

光纤Bragg光栅应变计在500m口径球面射电望远镜工程索力监测中的应用

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Application of optical fiber Bragg grating strain gauge to cable force monitoring of FAST

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摘要

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摘要 为了实时监测500 m口径球面射电望远镜(FAST)索网支撑结构的典型索力,避免传统索力监测方法对索网支撑结构的影响和工作中的电磁干扰,提出了一种间接获取索力值的方法。该方法使用光纤布拉格光栅(FBG)传感器监测索头应变值来间接测量索力。测量时将FBG应变计与补偿温度计通过专用安装底座焊接于索头线性应变区域轴向,防止直接焊接对索头结构性能的影响;然后使用温度应变补偿法补偿温度变化对FBG应变计测量结果的影响。在索体出厂预张拉过程中对该方法进行标定得到相关索力换算公式系数,从而在实际工程应用中实现了索力的测量。试验结果表明,索力与索头应变线性拟合度高达0.98,实际测量中绝对误差均方差为1.38 t,在FAST工程主索工作索力范围内相对误差优于3%,满足工程需求。该方法无电磁干扰,耐用性久,布线灵活简单,已成功应用于FAST工程中的316根典型主索的索力监测中。

关键词 : 光纤Bragg光栅, 应变计, 索力监测, 温度补偿, 射电望远镜

Abstract : To monitor the cable force of the cable-net supporting structure of the Five-hundred-meter Aperture Spherical radio Telescope(FAST) and to avoid the effect of traditional measuring methods on the cable-net supporting structure and the electromagnetic interference, this paper presents a method to obtain the cable force values indirectly. The method uses Fiber Bragg Grating(FBG) sensors to monitor the cable connector strain to measure the cable force indirectly. In the measurement, a FBG strain gauge was installed at the linear strain region of the cable connector axially by using a dedicated welded base, by which the adverse effect of welding directly on the performance of cable connector structure was avoided. A temperature compensation method was used to compensate the effect of temperature changes on the FBG strain gauge measurement. The correlation coefficients were acquired by the calibration of the cable prestressing process. The cable force monitored then was calculated from the calibrated relation in actual engineering applications. Test results indicate that the fitting linearity of the cable force and the cable connector strain is up to 0.98 and the Root Mean Square (RMS) error in practical measurement is 1.38 t. The relative error is better than 3% within the range of the cable force for the FAST. The method is characterized by no electromagnetic interference, simple wiring, good reliability and long duration. It has been successfully applied to the cable force monitoring of 316 typical cables of the supporting cable-net in the FAST project.

Key words : Fiber Bragg Grating(FBG) strain gauge cable force monitoring temperature compensation radio telescope

收稿日期: 2014-09-29

中图分类号: TN253

TH743

基金资助:国家自然科学基金资助项目(No.11173035, No.11273036)

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引用本文:

孙晓, 王启明, 朱明, 吴明长. 光纤Bragg光栅应变计在500m口径球面射电望远镜工程索力监测中的应用[J]. 光学精密工程, 2015, 23(4): 919-925. SUN Xiao, WANG Qi-ming, ZHU Ming, WU Ming-chang. Application of optical fiber Bragg grating strain gauge to cable force monitoring of FAST. Editorial Office of Optics and Precision Engineering, 2015, 23(4): 919-925.

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