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Theory of gyroscopic effects

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Abstract

Throughout the centuries, researchers derived several the gyroscope theories for solving gyroscopic effects which manifested by the action of the undiscovered inertial torques. Only one component of the change in the angular momentum was described by L. Euler. The physics of gyroscopic effects are many times harder than could imagine. The torques acting on the rotating objects contain eight interacted components operating by the centrifugal, common inertial, Coriolis forces, and the change in the angular momentum, which entailed by the ratio of the angular velocities of the rotating objects around their axes of motions. This system of inertial torques and the ratio of the angular velocities construct the fundamental principles gyroscope theory.

Keywords: inertial torques, gyroscopic effects, ratio of angular velocities

Introduction

Rotating objects in engineering are represented by a vast group of machine components of different designs (disc, cylinder, ring, sphere, cone, paraboloid, propeller, etc.). The movable rotating objects manifest gyroscopic effects, which physics remains not adequately explained [1 - 4]. Known analytical and numerical models do not satisfy practice [5 - 7]. The physics of gyroscopic effects are compound. Gyroscopic effects are a result of the activity of the system interacted inertial torques generated by the centrifugal, common inertial, and Coriolis forces and the change in the angular momentum. The ratio of the angular velocities of the rotating objects around the axes combines all inertial torques [8 - 10]. The inertial torques and the ratio of the angular velocities construct the fundamental principles of the gyroscope theory.

Methodology

The inertial torques acting on the rotating disc are represented by the following equation: - the torque of centrifugal and common inertial forces - the torque of Coriolis forces - the torque of the change in angular momentum

where ωi is the angular velocity of the spinning disc around axis i; ω is the angular velocity of the spinning disc around axis oz; J is the mass moment of inertia of the spinning disc.

Rotating objects can have represented by different designs and the equations of the mass moment of inertia and inertial torques will have different expressions. The inertial torques have direct dependencies on the location of distributed masses of the rotating objects.

The action of the system of the interacted inertial torques on the rotating disc demonstrated in Fig. 1. The inertial torques acting around axes express the kinetic energies of the rotating disc are equal by the principle of the conservation of mechanical energy. Equality of the inertial torques around two axes expresses the ratio of the angular velocities around axes of the rotating disc that represented by the following equation:

$$\frac{\omega_y}{\omega_x} = \left[\frac{2\pi^2 + 8 + (2\pi^2 + 9)\cos\gamma}{2\pi^2 + 9 - (2\pi^2 + 8)\cos\gamma}\right]$$

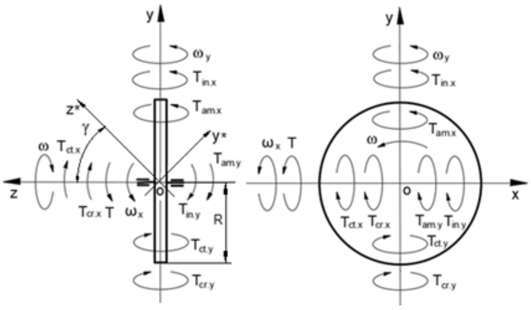

Figure 1. The action of interacted inertial torques and motions of the rotating disc

The ratio ωy/ωx is variable and depends on the angle γ of the axis of the spinning disc location (Fig 1). For the horizontal location of the spinning disc (γ = 0), the ratio ωy/ωx = 4π2 + 17 is maximal. For the vertical location of the spinning disc (γ = 90o), the ratio ωy/ωx = 0 is null, where the precession torques are absent, and the gyroscope turns on the maximal angle . The turn of the gyroscope of the horizontal location around the vertical axis leads it turns on the maximal angle around another axis. The maximal turn of the gyroscope around the vertical axis is on the angle γ = 164,841101855o/(4π2 + 17) = 2.918656521o that maintain the ratio ωy/ωx. The internal torques and the ratio ωy/ωx of the angular velocities of the gyroscope represent the fundamental principles of the gyroscope theory.

Results and discussion

Mathematical modeling of gyroscopic effects did not solve until new breakthrough formulation for the system of interrelated inertial torques of rotating objects. Obtained equations for the system inertial torques acting on the rotating objects and the ratio of the angular velocities around axes of motions open the ability to formulate the motions of the rotating objects. This statement validated by the practical tests of the rotating disc around two axes at the 3D coordinate system.

Conclusion

The new research of gyroscopic effects discovered the system of the interrelated inertial torques acting on the rotating objects. These inertial torques combined by the ratio of the angular velocities of the rotating objects around axes of motions. The system of the eight inertial torques and the ratio of the angular velocities of the rotating objects constitute the fundamental principles of the gyroscope theory. This result represents the breakthrough solution and opens a new chapter for classical mechanics. Gyroscope problems solved finally and manually and can be used for solving any problems of rotating objects moving in space. New studies and solutions to the dynamics of rotating objects will be represented in textbooks and handbooks.

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