J Intell Manuf (2013) 24:877–885
DOI 10.1007/s10845-012-0691-0

Mass customization in the product life cycle

Shana Smith · Gregory C. Smith · Roger Jiao · Chih-Hsing Chu

Received: 11 August 2012 / Accepted: 23 August 2012 / Published online: 5 October 2012

Abstract This study presents an introduction to mass customization in the product life cycle—the goal of mass customization, mass customization configurations, and new customer integration techniques, modular design techniques, flexible manufacturing systems (FMSs), and supply chain management methods. The study reviews three selected books and twenty-one selected papers—early papers that describe the goal of mass customization, early papers that describe mass customization configurations, and recent papers that describe new customer integration techniques, modular design techniques, FMSs, and supply chain management methods. The study shows that the goal of mass customization is to create individually customized products, with mass production volume, cost, and efficiency, that most companies use 'assemble-to-order' configurations to create standardized products, and that more work is needed on interactive customer integration techniques, collaborative modular design techniques, reconfigurable manufacturing systems, and integrated supply chain management methods to achieve the goal of mass customization.

S. Smith (✉) · G. C. Smith
Department of Mechanical Engineering, National Taiwan University, No.1, Sec. 4, Roosevelt Road, Taipei, Taiwan, ROC
e-mail: ssmith@ntu.edu.tw

R. Jiao
School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, Georgia, USA

C.-H. Chu
Department of Industrial Engineering and Engineering Management, National Tsing Hua University, Hsinchu, Taiwan, ROC

Keywords Mass customization · Product life cycle · Customer integration techniques · Modular design techniques · Flexible manufacturing systems · Supply chain management methods

Introduction

This study presents an introduction mass customization in the product life cycle—the goal of mass customization, mass customization configurations, and new customer integration techniques, modular design techniques, flexible manufacturing systems (FMSs), and supply chain management methods.

The study reviews three selected books and twenty-one selected papers—early papers that describe the goal of mass customization, early papers that describe mass customization configurations, and recent papers that describe new customer integration techniques, modular design techniques, FMSs, and supply chain management methods.

The study shows that the goal of mass customization is to create individually customized products, with mass production volume, cost, and efficiency, that most companies use 'assemble-to-order' configurations to create standardized products, with mass customization volume, cost, and efficiency, and that more work is needed to achieve the goal of mass customization

The study describes the goal of mass customization, mass customization configurations, customer integration techniques, modular design techniques, FMSs, and supply chain management methods. The study also describes future work and presents conclusions.

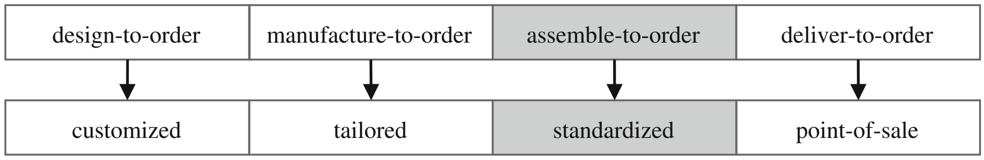


Fig. 1 Customer integration (CI) configurations

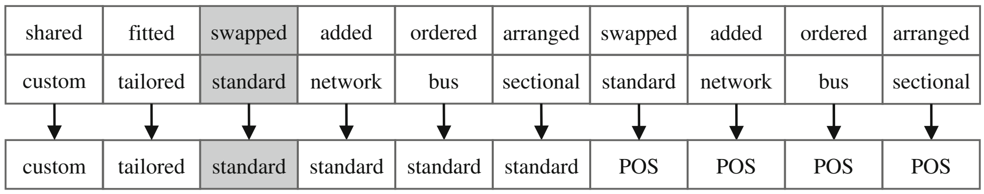


Fig. 2 Modular design (MD) configurations

The goal of mass customization

The goal of mass customization is to create individually customized products, with mass production volume, cost, and efficiency (Davis 1987; Pine 1993). Companies are pursuing the goal (Pine et al. 1993, 1995). However, most companies use 'assemble-to-order' configurations to create standardized products (McCarthy 2004). Companies need new configurations to achieve the goal of mass customization.

