



航空学报 » 2013, Vol. 34 » Issue (6) :1336-1346 DOI: 10.7527/S1000-6893.2013.0234

固体力学与飞行器总体设计

最新目录 | 下期目录 | 过刊浏览 | 高级检索

<< << 前一页 | 后一页 >> >>

热声载荷作用下薄壁结构的非线性响应特性

沙云东, 魏静, 高志军, 赵奉同, 鲍冬冬

沈阳航空航天大学航空航天工程学部, 辽宁 沈阳 110136

Nonlinear Response Characteristics of Thin-walled Structures Under Thermo-acoustic Loadings

SHA Yundong, WEI Jing, GAO Zhijun, ZHAO Fengtong, Bao Dongdong

Faculty of Aerospace Engineering, Shenyang Aerospace University, Shenyang 110136, China

摘要

参考文献

相关文章

Download: PDF (7551KB) HTML 0KB Export: BibTeX or EndNote (RIS) Supporting Info

摘要

高速飞行器面临着严酷的高温强噪声环境。温度载荷不仅使结构产生热应力,还会改变材料的物性参数,这使得薄壁结构在宽频噪声激励下具有复杂的运动形式,表现出强非线性特性,严重影响了结构的疲劳寿命。针对热声载荷对结构非线性特性的影响,建立了热声载荷下的非线性大挠度偏微分控制方程,对偏微分方程使用Galerkin法得到了模态坐标下的常微分方程组。计算了四边简支矩形钛合金板在不同温度和声压级(SPL)组合下的动态响应,得到了典型的热声响应运动形式,包括屈曲前的线性随机振动、屈曲后的跳变运动和围绕一个平衡位置的随机振动。通过分析方程中的恢复力项和响应的功率谱密度(PSD)随着温度和SPL的变化规律,对热声响应的非线性特性进行了研究。研究表明,热载荷和声载荷对响应非线性特性的影响方式不同:热载荷改变结构刚度特性曲线的形状,以临界屈曲状态的刚度为参照,屈曲前降低结构刚度,屈曲后增加结构刚度;噪声载荷使得结构工作在刚度曲线的不同区域,以不受载荷时的结构刚度为对照,强噪声载荷引起的持续跳变使得结构工作在硬化区域,间歇跳变时结构工作在软化区域。

关键词: 薄壁结构 热声载荷 非线性响应 热屈曲 跳变响应

Abstract:

Hypersonic vehicles suffer high intensity acoustic loadings in an elevated temperature. Owing to the temperature loadings, not only will thermal stresses be produced, but the material physical parameters are also changed. The thermal loadings will result in complicated motion forms of thin-walled structures with strong nonlinear characteristics through wide-band noise excitation. The complicated dynamics will decrease the fatigue life seriously. Considering the effect of thermo-acoustic loadings on the structural nonlinear behaviors, a nonlinear partial differential equation of large deflection under thermo-acoustic loadings is derived and then is treated with Galerkin method to obtain an ordinary differential equation under modal coordinates. The thermo-acoustic responses of simply supported rectangular titanium plates with different temperature and sound pressure levels (SPL) combinations are obtained, including random vibration in pre-buckled region, snap-through motion between post-buckled equilibrium positions and nonlinear vibration around one post-buckled position. Then the restoring force term and power spectral density (PSD) characteristics with temperature and SPL are analyzed for further research on nonlinear characteristics. Research results show that thermal loadings and acoustic loadings affect nonlinear characteristics differently. Thermal loadings will change the shape of stiffness curves. Taking the stiffness of critical buckling as standard, thermal loadings can reduce the stiffness of a structure in the pre-buckled region and increase the stiffness in post-buckled region. Due to the influences of acoustic loadings, the structures will work at different stiffness curve regions. Taking the stiffness of the structure without loadings as standard, the structures will work at hardened area while undergoing persistent snap through and work at softened area while undergoing intermittent snap through.

Keywords: thin-walled structure thermo-acoustic loading nonlinear response thermal-buckling snap-through response

Service

- ▶ 把本文推荐给朋友
- ▶ 加入我的书架
- ▶ 加入引用管理器
- ▶ Email Alert
- ▶ RSS

作者相关文章

- ▶ 沙云东
- ▶ 魏静
- ▶ 高志军
- ▶ 赵奉同
- ▶ 鲍冬冬

Fund:

航空科学基金(02C54007)

Corresponding Authors: 赵奉同, Tel.: 024-89723890 E-mail: ftzhao@sina.com Email: ftzhao@sina.com

About author: 沙云东 男, 博士, 教授, 硕士生导师。主要研究方向: 航空发动机强度、 振动及噪声。 Tel: 024-89723890 E-mail: ydsha2003@vip.sina.com; 赵奉同 男, 工程师。主要研究方向: 航空发动机强度、 振动及噪声。 Tel: 024-89723890. E-mail: ftzhao@sina.com

引用本文:

沙云东, 魏静, 高志军, 赵奉同, 鲍冬冬. 热声载荷作用下薄壁结构的非线性响应特性[J]. 航空学报, 2013, 34(6): 1336-1346. DOI: 10.7527/S1000-6893.2013.0234

SHA Yundong, WEI Jing, GAO Zhijun, ZHAO Fengtong, Bao Dongdong. Nonlinear Response Characteristics of Thin-walled Structures Under Thermo-acoustic Loadings[J]. Acta Aeronautica et Astronautica Sinica, 2013, 34(6): 1336-1346. DOI: 10.7527/S1000-6893.2013.0234