Paper ID: MT670

The 3rd International Conference on Mechatronics and Automation Technology (ICMAT2024)

Study on Electromechanical Coupling Dynamic Characteristics of Cabin Door Drive System for Aircraft

HU Xiaohang

State Key Laboratory of Mechanics and Control for Aerospace Structures, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China

Corresponding Author's email: Huxiaohang@nuaa.edu.cn

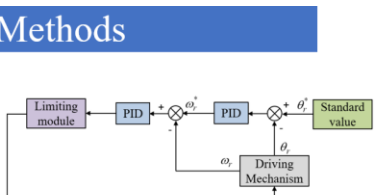
Introduction

With the advancement of modern technology, the requirements for aircraft are becoming increasingly stringent. As a critical component for ensuring the successful completion of missions, the cabin door drive system is gaining significance within the overall aircraft system. The electrically driven cabin door drive system features a compact structure, lightweight design, and rapid response, making it widely utilized in the field of cabin door operation.

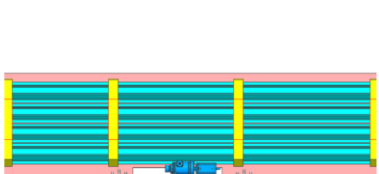
Research objectives

■ The response analysis of the drive system is based on factors such as cabin door speed, deployment angle, motor output torque, and motor power. The study investigates the impact of various driving forms on the electromechanical coupling characteristics of the system.

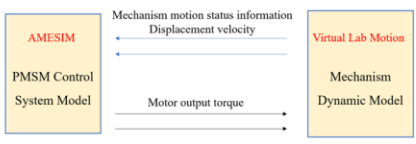
Methods



A dynamic model of the mechanism has been established using the LMS Virtual Lab Motion, while a motor control system model has been developed on the Simcenter AMEsim.



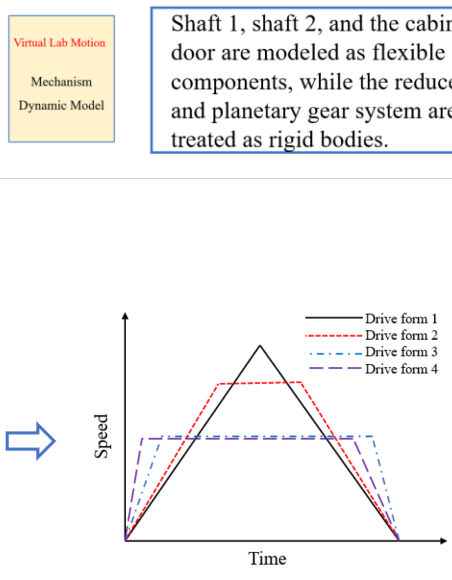
The control circuit employs a three-loop configuration: a current loop, a speed loop and a position loop.



Shaft 1, shaft 2, and the cabin door are modeled as flexible components, while the reducer and planetary gear system are treated as rigid bodies.

Numerical simulation

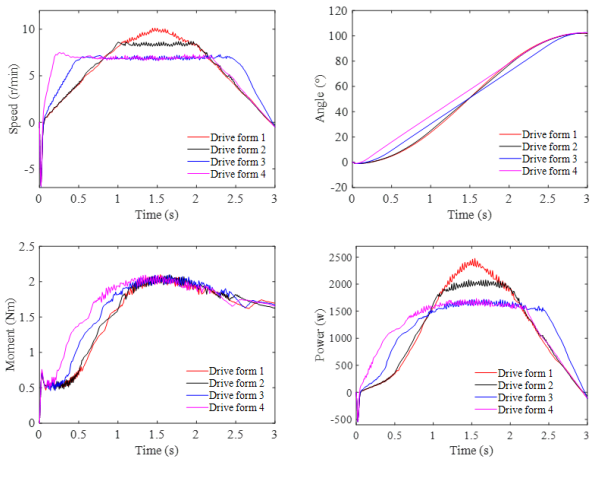
During aircraft flight, the cabin door drive system must accommodate various deployment processes depending on the flight environment. The unfolding mechanism of different cabin doors is primarily influenced by the type of motor drive employed. The different motor drive configurations significantly affect the motor's output torque, output power, and the speed of cabin door. Consequently, this paper examines the impact of motor drive types on the dynamic response of cabin door drive systems.



Results

The maximum speed of the cabin door in drive form 1 is 10.1 r/min. In contrast, the maximum speeds in drive form 3 and drive form 4 are the lowest, recorded at 6.94 r/min and 6.96 r/min. The final deployment angle of the cabin door is nearly identical across all forms. The maximum output torque of the motor is approximately 2.1 Nm. The maximum output power of the motor is approximately 2469 W.

Drive forms	Extreme speed of cabin door (r/min)	Opening angle of cabin door (°)	Extreme value of motor output torque (Nm)	Extreme value of motor power (W)
Drive form 1	10.1	101.98	2.10	2469
Drive form 2	8.2	102.10	2.09	2142
Drive form 3	6.94	102.46	2.06	1622
Drive form 4	6.96	102.32	2.07	1698



Conclusions

- This article establishes a mechatronic coupling analysis model for the aircraft cabin door drive system.
- Fluctuations of the motor output torque affect all responses of the control system and drive mechanism.
- The impact of various motor drive forms on the control system is primarily evident in the speed of the cabin door and the power output of the motor.

References

[1] Wang X, Liu Z, Cong Y, et al. Miniature fixed-wing UAV swarms: review and outlook [J]. Acta Aeronautica et Astronautica Sinica, 2020, 41 (04): 20-45
[2] Wang H. Key technologies in collaborative airframe-engine design for high performance fighters [J]. Acta Aeronautica et Astronautica Sinica, 2024, 45 (5): 529978.
[3] Fu L. Design and research of electric drive control system for aircraft door [D]. Northeastern University, 2016
[4] Chen Y. The design and analysis of actuation system for the nose landing gear of an aircraft [D]. Nanjing University of Aeronautics and Astronautics, 2014
[5] Raman G, Mclaughlin D. Highlights of aeroacoustics research in the U.S.—1998 [J]. Journal of Sound and Vibration, 1999, 228 (3): 589-610
[6] Zhang L, Zhong S, Liu X, et al. Development and application of strength design technology of high performance fighter [J]. Acta Aeronautica et Astronautica Sinica, 2020, 41 (6): 523480
[7] Li Y, Qi R, Zhou S, et al. Research on a centralized control scheme of civil aircraft electromechanical actuating cabin door [J]. Advances in aeronautical science and engineering, 2022, 13 (04): 124-130
[8] Liu W, Sun A, Wang L, et al. Failure analysis on motion trend of weapon door drive system of a certain aircraft [J]. Mechanical Research and Application, 2023, 36 (06): 16-19
[9] Ma J, Ma M. Strength simulation and design of CFRP drive shaft for a certain aircraft door drive system [J]. Mechanical Research and Application, 2023, 36 (03): 5-9