Customer integration configurations

Companies use 'design-to-order', 'manufacture-to-order', 'assemble-to-order', or 'deliver-to-order' customer integration (CI) configurations to create customized, tailored, standardized, or point-of-sale products (Duray 1996; Duray et al. 2000; McCarthy 2004). However, most companies use 'assemble-to-order' CI configurations to create standardized products (McCarthy 2004) (Fig. 1).

Modular design configurations

Companies use 'shared custom-module', 'fitted tailored-module', 'swapped standard-module', 'added network-module', 'ordered bus-module', or 'arranged sectional-module' modular design (MD) configurations to create customized, tailored, standardized, or point-of-sale products (Duray 1996; Duray et al. 2000; McCarthy 2004). However, most companies use 'swapped standard-module' MD configurations to create standardized products (McCarthy 2004) (Fig. 2).

Flexible manufacturing system configurations

Companies use 'make-to-order', 'build-to-order', 'build-to-stock', or 'just-in-time' FMS configurations to create customized, tailored, standardized, or point-of-sale products (Duray 1996; Duray et al. 2000; McCarthy 2004). However, most companies use 'just-in-time' FMS configurations to create standardized products (McCarthy 2004) (Fig. 3).

Supply chain management configurations

Companies use 'in-house', 'supplier', and 'stock' supply chain management (SCM) configurations to create customized, tailored, standardized, or point-of-sale products. However, most companies use 'supplier' SCM configurations to create standardized products (Mikkola and Skjott-Larsen 2004) (Fig. 4).

Mass customization configurations

Companies use different (CI, MD, FMS, SCM) configurations to create customized, tailored, standardized, or point-of-sale products. However, most companies use ('assemble-to-order', 'swapped standard-module', 'just-in-time', 'supplier') configurations to create standardized products (McCarthy 2004) (Fig. 5).

Companies need new (CI, MD, FMS, SCM) configurations to achieve the goal of mass customization (Pine and Gilmore 2000). More work is needed on ('design-to-order', 'shared custom-module', 'just-in-time', 'supplier') configurations to create individually customized products, with mass production volume, cost, and efficiency.

New customer integration techniques

Companies need new customer integration techniques to identify individual customer requirements (ICRs). Recent papers describe new interactive customer integration techniques, new collaborative customer integration techniques, new experiential customer integration techniques, and new data mining customer integration techniques.

