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Short communication

Upgrade of an automated line for plastic cap manufacture based on experimental vibration analysis

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ABSTRACT

The study deals with an experimental campaign to analyze the effects on an automatic machine for plastic cap assembly of the increased vibrations occurring when speeding up its operation. The new velocity specifications are required by the machine manufacturer for raising the production capacity. The analysis successfully identified the functional units critically affected by elastodynamic issues related to the speed increment. Hence it permitted to focus the redesign process on the critical groups in order to implement the desired machine upgrade by means of limited modifications to the current machine version. The most relevant experimental results are presented and discussed. The paper also reports data provided by further tests carried out on a machine variant (obtained after the implementation of the first design modifications), which prove the effectiveness of the proposed solutions to improve the machine performance.

1. Introduction

The presented activity relates to the upgrade of an automated line for the manufacture of plastic resealable opening devices for packages of pourable food [1]. The primary objective is increasing the machinery nominal production capacity by about 50%, from 680 to 1000 products per minute (*ppm*). This goal has to be achieved through a proper rise in the working velocity and only limited modifications of the existing machinery design.

This study focuses on the automatic machine that assembles the end product starting from its three components. The remarkable speed increment required to meet the desired production target may trigger elastodynamic phenomena possibly detrimental for both the performance and the reliability of the machine. An experimental campaign was carried out to investigate these potential issues by means of vibration measurements. The analysis aimed at identifying the functional groups characterized by critical elastodynamic behavior, thus providing the guidelines for a partial machine redesign.

The current configuration does not allow exceeding 25% of the nominal production capacity. Hence, the experiments were designed both to monitor (when possible) and to predict the machine behavior when operating in different working conditions, by arranging special sensor and machine setup.

The analysis yielded a reliable estimation of the machine elastodynamic behavior, thus permitting to define the required design modifications. Relevant results concerning some critical functional units are presented and discussed. Measurements from follow-up tests performed after implementing some modifications of the most critical unit confirmed a significant enhancement of the machine performance.

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2. Description of the assembly machine

A simplified schematic of the machine layout is presented in Fig. 1, where only the main functional units are shown. The machine reference coordinate system is also reported. A pick-and-place unit (referred to as *P&P1*) takes the three product components (*Comps*) from the corresponding buffers, located next to the machine input area (*IN*), and loads them onto properly shaped trays. Each product tray carries 10 items of each *Comp*, so that 10 caps are assembled in a working cycle. The trays are conveyed by the *Main Transfer Unit* (*MTU*), with intermittent motion, to the next functional groups, for subsequent operations (performed during the rest phase of the *MTU* cycle). The *MTU* is driven by a power transmission chain formed by an *Indexer* and a *Timing Belt* (*TB*). The *Orientation unit* (*OR*) rotates the *Comps* around the vertical axis (direction *Z*) to provide them with the required relative orientations. The assembly task is performed in two steps by the two *Assembly units* (denoted as *As1* and *As2*, respectively). A second pick-and-place unit (*P&P2*), mechanically coupled to the *P&P1* by the *Linkage*, transfers the assembled caps from the trays to the end product buffer, located at the machine output area (*OUT*). The unit referred to as *Lock* engages the product trays processed by the functional units to ensure their accurate positioning during the related operations.

3. Experimental setup and test conditions

Since very few information about the elastodynamic behavior of the machine was available, all the main units and structures were monitored by proper transducers. Preliminary visual inspection of working cycles at 840 *ppm* had reveled significant oscillations affecting both the *Linkage* and the *MTU*, which therefore underwent deeper investigations. In particular, the displacement and the velocity of the product trays along the conveying direction (*Y*-axis) were detected by a laser vibrometer (Polytec HSV-2002, Fig. 2a). These measurements required arranging two "dummy trays" that were installed on the *MTU* by replacing two adjacent product trays. Both dummy trays feature a reflective surface targeted by the

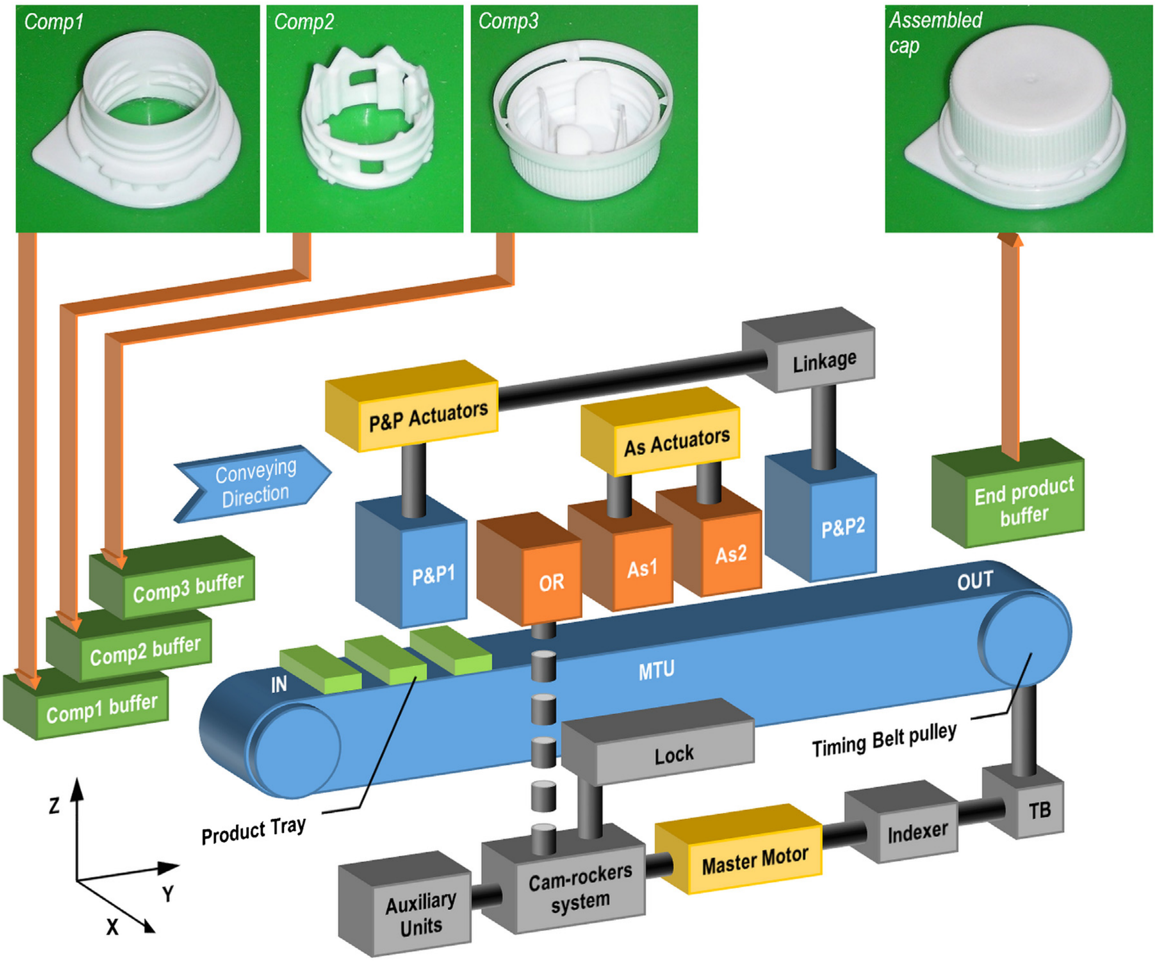

Fig. 1. Simplified schematic of the machine layout.