

Chapter 23

Optimizing the Reconfiguration of Machining Desktop Micro–Factory Based on Scheduling Simulation

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ABSTRACT

Today, the micro-factory concept of downsizing production systems is essential to manufacturing small products in sustainable growth. Concerning this, this paper presents the developments accomplished during the recent years at Tecnológico de Monterrey (Mexico) and Holguin University (Cuba) introducing new findings related to the design of reconfigurable micro-factories based-on micro-machine tools. The chapter discusses the proposed framework for the optimizing the development of micro-factories in the context of micro-reconfigurable manufacturing systems based-on micro-reconfigurable machine tools. The novel methodology for optimizing the scheduling of reconfigurable micro-factories were exposed and a scheduling optimization of a reconfigurable micro-factory prototype was designed and tested.

INTRODUCTION

From the end of last century, there is a continuous process of technological improvements in manufacturing systems. The globalization of the world economy has meant the current production systems are subject to increased production in small batches, with increased flexibility, reducing production costs and

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increasing product quality. The context of current technological development has increased the demands of miniature and micro products, such as micro sensors, accelerometers, micro mirrors and fiber optics connectors have a high growth. These micro components are indispensable in computer peripheral, bio-medicine and telecommunication, to cite a few examples (Mishima *et al.*, 2010; Hoffmeister *et al.*, 2013).

In this market, there are several mechanical products at scales ranging from 10 microns to 1 mm (Shiou *et al.*, 2013), such as those used in mobile phones, medical devices and household electrical appliances. However, manufacturing systems of these devices are large and complex as compared to the dimensions of the devices. For this type of products, manufacturing systems must be as small as possible, satisfying the requirements of production.

The emerging emphasis on downscaling of the manufacturing equipment for the manufacture of micro/meso-scale components is by no means a “fashion-trend” attempting to keep pace with the miniaturization of electronic circuits and products, but instead, a technological and economic necessity (Subramaniam *et al.*, 2013; Pérez *et al.*, 2014).

It is appreciated therefore a trend towards miniaturization of components and towards miniaturization of machines and factories. For this, a study of the optimization of production flow in the case of reconfigurable micro-factories becomes necessary, in order to obtain settings that respond to current needs.

STATE OF THE ART

Today the miniaturized production systems, i.e. micro and desktop factories, are widely studied in several universities and research centers around the world (Park *et al.*, 2010; Ashida *et al.*, 2010; Endo, 2010; Wang *et al.*, 2013; Chen *et al.*, 2013; Pérez *et al.*, 2014). This trend of development is supported by the commitment of governments and large-scale companies to move towards more environmental friendly production. Mini, micro and desktop factories are expected to decrease the factory space, reduce energy consumption and improve material and resource utilization, which is strongly supporting the new sustainable manufacturing paradigm (Okazaki, 2010).

In Japan in the 90's in order to economize energy, consumption emerged the concept of a chain of small-scale production called micro-factory. Besides the reduction of space, micro-factories significantly reduce energy consumption. Estimates indicate that a reduction in space by a factor of 10 reduces energy consumption by a factor of 100. The small sizes of micro-machines reduce the inertial forces, movement of material and time of transportation. The concept came true in 1999 in a portable micro-factory (Mishima *et al.*, 2010).

Starting from these early experiences begins a process of diversification, both in research and in practical applications of micro-factory concept. There are a set of investigations related to the architecture of micro-factories, both in terms of production, such as process control (Li *et al.*, 2008). This has led to the development of new types of spindle and actuators (Kato *et al.*, 2010) specific to the micro-machining process. Its application has spread to various areas of the new frontiers of engineering, such as nanotechnology and MEMs (Microelectromechanical Systems) (Wang *et al.*, 2013, Chen *et al.*, 2013).

Other authors have investigated the practical applications of micro-factories. Architectures of micro-factories have been developed based-on modular integration into a centralized control structure, allowing flexibility, modularity and automation (Pérez *et al.*, 2013). Meanwhile, researchers at the Tampere University of Technology developed a micro-factory with modular structure (Heikkilä *et al.*, 2010) addressed in the area of biomedicine.

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