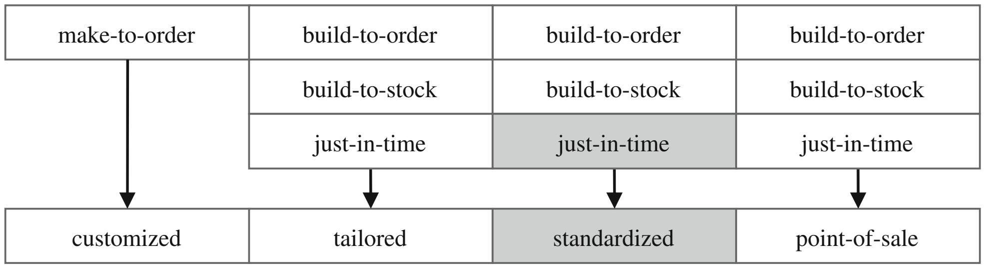


Fig. 3 Flexible manufacturing system configurations

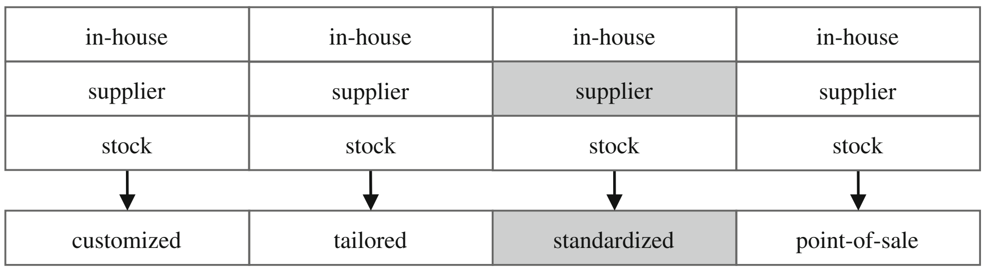


Fig. 4 Supply chain management configurations

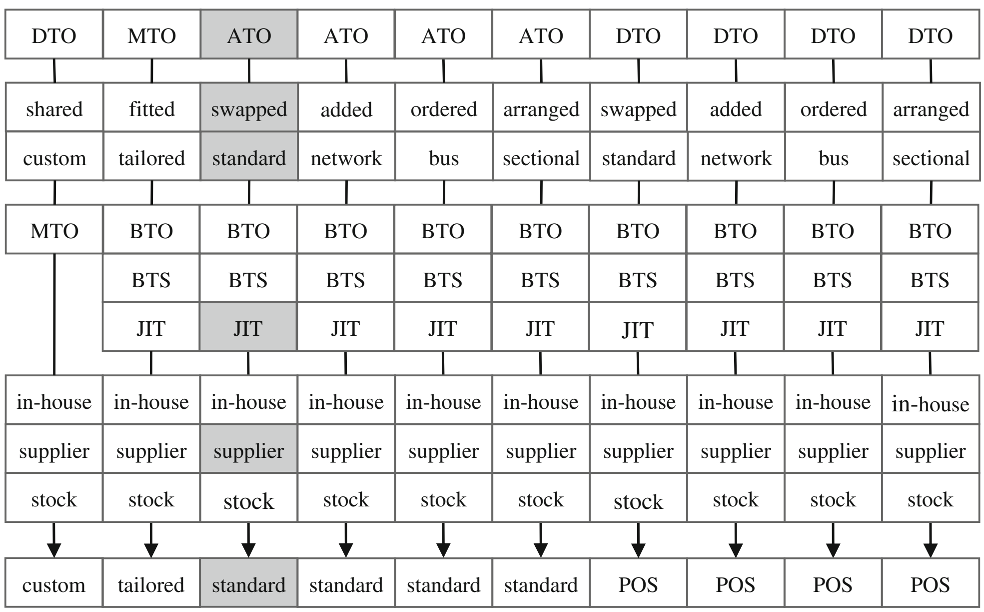


Fig. 5 Mass customization configurations

New interactive customer integration techniques can be used to identify ICRs. Some techniques use interactive questions, requirement pattern analysis, and requirement management systems to identify ICRs. Some techniques use 3D scanners (or 3D scanners with augmented reality viewing systems) to identify ICRs for shoe fit (Du et al. 2006; Zhang et al. 2011; Huang et al. 2012) (Fig. 6).

New collaborative CI techniques can be used to identify ICRs. Some techniques use semantic differential (SD) scale surveys and sample designs to identify ICRs. Some techniques use innovation toolkits to identify latent ICRs. Some techniques use 3D design databases to identify visual ICRs (Tseng et al. 2010; Zhang et al. 2011; Smith and Smith 2012).

Some techniques use product configuration tools (with web viewers and embedded CAD functions) to identify visual ICRs. Some techniques use product configuration tools (with web viewers, embedded CAD functions, and PDM servers) to identify visual ICRs. Some techniques use web viewers and ergonomic models to identify ergonomic ICRs. (Kuo and Chu 2005; Chu et al. 2009) (Fig. 7).

