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HOW TO PERFORM SIMULTANEOUS PROCESS ENGINEERING

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se of innovation to achieve a competitive advantage is not new. What is of current interest is ome manufacturing organisations have used the speed of product innovation to gain ɜtitive edge. To implement such a competitive strategy effectively, many firms have applied chnique of simultaneous engineering.

nost common subject of previously published research on simultaneous engineering has been its ;ation to product innovation. The subject of this paper is simultaneous process engineering. im of the paper is to explain how the principles of quality function deployment, which are for product design, can be applied to manufacturing process design. The lessons learnt from ing such an approach for simultaneous process design are also detailed in the paper.

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uture for the UK manufacturing industry is the prospect of another step change to the ;ity of international competition in its domestic market. This is the consequence of the on of the single European market and the attack on this market by a growing number of etitors from outside it. If UK manufacturing firms are to survive, they must be both quick lexible in their response to the changing needs of their customers and the actions taken by their competitors [1]. The removal of any protection afforded to UK manufacturing businesses, by the imposition of import tariffs and controls, has compounded their problem of creating or sustaining a competitive advantage. However, the elimination of one form of entry barrier to the UK market for manufactured products could be overcome by the creation of another, i.e. the competitive use of advanced technology. Innovation could be used to gain competitive edge through either product or manufacturing process design or through a combination of both these design opportunities.

An examination of manufacturing companies' use of innovation to gain competitive edge should provide a guide to its value as a competitive weapon. Recent studies of the strategic management of manufacturing, by Roth and Miller [2], De Meyer [3] and Sweeney [4] have shown that a large number of companies have adopted a competitive strategy which consists of innovating their products at a rate that is much quicker than the competition. Gomory and Schmitt [5] have observed "that a firm able to quickly introduce new products will appear to have newer products with newer technologies. This gives the firm a reputation for technical innovation and leadership, thus enhancing the company's image. It only takes a few new product introductions to build up a significant product lead, which of course enhances the firm's market share".

Is such a strategy appropriate only to a select group of firms within an industry? Riedel and Pawar [6] suggest that "if a firm needs to maintain its competitive edge by being first to market then the implication is to value the time benefit over the cost risk and choose simultaneous engineering". This recommendation correctly links simultaneous engineering as the means of reducing the design-to-manufacture lead time, which is ideal for a first to market competitive strategy. However, it is just as appropriate to a company adopting the fast follower product strategy. It would seem that simultaneous engineering is an innovation management technique that could be applied by all firms that engineer a product or a process.

Background

It was Abernathy [7] who first described the differences between sequential and parallel product development strategies. That was approximately twenty years ago. However, simultaneous engineering has been rediscovered by a much larger audience through Imai et al [8] on five cases in the Japanese industry, Hayes et al [9] and the studies carried out by Clark and Fujimoto [10] on the world-wide motor industry.

Much of the recently published research has concentrated on the development and use of tools to ensure an integrated approach to product design by the marketing, development and manufacturing specialists. (For details refer to Hartley and Mortimer [11] and the proceedings of the first international conference on simultaneous engineering [12]).

The Empirical Research Objectives

Very few studies have been carried out on the process of simultaneous manufacturing system design. As a consequence, very little has been published on this important stage of the simultaneous engineering process. This is the subject of this paper.

The objective of the empirical research was to propose a practical approach to simultaneous process engineering. The practice of simultaneous process engineering requires further explanation because there are still many gaps in the published literature on this subject.

The proposed methodology, detailed in this paper, is the result of a retrospective analysis of the problems encountered during a simultaneous engineering project and the solutions that were found. The paper is intended as a guide to increasing the effective use of simultaneous process engineering to gain a competitive advantage through manufacturing system design. Such a competitive advantage is one that is not easy to copy. It therefore offers an opportunity to achieve a competitive advantage, that is more difficult to neutralise. The methodology described is not intended as a definitive statement of the approach to be used because it has been based upon the experience gained from a single project. It is therefore a prototype model.

To explain the emirical research findings, the paper has been divided into three parts. In the first part a conceptual model of simultaneous engineering is presented with a discussion of the critical problems of simultaneous process engineering. The second part of the paper consists of a description of a methodology recommended to aid the design of the production system. This methodology has been developed to ensure that the voice of the customer (marketing) is used for the design of the production process, which is essential to achieving competitive edge. Its purpose is to improve the quality of process design and to increase design efficiency.

The final section of the paper provides an illustration of how this approach was employed for a case-based research project, which was carried out recently in a UK manufacturing company, with the conclusions drawn from the experience.

Simultaneous Engineering

The Rolls-Royce definition of simultaneous engineering [13], which really defines the objective rather than the process, is as follows:

"Simultaneous engineering attempts to optimise the design of the product and manufacturing process to achieve reduced lead times and improved quality and cost by the integration of design and manufacturing activities and by maximising parallelism in working practices".

