

Achieving Manufacturing Flexibility Through Product Design

abstract

Manufacturing professionals are actively seeking ways to lower costs, increase flexibility, and position their companies to meet competition. However, to a large extent, manufacturing (as well as customer service and finance) must follow where development and marketing lead. While there are many things manufacturing can do to improve flexibility in manufacturing processes, even greater gains can be made through product design. Furthermore, a three-pronged design approach that involves manufacturing, development, and marketing can help sell investments in computer-integrated manufacturing to the rest of the organization.

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conference

CIMCOM '85
April 15-18, 1985
Anaheim, California

index terms

CIM
Design
Manufacturing Systems
Product Design



1985

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A NEGATIVE EXAMPLE

To emphasize the importance of product design and its impact on manufacturing, let's look at a typical negative example in a small company or a division of a large company.

An entrepreneurial individual spots a market niche and develops a product to serve it. The major marketing, financial, and technical issues are resolved in the entrepreneur's own head or within a small, close-knit start-up team. The company is often partially financed by orders from one or two large customers, who are intimately involved in the evolution of the product line and who want special, unique product features. The sales force, focused on getting the orders that are the lifeblood of the young company, begins to request more special features and functions that will allow them to reach a broader customer base. Products are rushed to the market too soon in order to generate receivables that can be factored at the bank; they are poorly documented, and quality assurance is primitive if it exists at all.

The company attracts competition, which focuses attention on weaknesses in the product line and puts even more pressure on development to do "quick fixes" to overcome them. The growing customer base with its variety of hardware and software revisions demands to be serviced.

PROBLEMS CAUSED BY POOR PLANNING AND DESIGN

This typical scenario creates a corporate disease whose symptoms often become visible first in manufacturing. It is not uncommon for manufacturing to look at a design and conclude that it cannot be built on existing equipment or that it cannot be built within specified unit cost parameters. However, even if the design gets beyond these hurdles, a host of other problems are sure to emerge:

--Single source, specialized parts may cause production delays, money tied up in stockpiling, and dependence on a single vendor, who may suddenly demand COD terms or refuse to ship at all. Imagine our dismay when we discovered that the minimum ordering quantity for a certain polypropylene capacitor would last us 10 years at current levels of production! There was no substitute for the part and no other manufacturer.

In another extreme case, a computer systems house bought disk drives of various sizes from a large, well known vendor, which demanded COD certified check terms. The operation of the entire company revolved around the weekly decision on which disk drives to buy. If there was no backlog of orders, we waited on sales to close a deal for a particular configuration; the type of configuration determined the number and size of the drives required. If there was an order backlog, manufacturing had to determine which combination of working components could be assembled to match one of the available orders. Only then could it specify the types and sizes of drives to be ordered. All this had to be accomplished before noon each Wednesday to give the accountant time to get the certified check and meet the vendor's timetable for shipment.

--Tolerances that are too tight cause a large amount of rework. On the first batch of devices to come off the production line, we noticed that the holes for the screws were too close to the holes for the connectors. Manufacturing informed us that the engineer had specified drilling tolerances that made consistent spacing difficult to achieve.

--Quick and dirty design requires too many expensive operations, such as welding, cutting, soldering, and custom work. Once we were given a design that consisted of a printed circuit board inside a plastic box. The box was an off-the-shelf item; unfortunately several holes had to be cut and drilled into it, and other cutting and gluing operations had to be performed inside. What the designer thought he had saved in using a standard box was more than lost by all of the special operations that had to be performed on it. If this weren't bad enough, the plastic did not hold up well in the customer environment.

--Unpredictable product demand creates peaks and valleys in scheduling. In peak periods, operators make errors through haste; in slow periods they make them out of boredom or to make extra money through reworking. A fuse company watched the demand for its products fluctuate with the weather. In seasons with abnormally high temperatures people ordered more time delay fuses; when there were lots of electrical storms, demand for quick react fuses went up. The company smoothed the peaks and valleys in its production

schedule by designing a fuse that could function in either time delay or quick react mode by a one-time adjustment made at the factory.

--Dependence on one type of machine or one type of production line creates scheduling conflicts and production delays when machines or operators are unavailable.

--Failure to design for the most efficient or most reliable process increases unit cost.

--Failure to design for automation increases the cost and length of time required to meet unexpected demand.

--Proliferation of products results in large inventories of less popular models, large overhead in the learning curve for building "specials," and poor quality control. In the basement of one company was a large collection of obsolete and unrepairable products called affectionately "the catacombs." Its only value was as a source for spare parts. The keeper of the catacombs was the manufacturing department, not because it had created the problem but because it had responsibility for plant and equipment.

Eventually marketing and customer service are also impacted.

--marketing experiences unpredictable delivery dates, too much or not enough product when needed, products that don't work as expected, and complaints about quality and/or service.

