DFM Experiences and Strategies for Implementation

K G Swift and N J Brown*
School of Engineering, University of Hull, Cottingham Road, Hull, UK, HU6 7RX

Abstract

The paper touches on the experiences gained from numerous applications of design for manufacture (DFM) techniques, across a wide range of business sectors and production volumes. It describes the benefits that have accrued in terms of part count reduction and savings in component manufacture and assembly costs. The paper also focuses on implementation strategies for DFM. It describes the way in which businesses have approached the issue, the problems faced, the processes involved and the planning and organisational aspects that need to be addressed in order to maximise the benefits from the technology.

Introduction

In today's environment, manufacturing businesses are facing fierce competition and operating in changing markets. Customer demands for higher quality products at lower costs and shorter product lifecycles are putting extra pressure on the product introduction process.

Cost and quality are essentially designed into products (or not!) in the early stages of the product introduction process. The designer has the great responsibility of ensuring that the product will conform to customer requirements, comply with specification, and ensure quality in every aspect of the product, including its manufacture and assembly, all within compressed time-scales. The company that waits until the product is at the end of the line to measure its conformity, performance and cost will not be competitive. The need to understand and quantify the consequences of design decisions on product manufacture and quality has never been greater.

There is extensive evidence to show that products are being designed with far too many parts and with many complex assembly and manufacturing requirements. It has been found that more than 50% of product development effort can be wasted on rework (1) and it is not uncommon for manufacturing operations to have a "cost of quality" equal to 25% of total sales revenues. Even Fortune 500 quality leaders face intimidating quality losses. (2).

Why do businesses continually face such difficulties? The costs 'fixed' at the planning

and design stages in product development are between 60 to 85%, while the costs actually incurred at that stage may range from only 5 to 7% (3). Therefore, the more problems prevented early on, through careful design, the fewer problems that have to be corrected later when they are difficult and expensive to change. However, to achieve this it is necessay to reduce the 'gap in the knowledge' between design and manufacture as shown in Figure 1.

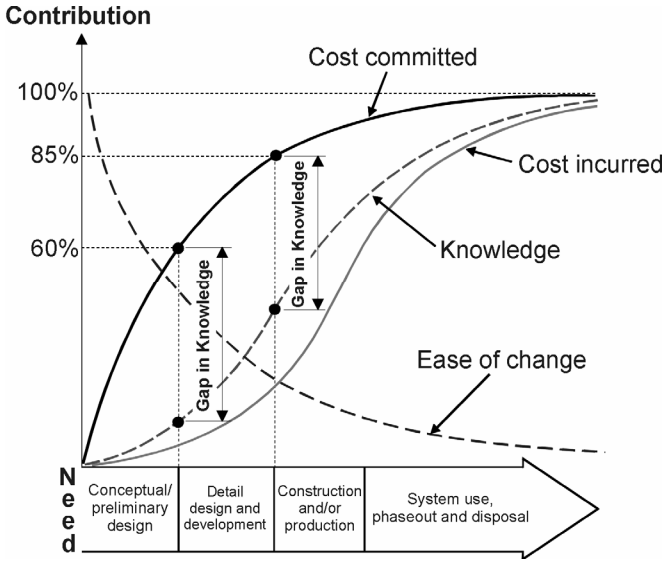

Figure 1 Commitment and Incursion of Costs During Product Development (or the 'gap in knowledge' principle) (After Fabrycky (3))

Some designers have practical experience of production and understand the limitations and capabilities they must work within. Unfortunately, there are many more that do not.

Furthermore, the effects of assigning tolerances and specifying geometry and materials in design have far reaching implications on manufacturing operations and service life, and the associated risks are not properly understood. Understanding the effects of variability and the severity/cost of failure is key to risk assessment and its management.

Competitive Product Introduction and Techniques in DFM

Experience in the introduction of new products over many years has indicated the need to adopt a concurrent engineering approach in new product development, undertaken by enterprise-wide teams, within a professionally managed product introduction process and supported by DFM tools and techniques (4).