Hartley and Mortimer provide a clearer description of the process [14]:

"Simultaneous Engineering is not just project management by Task Force under another name. Vital elements include:

Multi-disciplinary Task Force;

Product defined in customer's terms, then translated into engineering terms in considerable detail;

Parameter design to ensure that the product is optimised for use and quality;

Design for Manufacture and Assembly (DFMA)

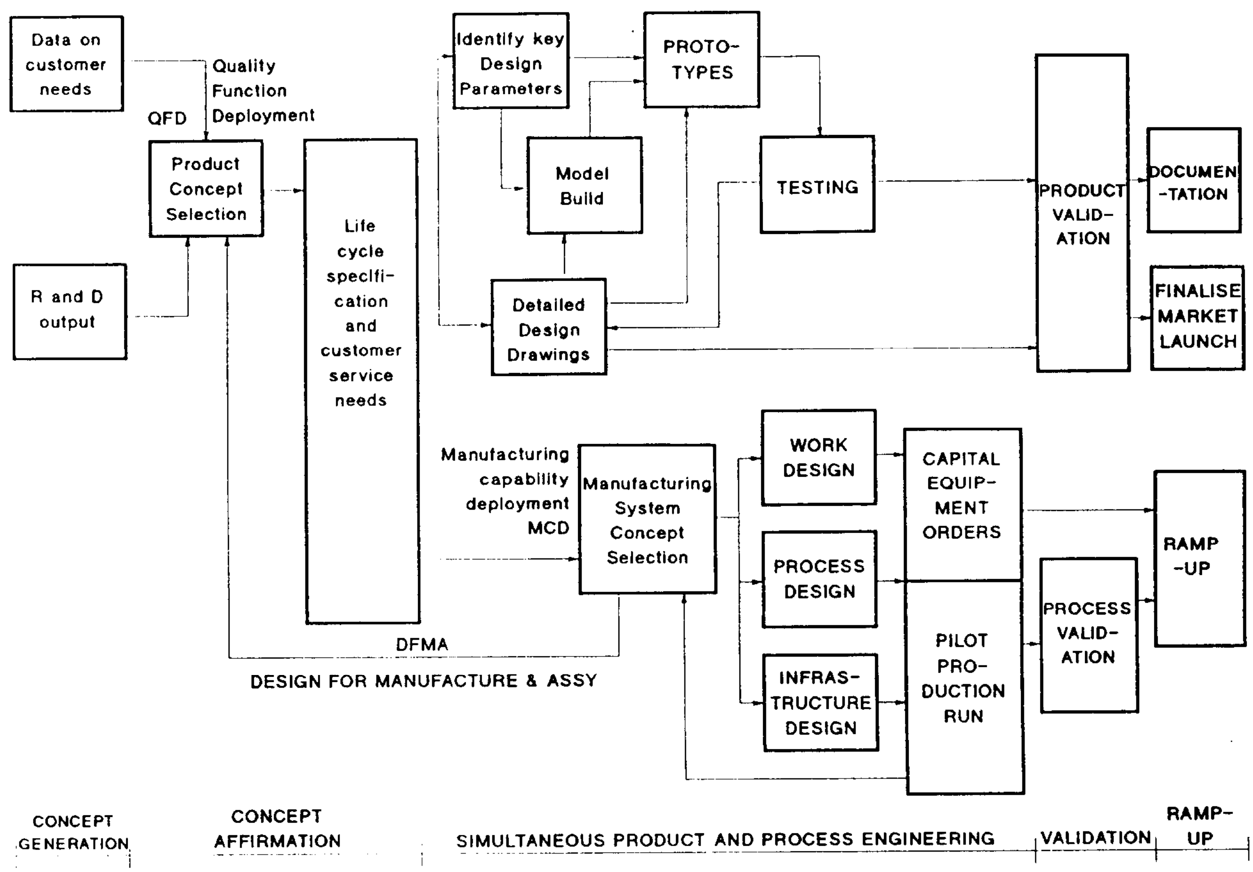
Simultaneous development of the product, the manufacturing equipment and processes, quality control and marketing".

This process is shown in figure 1. The use of the quality function deployment technique (QFD) and DFMA are essential for an appropriate definition of the product concept. The quality function deployment technique is carried out to ensure that the customer's requirements, or the customer's voice, is heard when decisions are taken which define the quality and performance characteristics of the product. In addition, the QFD approach also includes a comparison of the firm's product quality with those of competitors' products which helps establish how competitive edge can be achieved.

