

- [20] 曲凯, 邢耀国, 张旭东. 摇摆载荷作用下舰载固体火箭发动机药柱疲劳损伤[J]. 航空动力学报, 2011, 26(11): 2636-2640.
QU Kai, XING Yao-guo, ZHANG Xu-dong. Fatigue damage of shipborne solid rocket motor propellant under swing loading[J]. *Journal of Aerospace Power*, 2011, 26(11): 2636-2640.
- [21] 曲凯, 张杰, 张旭东. 舰船运动对固体火箭发动机粘接界面疲劳损伤研究[J]. 兵工学报, 2012, 33(8): 986-990.
QU Kai, ZHANG Jie, ZHANG Xu-dong. Research on effects of ship motion on interface fatigue damage of solid rocket motor [J]. *Acta Armamentarii*, 2012, 33(8): 986-990.
- [22] 李记威, 房雷, 周建军, 等. 某空空导弹发动机装药挂飞振动疲劳寿命分析[J]. 弹箭与制导学报, 2016, 36(1): 89-92.
LI Ji-wei, FANG Lei, ZHOU Jian-jun, et al. Fatigue life analysis for a solid rocket motor of air-to-air missile under hanging flight vibration[J]. *Journal of Projectiles Rockets Missiles and Guidance*, 2016, 36(1): 89-92.
- [23] ZHANG Wei-yao, GAO Jing-bo, WANG Cong. Rigid-flexible coupling dynamic analysis of sub-Launched vehicle during the vertical tube-exit stage[J]. *Journal of Harbin Institute of Technology (New Series)*, 2015, 22(2): 26-33.

Numerical Analysis of the Vibration Fatigue of the Rocket Warhead Charge in the Transportation Process

ZHANG Wei-yao, TU Xiao-zhen, LAN Lin-gang, DONG Tian-bao

(Energetic Materials Measurement and Evaluation Center of CAEP, Institute of Chemical Materials, Mianyang 621999, China)

Abstract: In order to understand the structural reliability of the solid rocket warhead in transport, the frequency domain method is used to evaluate the fatigue damage degree. The simplified kinetic model of the rocket launcher was built and the base excitation PSD (power spectrum density) of the charge was calculated by the transfer function and road load PSD; the finite element model of the charge was established and dynamic responses were solved by mode superposition methods; the fatigue damage degree was evaluated by Steinberg's 3- σ Law. Results show that the random vibration of the warhead charge causes the dynamic stress, and the inner face of the top hole is the danger place with the stress peak value of 4.86 MPa. When the loading time reaches 250 h the damage degree is 1.12, which reveals that the warhead charge has been broken. The road roughness load can bring about the fatigue damage of the warhead charge, which has negative impacts on the structural reliability.

Key words: rocket warhead charge; road roughness loads; random vibration; fatigue damage

CLC number: TJ55; O324

Document code: A

DOI: 10.11943/j.issn.1006-9941.2017.01.003



《含能材料》“观点”征稿

为了丰富学术交流形式,及时传递含能材料领域同行们的学术观点和思想,《含能材料》开设了“观点”栏目。“观点”栏目的来稿应观点鲜明、内容新颖、形式上短小精悍。欢迎含能材料各领域的专家积极来稿。来稿时请附个人简介及主要研究工作介绍。

《含能材料》损伤与点火专栏征稿

含能材料的损伤特征与点火过程有密切的联系,炸药、推进剂的内部损伤及其对力学特性、安全特性和点火行为的影响规律受到了含能材料学界的高度重视,为推动这一重要研究方向的学术交流,本刊特设立“损伤与点火”专栏。专栏主要征集炸药、推进剂等含能材料的损伤观测与多尺度表征技术、含损伤的本构方程、准静态与动态损伤演化规律、损伤与破坏的宏(细)观模式、损伤对起爆、爆炸、爆轰成长以及非冲击起爆行为的影响等方向的原创新性研究论文。来稿请注明“损伤与点火”专栏。

《含能材料》编辑部