Chapter 7

Reconfigurable Machine Tool Design

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7.1 Introduction

In today’s competitive markets, manufacturing systems must quickly respond to changing customer demands and ever-shorter product life cycles. Traditional transfer lines are designed for high volume production and operate in a fixed automation paradigm. They cannot, therefore, accommodate changes in the product design. On the other hand, conventional CNC-based “flexible” manufacturing systems may offer flexibility, but are generally slow and expensive because they are not optimized for any particular product or a family of products.

A manufacturing system that quickly responds to changes in product design should be inherently reconfigurable and it should embody the principles of customized flexibility [1, 2]. Such a manufacturing system can be built with Reconfigurable Machine Tools (RMTs). In order to provide customized flexibility, and therefore, exactly the functionality and capacity needed to process a family of parts, RMTs must be designed around the given family of parts. Such RMTs, if properly designed, provide the necessary speed and accuracy in any given configuration and yet they can be quickly reconfigured to machine a different part within the same family. To design such RMTs, you need a different paradigm for machine tool design. In this paradigm, machine tool design starts from a process plan or a set of process plans. Once you know the set of operations that the RMTs must perform, you can configure them by assembling appropriate modules or building blocks.

Future Reconfigurable Manufacturing Systems (RMSes) will possess several essential characteristics: modularity, convertibility, customization, integratibility and diagnosability. Although many European and some Japanese and U.S. companies are producing modular machine tools, users cannot configure the individual modules for different machining applications. Designers and users do benefit from the availability of these standard modules, but the idea of RMTs goes beyond simple modularity. RMTs allows mass customization, makes it easier to integrate new technologies, are cost-effective, and provide high-speed capability.

There are two ways of making a machine tool reconfigurable: the first is to replace machine modules (Fig. 1), the second is to use a machine tool’s integrated reconfiguration functions (Fig. 2). Machine modules used in modularized machine should have standard interfaces to allow a wide variety of machine tool configurations. Reconfiguring a machine tool by replacing a machine modules will require
that you disassemble and reassemble the machine, as well calibration, parameter set-up, and other operations. The set-up time will be shorter than that of purchasing a new machine tool and putting it on line, but it will be longer than reprogramming a CNC.

To shorten the reconfiguration time, consider using machine tools with integrated reconfigurability. Machine tools with integrated reconfigurability have reconfiguration functions that are integrated into the machine module or machine tool. Generally, the reconfiguration functions are not correlated with the principle functionality of the machine tool. In practical RMT designs, you should use both modular machine modules and integrated reconfigurability to optimize the performance of the RMT.