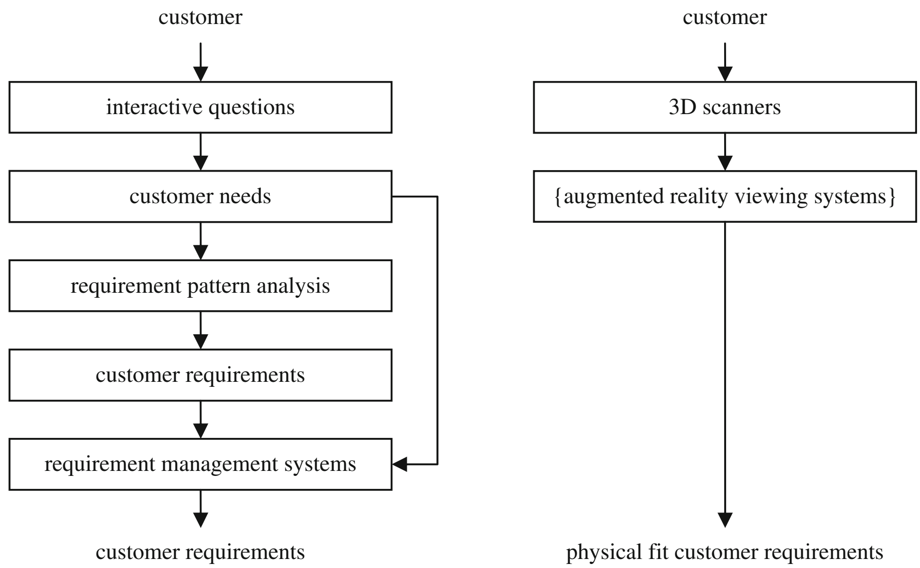


Fig. 6 Interactive customer integration techniques

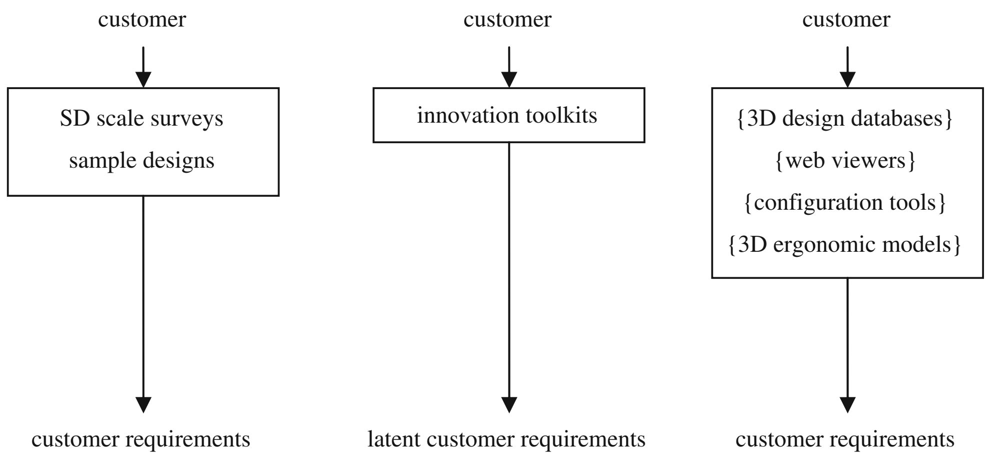


Fig. 7 Collaborative customer integration techniques

New experiential CI techniques can be used to identify individual customer needs (ICNs). Some techniques use virtual environments and customer-customer, customer-product, product-product, and customer-environment interactions to identify functional, affective, and cognitive ICNs (Jiao 2011) (Fig. 8).

New data mining CI techniques can be used to identify individual product requirements (IPRs) from web pages or design databases. Some techniques use genetic algorithms (GAs) and Pareto optimization fitness functions to identify IPRs from design databases. Some techniques use web learning or data mining to identify IPRs or latent IPRs from design databases or web pages (Yu and Wang 2010; Tseng et al. 2010; Jiao 2011) (Fig. 9).

New interactive CI techniques can be used to identify ICRs. New collaborative CI techniques can be used to identify ICRs, latent ICRs, visual ICRs, or ergonomic ICRs. New experiential CI techniques can be used to identify functional, affective, and cognitive ICNs. More work is needed on identifying ICRs, latent ICRs, visual ICRs, ergonomic ICRs, affective ICRs, and cognitive ICRs.

