Proceedings of the 7th International Conference on Mechanics and Materials in Design,
Albufeira/Portugal 11-15 June 2017. Editors J.F. Silva Gomes and S.A. Meguid.
Publ. INEGI/FEUP (2017)

PAPER REF: 6543

DYNAMICS MODELLING AND SIMULATION OF A DOUBLE-AXIS SWING TABLE

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ABSTRACT

During the development of vessel devices, it is necessary to test the capability of these devices many times in navigation conditions. The high cost of navigation testing and high consequence of system failure during an actual mission make the ground-based testing important and even essential. A double-axis swing table is a frequently used experiment equipment which is able to provide a combined rolling and pitching navigation environment. In this paper, the effect of the inertia coupling and eccentricity on the dynamic performance of the double-axis swing table was researched. And then the dynamic model was established. At last, the simulation was done to validate the dynamics modelling.

Keywords: swing table, dynamics modelling, dynamics coupling.

INTRODUCTION

A double-axis swing table is essential for ground-based testing in a navigation condition. The double-axis swing table is a multi-body mechanical system composed of three rigid bodies, namely, a base, an inner gimbal, and an outer gimbal. The base is connected to the outer gimbal by a revolute joint. The inner gimbal is then connected to the outer gimbal by a revolute joint.

Loads of the swing table mainly contains inertia load, gravitation load caused by eccentricity, and friction load. All these loads will debase the control precision of a swing table. Aimed at the low precision swing table, friction is not needed to be compensated. Therefore, it is not considered in the research. However, for the double-axis swing table with large dimension and huge load, the effect caused by dynamics coupling and eccentricity is needed to be considered. In this paper, the dynamics modelling including dynamics coupling and eccentricity is established. By analysis and simulation, effect on the control precision is studied. The possible method to eliminate the effect is proposed. The analysis can also provide a reference for similar swing table designers.

RESULTS AND CONCLUSIONS

The study shows that inertia coupling and dynamics coupling between the inner gimbal and the outer gimbal cannot be ignored when designing a double-axis swing table. Besides, the effect on the outer gimbal is much bigger than the inner gimbal. The reason is listed as follows. Firstly, moments of inertia of the non-rotational axis are quite different from each

other. Second, moments of inertia of rotational axis of inner gimbal and outer gimbal are large. Therefore, objective of the optimization should contain minimum of the moments of inertia of the rotational axis of both the inner gimbal and outer gimbal and minimum of the moments of inertia of the non-rotational axis of the inner gimbal.

Eccentricity torque is related to the place of center of mass and the swing situation. The simulation shows that effects of the eccentricity torque on rotation of inner gimbal in the four quadrants are speeding, blocking, speeding and blocking. Effects of the eccentricity torque on rotation of outer gimbal in the four quadrants are speeding, speeding, blocking and blocking. Due to large variety of the eccentricity torque, design of balance weight is essential and an important way to eliminate the effect of the eccentricity torque on the control precision.

ACKNOWLEDGMENTS

Thanks are due to Mingxiang Ling for his assistance in simulation.

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