Numerical and experimental analyses to enhance the vibration response of rotary transfer machines

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Abstract

This work deals with the elastodynamic analysis of rotary transfer machines. Such systems are machine tools conceived for the mass-production of families of components. They typically feature a rotary indexing table carrying the workpieces and multiple machining units operating simultaneously [1]. Cutting forces between tools and workpieces and rapid motion of both the indexing table and the machining units can excite the system resonances in a wide frequency range and trigger elastodynamic phenomena possibly detrimental for both the quality of machined surfaces and the tool life. Assessing and solve potential vibration issues is therefore essential to ensure the correct operation of the machine tool.
The study focuses on a new machine tool designed for machining components for the lock&keys industry
(Fig. 1). It features ten functional stations and fifteen CNC machining units (nine located on the main structure, six on external supports). The manufacturer aims at reducing the vibration levels by improving the current design of the machine tool. Two strategies are investigated to attain the goal. The first (more conventional) approach consists in optimizing the vibration response of the system through changes of the geometry and/or the inertial properties of its structure and/or subassemblies. A Finite Element model of the whole machinery was implemented to evaluate the effects of possible modifications (e.g. additional stiffeners), by performing numerical modal analyses. The model was validated through Experimental Modal Analysis (EMA) to achieve an adequate reliability. EMA was carried out by considering about 30 measuring points as well as a highly redundant dataset. Indeed, numerous signals were required to correctly identify the mode shapes, due to the high modal density of the system. Moreover, redundant data were exploited for comparing the results provided by different subsets, in order to determine the most effective subset for estimating the modal parameters (since exciting properly the system proved a challenging task, due to its complexity).

The second strategy is based on the use of polymer concrete for filling some of the primary structures of the machine tool to increase their damping [2]. The study (still at an early stage) started with experimental tests to assess the effects of polymer concrete on the damping parameters of simple profile bars. Further experiments with more complex components of the real machine tool are being conducted.
Keywords: Experimental Modal Analysis; polymer concrete; machine tool.

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