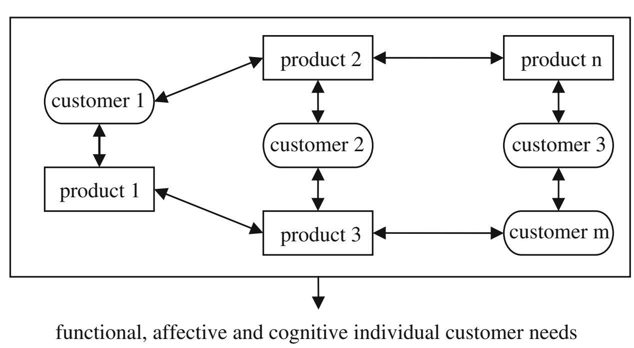


Fig. 8 Experiential customer integration techniques

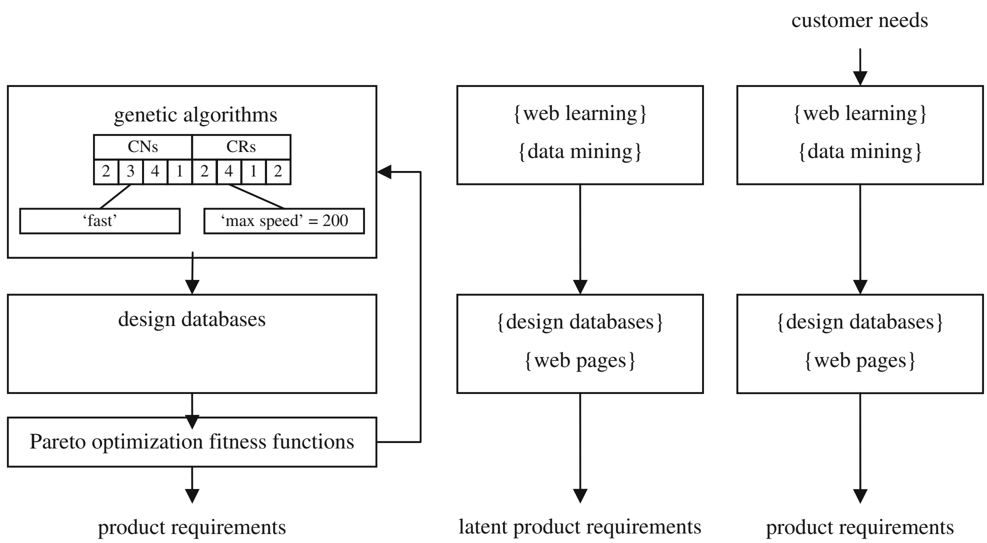


Fig. 9 Data mining customer integration techniques

New modular design techniques

Companies need new modular design techniques to match ICRs to designs. Recent papers describe new integrated product family architecture (integrated PFA) design techniques, new modular product family architecture (modular PFA) design techniques, and new integrated product family ontology (integrated PFO) design techniques.

New integrated PFA design techniques can be used to match grouped CRs to integrated (platform-module) PFA designs. Some techniques use Pareto optimization, analytical hierarchical process (AHP) structures, fuzzy cluster analysis (FCA) functions, design rules, and utility functions to match grouped CRs to integrated PFA designs that improve FMS volume, cost, and efficiency.

Some techniques use profile cards, images, CAD models, or virtual reality (VR) models, and quality function deployment (QFD), conjoint analysis (CA), Kansei engineering (KE), or latent semantic engineering (LSE), and experts, analogies, parametric estimation, industrial engineering, utility functions, or matching functions to match grouped or individual CRs to integrated PFA designs that improve product cost and quality. Some techniques use design rules or customer interaction to match grouped CRs to integrated PFA designs (Jiao and Tseng 1999; Du et al. 2006; Zhang et al. 2011; Jiao 2011; Smith and Smith 2012) (Fig. 10).

New modular PFA design techniques can be used to match grouped CRs to modular (module-module) PFA designs. Some techniques use Pareto optimization and quality loss functions to match grouped CRs to modular PFA designs that improve modular PFA design time, cost, and quality (number of common modules, module qualities, module weights) (Rai and Allada 2003) (Fig. 11).

New integrated product family ontology (PFO) design techniques can be used to match grouped data to integrated PFO designs. Some techniques use data mining and formal concept analysis to match grouped data (entities, relationships, rules) from (specifications, disassembly graphs, BOMs) to integrated PFO designs that improve MD quality and enterprise integration (Lim et al. 2011) (Fig. 12).

New integrated PFA design techniques can be used to match grouped CRs to integrated PFA designs. New modular PFA design techniques can be used to match grouped CRs to modular PFA designs. New integrated product family ontology (PFO) design techniques can be used to match grouped data to integrated PFO designs. More work is needed on matching ICRs to individually customized designs.

