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Design Methods that Work

# 'PRODUCT IMPROVEMENTS THROUGH A COOPERATIVE DESIGN APPROACH BETWEEN INDUSTRY AND ACADEMIA'

**A.J. Medland & G. Mullineux**

Department of Mechanical Engineering
University of Bath
Bath BA2 7AY, UK
email: A.J.Medland@bath.ac.uk

**Abstract:** *Considerable effort has been put in over the last decade into the creation of approaches to design by the design research community. However very few of these methodologies have ever found their way into industry and have had little to no effect on the creation of new products.*
*The research group at the University of Bath has been working closely with its industrial collaborators for many years. Some companies were first involved in a research programme into the 'Redesign of Packaging Machines' in which a redesign methodology was created. Two of these companies continued their association by a further set of Teaching Company Schemes.*
*In one, an approach has been developed in which a programme of machine optimisation has been undertaken in parallel to the creation of the prototype for a new range of machines. This has allowed the company design team to develop the basic concepts and structural form, whilst the research team is working alongside on the analysis and refinement of the core mechanical elements.*
*Currently the prototype machine has been built and the second, with the optimised mechanisms, is awaiting its build in the workshop. Both are to be instrumented and their performances evaluated.*

## 1. INTRODUCTION

The design research community has put in tremendous effort over the last decade into understanding the technologies and processes but have had little effect on the activities of most engineering companies. Some major companies have indeed been influenced by proposed new approaches. But the majority, and particularly the small to medium enterprises (SMEs), that make up most of the industry, have been little affected [1]. The only significant change during that period has only been in the introduction of the CAD system to replace the drawing board.

As the CAD systems have advanced (from simply electronic drafting machines to full solid modellers and analysis systems) the level of technological awareness in the design office has vastly improved. The processes and approaches adopted to designing has however remained the same.

Most SMEs are reliant upon the skill and experience of their staff to be able to modify and extend their existing products to meet new and expanding markets. As many of their products already have a long and involved history, based more on experience than analysis, it is difficult for them to make rapid changes or enter new markets without incurring large risks.

It was with this understanding that the Design Group at the University of Bath commenced a series of research activities, over five years ago, with companies creating machines for the packaging industry.

## 1.1. Limits to a design

Whilst the ultimate aim of this research programme (supported by a range of grants) was to increase the companies' ability to design new machines, the starting point was for them to understand their existing products. The design of new products, whilst exciting, is highly risky, as it abandons a large amount of experience gained over the life of the previous product. A new product should thus only be considered when the limits of the existing design are known and quantified. The first step in new product development is thus an understanding of the existing products.

Within this programme a group of researchers worked with a number of design and manufacturing companies. During this study a redesign methodology [2] was developed, as shown in Figure 1. Within this approach the research team worked with the company design team to determine what were the actual limits of the existing designs.

ing design. These opinions were gathered from many sources beyond just the design team. They included such people as the fitters, maintenance and service teams, the sales force as well as the customer. Everyone was allowed to contribute to the discussion.

Once collected these opinions were rationalised and classified. Means were then proposed by which they could be evaluated. This led, in the main, to the two parallel activities of modelling and experimentation, as show in the figure. In this study models were created within the university constraint modelling environment [3]. This modelling environment, created by the authors, uses rules to define the relationships and objectives of a design and has been used to define and resolve complex problems in machines. It can be used to create kinematic models of different aspects of the machine and to investigate both its performance and compliance with the design rules [4].

