. To solve problems based on this type of flow schemes were developed which wee of the conservative nature and the focus was how to make these schemes best. For the study of this type of problems a model was taken which was in a very simple form. This model consists of governing equations. In the governing equation the terms of hyperbolic nature in Euler's equation were taken. The care has been taken to remain the model in hyperbolic terms even in the case when there was a variation in the ratio of specific heat and molecular weight. After all it was extended to Euler s system consisting of multi components.

Toro, E.F.et.al.1994 tested his results with the experimental values. This was done for a two dimensional problem. Also in case of one dimensional problem results were tested with the help of solutions which are exact. In this study the contact surface which was missing was restored. For this the basics of original solver were followed. When this solver was compared with the Riemann solver it was observed that it was as accurate as Riemann. But it was observed more effective and accurate with the latter one.

2. Results

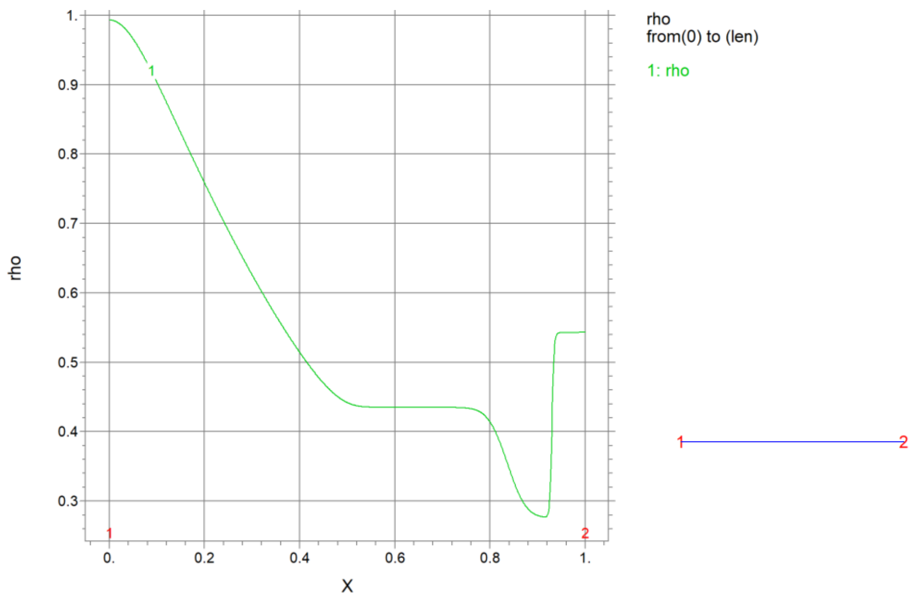

Figure 1. Variation of Density.