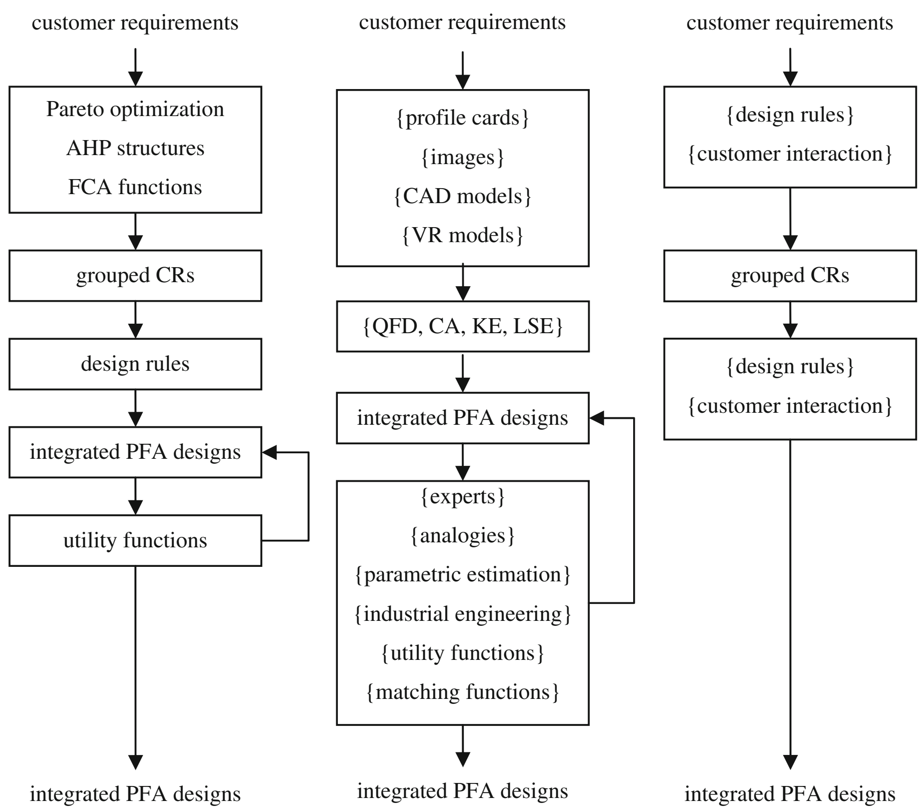
New flexible manufacturing systems

Companies need new FMSs to convert individually customized designs into individually customized products. Recent papers describe new FMSs and new reconfigurable manufacturing systems.

New FMSs can be used to convert customized designs into customized products. Some systems use flexible facilities, cells, assembly lines, machines, and flexible groups, plans, and schedules to convert customized designs into customized products, with mass customization volume, cost, and efficiency (Molina et al. 2005).

New reconfigurable manufacturing systems can be used to convert individually customized designs into individually customized products. Some systems use intelligent, open, networked, multi-agent, modular, reconfigurable facilities, cells, assembly lines, machines, and modular, reconfigurable groups, plans, and schedules to convert individually

Fig. 10 Integrated PFA design techniques



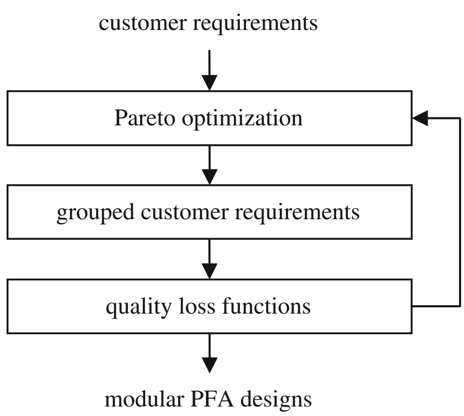


Fig. 11 Modular PFA design techniques

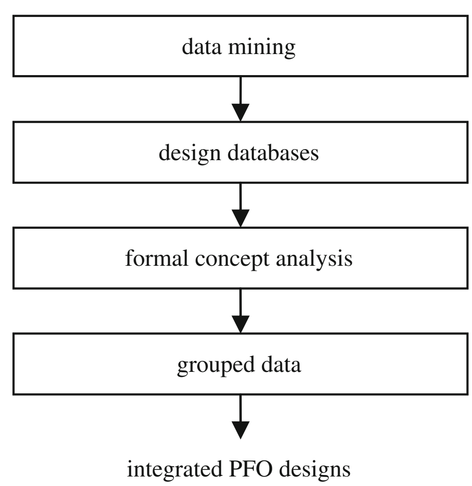


Fig. 12 Integrated PFO design techniques

customized designs into individually customized products, with mass customization volume, cost, efficiency, accuracy, and reliability (Molina et al. 2005) (Fig. 13).

