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空中加油对接过程的动力学建模与仿真

张雷雨[1], 张洪[2], 杨洋[1], 黄龙[1]

1. 北京航空航天大学 机械工程及自动化学院, 北京 100191;
2. 中航工业成都飞机设计研究所 机电部, 四川 成都 610041

Dynamics Modeling and Simulation of Docking Process in Aerial Refueling

ZHANG Leiyu[1], ZHANG Hong[2], YANG Yang[1], HUANG Long[1]

1. School of Mechanical Engineering and Automation, Beihang University, Beijing 100191, China;
2. Electromechanical Department, AVIC Chengdu Aircraft Design & Research Institute, Chengdu 610041, China

摘要 空中加油的成功与否主要依赖于加油锥套与受油插头的顺利对接,对对接过程中产生的动力学行为的研究是实现顺利对接的前提。利用多刚体系统动力学建立对接过程的动力学模型,求解出加油锥套与受油装置间的广义速度;并依据建立的接触动力学模型,得到局部接触点间的相对速度。基于非线性连续碰撞理论,提出对接过程中碰撞力的计算方法,并在机械系统动力学仿真软件ADAMS的环境下,构建加油锥套和受油装置的对接虚拟样机。通过对虚拟样机的动力学仿真,得到了对接过程中的碰撞力及速度响应曲线,同时,得出能够实现成功对接时各参数的具体范围。结果表明,制约对接成功的主要参数是初始相对速度、加油锥套的俯仰角和相对偏距。该研究对空中加油的对接和受油机的导航控制具有重要的意义。

关键词： 空中加油 对接 接触动力学 非线性连续碰撞理论 碰撞力

Abstract： The success of an aerial refueling task depends on the successful docking between the refueling drogue and the probe of the receiver aircraft. The study of contact dynamic behaviors during the process is the prerequisite to realize successful docking. A dynamics model of the docking process is established according to the multi-body dynamics theory to obtain the generalized velocity between the refueling drogue and the receiver aircraft. The relative velocities among local contact points are obtained through the contact dynamics model that has been established. Based on the nonlinear continuum collision theory, this paper proposes a calculation method of the collision force during the docking process. Meanwhile, a virtual prototype for docking is created by means of software ADAMS. The response curves of the collision force and velocity are obtained through dynamic simulations of the virtual prototype. Meanwhile, the specific ranges of each parameter in a successful docking are obtained. The results indicate that there are three main parameters that affect the docking process: the initial relative velocity, the pitch angle of the refueling drogue and the centerline offset between the refueling drogue and the probe. The study is significant to the docking process and receiver aircraft navigation in an aerial refueling.

Keywords： aerial refueling docking contact dynamics nonlinear continuum collision theory collision force

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Corresponding Authors: 杨洋,Tel.: 010-82338386 E-mail: yang_mech@buaa.edu.cn Email: yang_mech@buaa.edu.cn

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