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Comparison of Energy Efficiency of the Redundant Actuation of Positioning Axes

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Abstract: Presently, production machines and mainly contemporary machining centers are subjected to ever increasing pressure to enhance energy efficiency, both from the side of customers and also in terms of legislative regulations. A selection of drives for the individual axes is primarily a compromise between achievable dynamics, precision and price. The electrical efficiency and energy consumption is not usually taken into consideration during the design of the axis. In this paper, the electricity consumption of single drive axis actuator and redundant actuation through two drives is compared under various operating conditions. The measurement results are used to assess the benefits of redundant actuation of positioning axes with emphasis on energy efficiency, which is consistent with the current trend of the so-called Ecodesign.

Introduction

Increasing energy efficiency of the production machines is a very topical and live issue among the development teams of leading manufacturers and customers. Reducing energy costs with maintaining the technical and operational characteristics requires knowledge of the energy consumption characteristic of the machine. Case studies or statistical data of production facilities are usually the base of these characteristics, which are then used for potential increase in energy efficiency. During this process, a methodology of various test procedures is also derived [1, 2, 3].

A power consumption measurement itself is a partial task. Generally, there are two methods of how to approach this task; to measure torque and speed on the electric motor shaft, or to measure the total electrical power supplied to the motor [4]. Each of these two methods is appropriate for different goals. This article is devoted to the measurement of electrical power delivered to the motor.

However, when exploring the opportunities for increasing the energy efficiency of already manufactured production equipment, i.e. the one physically existing, it is not possible to significantly affect its conception, hence the structure or the drive unit topology. The measured data of the drive properties in terms of energy consumption are not always available during the design phase of the machine; therefore it is necessary to rely on theoretical knowledge and measurement methodologies. Enhancement of energy efficiency in the design phase therefore requires knowledge of new energy-efficient topology and the use of adequate products [5].

The aim of this research is to experimentally compare the energy consumption of one linear axis with ball screw, when designed with one drive and with redundant actuation with two drives from each side of the screw driven in master-slave mode. While carrying out all parts of the experiment, it was necessary to maintain the same operating parameters, including the same climatic conditions that correspond to typical conditions of production workplaces. This research is related to the theoretical knowledge of the authors [6], who refer to potential energy savings when using the redundant actuation under certain operating conditions. The entire experimental stand is shown in Fig. 1.

Fig. 1: Experimental stand for testing of linear axis with ball screw

Results and summary

The experiment results demonstrate the potential energy savings of ca. 7% for the drive solution by redundant actuators. These savings were achieved under specific operating conditions, particularly at lower values of acceleration and higher speeds; this confirms theoretical assumptions [6]. These savings for one motion axis are undoubtedly interesting. However, during the operation of the machine, its operating conditions can change; therefore these results cannot be considered the final energy savings of one linear axis. More *feasible* savings will be verified in the future using the known trajectory reconstruction obtained during the machining of specific component.

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