Dynamic modeling and control of a new automatic corksing machine for threaded plastic caps

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Abstract

The aim of this work is to model a new electromechanical system for applications in the field of automated corksing machines. The paper presents the dynamic modeling of a new automatic corksing machine for threaded plastic caps. The model is obtained using the energy-based modeling technique named “Power-Oriented Graphs” (POG). The considered corksing machine is an electromechanical system with two degrees of freedom composed by two electrical motors moving a ball screw/spline that realizes the linear/rotary motion necessary to screw a plastic cap on a bottle. The paper presents the dynamic model of the machine and the interaction between the cap and the bottle. In the paper a control algorithm is proposed. Some simulation results are presented and compared to experimental results.

1. Introduction

When dealing with the modeling of dynamic physical systems, the choice of a modeling technique is a very important issue. Many graphical energy-based modeling techniques have been introduced in the past years: the Bond Graphs (BG) [3], [1], the Power-Oriented Graphs (POG) [4] and the Energetic Macroscopic Representation (EMR) [2]. All these techniques are based on the concept of energy moving within the system. In this work the Power-Oriented Graphs (POG) modeling technique is exploited taking advantage of its main properties such as compactness, direct correspondence with state space equations, possibility to translate block schemes directly into Simulink for simulations and possibility to transform (reduce and/or invert) dynamical systems. POG schemes clearly show the power flows within the system thus allowing a precise analysis and to keep always the corresponding physical meaning. Because of the POG modular structure, complex physical systems can be modeled by composing subsystems models.

2. Power-Oriented Graphs basic features

The POG block schemes are standard block diagrams combined with a particular modular structure essentially based on the use of the two blocks shown in Fig. 1.a and Fig. 1.b: the elaboration block (e.b.) stores and/or dissipates energy (i.e. springs, masses, dampers, capacities, inductances, resistances, etc.); the connection block (c.b.) redistributes the power within the system without storing nor dissipating energy (i.e. gear reduction, transformers, etc.). The e.b. and the c.b. are suitable for representing both scalar and vectorial systems. In the vectorial case, $G(s)$ and $K$ are matrices: $G(s)$ is always a square matrix composed by positive real transfer functions; matrix $K$ can also be rectangular. The circle present in the e.b. is a summation element and the black spot represents a minus sign that multiplies the entering variable. The POG put in evidence the power flows within the system and keep a direct correspondence between the dashed sections of the graphs and real power sections of the modeled sys-