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Agile manufacturing systems in the automotive industry

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Abstract

In the automotive industry, it is thought that agile manufacturing systems will permit fast cost-effective responses to unpredictable and ever-changing product demand, and support rapid product launches for previously unplanned products tailored to meet changing customer desires. We discuss two simple decision models that provide initial insights and industry perspective into the business case for investment in agile manufacturing systems. The models are applied to study the hypothetical decision of whether to invest in a dedicated, agile, or flexible manufacturing system for engine and transmission parts machining. These decision models are a first step toward developing practical business case tools that help industry to assess the value of agile manufacturing systems.

Keywords: Agile manufacturing; Flexible manufacturing

1. Introduction

Automotive companies must consider strategic initiatives such as agile manufacturing systems to compete globally and respond to dynamic customer demand. In this paper, we explore agile manufacturing systems for engine and transmission machining applications as a key enabler in an automotive agile manufacturing strategy. We describe two simple decision models that help distinguish agile systems from dedicated or flexible machining systems (FMSs).

Gunasekaran (1998, 1999a) describes agile manufacturing as "the capability to survive and prosper in a competitive environment of continuous and unexpected change by reacting quickly and effectively to changing markets, driven by customer-designed products and services." Goldman et al. (1995) have a slightly different definition, with agile manufacturing allowing companies to be capable of operating profitably in a competitive environment of continually and unpredictably changing customer opportunities. Both definitions apply to the automotive industry's goals of operating profitably, and sensing and responding effectively to changing demand trends. Conceptually, an agile manufacturing system allows an automotive company to re-allocate production line capacity to products that are in

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higher than expected demand, rapidly launch new products (not previously conceived when the manufacturing system was designed), and yet retain production ability for other products with lower than expected demand.

Automotive companies are attracted to agile manufacturing systems, because of the potential for equipment reuse and equipment investment cost reductions over time. The promise of equipment reusability has also been associated with flexible manufacturing systems (FMSs). For example, Goranson (1998) defines a flexible system as a production system capable of dealing effectively with a specific (or predictable) scope of product variation. A FMS, as defined by Askin and Standridge (1993), refers to a set of computer numerically controlled (CNC) machine tools and supporting workstations that are connected by an automated material handling system and are controlled by a central computer. Shim and Siegel (1999) characterize a FMS as a computer-controlled process technology suitable for producing a moderate variety of products in a moderate flexible volume. More recently, Hallmann (2003) describes the implementation of an FMS for automotive parts machining that promises cost and time effective implementation of engineering change orders (ECOs), and thus continual process improvement. Agile systems differ from flexible systems in a critical way: the agile system has capability to adapt *rapidly and cost-effectively* within a predicted scope of product variation (out of scope is ideal but impractical) to allow future *unplanned* products to be manufactured. Automotive companies have previously experimented with and been disappointed by FMS for machining applications, because the promise of cost reductions for equipment reuse has not materialized as expected. In practice, to respond to changing demands, a FMS requires significant additional expenditures and a long time to convert or adapt to new "unplanned" products. Thus FMS do not meet the "agility criteria," i.e., rapid and cost-effective reuse in response to changing product demands.

The remainder of the paper is organized as follows. In Section 2, we briefly review the technical literature on agile and FMSs. Section 3 summarizes how automotive engineers perceive the differences between dedicated, agile, and FMSs for engine and transmission machining applications. Two key terms, in-family flexibility and cross-family flexibility are introduced to help explain why automotive engineers are interested in agile and FMSs. We propose two simple decision models in Section 4 and use these models to provide insights into the business case for investment in agile manufacturing systems. Section 5 summarizes the insights gained and identifies opportunities for future research.

2. Related research

There is an extensive amount of research in the open literature discussing agile and flexible manufacturing philosophies. Industry has led the way in directing the research in this important area by collaborating to define the future needs of agile manufacturing. In particular, the Iacocca Institute Report on 21st Century Manufacturing Enterprise Strategy (Nagel et al., 1991) provides a valuable guide to the broad spectrum of applications for agile production systems. Authors have identified the drivers of agility (Yusuf et al., 1999), future research needs and opportunities (Gunasekaran, 1999b; DeVor et al., 1997), and strategic advantages of agility (Gunasekaran, 2001). Gupta and Goyal (1989) provide an extensive literature review on the different ways researchers have defined flexibility and attempted to measure it. Sanchez and Nagi (2001) also provide a thorough review and classification scheme for the open literature on agile manufacturing systems.

Several authors have proposed methods to measure flexibility in manufacturing systems (Kulatilaka, 1988; Chryssolouris and Lee, 1992; Das, 1996; Sieger et al., 2000; Giachetti et al., 2003). Others (Charles et al., 1999; Newman et al., 2000; Fernandez and Patrick, 2000) present best practices and lessons learned in designing agile and re-configurable manufacturing systems to support product flexibility, volume flexibility, and general equipment reusability. Shewchuk and Moodie (2000) investigate the effect of manufacturing system design on system flexibilities (product,