



航空学报 » 2013, Vol. 34 » Issue (5) :1232-1240 DOI: 10.7527/S1000-6893.2013.0209

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面向柱面结构的自动铺带四轴联动成形研究

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Research on Four-axis Simultaneous Motion Controlled Automated Tape Laying for Cylindrical Structures

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摘要

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摘要

根据柱面的结构特点,提出了面向柱面复合材料结构的自动铺带四轴联动成形方案,并以卧式自动铺带机为例进行分析。以保证铺放头压力线平行于曲面在铺放点的法线和保证铺放速度恒定为原则,根据D-H理论建立柱面固定角度铺放成形时铺带机各关节运动量的计算方法。应用逆运动学理论,对四轴联动铺带成形进行了运动学分析。从四轴联动铺带机的机构与控制、铺放速度、成形效率、方案可行性4个方面进行了深入分析,并进行可视化仿真和实验验证。结果表明应用本文方法,可实现用四轴联动铺带机完成柱面复合材料自动铺放成形,对于铺放成形效率要求不苛求的小批量实验或生产,具有低成本的突出优势。

关键词: 复合材料 自动铺带 柱面结构 四轴联动 逆运动学

Abstract:

In this paper, the features of cylindrical structures are analyzed, and then a scheme of 4-axis simultaneous motion controlled automated tape laying (ATL) manufacturing is advanced for them. Furthermore, the scheme is illustrated in the model of a horizontal ATL machine. By the D-H method, the paper proposes a method to calculate the feed amount of the joints during the manufacturing process of cylindrical components when the trajectory path is designed by the fixed angle method. The solution is made observing two principles: to guarantee that the pressure direction of the ATL head is parallel to the normal direction of the molding surface in the tape laying place, and to guarantee the tape is laid in a constant tape laying rate. In addition, the scheme is examined in detail in terms of system and controlling, tape laying rate, manufacture efficiency and feasibility. According to reverse kinematics, the scheme is further discussed by kinematic analysis, visual simulation and experiment trials. Finally, the conclusion is made that the low-cost 4-axis simultaneous motion controlled ATL manufacturing method can be applied to manufacturing composite components in cylindrical structures in experiments and small-scale production where requirement for production rate is not demanding.

Keywords: composite materials automated tape laying cylindrical structure 4-axis simultaneous motion reverse kinematics

Received 2012-06-01; published 2012-08-11

Fund:

国家自然科学基金(50905088); 国家科技重大专项(2010ZX04016-013); 中央高校基本科研业务费专项资金(NS2012112)

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李俊斐, 王显峰, 肖军, 肖健, 方宜武. 面向柱面结构的自动铺带四轴联动成形研究[J]. 航空学报, 2013, 34(5): 1232-1240.DOI: 10.7527/S1000-6893.2013.0209

LI Junfei, WANG Xianfeng, XIAO Jun, XIAO Jian, FANG Yiwu. Research on Four-axis Simultaneous Motion Controlled Automated Tape Laying for Cylindrical Structures[J]. Acta Aeronautica et Astronautica Sinica, 2013, 34(5): 1232-1240.DOI: 10.7527/S1000-6893.2013.0209