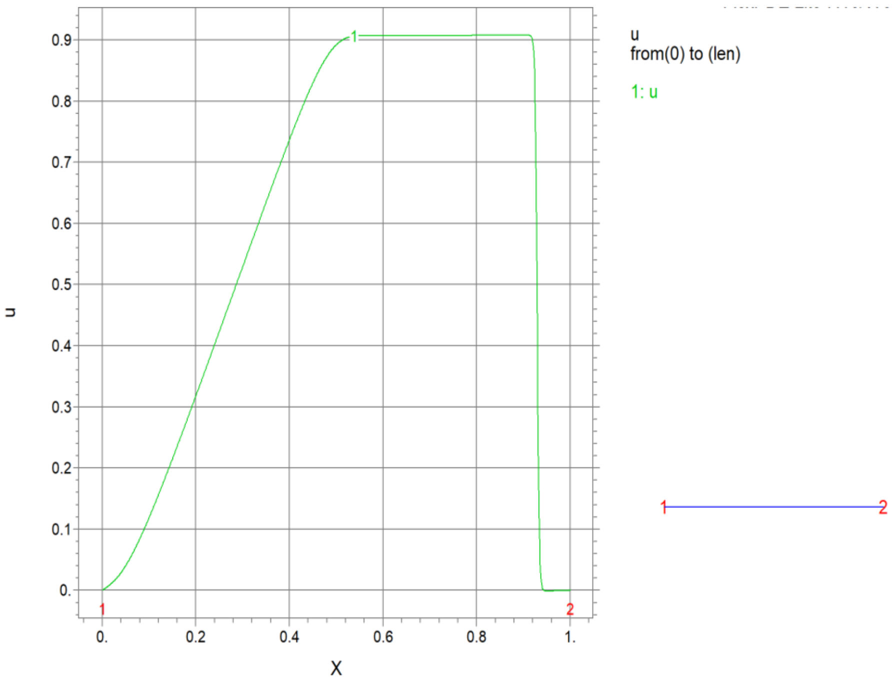

Figure 2. Variation of Velocity

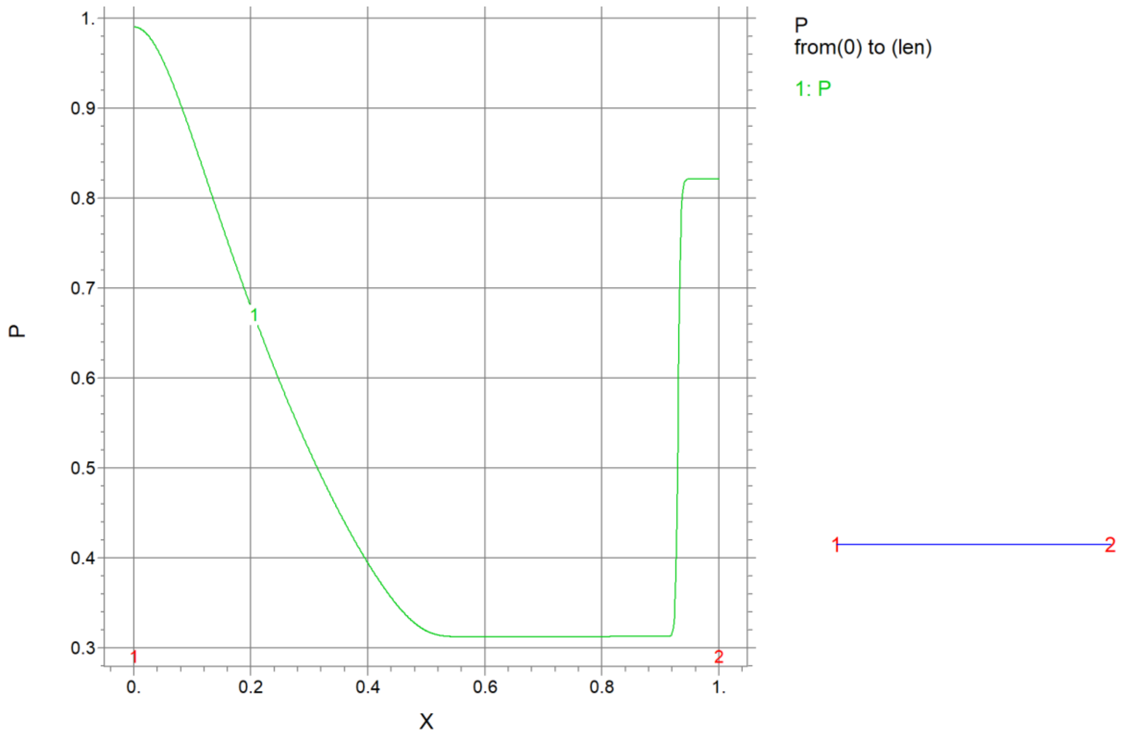

Figure 3. Variation of Pressure

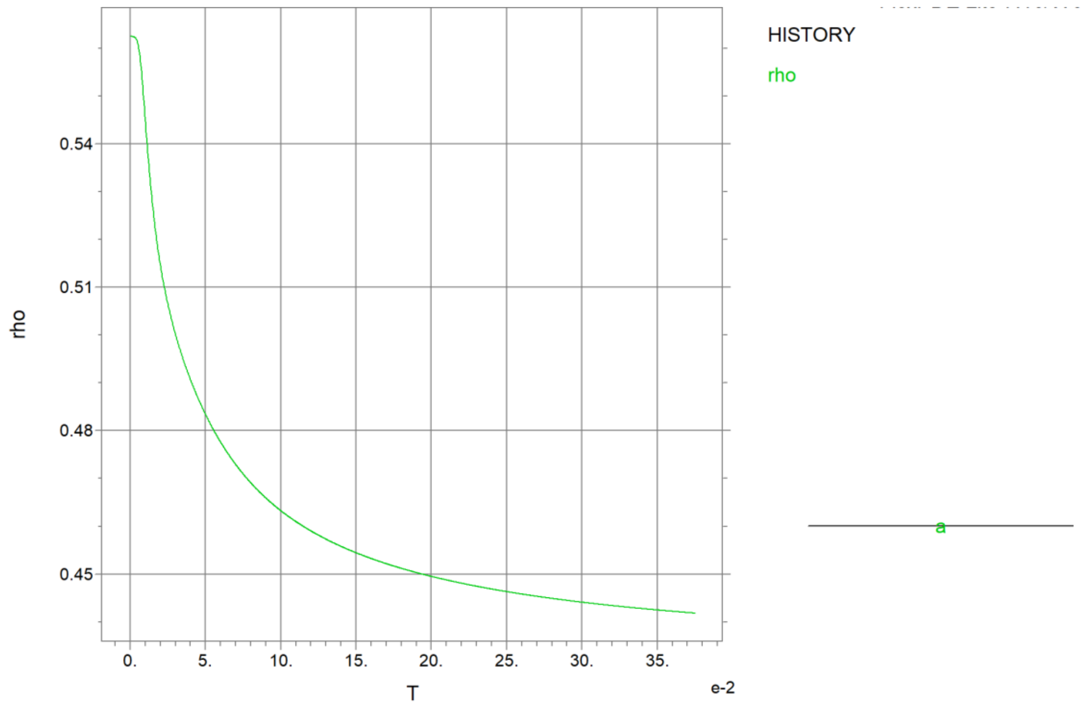

Figure 4. Variation of Density

