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Theoretical and Numerical Research on the Vertical Impact of a Slender Flat-Ended 316 Stainless Steel Rod

Yifan Wang[1], Tao Wang[1,*] and Xuan Ye[2,*]

[1]State Key Laboratory of Explosion Science and Technology, Beijing Institute of Technology, Beijing, 100081, China

[2]Institute of Nuclear and New Energy Technology, Key Laboratory of Advanced Reactor Engineering and Safety of Ministry of Education, Tsinghua University, Beijing, 100084, China

[*]Corresponding Authors: Tao Wang, Xuan Ye. Email: wang_tao@bit.edu.cn, yexuan@tsinghua.edu.cn

ABSTRACT

Rod occasionally drops and impacts on a substrate, which can induce drastic vibration within the rod. Acquaintance with the mechanical and motional responses helps to evaluate the structure. In this study, the vertical impact of a slender flat-ended 316 stainless steel rod on a rigid flat was investigated. The rod was basically elastic despite minute plastic dissipation, which accounted for around 0.11% of the total energy, probably due to the convergence of the incident stress waves. Theoretical models describing the longitudinal vibration of the rod was established respectively using the contact-impact force and the displacement boundary condition based on the one-dimensional hypothesis. In the former boundary condition, the contact-impact force is assumed to be constant during the impact, and the displacement variation was solved using the method of variable separation; in the latter boundary condition, the material points at the impacting end remain static, and the displacement variation was derived through Laplace transform. Excellent quantitative agreement was achieved between the predicted results by the two theoretical models and the numerical results by finite element method. The displacement variation at the free end of the rod is consistent with the variation of elastic strain energy. A buffering nose at the impacting end of the rod is suggested in order to guarantee the structural integrity of the cylindrical part lest the incident velocity becomes greater. The longitudinal vibrational responses of the slender rod only depend on the rod length and the material according to the proposed theoretical model.

KEYWORDS

Flat-ended rod; vertical impact; boundary conditions; theoretical models

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