The application of DFM tools and techniques that quantify manufacturing and assembly problems and identify opportunities for redesign are the major means available for bridging the knowledge gap.
It has been found that DFM/DFA analysis leads to innovative design solutions where considerable benefits accrue including functional performance and large savings in

manufacturing and assembly cost. DFA is particularly powerful in this connection and is probably the single most valuable product introduction technique.

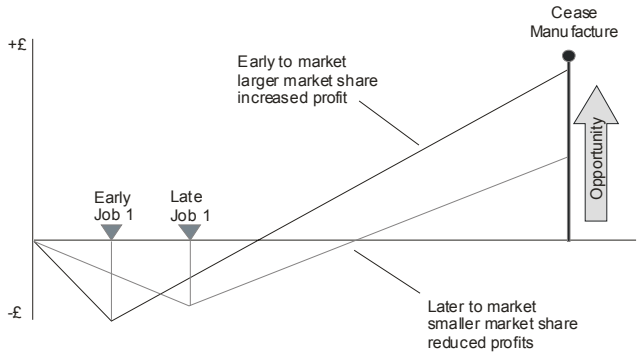

Figure 2

Although the use of design for manufacture and assembly techniques requires additional up-front effort when compared with the more conventional design activity, overall the effect is to reduce the time-to-market quite considerably. This is primarily due to fewer engineering changes, fewer parts to detail, document and plan, and a less complex product with good assembly and manufacturing characteristics. An illustration of the business benefits of reducing time-to-market is given in Figure 2 (4).

Very substantial reductions in part count and component manufacture and assembly costs have resulted from using DFM techniques in product development teams. Figures 3 & 4 give examples of what can be achieved in terms of product rationalisation.

