Industry White Paper

Mass Customization of Highly Configurable Products

Designing, Selling and Producing "Simple" Products

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Executive Overview

Imagine walking into a car showroom and saying "I want the late model sedan, but please give it to me with 4 more inches of legroom in the front, the tachometer moved to the left of the dash, and with an additional trunk release lever on the passenger side". What you would find is that the automotive industry, while they offer many features and options on their products, has significant limitations in providing truly customized products. But these types of requests are commonplace for highly configurable products like windows, doors, kitchen or bath cabinets, office furniture and even some industrial equipment like hydraulic valves. It seems counterintuitive, but the process of selling, designing, and producing what appear to be "simple" products becomes surprisingly complex when manufacturers introduce high levels of customization. And demand for customization is on the increase.

As Pine, Pepper and Rodgers said in a Harvard Business Review article in 1995, "Customers … do not want more choices. They want exactly what they want – when, where, and how they want it ... ". This comment highlighted the increasing demand for products that are highly tailored to meet specific customer demands. This concept provided the motivation for many manufacturers to re-engineer sales and marketing processes to offer more customized products to their customers. The article highlighted increased production flexibility and more advanced design tools as key enablers of this concept. But the ability for manufacturers to meet demands for highly customized products, sometimes known as "mass customization", varies greatly depending on the company's ability to bridge the gap between selling a customized product and being able to produce it rapidly and cost effectively. Some industries are delivering mass customized products today, but those that do are struggling with manual and inefficient processes to bring together the configured sales process and the design and production of the configured item.

This paper explores opportunities for manufacturers to improve their competitiveness and profitability based on their ability to effectively provide customized products - products that can be delivered in a large number of variations or configurations - at cost levels comparable to mass production. The paper tries to answer the following questions:

- What challenges must manufacturers overcome in order to provide world-class performance in selling and delivering customized products?
- How can manufacturers provide customers with seemingly infinite flexibility in product choices and still keep their margins in check?
- How can manufacturers turn these capabilities into more deals won, and deals won at better margins?
- How can manufacturers improve their overall throughput and shorten the delivery cycle for mass customized products?
- How can manufacturers design and manage products in a way that streamlines and automates the customization effort once the product is ordered?

To explore the answer to these questions, we will review the lifecycle of two very different products. The first product will be a new car, arguably a product with complex engineering, and one that is available with many different features and options. The second will be a new picture window for a living room, perhaps to let us look at our new car in the driveway. The results will surprise many people as we find that while the design of the automobile is complex, there are also many complexities for manufacturers that produce products like windows that defy their simple appearance. In fact, these complexities reach past the design cycle into the order cycle, where customization to specific customer requests transitions from validating and pricing the order to designing, producing and delivering the requested product. We will highlight some very complex and difficult challenges in selling, designing and producing customized versions of these products that have a seemingly infinite number of end configurations, and point out improvement opportunities to allow manufacturers of these products to become more competitive and profitable.

Introduction

Many products most consumers think of as 'simple', such as windows, cabinets, etc., are actually quite complex because of their level of variability in terms of dimensions, materials, accessories, and other specifications. In fact, this high level of variability introduces challenges and complexities into everything manufacturers of these products do, from design to sales to manufacturing to service. In many ways, these processes are actually much more complex than processes for products we think of as being far more complicated, such as cars. Imagine if you were able to buy a car the way you can buy a custom window, you would be able to specify changes in many aspects of the design to make the car fit your wishes exactly.

The truth is that cars have features and options, but for the most part they are not really mass customized. It isn't likely that the majority of cars sold will become truly custom cars any time soon. But, if you buy custom windows, cabinets, or other products with significant variability, you will find that those manufacturers are already providing a significant level of product customization. The problem is that they are doing it at quite a cost in terms of product lead-time, effort and expense. The manufacturers who lead the way to reducing those factors are likely to be the winners in the coming years as consumers continue their trend to demand products more specific to their needs. So what can manufacturers do to compete?

Offer "Infinite" Product Options

Some products, particularly those with dimensional characteristics like windows, have a seemingly unlimited number of possible options. The dining room window we discussed can be sold in multiple widths, heights, materials, and colors. It can be produced with different types of glass in order to provide varying levels of insulation or to filter certain types of damaging light. It can be sold with multiple grid styles to provide the proper decorative effect. When all of the options are considered together, the number of window designs seems almost infinite. Without automation in the sales, design and production processes, the number of designs can quickly become unmanageable and lead to higher costs, excessive lead-times, and frequent waste from production mistakes.

To add to the complexity, there are typically complex rules that determine how the window will be produced. At the same time that visible options are being determined, other design decisions are being made. If the difference between the width and the height is significant, say for a wide opening, then the window requires reinforcement. If the width reaches a certain measurement, then reinforced glass must be used and an additional latch will be required. Often these changes are not visible to the customer, but make a significant difference in the production process and the associated production cost. Without automation, significant manual effort is required to price the requested product and to generate the required parts lists, production instructions, tooling requirements, and engineering drawings required to produce the window.

