1. INTRODUCTION

Product family is a group of related products that share common features, components, and subsystems, and satisfy a variety of market niches. Product platform is a set of parts, subsystems, interfaces, and manufacturing processes that are shared among a set of products (Meyer and Lechnerd 1997). A product family comprises a set of variables, features or components that remain constant in a product platform and from product to product. Platform-based product family design has been recognized as an efficient and effective means to realize sufficient product variety to satisfy a range of customer demands in support for mass customization (Tseng and Jiao 1998). The platform product development approach usually includes two main phases: 1) the establishment of the appropriate product platform; and 2) the customization of the platform into individual product variants to meet the specific market, business and engineering needs. The establishment, maintenance and application of the right product platform are very complex.

Contemporary design processes have become increasingly knowledge-intensive and collaborative (Tong and Sriram 1991a,b; Sriram 2002). Knowledge-intensive support becomes more critical in the design process and has been recognized as a key solution towards future competitive advantages in product development. To improve the product family design for mass customization process, it is imperative to provide knowledge support and share design knowledge among distributed designers. Several quantitative frameworks have been proposed for both phases in platform product development.
They provide valuable managerial guidelines in implementing the platform product development approach. However, there are very few systematic qualitative or intelligent methodologies to support the product development team members to adopt this platform product development practice, despite the progress made in several research projects (Zha and Lu 2002a,b).

The aim of this chapter is to discuss knowledge support methodologies and technologies for platform-based product family design. An integrated modular product family design process with knowledge support is explored. This process includes customer requirements modeling, product architecture modeling, product platform establishment, product family generation, and product assessment. The driving force behind this work is to develop a formal, technical approach based on the modular product design paradigm to efficiently and effectively model and synthesize a family of products (product platform and variants) which can provide increased product variety necessary for today's market.

The organization of this chapter is as follows. Section 2 reviews the background and current research status related to platform-based product development and product family design. Sections 3 and 4 outline a platform-based product development model and a modular design methodology for product family design. Sections 5 and 6 discuss the module-based product family design process and discuss a knowledge support framework for modular product family design respectively. Section 7 addresses the relevant issues and technologies for implementing the knowledge intensive support system for modular product family design. Section 8 summarizes the chapter and explores the future work.

2. LITERATURE REVIEW

In this section, we briefly review the background and current research status related to platform-based product development and product family design. Various approaches and strategies for designing families of products and mass customized goods are reported in the literature. These techniques appear in varied disciplines such as operations research (Gaithen 1980), computer science (Nutt 1992), marketing, management science (Kotler 1989; Meyer et al. 1993; Pine II 1993), and engineering design (Fujita et al. 1997; Simpson et al. 1998, 2001; Ulrich et al. 1995).

Two key concepts underlie existing schemes for product family modeling: product family architecture and product family evolution. There are three kinds of approaches widely used for representing architecture and modularity for product family: 1) product-modeling language (Erens et al. 1997), 2) graphic representation (Ishii et al. 1995; Agarwal and Cagan 1998), and 3) module or building block (BB) (Tseng and Jiao 1996; Gero 1990; Fujita and Ishii 1997; Rosen 1996). The product modeling language allows product families to be represented in three domains: functional, technological, and physical. It provides an effective means for representing product variety, but offers little aid for design synthesis and analysis. In the graph structure, the different types of nodes denote the individual components, subassemblies and fasteners, and the links denote dependencies between the nodes. However, it lacks