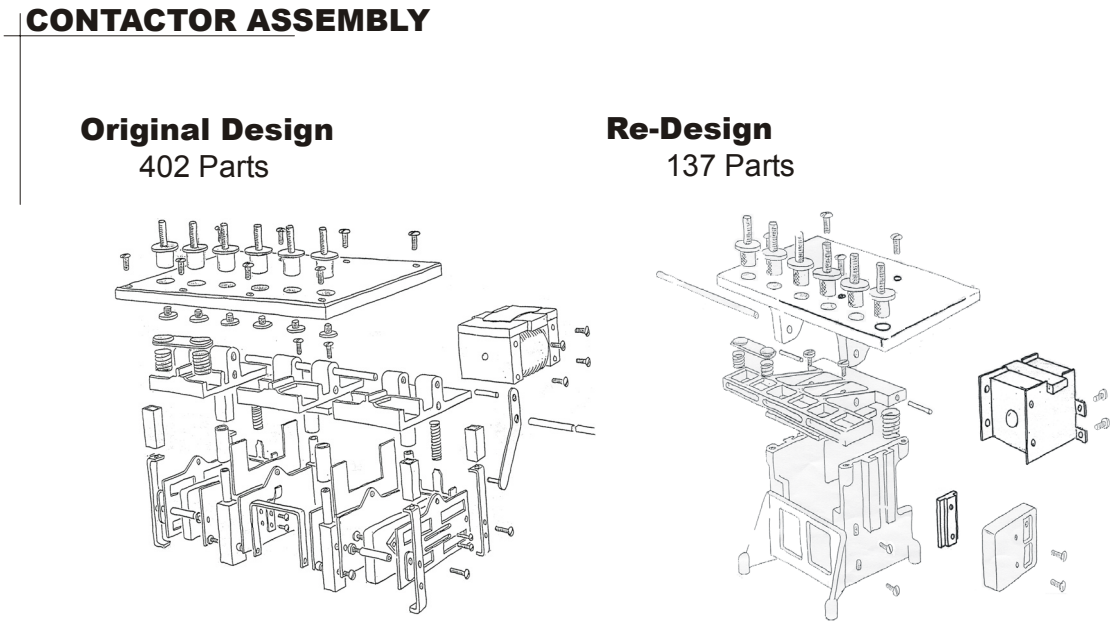

Figure 3 Contactor

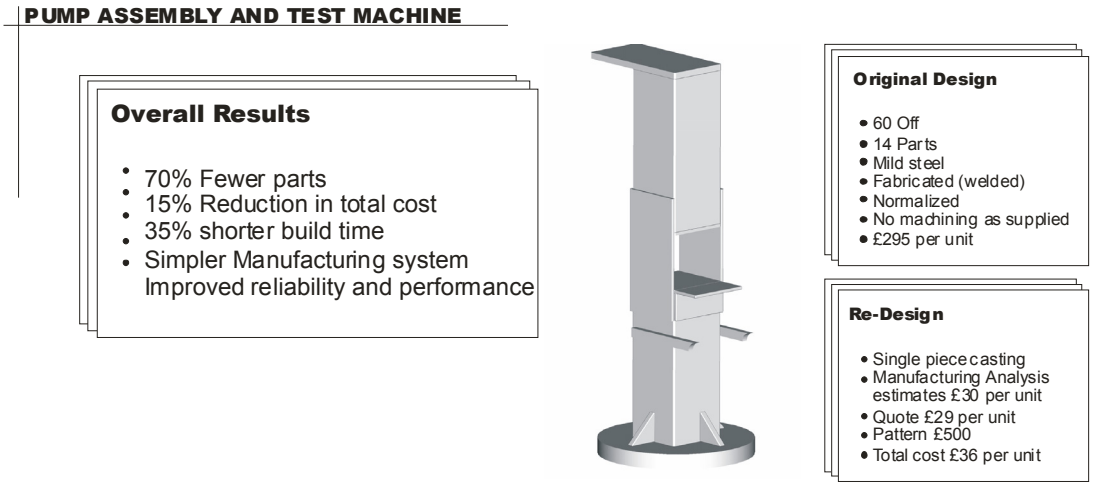

Figure 4 Pump Assembly and Test Machine

The results of sixty documented applications, carried out recently in a wide variety of industries, show that the average part count reduction was almost 48% and the assembly cost saving was 45% (See Table 1). It is interesting to note that there proved little difference, in terms of means and standard deviations, across the aerospace/defence, automotive and industrial equipment business sectors. This indicates that the applicability of the methods is not particularly sensitive to product demand levels or technology. Indeed the largest single benefit achieved resulted from the redesign of a range of assembly and test machines.

Business Sector	Automotive	Aerospace/ Defense	Industrial Equipment	All Sectors
Average Part-count Reduction	44%	52%	51%	48%
Average Assembly Cost Saving	43%	47%	48%	45%

Table 1 Results from 60 product studies

Similar savings have been reported by others involved with the application of techniques in design for manufacture and assembly (5). It is also worth commenting that the designs coming out of the process tend to be more reliable and are easier to manufacture.

Strategies for implementation

Having made the case for DFM techniques the following section considers the options for implementation. In response to market demands two distinct strands of DFM business have emerged (6):

- Product Studies, and
- Organisational Alignment Projects

While each of the above tend to have the objectives of wide-ranging cost reduction, including quality improvements on particular products or product families, Organisational Alignment Projects involve major improvements to business processes. Each of these areas will be touched on in a little more detail in the following paragraphs.

DFM Product Studies

Product Studies have normally taken the form of three to five day workshops and have, in the main, addressed existing products. Normally DFM specialists have been involved in facilitating the workshops and providing the necessary training.

What is involved in a typical study? The process and the outcomes are briefly explained below:

Do the initial training: The workshop sessions begin with a half-day training exercise in the DFM method. Typically small case studies are used by the DFM Facilitator to support the teaching of the method. They illustrate simply how it can be applied and the benefits that can accrue from its application. The training always involves team-based activity and forming the teams is a crucial first step in any study.