The application of these methods is beginning to be better understood in the UK although the extent of their use in British firms is still unclear and does not seem to have been researched. However, in Japan, QFD and DFMA have been used for many years, apparently to good effect [15]. It is their method of gaining, in a systematic way, a consensus on the product concept. This is a crucial strategic decision. The value of QFD is well recognised now because it has proved that its use can induce a disciplined approach to designing the product to customer needs. Its use therefore should eliminate the tendency to design to what is believed, usually by the uninformed, to be what the customer wants.

Figure 1 has been produced to illustrate an equally important need, which is the preparation and evaluation of a concept for the manufacturing system design. It is essential that this design should also satisfy the customer's needs, i.e. the marketing and sales functions of the firm. Consequently, the same discipline and rigour should be used for process engineering as that for product engineering. Such a logical proposition leads to the adoption of a technique similar to QFD for the selection of a concept for the manufacture of the product. To achieve competitive edge it will also be necessary to compare the manufacturing capabilities of the firm with those of its competitors. Such a comparison will help determine how the firm should deploy its manufacturing resources to provide a customer service with competitive edge.

Figure 1. Product development lead time with simultaneous engineering



Manufacturing Capability Deployment (MCD)

Figure 1 shows the progressive development of a product concept into a tested and approved/validated product design. The diagrams show that QFD and DFMA are tools used to aid the design of the product concept.

Figure 1 also shows the simultaneous development of the manufacturing process. For simplicity, this is shown to consist of three major elements, i.e. the manufacturing process design, the design of the allocation of work and the manufacturing management information system design. However, all three elements of the manufacturing system cannot be designed until a manufacturing capability concept has been defined. Just as the product concept defines how the specified customer requirements are to be satisfied and how it will outperform the competitors' product, so the manufacturing system concept converts customer service requirements, i.e. the manufacturing capabilities desired by the marketing and sales functions, into process characteristics. These, in turn, signify how the manufacturing resources need to be deployed. The process is a similar one to QFD. The tool developed to aid the process of selecting a manufacturing system concept, which has been entitled manufacturing capability deployment (MCD), has been designed on similar lines to that used for QFD. This is shown in figure 2.

	PROCESS CHARACTERISTICS							
Competitive Capabilities	SPC Product	SPC Process	CAD	CAM	JIT	MPR	Importance Rating (%)	Competitor Evaluation HI – LO
Low Price							10	
Design Flexibility							15	
Volume Flexibility							0	
Quality Conformance							30	
Product Performance							10	
Delivery Speed							20	
Delivery Reliability							10	
Product Variety							5	
After Sales Service							0	
Percentage In - House Application	50	50	10	0	5	100		
Competitor	100	100	0	0	50	100		
Importance Rating (%)	30	20	15	10	25	0		

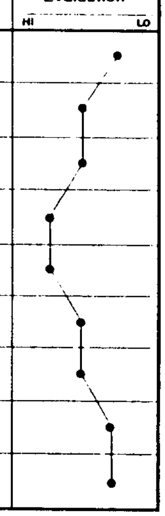


Figure 2.
Manufacturing capability deployment

The competitive capabilities listed are the same as those used by Roth and Miller and De Meyer in their studies of manufacturing strategies. They are to be interpreted as follows:

Low Price	The capability to compete on price
Design Flexibility	The capability to make rapid design changes and/or introduce new products quickly
Volume Flexibility	The capability to respond to swings in volume

Quality Conformance	The capability to offer consistent quality
Product Performance	The capability to provide high performance products
Delivery Speed	The capability to deliver products quickly
Delivery reliability	The capability to deliver on time (as promised)
Product Variety	The capability to deliver a broad product line
After Sales Service	The capability to service parts, support etc.

For each of these capabilities the management should compare their capability with competitors and rank the significance of this capability to the needs of the market. Examples of the range of process characteristics that could be used for this analysis are as follows:

Process Characteristics List

Manufacturing Process Design	Organisational and Information Infrastructure
Cellular Production - Product based	Computer Aided Design
Cellular Production - Process based	Statistical Process Control - Product
Assembly Line production	Statistical Process Control - Process
Flexible Manufacturing system - FMS	Material Requirements Planning
Robot Production - Welding, assy, etc	Manufacturing Resource Planning (MRPII)
Computer Aided Manufacture - CNC, DNC	Electronic Data Interchange (EDI)
Just in Time Production control	EDI with suppliers
Strategic Stock holding - RM, WIP, FGS	Shop Floor Data Capture (SFDC)
	Specialist Skill workforce
	Multiskill workforce
	Group Working
	Total Quality Management (TQM)

Manufacturing capability deployment (MCD) requires the matching of the most appropriate process characteristics with the capabilities that will establish competitive edge. In this case - research project the desired competitive manufacturing capabilities were quality conformance, product variety, delivery speed and after sales service. This was also the order of importance rating that resulted from a comparison with competitors.