The complexity of simple products can be compounded by the fact that customized items are frequently sold with accompanying custom products. For example, our living room window may have matching casement windows on either side. The dimensions for each window are important, but also the overall dimensions for the combination of the windows in the requested layout must be taken into account. The layout must also be considered, as well as options that apply to the combination of products as opposed to an individual product, such as the color, glass type and alignment of the grids across all of the windows.

Another complexity is that manufacturers have to be careful not to sell what can't be made. Car dealers are smart not to sell the car with additional legroom, because they can't deliver on the request. The additional engineering work required to change the body panels, the drive train, and many other impacted elements of the design would be cost prohibitive. And the production facilities are not designed for this type of customization. This is also a challenge for mass customizable products like windows. Some options aren't compatible with others, and some options can't be produced on the equipment available in the plant. Orders that can't be produced must be flagged immediately so that time isn't wasted in finding an alternative product or configuration for the customer. In industries where orders are frequently taken through dealers and distributors, the need for automation increases dramatically because there are too many people to keep informed of the rules, and paper-based or even CD-based rules can't be kept up to date.

Mask the Complexity

Now that we have discussed some of the complexity involved in providing mass customization in simple products, we should remember that the customer still views the product as simple. The complexity should be masked from them, because they value a product that works and do not value the complexity that the manufacturer faces in providing it. A customer should be easily guided in selecting the proper product to order based on their needs, and then also guided in selecting the proper options to make it work for them. This concept, known as "guided selling", is an excellent way to help the customer navigate the complexity of the product without being exposed directly to it. By varying features and options, the customer or distributor should be able to instantly see whether the choices are valid, and see the associated impact on the price of the product. For the car, the prices are associated with the features and options in a menu-based format. For more complex customization, like the window, the cost may come from design decisions driven indirectly by the options, or by a combination of options. Because the pricing may not be intuitive, the customer requires real-time visibility to pricing impacts from changes in the design of the product they are ordering.

Another important factor in masking the complexity of the product is to provide visual feedback as the product is configured. By providing a representation of the product ordered, the customer can more easily comprehend the product that they are ordering. This leads to significant reduction in order errors and changes. To be highly effective, a three dimensional representation should be available that can easily be viewed from all angles as the order is being placed. The real-time visual feedback provides confidence that the customer is ordering the product that they want, and that the manufacturer will be able to produce the product. In an ideal environment, this visualization should be a view of the actual production-ready CAD (Computer Aided Design) model of the product from which drawings and other production instructions will be generated. Beyond simply changing the color of the car on an auto-maker's website, complex configurations require engineering logic and calculations to ensure a proper representation of the finished product. The power in modern CAD tools is there to accomplish this, but it is largely untapped in most companies today.

Visualization is also important for related products, like the layout of our window with the casement windows on the side. In this scenario, visualization goes beyond viewing the product to viewing the product in the context in which it will be installed. A complex issue, to say the least, but one that can greatly reduce the complexity for the customer if they can be provided a simple view or drawing of the layout.

Be Responsive To Win Business

The company that is the fastest to respond to a customer, dealer, or distributor request has a significant advantage in winning the order. Time is critical, and expectations for rapid response have increased with the growth of web-based shopping. For example, customers can quickly compare options and pricing for cars over the web, and request a quote. For products that are perceived as being more simple, the expectation for pricing is instantaneous. Without automation, this can't be achieved.

The response to requests has to be fast, but it must also be accurate. A fast quote followed up by a phone call that says the product can't be produced, or that the quoted price was incorrect can be more damaging than a delayed response. The manufacturer must not only be able to respond quickly, but to deliver what they say they will, when they say they will. Manual handoffs of information from inquiries to quotes, quotes to orders, orders to designs, and designs to production orders waste time and provide significant opportunities for mistakes to enter into the process. Unlike the car, which has been pre-designed for each combination of features and options, the production of the highly customizable product may be different every time. Each configuration must be quoted individually.

Another difference between the "simple" product and the automobile is that with limited features and options, the car may already be on the production schedule or sitting in inventory somewhere. Highly customized products do not allow for pre-production and are typically built to order. Responsiveness to win business is not just about the speed to quote the order, but speed to design and produce the item as well. In many industries, the design of each individual order consumes precious lead-time and requires the use of design engineers to manually produce drawings and production documentation. Without the introduction of automation throughout the process, including design, customer responsiveness to delivery dates is not possible.

Design (Up Front) for Mass Customization

Responsiveness in generating quotes is now expected, and automation of configured quotes and sales orders is not new. Product configurators have provided, to some extent, an ability to automate the process of developing accurate quotes. But most solutions in place today lack integration with design and production, and therefore automate only a part of the process, and often in a way that produces "islands of automation". Without a direct connection between the detailed product design that drives manufacturing and the configuration process used to develop the quote or order, the complete "quote to delivery" process will remain fragmented and inefficient. To shorten product lead-times and reduce inefficiencies, the manufacturer can't design the product after the order is taken. Product designs must incorporate, in advance, the ability to accept customer-specific requirements. By producing product models that incorporate design rules and flexibility, the order-specific design work can be automated. For example, the number and spacing of the grids in the window should be calculated based on the window dimensions, as should the number and location of the window latches. If 3-Dimensional CAD models are used for these calculations, the engineering automation can also include the generation of production-ready drawings and manufacturing instructions. In addition, the models can support engineering analysis. For example, the window that was ordered could be automatically subjected to a finite element analysis to confirm design pressure ratings. Without detailed CAD models, this analysis is not possible. With detailed models generated from the quote or order combined with engineering automation, the engineering analysis can be performed automatically while the customer is ordering the product.