Do the analysis: Having a knowledge of the DFM method the team (typically three to five personnel depending upon the size and complexity of the product) apply the method to the product under consideration. (The analysis is often supported by simple spreadsheet software, which facilitates the assignment of metrics, calculation of variables, and the documentation and reporting of the study.)

Do 'brain storming': Using the DFM analysis results as an input the team are involved in 'brain storming' to create improved design concepts and/or embodiments that are capable of overcoming the problems identified by the analysis.

Do the analysis on the new design: Here the team apply the DFM method to the redesign solutions and generate the necessary measures of performance so that the likely benefits can be quantified.

Converge the concepts: This involves taking the best ideas from the redesign solutions generated by the teams to produce a small number of proposed designs which are likely to offer the most benefits to the business.

Do the risk assessment: The team assesses the various risks and ease of implementation associated with the proposed designs. A matrix of risk and ease of implementation is used to enumerate the consequences of change.

Feedback to management: The results of the Product Study are presented to the business managers. The likely benefits and risks, and the necessary investment are reviewed and decisions are made as to whether or not to proceed with the necessary engineering changes to the product or design under consideration.

Organisational Alignment Projects

Interest in implementing DFM across a business usually comes from wider diagnostic studies where senior management has identified weaknesses in product competitiveness. DFM implementation projects would typically be required where businesses are operating with, for example, high product costs and/or poor product or process quality. Some of the organisational issues considered to be key to the successful implementation of DFM are also touched on below:

Adopt Matrix Management: Experience in the implementation of DFM methods has shown that in every case there is a need to change the organisational structure towards matrix management and away from functionally organised departments. (This is not to say that functional specialists are not needed, but rather that their involvement in a product introduction project is the crucial role of assuring the quality of the work in the project teams, not just doing their bit and passing the work on to the next owner.)

Change the Culture: A crucial requirement for making DFM methods stick in a business is the introduction of a DFM culture. In order to realise this, education and training in DFM and the adoption of a management style and mind-set, which can promote DFM are critical. Examples of best practice are important in this connection.

Build DFM into Design Reviews: Design reviews provide a well established and formal procedure to report technical decisions and performance against requirements. They are formal meetings with a chairman and minutes and provide traceability. Design reviews provide a formal opportunity for the team, customers and suppliers to be involved with and discuss progress in the context of DFM.

Set DFM Targets: Useful targets for DFM can include part-count, and setting process cost targets for critical design characteristics. In addition, the implementation of DFM has been shown to reduce both time-to-market and the number of engineering changes.

Prepare a DFM implementation plan: In the preparation of the project plan for a product introduction project DFM should be included from the outset. Only in this way can the necessary actions be properly timed and funded.

Sell DFM to Middle Management: Do not underestimate the importance of gaining the commitment of middle management! The need for DFM and the benefits that are available must be made plain for without their support the potential will not be realised.

Select a DFM Champion: It is always a big advantage to have a DFM Champion(s). Leading the application in the business, keeping up-to-date with developments in the field and assuring the quality of the DFM work in the business are some of the duties of the DFM Champion. Training in DFM should flow through the Champion.

Apply DFM as soon as possible: At the product structure level apply DFM to design modules, standardise on DFM designs and reduce part-count. At the assembly sequence level apply DFM to facilitate the design of parts for manufacture and assembly, and use the structured flowchart approach to aid assembly sequence design.

Use IT: For the application of DFM. Use DFM in the CAD system and use IT for helping to support the interfaces, for modular design and for variant reduction. IT provides a means of documenting and reporting DFM studies.

Concluding remarks

The need to improve the way in which products are brought to market and the crucial role of techniques in DFM has been demonstrated. The benefits that can realised from the application of the techniques has been described and strategies for their implementation have been proposed.

However, there remain many gaps- we need to understand more about the way in which techniques in DFM can be employed to influence the design process in a more proactive way, and we need to understand more about the influence of the business environment. Theses are topic areas where research could usefully be directed.

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