Theoretical Study of One-dimensional Isentropic Flow under Ramp Wave Loading

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Compression characteristic study of material in the state of high pressure and high density is an important aspect of geophysics, material synthetic, and condensed matter physics. Ramp compression, as a supplement and development method of shock compression, is regarded as an effective approach to obtain high pressure and high density state of investigated material. The theory of one-dimensional isentropic flow is the basis of understanding and describing the flow field, and it is also indispensable for the evaluation of experimental results. In this work, a novel approach to study the optimal waveform of ramp wave compression has been proposed. Based on the simple wave theory, the analytic expression which described the transition of ramp wave to shock wave is deduced. This analytic expression allows us to establish the relationship between the history of loading pressure and the medium's internal flow field by using the characteristic line method. It has been shown that there is a threshold for the pressure rising rate which depends on the compression parameters and the thickness of the sample, and this threshold exists in every pressure value investigated. Shock wave would be created when the rate of pressure rising exceed the threshold. Hence, the design of the experimental parameters and the optimization of waveform can be achieved. Moreover, the ramp wave compression with free surface boundary condition has also been explored. By assuming the free surface velocity has already been obtained, the flow field can be calculated without giving the Equation-of-State. The computational method has demonstrated high accuracy and robustness in data processing when there is no strength effect. Comparing with the conventional method and the ls-dyna commercial software, the proposed method can produce better results even when strength effect is considered, especially in describing the original compression characteristics of the material.