--customer service has to re-engineer products on the spot, often with substitute parts. Cash flow problems made worse by large inventories and expensive manufacturing processes leave little money for spare parts, good test equipment, or adequate documentation.

Even product development, which along with sales must share much of the blame for the problems, exhibits its own symptoms.

--an enormous amount of time is spent on solving variations of the same problem.

--development staff are so busy helping marketing figure out to sell the product, helping manufacturing overcome quality control problems, and solving customer service problems that they hardly have time to do any engineering or design.

--people rarely complete projects because development priorities are constantly changing.

BARRIERS TO CHANGE

Clearly the entire organization stands to benefit from a more intelligent approach to product planning. But while each department may feel symptoms of the disease, the cure may be difficult. Moreover, unless a company or division is very well financed and has very patient investors, the very process of growth makes the disease almost inevitable. Here are some of the major reasons why there is resistance to change:

--Marketing, financial, and technical issues can no longer be synthesized in the entrepreneur's head or within a small team. The cooperation of several different individuals is required, each of whom has his or her own territory and perks to protect. Each looks at the product from a different point of view, a natural consequence of the specialization that occurs within a company as it grows. These differences are best illustrated by a quote from Innovation magazine (January, 1971):

- To the lab scientist, a development is something to be improved upon - constantly.
- To the product engineer, the feasibility model isn't feasible at all.
- To the system designer, new technology is a damned inconvenient fit.
- To the manufacturing engineer, the problem is reproducibility.
- To the customer, the product should be in a very neat package.
- To the maintenance engineer, the product is something to be kept alive in an unfriendly environment.
- To the salesman, new technology can seem too formidable to be explained to the customer.
- The company's existing commitments to piecemeal development projects, marginal markets, and an established customer base make it difficult to change course drastically.

--The responsiveness which served a company or division well in its early years encourages and rewards individuals who fix specific problems, not those who advocate comprehensive plans to reduce the number of problems. We are reminded of the technician who used a Radio Shack computer at home to design an ingenious test fixture for a light pen product. As the company grew, it became increasingly dependent on him to solve the really tough

customer service problems, to remember how the "dinosaurs" in the product line worked, and how to select new components so that they would interface with the old ones. Unhappily, this individual contributed to the problem by continuing to put out fires. The only real progress was instituted by the Vice President for Manufacturing, who was a degreed engineer and insisted on instituting systems and procedures.

The technician left the company never understanding why he was no longer appreciated. The V.P. of Manufacturing helped the company grow out of adolescence into maturity, but he was never very popular except with the owners of the company.

--The cure for the disease requires time, reallocation of financial resources, and a new way of orchestrating the entire company's approach to product design.

SELLING THE SOLUTION TO DEVELOPMENT AND MARKETING

Attacking the problem at the design stage not only provides a more comprehensive and lasting cure for manufacturing's ills, but creates an organizational dynamic in which it is easier for manufacturing to gain support for other proposals which will make its life easier. Effort spent, misspent, or neglected at the beginning in research and development has an escalating impact on other areas in the company, whether for good or ill. (See Figure 1). Most important, poor performance in the design stage eventually creates opportunities for competition while strangling a company's ability to respond to the threat.

But what does this mean for marketing and development?

For marketing, it means:

--Anticipating product evolution to minimize the need for "specials." This usually involves looking beneath the obvious, concrete uses for a product and discovering broader, generic needs. One company we know began by supplying touch screen terminals to its parent organization. The screen had 32 etched pads that were fixed in specific locations on the screen surface. This arrangement was fine for the original application but severely restricted the market for the technology. Eventually the company developed a screen with programmable touch pads, but the effort took longer than it should have, costing the company many sales and market share.

--Accurately gauging market breadth and depth to minimize redesign for such things as hardware/software compatibility or larger quantities. Once the touch screen company decided to abandon the fixed pad approach, it moved next to making components with RS-232-C input and output. It soon discovered, however, that those companies using a standard

serial approach to interfacing a touch screen to a terminal were selling fewer systems than those companies desiring to use a parallel interfacing approach. In fact, companies planning to build very large quantities of touch screen systems wanted to interface right on a single printed circuit board. It took the company four years to realize that perhaps it should have designed a set of chips that could be used in a product line serving all types of customers. By then their time and money was running out.

--Understanding the customer environment to avoid redesign due to misuse, abuse, or hostile environmental factors. One company developed a line of hardware for use in school laboratories. Specific instructions went with each device for a set of experiments that could be performed. The customer insisted on using the device for other types of experiments, in some cases with disastrous results. The company recently established a department to handle customer complaints, which of course is soaking up profits. Furthermore, customer dissatisfaction is creating opportunities for competition.

