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Modeling of Reaction Wheel

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Abstract: Precision attitude control subsystems are now more essential than ever because of recent developments in the spacecraft manufacturing sector. One of the complex spaceship subsystems, attitude control, is frequently hampered by both internal and external disturbances. The output torque of a reaction wheel should, in theory, be proportional to the input current, even though there are numerous disturbances in practice. This proposal provides a technique to implement the change in the allocated torque to the wheel that takes disturbance torques into account. The results then demonstrate how disturbance torques affect the reaction torque and wheel speed of the reaction wheel.

Keywords: Reaction Wheel, Attitude Control System (ACS), Wheel Torque, Spacecraft Dynamics

I. INTRODUCTION

For spacecraft missions requiring extremely precise pointing, the Attitude Control Subsystem (ACS) with specific actuators will be used. An essential actuator for the spacecraft's attitude control system is the reaction wheel (RW) (ACS). Accurate modeling of the spacecraft reaction wheel is advised for design, simulation, analysis, and fault diagnosis applications. The accuracy of the whole ACS modeling process will rise as reaction wheel modeling accuracy is improved. Precision attitude control modules are in higher demand due to recent developments in the spacecraft manufacturing sector. One of the more intricate spaceship subsystems, attitude control is frequently harmed by both internal and external disturbances. In theory, a reaction wheel's output torque ought to be proportionate to its input current, but in practice, there are multiple disruptions. Unbalanced flywheel, bearing friction, bearing torque noise, rippled motor torque, and cogging are some of the most frequent forms of disturbance. The method for determining the change in torque assigned to the wheel while taking disturbance torques into account is suggested in this proposal.

II. RELATED SURVEY

The EOMs for a spacecraft with Nrw RWs susceptible to general static and dynamic imbalances are provided using a first-principles approach. This completely connected jitter phenomenon is nevertheless governed by the real physics as a result of the formulation. As a result, using this model, energy and momentum tests are possible. The formulation method is Newtonian/Eulerian. However, the formulation was created in a way that makes it very easy to include other modes like flexing and gasoline slosh. Also highlighted is the connection between the completely coupled, first-principles-based RW model and the manufacturers' standards for RW static and dynamic imbalances. The manufacturers' basic first-order RW jitter performance using the static and dynamic imbalance parameters makes this of interest. The validity of the presented RW is examined using numerical simulations [1].

The reaction wheel component model was built to create an accurate reaction wheel model for the spacecraft attitude control unit. As a result of recent changes in spacecraft manufacturing, the demand for accurate attitude control subsystems is increasing. As one of the more complex spacecraft systems, attitude control often suffers from poor performance due to both internal and external disturbances. Theoretically, the output torque of the reaction wheel should be based on the input current, but in practice, there are additional disturbances as well. The precision response wheel model proposed in this study takes disturbance torques into account. The results then show how disturbance torque affects the angular momentum, wheel speed, and reaction torque of the reaction wheel [2].

A complex regulated system like a spacecraft necessitates digital simulation for improved analysis and design. Using block diagrams in a top-down manner, such as in Matlab-Simulink, is a good technique since it allows for better and quicker creation, understanding, visualization, and adaptability. To simulate the various types of spacecraft in various modes, a new Matlab-Simulink Library has been conceived and developed, and ongoing enhancements are being made to it. The spacecraft control system is described by the custom models of various blocks found in the library. Models of several spacecraft components have been created utilizing Matlab's built-in components and bespoke component building features using S-functions [3].

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One of the primary actuators for regulating the attitude of a spaceship is the reaction wheel. However, it causes undesirable micro-vibrations that make attitude control less effective. These missions' micro-vibrations lead to stability issues that lower these gadgets' effectiveness. The suggested model's primary benefit is its ability to analytically describe the many forms of interference. This enables reaction wheel designers to anticipate reaction wheels' micro-vibration behavior before they are produced or even at the design stage [4].

An inverted pendulum is designed, modeled, simulated, implemented, and controlled using mechatronics by applying regulated torques to a reaction wheel. Additionally, how to choose an electric motor as well as how to simulate and evaluate various motors' performance are covered [5].

To forecast how vibrations would affect the performance of precision space-based telescopes like the Space Interferometry Mission, accurate disturbance models are required (SIM). A method has been developed and made available as a MATLAB toolbox to extract parameters from RWA micro-vibration data for an empirical disturbance model. Given steady-state vibration data, the MATLAB toolbox enables the extension of this empirical disturbance model for use with any reaction wheel. It is demonstrated, nonetheless, that for specific wheel speed ranges, a model of this kind underestimates the disturbances. Because the empirical model does not take into consideration disturbance amplification brought on by interactions between the harmonics and the structural modes of the wheel, the association is low [6].

The effectiveness and dependability of the attitude control system, which is made up of several actuator types including response control thrusters, reaction wheels, and magnetic actuators, are crucial factors in determining the success of a spacecraft mission. Solutions to spacecraft attitude control issues typically start with the underlying presumption that the onboard actuators can produce the precise torque that the attitude controller needs at a specific moment. Even though this method has previously been successful, it is clear that attitude actuators, like all electromechanical devices, have dynamics that could affect controller effectiveness. Actuator dynamics must be considered in the control strategy because of the increased demand for high-precision attitude control for applications like formation control and optical navigation [7].

For precise space-based observatories like the Space Interferometry Mission (SIM) and the Next-Generation Space Telescope, accurate disturbance models are required to forecast how vibrations will affect their performance (NGST). According to the model, the disturbances are discrete harmonics of the wheel speed, and their amplitudes are proportional to the square of the wheel speed. The empirical model may be altered to work with any wheel thanks to the development of MATLAB tools that extract the model parameters from steady-state RWA data. This model takes into account both the entire wheel harmonic spectrum as well as the disturbance amplification brought on by the harmonic activation of the structural wheel modes. Also presented are preliminary studies that explore the dynamic interaction between RWA and spacecraft [8].

CONCLUSION

We have modeled a method for determining the disturbance in the torque of the spacecraft reaction wheel, we conclude after evaluating the prior research. This model can be used to imitate the attitude control subsystem by using motor torque and bus voltage as inputs and angular momentum, response torque, wheel speed, and disturbances as outputs. The precise model has produced results that show how disturbance torques affect the response wheel's wheel speed and reaction torque.

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