An experimental investigation was undertaken in par-

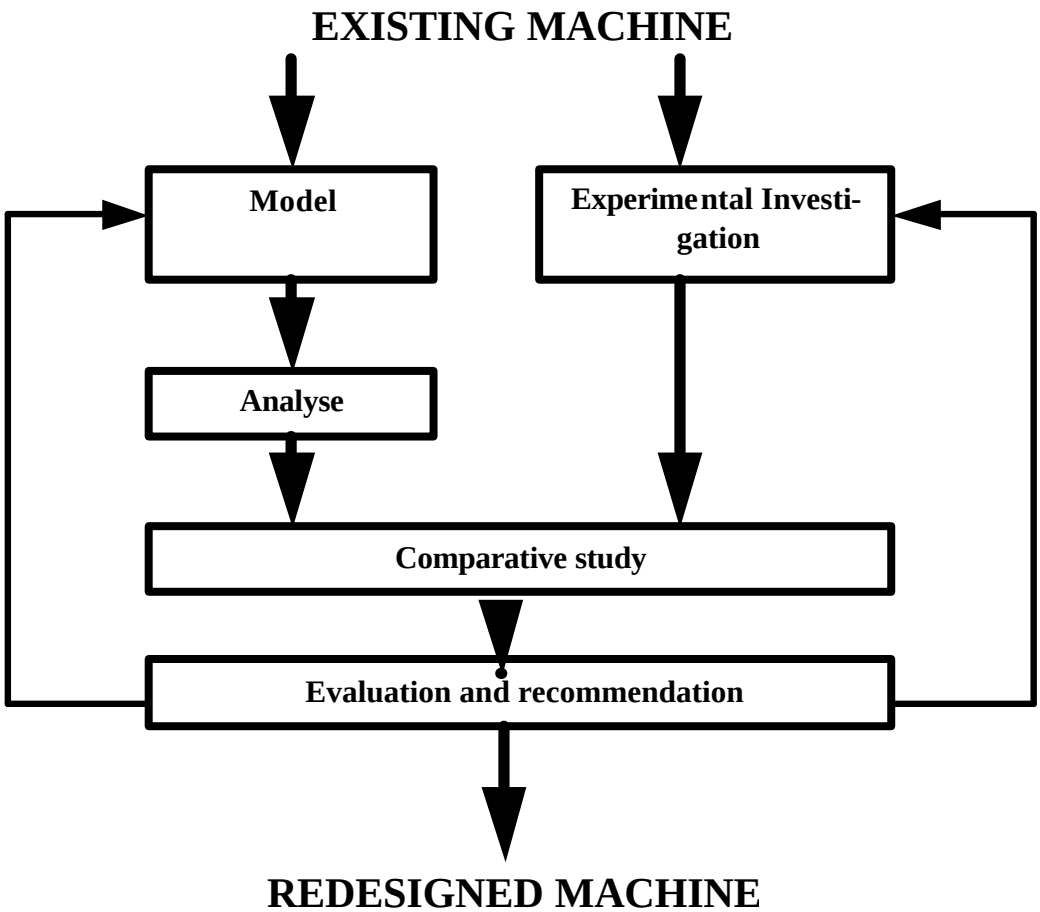


Fig. 1. *Redesign methodology adopted*

The process commenced with discussions and brainstorming activities that were designed to determine what were considered to be the problems of the exist-

allel with the modelling in order to both validate the models and to provide evidence that either supported or repudiated the suggested machine problem.

Once a problem was reproduced and the models validated, the constraint modelling process was inverted and the models used to determine ways in which the problem could be eradicated.

This process of investigating problems through modelling, experimentation and evaluation (with the design team) led to an iterative cycle of activities that resulted in proposals being made on how the machine would need to be redesigned if all identified problems were to be removed.

This, in turn, led to the definition of three categories of change that are shown in Figure 2. These were established to allow the designer and the company to agree the extent of the changes that would be necessary if the machine problems were to be eliminated.

***Class 1.***

This class was chosen to indicate that the problems could be address both within the concept of the existing machine and within its existing design envelope. In some cases it was determined that the objectives could be met through simple changes in geometry or choice of components. These may require the manufacture of modified part, although in some cases these could be achieved within the allowable adjustment of the existing parts.

***Class 2.***

Here the investigations established that the overall concept was viable but one element failed to meet the performance requirements. Here one aspect or subassembly of the machine would need to be redesigned before all of the problems could be addressed.

***Class 3.***

In this final class the investigations indicated that the design concept had reached its limit of development. Further improvements could not be made on the existing design and further performance gains could only be achieved by the introduction of new concepts and a significantly new design.

Within this research programme, machines were investigated that fell into all three classes. Discussions with