New reconfigurable manufacturing systems can act, sense, learn, reason, respond, grow, adapt, and solve problems, they are easy to build, upgrade, customize, scale, extend, operate, adjust, maintain, and service, and they can be reconfigured (to individual customer level) for new customer requirements, designs, manufacturing system elements, supply chain configurations, and company needs (Molina et al. 2005).

New reconfigurable manufacturing systems can be used to convert individually customized designs into individually customized products, with mass customization volume, cost, efficiency, accuracy, and reliability. More work is needed on reconfigurable manufacturing systems that can convert individually customized designs into individually customized products, with mass production volume, cost, and efficiency.

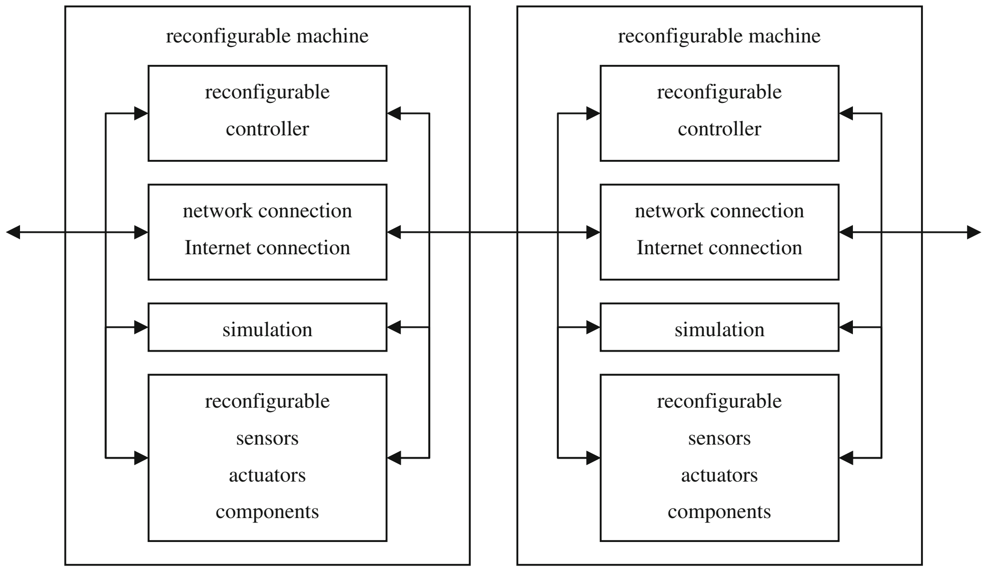


Fig. 13 Reconfigurable manufacturing systems

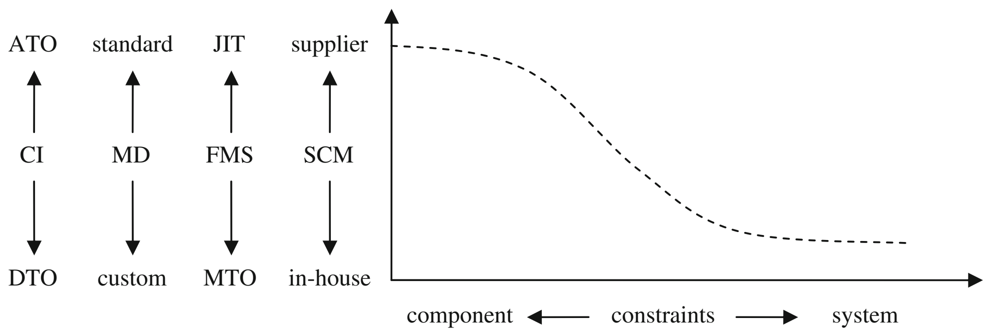


Fig. 14 Integrated supply chain management methods

New supply chain management methods

Companies need new supply chain management methods to convert materials into individually customized products. Recent papers describe new integrated supply chain management methods and new reconfigurable supply chain management methods.

New integrated SCM methods can be used to convert materials into customized products. Some methods use 'modularization characteristic curves' to select integrated (CI, MD, FMS, SCM) configurations that convert grouped CRs and materials into customized products, with improved customer integration, design customization, and enterprise integration (Mikkola and Skjott-Larsen 2004) (Fig. 14).