For development, it means:

--Maintaining good communication with sales and marketing. Aware that it must redesign its products to meet present and future customer needs, one company created a separate development team to start from scratch and "do it right." Unfortunately, the "Version 11" team was almost completely isolated from the rest of the company. Before getting the ax after two years of work, the team had soaked up enormous amounts of company resources and demoralized many good designers.

--Designing to minimize the number of ECO's and obsolescence of parts. This, of course, is easier said than done, especially in the computer field. What seems to be the best new processor in terms of price and performance may die through lack of marketing, funding, or management two years later. That's about when your company or division will have its new product ready for shipment.

--Taking advantage of technical trends, such as computer intelligence, factory automation, emerging hardware technologies.

--Keeping the design simple so that it is easy to procure the parts, easy to build on a variety of manufacturing configurations, easy to service, and easy to change. A fuse manufacturer used thin silver wire in one of its products. It was difficult to produce wire of the required thinness and length. A redesign that substituted copper for silver and replaced a long strand of wire with an accordion folded piece. The new product was less expensive, easier to make, more reliable, and had higher performance characteristics.

How do we implement manufacturing flexibility through design in an environment in which:

--Development is seduced by the latest chip, in love with the "elegant" solution, and ignorant of many of manufacturing's problems.

--Marketing is under pressure to increase short term sales volume, make accurate quarterly forecasts, and is even more in the dark than development about how products actually get built.

--Finance is focused on relatively short term time horizons and only trusts forecasts that can be verified with historical financial data.

The key is in selling marketing, finance, and development on the benefits of manufacturing flexibility in their own areas and in creating an environment where marketing, development, and manufacturing work closely together in the design stage to keep the company healthy.

BENEFITS OF MANUFACTURING FLEXIBILITY THROUGH DESIGN

For marketing, these benefits are:

--Broadening the markets, increasing the number of potential customers by designing products which have a number of applications.

---Making delivery schedules and product quality more predictable.

--Permitting more efficient management of finished goods inventories.

--Making the product line a "neater" package that requires less specialized knowledge to sell.

For development, the benefits are:

--Engineers and designers can settle down to design instead of being called on to fight fires.

--Staff can finish jobs instead of continually getting shifted from one job to another as sales priorities change.

--The department can do comprehensive projects that are more likely to be "elegant" conceptions than a series of quick and dirty specials.

--Engineers and designers can feel that they are doing something truly useful instead of designing products that will sit on the shelves.

For finance, some benefits are:

- Budgeting becomes more predictable and reliable.
- Costs of manufacturing and service go down.
- Cash flow is easier to manage because there are several vendors to choose from and it is possible to negotiate better deals with them.
- Less money need be tied up in inventory.

SUMMARY

In summary, by pushing the design stage further back into the planning and design cycle and increasing the level of effort in research, development, and product design, a company or division can not only enlarge its market but can also insure that it serves that market well (see Figure 2). Closing market gaps and keeping existing customers happy are the best ways to keep competition at bay.

But while manufacturing may be in an ideal position to identify many design problems and propose cost effective solutions for some of them, comprehensive solutions must involve a new methodology for involving other parts of the company in a cooperative effort.

FIGURE 1

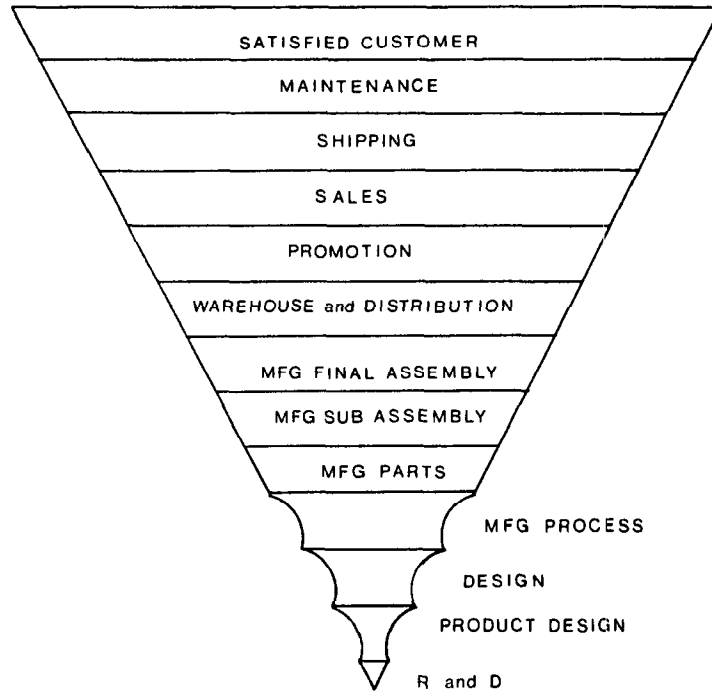


FIGURE 2