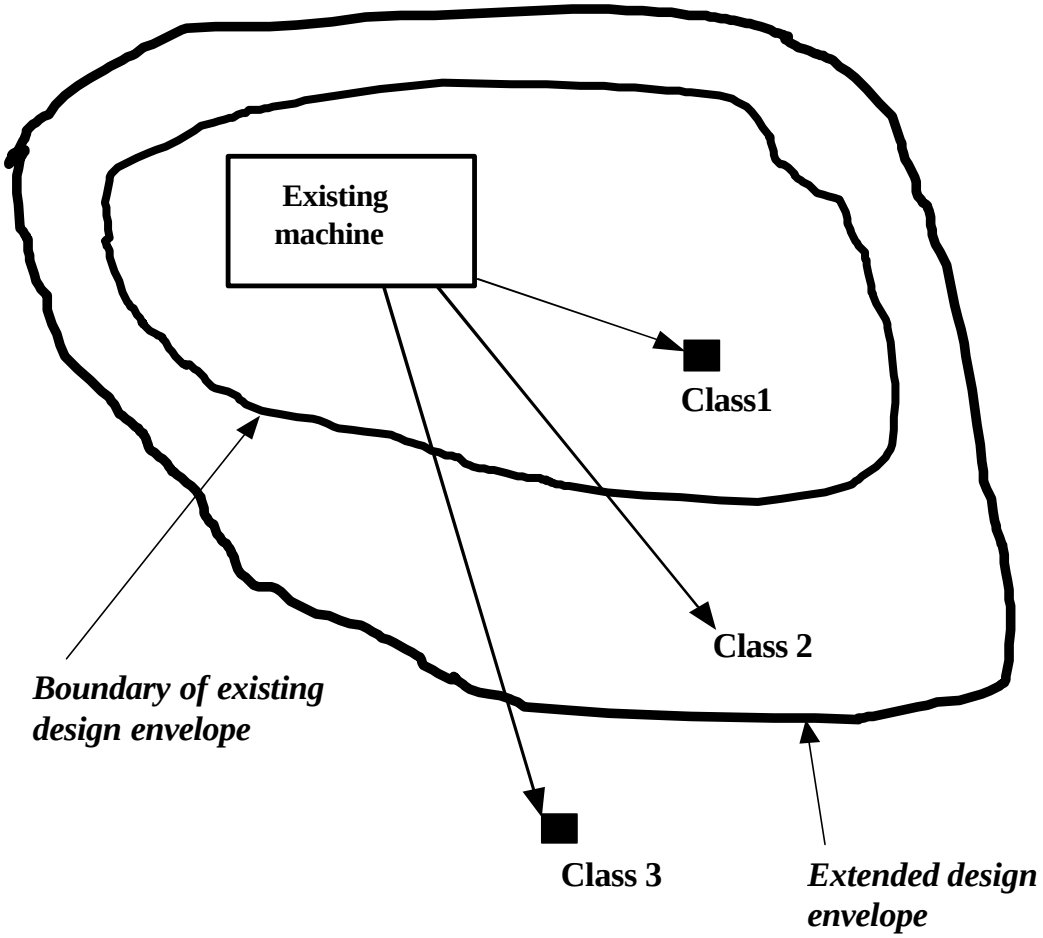


Fig. 2. *Classification of levels of redesign*

the companies have led to various programmes of research and development that have extended the initial capability of the machines. In others the work has led to the creation of a cooperative approach in which new machines and variants could be developed.

## 2. COOPERATIVE DEVELOPMENT PROGRAMME

Two of the original collaborating companies entered into Teaching Company Schemes with the Bath Design Group. In both cases cooperative programmes of development were created. One of these is discussed here.

The company was embarking upon the creation of a new style of packaging machine to meet a set of customer demands. As the Bath team had experience of previous product developments in the company, it was decided that the TCS Associate (a member of the university staff working in the company) would be used, with the support of the academic staff, to undertake a parallel but phased development of a second new prototype. Such an approach had a number of advantages.

- ?? It firstly allowed the original prototype design to proceed in a normal manner to meet the customer's needs and deadlines. The new approach was designed to cause the minimum of disturbance to the design office's normal approach.
- ?? As many of the design requirements and objectives were well understood by the designers, many were not written down in a formal specification. Only the customer and performance specification were formalised. This cooperative approach allowed the Associate to gather this additional information and company knowledge by working alongside the design team. Without their experience many mistakes and redesigns would have occurred.
- ?? Key elements of the design could be considered in more detail whilst the overall design of the original prototype was being advanced.