New integrated SCM methods can be used to convert materials into customized products, with improved customer integration, MD customization, and enterprise integration. More work is needed on converting materials into individually customized products, with mass production volume, cost, and efficiency.

Future work to achieve the goal of mass customization

The goal of mass customization is to create individually customized products, with mass production volume, cost, and efficiency. Mass customization improves overhead, price, profit, and company success. However, mass customization also reduces volume, increases cost, and reduces efficiency (Piller et al. 2004). As a result, most companies create standardized products to improve volume, cost, and efficiency.

Companies need new (CI, MD, FMS, SCM) configurations to achieve the goal of mass customization (Pine and Gilmore 2000; McCarthy 2004). More work is needed on ('design-to-order', 'shared custom-module', 'just-in-time', 'supplier') configurations that can create individually customized products, with mass production volume, cost, and efficiency.

More work is also needed on 'deliver-to-order' configurations that can create point-of-sale products, with mass production volume, cost, and efficiency. 'Deliver-to-order' configurations can improve customer integration, customer satisfaction, design customization, and manufacturing system volume, cost, and efficiency (Duray 1996).

Companies need new CI techniques, MD techniques, RM systems, and SCM methods to achieve the goal of mass customization. More work is needed on identifying ICRs, latent ICRs, and affective ICRs. More work is needed on matching ICRs to individually customized designs. More work is needed on converting individually customized designs and materials into individually customized products, with mass production volume, cost, and efficiency.

In particular, more work is needed on interactive CI techniques, collaborative MD techniques, RM systems (facilities, machines, controllers, software, software tools, simulation, sensors, actuators, tools, dies), integrated SCM methods (information systems, information models, and information processing), product support systems, and product replacement techniques (Da Silveira et al. 2001; Molina et al. 2005).

Conclusions

This study presents and introduction to mass customization in the product life cycle. This study describes the goal of mass customization. This study describes mass customization configurations. This study also describes new customer integration techniques, modular design techniques, FMSs, and supply chain management methods.

This study shows that the goal of mass customization is to create individually customized products, with mass production volume, cost, and efficiency. This study shows that most companies use ('assemble-to-order', 'swapped standard-module', 'just-in-time', 'supplier') configurations to create standardized products.

This study shows that companies need new CI techniques to identify ICRs. New interactive CI techniques can be used to identify ICRs. New collaborative CI techniques can be used to identify ICRs. New experiential CI techniques can be used to identify ICNs. More work is needed on identifying ICRs, latent ICRs, affective ICRs, and cognitive ICRs.

This study shows that companies need new MD techniques to match ICRs to individually customized designs. New integrated PFA design techniques can be used to match grouped CRs to integrated PFA designs. New modular PFA design techniques can be used to match grouped CRs to modular PFA designs. More work is needed on matching ICRs to individually customized designs.

This study shows that companies need new reconfigurable manufacturing systems to convert designs into products. New reconfigurable manufacturing systems can be used to convert individually customized designs into individually customized products. More work is needed on converting individually customized designs into individually customized products, with mass production volume, cost, and efficiency.

This study shows that companies need new supply chain management methods to convert materials into individually customized products. New integrated SCM methods can be used to convert materials into customized products. More work is needed on integrated ('design-to-order', 'shared custom-module', 'just-in-time', 'supplier') configurations that can create individually customized products, with mass production volume, cost, and efficiency.

More work is also needed on 'deliver-to-order' configurations that can create point-of-sale products, with mass production volume, cost, and efficiency. 'Deliver-to-order' configurations may improve customer integration, customer satisfaction, design customization, and manufacturing system volume, cost, and efficiency more than 'assemble-to-order' configurations.

More work is needed on interactive CI techniques, collaborative MD techniques, RM systems (facilities, machines, controllers, software, software tools, simulation, sensors, actuators, tools, dies), SCM methods (information systems, information models, and information processing), manufactured products, and service products.

Most early papers describe the goal of mass customization or mass customization configurations. Most recent papers describe new CI techniques, MD techniques, RM systems, and SCM methods. More work is needed on product delivery, product use, product service, and product replacement. More work is needed to achieve the goal of mass customization.

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