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A method for measuring the inertia properties of rigid bodies

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ABSTRACT

A method for the measurement of the inertia properties of rigid bodies is presented. Given a rigid body and its mass, the method allows to measure (identify) the centre of gravity location and the inertia tensor during a single test. The proposed technique is based on the analysis of the free motion of a multi-cable pendulum to which the body under consideration is connected. The motion of the pendulum and the forces acting on the system are recorded and the inertia properties are identified by means of a proper mathematical procedure based on a least square estimation. After the body is positioned on the test rig, the full identification procedure takes less than 10 min. The natural frequencies of the pendulum and the accelerations involved are quite low, making this method suitable for many practical applications. In this paper, the proposed method is described and two test rigs are presented: the first is developed for bodies up to 3500 kg and the second for bodies up to 400 kg. A validation of the measurement method is performed with satisfactory results. The test rig holds a third part quality certificate according to an ISO 9001 standard and could be scaled up to measure the inertia properties of huge bodies, such as trucks, airplanes or even ships.

1. Introduction

In many applications the analysis of the motion of a complex system is required. An accurate analysis can be performed only if the *inertia properties* of each rigid body of the system are known. The inertia properties of a rigid body are a set of ten parameters, namely the *mass, the location of the centre of mass and the inertia tensor-3 $\times$ 3 matrix*. Due to the difficulties in getting such data, very often, the inertia properties are roughly estimated reducing very much the accuracy of simulation analyses.

The discussion is still open on the problem of defining an acceptable level of uncertainty on the inertia properties, considering that testing time and costs normally rise with precision [1]. Referring to vehicle simulations, (both ground or aero-space vehicles), it has been proved that small errors in the inertia properties produce non-negligible errors in the computed dynamic responses [1–5]. Furthermore, for ground vehicles, it has been found that not only the main diagonal components of the inertia tensor (moments of inertia—MOIs), but also the extra diagonal components of the inertia tensor (products of inertia POIs) can greatly affect comfort and driveability [2–4]. For air and space vehicles, the knowledge of the inertia tensor and of the orientation of the principal axes of inertia is of crucial importance for flight controls and performances [5].

From the above mentioned analyses, it can be argued that the full inertia tensor, along with the location of the centre of mass, should be known for a wide class of mechanical systems. A common practice for the estimation of rigid body inertia

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