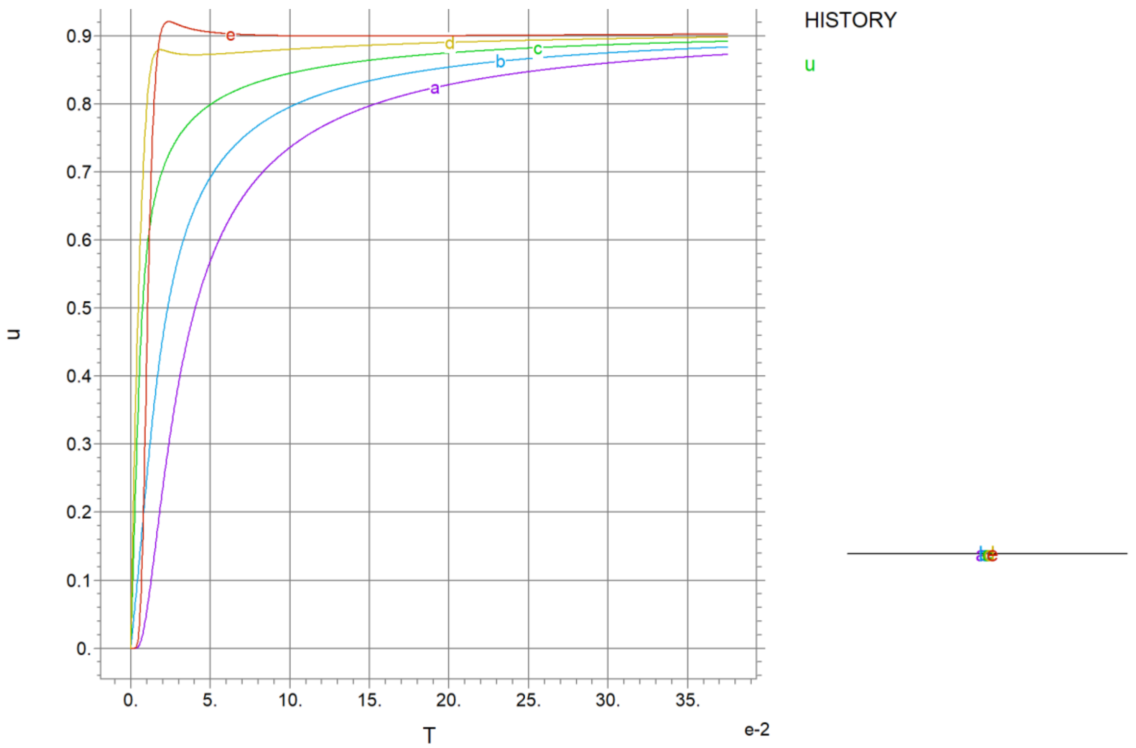

Figure 5. Variation of Velocity

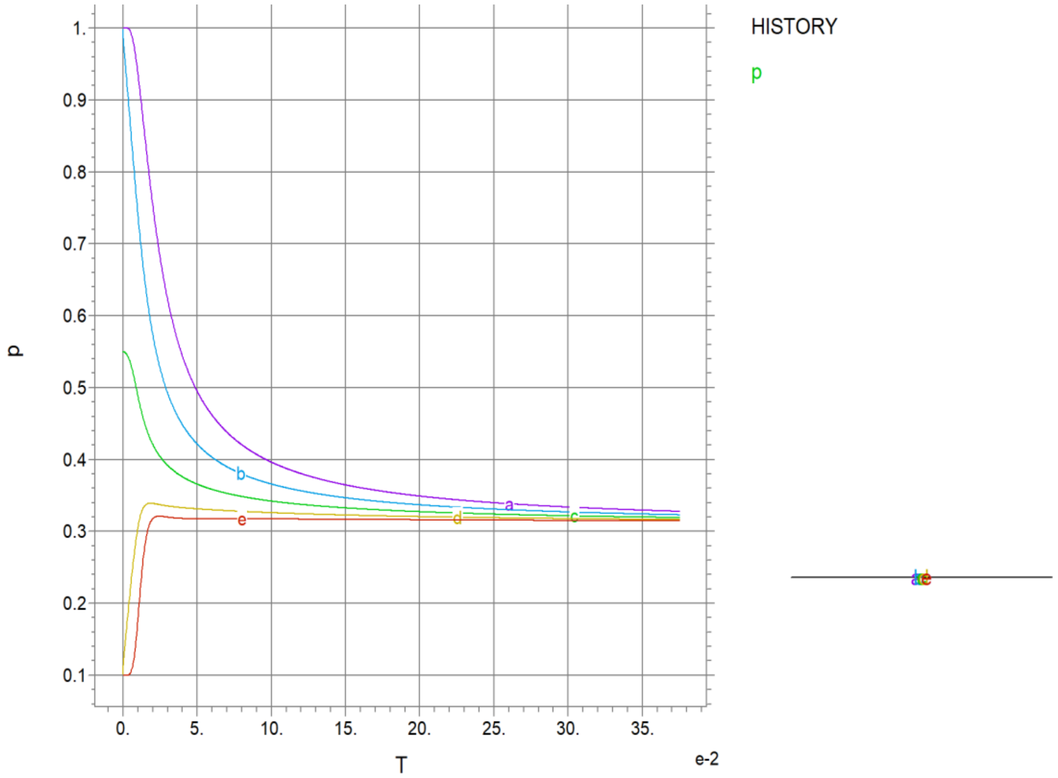

Figure 6. Variation of Pressure

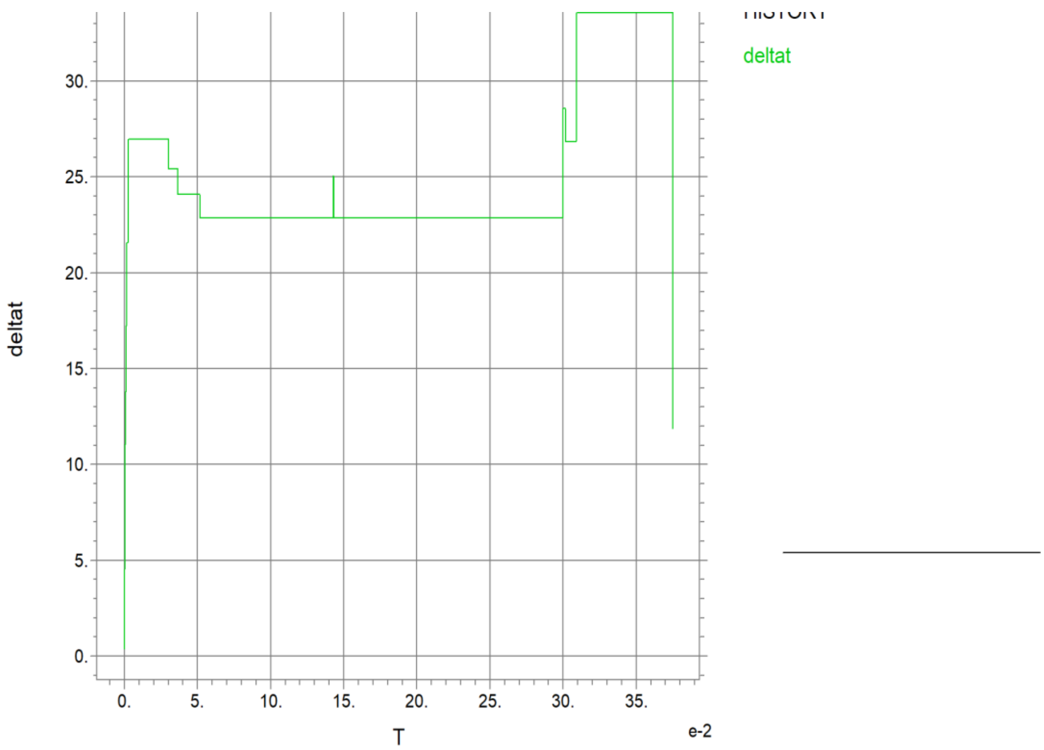

Figure 7. Variation of Temperature Difference

