Research on Opening and Closing Synchronization of Flexible Hatch on Space Shuttle

Yue Wang, Research and Development Center, Beijing, China
Hong Liu, Harbin Institute of Technology, Harbin, China
Bo Peng, China Academy of Launch Vehicle Technology, Beijing, China

ABSTRACT

The space industry is developing rapidly, specifically with the development of the space shuttle. The position accuracy of the shuttle hatch is always a key problem when the space shuttle is in orbit. When hatch position accuracy meets the requirement of the central lock acquisition domain, the central lock can capture and lock, otherwise it will cause the hatch to not close properly. Aiming at this problem, this article solves it by using the basic theory of flexible body ADAMS. First, composite hatches are converted into an equivalent shell by using the equal stiffness substitution principle, deriving the neutral file (MNF) of the hatch by a classical module in ANSYS, and testing synchronization and accuracy of it under the condition of ideal rigidity and flexibility. Eventually, we obtain the curve of motion displacement at key points, then we can estimate whether the synchronization and accuracy of the hatch meets the requirements.

KEYWORDS

Compound Material, Dynamics. Flexible Body, Hatch, Research and Development Center

1. INTRODUCTION

In the actual mechanical system, especially in the aerospace field, due to the use of composite materials, the absolute rigid body is not present. A multi-body system composed of multiple components, in the course of the movement, each component will reflect its flexible body characteristics at varying degrees, and flexible features will have a certain impact on the entire system. In order to react more effectively to the actual working state of the multi-body system, the multi-flexible system or the rigid-flexible coupling multi-body system dynamics modeling has become the focus of the multi-body dynamics modeling research.

Haug presented “Dynamics of flexible multibody systems” with careful study in many years ago. The dynamics of flexible multibody systems has become one of the research emphases in the dynamics of multibody systems. The flexible body simulation has become one of the hottest parts in dynamic simulation analysis of multibody in recent years (De, 2008). The study found that flexible body caused great influence on the whole system of high precision requirements, such as precision instruments, spacecraft, robotics, high-speed institutions. There will be incalculable consequences for the whole system in multibody dynamics simulation, if it does not consider the impact of flexible body (D.H. Guang, 2008). Qin Z. Wan F Y proposed a new method of rigid-flexible coupling modeling. The elasticity and flexural rigidity of the flexible rod is reduced with the increase of the damage

DOI: 10.4018/IJCINI.2018070104

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degree of the connecting rod, and movement precision of the door mechanism will be gradually decreased (Qin, 2013). Liu analyzed the rigid and flexible coupling dynamics of flexible beams. By Jourdain velocity variational principle is derived the rigid-flexible coupling equations of flexible beams, and the law of the wide range of flexible beams is obtained (Liu, 2002). Zhang, Xiao, Chen et al. through the mathematical relationship in the form of subroutines to simulate the role of cable, and study the synchronization of the docking system. Finally, according to the ADAMS simulation results, the main factors influencing the synchronization problem of the locking system are pointed out (Zhang, 2009). ZHAO Gaofei processes the key drive shafts which are flexibly by ADAMS, and the rigid - soft hybrid dynamic model of the system is established. The model is simulated and analyzed, but it is not accurate in the actual model (Zhao, 2012). MEI Ju use ANSYS to establish a flexible body of the neutral file, and combined with SolidWorks to create rigid and flexible coupling analysis model. Corresponding actual displacement output curve under the ADAMS (Mei, 2016). CAI Guang Proposed the use of ADAMS and ANSYS in their respective areas of the advantages of joint simulation. The dynamic simulation of the cantilever structure is carried out by using the method of establishing the flexible body, which avoids the establishment of complex mathematical model in traditional analysis, and the efficiency and precision are improved (CAI Guang, 2014). So, we analyze the system accurately by the co-simulation of ANSYS and ADAMS (Tao, 2012).

The world’s attention is gathered in the orbiter (space shuttle) with the rapidly development of science and technology. It is reported that the major space powers have transferred to the research of unmanned orbiter to complete the missions in orbit (Cheng, 2014). From the first Columbia space shuttle of United States to the space shuttle Discovery until the New Endeavour, the shuttle has got full development in recent years (Xin, 2011). At the same time, the three key points of space shuttle based on the research of many experts are the hatch mechanism, the hatch lock mechanism, and the seal performance of hatch.

In other words, there are high requirements about accuracy and synchronization of the position of space shuttle hatch. When the accuracy of hatch cannot meet the capture domain requirements at the closed position, it will cause the central lock what cannot be captured and locked; the aircraft is not operating properly. So the accuracy and synchronization of the position of space shuttle hatch is the key part of the research. This paper is based on Adams flexible modular, establishing flexible body of hatch and analysis the motion process, finally getting the curves of displacement of the key points.

2. FLEXIBLE BODY THEORY

For rigid-flexible coupled multi-body systems, it is necessary to distinguish between those components in the system what requires flexible processing, and those components are treated as rigid bodies. The distinction between rigidity and flexibility in the system is relative, and rigid bodies can be considered as those with less flexible or less flexible effects. In the system, the flexible body is described by structural mechanics and kinetic equations. From the calculation of multibody system dynamics, the mathematical model of rigid-flexible coupled multi-body system dynamics can be solved by using multi-rigid-body system dynamics and structural mechanics.

The modal flexible body is the most commonly used flexible body in the current rigid and flexible coupling analysis. Modal reduction (also known as FMBD) is a discrete finite element model to simulate the infinite degree of freedom of the continuum, thus describing the dynamic properties of the flexible body. The theoretical basis of the modal flexible body is a fixed interface modal synthesis method, first proposed by Hurty, followed by Craig and Bampton in 1966 on Hurty proposed theory to improve, so this method is also known as the Craig-Bampton method, belonging to the dynamic A method of molecular structure. The theoretical basis of the modal flexible body is a fixed interface modal synthesis method, first proposed by Hurty, followed by Craig and Bampton in 1966 on Hurty proposed theory to improve, so this method is also known as the Craig-Bampton method, belonging to the dynamic method of molecular structure. It can be seen that the modal
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