These were therefore to be the key process capabilities of the company's manufacturing operations. As a consequence they constituted the foundation for the creation of both a short-term and a medium term vision for the strategic development of its production operations.

Conclusions

The manufacturing capability deployment (MCD) analysis proved to be a useful tool to discipline and to give direction to the design of the manufacturing system. It was also helpful as a aid for the comprehensive evaluation of the process design options. As with QFD, its integrative value was to require the marketing personnel to prepare and present to manufacturing management their competitor evaluations and to lead the discussion on the most critical manufacturing capabilities required in the coming two to five years.

Figure 3 shows the resulting plan for the factory design. This included determining the Just in Time (JIT) batch size by carrying out a Computer Aided Design (CAD) analysis of the nesting of component profiles by major sub-assembly. It also included using simulation to evaluate the impact of batch size differences on throughput efficiency.

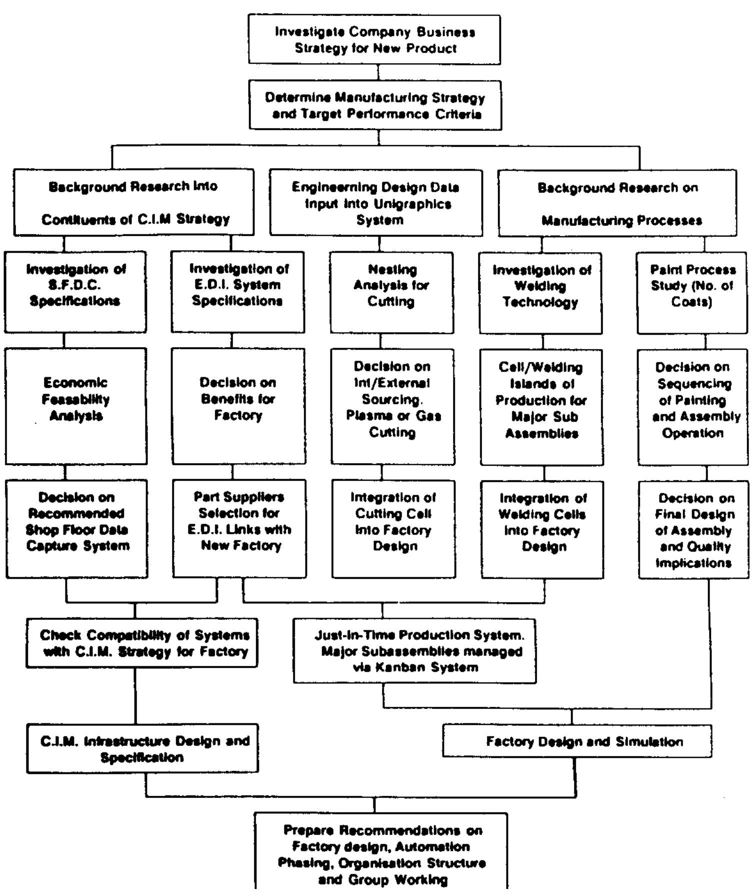


Figure 3 also provides an overview of the sequence of the key process design decisions that were taken during the life of the project and which derive from the agreed vision of the firm's manufacturing capabilities.

The senior management of the company that sponsored this trial application of simultaneous process engineering have confirmed that the use of this technique has reduced the lead time from product design to prototype production by approximately twenty percent. (The reason why this is not more precise is that previous experience of the same process has not been formally recorded). However, a number of simultaneous process engineering problems had to be overcome and each of these was counterproductive to reducing the design to manufacture lead time. These were as follows:

1. Insufficient knowledge about the competitor's manufacturing capabilities. This information had to be researched before a meaningful competitor evaluation could be carried out.

2. Knowledge of the competitive capabilities of the competitors was expressed in terms of current performance. Insufficient information had been gathered to forecast their future competitive capabilities. Consequently, the strategic plan for the firm's manufacturing operations was founded upon a judgement of the competitor's future actions that had been made using very limited information

3. Within the company there was only a limited understanding of the concepts used to determine a competitive strategy for a business and how this is to be used to influence the strategic plan for manufacturing operations. A considerable amount of time was required to develop an appropriate level of understanding of these concepts so that a common language could be used to enable an informed discussion of these issues.

An overall assessment of the use of simultaneous process engineering leads to the conclusion that there can be a steep learning curve to climb before the full benefits of the use of the technique can be realised. However, even with its initial use, the lead time from design to manufacture can be reduced and it is an excellent technique to use to design competitive advantage into the manufacturing process. Such a strategy can establish a competitive advantage that may prevail longer than product innovation because its emulation will require more than carrying out reverse engineering.

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