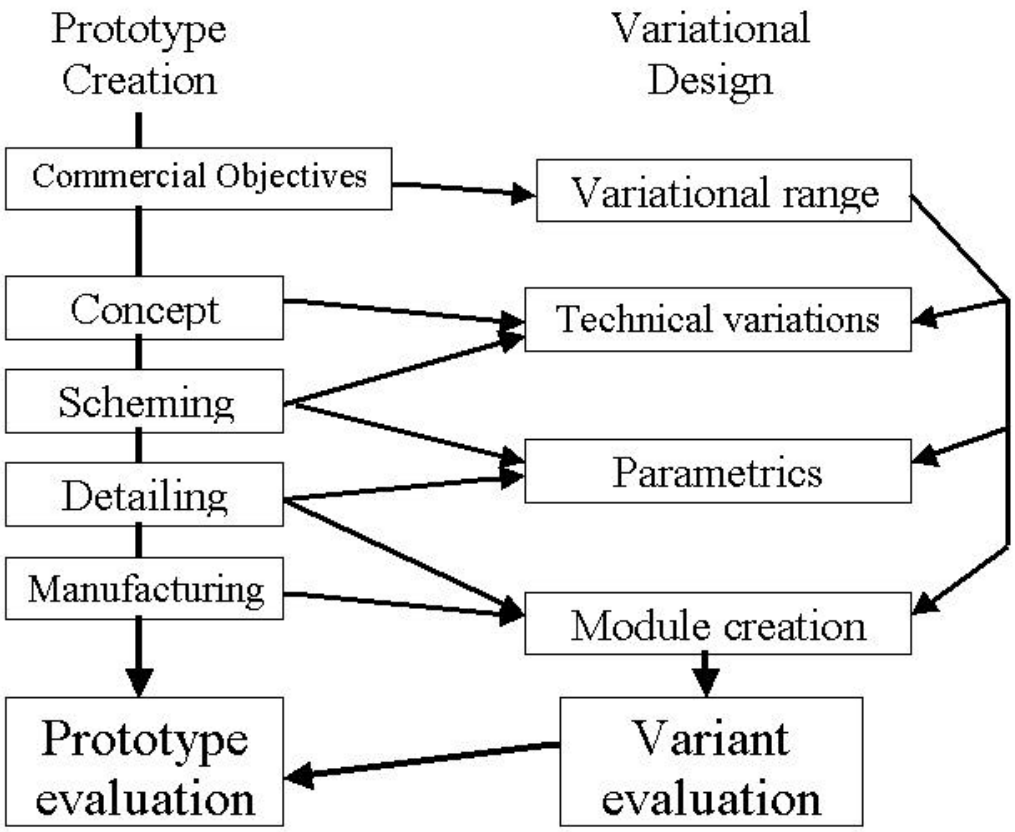


Fig. 3. *The cooperative development approach*

Any improvement, discovered during this analysis could be fed back to the designers.

?? Changes in some of the key elements could also be investigated in order to improve or optimise the performance of the machine. Similarly changes could be considered that may change the area of application. With this occurring during the period that the first prototype was still being developed, the opportunity existed to make agreed changes to some elements in order that these alternative or extended modules could be fitted into the spaces allocated within the main design.

The cooperative product development approach, as shown in Figure 3, was created to allow the original prototype development to be undertaken within the company's existing design approach. As second prototype was seen to be developed alongside in which the wider issues of performance and product range were considered.

The development of the two prototypes took place in a collaborative and not a competitive manner. The programme on the left is created to allow the designers to advance rapidly for the commercial objectives through to the creation of a prototype that can be both evaluated and demonstrated to the customer. Early agreement from the customer is important if time is not to be wasted in the detailed development of a machine that the customer will not purchase.

The right hand programme aimed to use and incorporate its findings to create a variation of the original machine. The second prototype is thus not a second design but one that incorporates variants of the original. These variants can then be incorporated into the final production version either as core units or as the basis for different models or applications.

## 3. DEVELOPMENT PROGRAMME

The original prototype machine is now being developed and has been demonstrated to a number of potential customers.

The parallel variational study has reached the stage where a new core drive module has been designed and is currently being built for evaluation. This core drive module has been optimised to minimise the forces during critical regions of lifting and control operations. The opportunity has also been taken to evaluate changes to simplify or indeed remove elements from the machine assembly to make maintenance and adaptation easier. Once assembled into the second machine these changes will be evaluated alongside the original machine.

The other aspects of the variational study have allowed the rules of these key units to be collected and parametric models generated in the constraint modelling environment. Not only did these lead to the concepts and form of the modified core drive unit, but also they have led to a broader study of the use being made by the company of parametrics for the design of its change parts.

## 4. CONCLUSIONS

The objective of this study was to create an approach that would allow a company to incorporate more advanced design techniques into the development of new products and variations of its existing product range.

Such techniques are necessary if a company is to move away from a programme of continuous adaptation of its products to meet new customer needs. This 'one-off and adapting' approach to design, whilst being in the past very successful, is highly dependent upon designer skills and experience. As the requirements advance it becomes more and more difficult to achieve the advancing needs for performance improvements. It also increases the problems of supporting a wider and wider range of product variants out in the field over a relatively long product lifetime.

Through this study the company has been provided with both a greater technical knowledge of the new products it is developing and techniques by which they themselves can explore and develop them. This provides the design team with the ability to be better able to predict what the customer is likely to require as the next development and able to evaluate whether their existing designs can be modified to meet it. They will also become increasingly aware of where they will meet the limits of their existing designs and in what directions they will need to search for new design approaches.

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