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Short Communication

Gyroscopic Effects of Rotating Objects

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Abstract

From ancient times gyroscopic effects of rotating objects attracted the attention of inquisitive people. They were endeavored not only to understand the properties of rotating objects but to use them in practice. Some rotating objects as the top, Tippe top and similar ones were commercialized for entertainment. Another one was the boomerang, spinning bullet and projectile were the hunting and shooting implements. At the time of the Industrial Revolution, the mathematician L. Euler described one a gyroscope property that is the change in the angular momentum of the spinning disc that did not explain its other effects. For more than two centuries researchers tried to discover the physics of gyroscopic effects but without success. It is necessary to mark they could not solve the gyroscope problem in principle because the fundamental principles of classical mechanics were finally formulated in the middle of the nineteenth century. The researchers of the following centuries could not use the obtained knowledge to describe gyroscopic effects. Today, this problem has been solved and the physics of gyroscopic effects are described by the action of the system of several interrelated inertial torques generated by the kinetic energy of the spinning objects.

Keywords: Inertial Torques of the Spinning Objects; Gyroscope Theory; Physics of Gyroscopic Effects

Introduction

In engineering, numerous mechanisms contain movable in space rotating objects of different forms that manifest the gyroscopic effects. Most of the rotating objects of mechanisms are designed and represented by simple and standard geometry as the sphere, circular cone paraboloid, ellipsoid, propeller, etc. The physics of their gyroscopic effects were described by the simplified mathematical models that do not satisfy engineering practice [1-9]. The reason for this phenomenon is the researchers could not use the known physical principles of classical mechanics to describe the integrated action of their several components on rotating objects in the space [10-13]. Today, the physics of gyroscopic effects are explained and described by mathematical models based on the fundamental principles of classical mechanics. Gyroscopic effects are the result of the action of the system of several inertial torques that interrelated by the ratio of the angular velocities of the spinning object around axes of motions. These inertial are generated by the action of the centrifugal, common inertial, and Coriolis forces as well as the change in the angular momentum that expresses the kinetic energy of the spinning object [14-16]. The inertial torques and the ratio of the angular velocities of the spinning object around of axes constitute the fundamental principles of gyroscope theory. Nevertheless, the spinning objects at the condition of the rotation around one axis demonstrate the deactivation of the inertial forces that contradicts the principles of physics mechanics. This phenomenon presents the challenge for the physicist and researchers.

Methodology

On any movable rotating objects in space are acting the system of the interrelated eight inertial torques around 3D axes of the coordinate system the generated by following inertial forces of classical mechanics: centrifugal, common inertial, Coriolis forces, and

the change in the angular momentum. These torques cannot be separated as far as they are generated by one rotating mass and interrelated by the ratio of the angular velocities of the spinning objects around axes of motions. The kinetic energies of the spinning objects along each axis of motion are equal and express the principle of the conservation of mechanical energy. The expressions for the inertial torques depend on the geometry of the spinning objects and enable deriving any mathematical models for the motions of spinning objects around axes of 3D coordinate systems. Such differences in equations of the inertial forces will be also for the expressions of the inertial torques for different designs of the spinning objects. The spinning objects can be axial symmetric as a spinning disc, cylinder, ring, cone spheres, paraboloid, propeller, etc., and nonsymmetrical rotating objects. The study of the action of inertial torques on the spinning disc represents fundamental properties of the spinning objects formulated by the mathematical models. The mathematical models for the top motions, motions of gyroscopes suspended from the flexible cord, and fixed one side support with the action of frictional torques, gyroscope nutation, and oscillation were validated by practical tests. The method of deriving mathematical models for the inertial torques acting on the spinning disc enables the development of the equations of the inertial torques for any spinning objects in engineering. This statement is based on the physical principles that are universal and can be applied not only to the earth but in space also.

Movable in a space the spinning objects of different designs manifest gyroscopic effects under the action of the external forces. At the condition of the weightless at orbital flight, the spinning objects demonstrate a cyclic inversion without the action of the external force. In the publications, this is called the Dzhanibekov effect. At the first sight, this phenomenon is the unknown property of the matter manifested in space. However, this statement is not correct. On the spinning object rotating around a fixed point is acting the inertial torque that turns the object around its center mass. This inertial torque was not described by classical mechanics and today is going on the heated arguments among the physicist about this topic. Nevertheless, this new inertial torque will be accepted because the evidence of its action is the rotation of the moon around its center mass and that facing of the one side toward the earth. This external inertial torque is manifested in the gyroscopic effects of the spinning object in a space that can be described by the new gyroscope theory.

Conclusion

Mathematical modeling of gyroscopic effects was complex until a breakthrough solution for the inertial forces and torques acting on spinning objects. The inertial torques acting on the spinning object are generated by the centrifugal, common inertial, Coriolis forces, and the change in the angular momentum produced by the rotating mass and combined by the ratio of the angular velocities of the spinning objects around axes of rotation. These five components express the kinetic energy of the spinning object and constitute the fundamental principles of the gyroscope theory. The problems of gyroscopic effects are finally solved irrevocably. Artificial terms invented by researchers, as gyroscope couple, gyroscope resistance, "anti-gravity effect", non-inertial property, etc., should be removed forever from the glossary of gyroscope theory. New studies in the area of dynamics of rotating objects discover the new property of the matter that is expressed by the deactivation of the inertial torques and the action of the inertial torque on the rotating objects around a fixed point. Obtained results open a new direction in the science of dynamics of classical mechanics, which will be presented in textbooks, and handbooks.

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