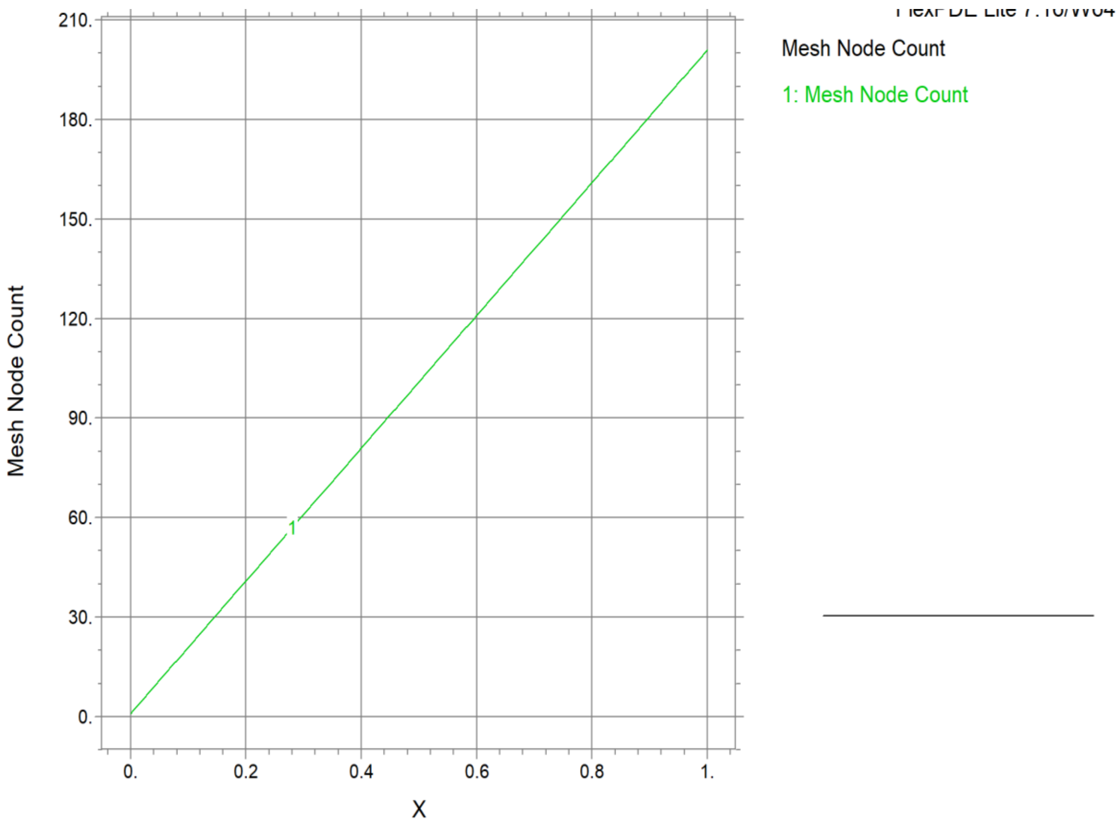

Figure 8. Variation of Mesh nodes Count

Conclusion

The variation of pressure, temperature and density has been shown with the help of graphs. Also the velocity distribution is shown. The variation is shown with the help of maximum and minimum values. The simulation outcomes are in a sincere transformation with the actual outcome.

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