Most products today, however, are not designed for mass customization. Designing for mass customization requires a design methodology that incorporates design rules and flexible design models. CAD models must be developed up front in a way that they can automatically accept the order options captured during configuration and execute logic to adjust the design accordingly. Once the CAD models have been customized to the order, our window could be automatically milled based on the order specifications using numerical instructions that can be fed directly to the production equipment, if such equipment is available. In this way, configuration drives from the order, through design and to production seamlessly. The real-time generation of accurate bills of materials, routings, models and drawings can significantly improve the lead-time and efficiency of delivering the custom product to the customer.

Another benefit of design for mass customization is removing the need to propagate designs and part numbers in advance. Because the general design incorporates rules for customization, the clerical design work required to detail drawings, material lists,

specifications and production instructions can be performed "on the fly" when the product is ordered. Design propagation can not only be automated, but actually eliminated for product configurations that are not ordered. A generic design model can also be used to automate the propagation of designs for standard configurations or specifications. Automatically developing designs in advance for standard products, such as standard window styles and dimensions, allows for efficient development of drawings, specifications and pricing that can be used to develop catalogues or price books in advance of actual orders.

Be Efficient - Price Matters

On reflection, selling, designing and producing the window now appears pretty complex, even when compared to a car. By building in increased customization, the complexity has increased tremendously. This complexity can drive significant additional costs for the manufacturer. Remember, though, that the customer doesn't care that you can provide just about anything. They only care that you can provide what they want. Flexibility is your benefit, not theirs, and they are not often willing to pay for your flexibility. In order to compete effectively, mass customization must come without additional cost and complexity for the customer. Mass customized products must be made available at prices that are competitive to standard products.

In order to offer a competitive price to the customer and still retain or improve margins, cost must be removed from the process. Cost comes in the form of waste from manually designing each order, rework and returns caused by errors, and inefficiencies caused by disconnects between departments. Today's environment of fragmented processes, standalone tools, redundancy of information and manual effort leads to inefficiencies and errors. To reduce cost, an integrated process and automation are required to break down silos and provide a streamlined approach. By tying the process together from the quote all the way through production of the product, time and waste can be removed from the process. If design for mass customization is used, then significant amounts of non-value-added work, such as administration and redundant engineering work, can be eliminated.

Another issue related to product costs is pricing. By rapidly developing an accurate cost based on the order, the manufacturer can be confident in their pricing. If accurate cost estimates are made, then true margins can be understood when costs are set or negotiated. Confidence means that discounting can be offered with full knowledge of the impact on margins, to allow greater flexibility and speed in negotiating prices without the need for "fudge factors".

Innovate For Success

Customers reward innovation. Particularly in a down economy where growth doesn't come from general market growth, growth must come from innovation. By freeing product engineers from clerical engineering tasks, companies can focus their engineering talent on developing new and innovative products instead of redundant and tiresome clerical design work. Instead of being under the gun to get drawings ready for an order that is past due, engineers can spend time improving quality, features, and aesthetics of their products.

Innovation isn't limited to products, either. Innovation is also shown by the services offered to the customer. Rapid quotes and visualization of orders reflects on the company as a leader and an innovator, which leads to a competitive edge in the sales process.

Summary

Designing complicated products like automobiles is difficult. Designing "simple" products, such as windows, doors, kitchen or bath cabinets, office furniture and industrial equipment provides a different set of complexities and challenges. Manufacturers that provide mass customized products can no longer afford to work with manual and disconnected processes among engineering, sales, and manufacturing if they want to be responsive to customers, provide them almost infinite options without subjecting them to complexity, and run efficient businesses so they can offer a competitive price without sacrificing margins. Better business processes and automation can provide significant business improvement by eliminating waste, improving efficiency, and allowing more time for product innovation. In particular, integration of sales configuration processes and tools with engineering design processes and models is needed in order to achieve the significant impact required for true competitive advantage. Manufacturers that provide mass customized products that do not streamline their processes and tools will suffer from increased costs, long lead-times, and lost sales. Manufacturers that automate best practices will benefit by increasing their market share and margins at their competitor's expense.

About the Author

Jim Brown has over 15 years of experience in management consulting and application software focused on the manufacturing industries. Jim is a recognized expert in software solutions for manufacturing and has broad experience in applying enterprise applications such as Product Lifecycle Management, Supply Chain Management, CRM and ERP to improve business performance. Jim has direct experience implementing product configurators and is very active in Product Lifecycle Management and other initiatives to improve engineering processes. Jim created his consulting firm, Tech-Clarity Associates, to make the value of technology clear to business. Jim can be reached at jim.brown@tech-clarity.com.