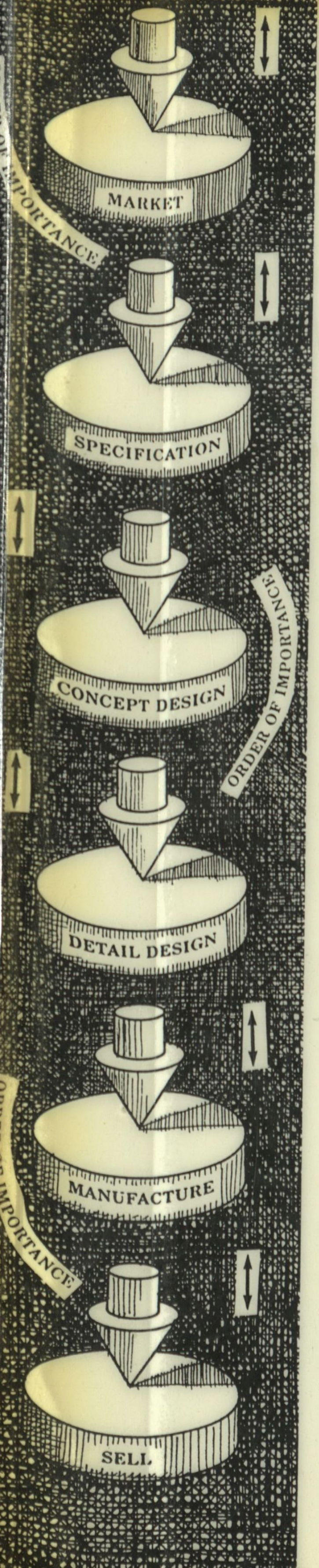
TOTAL DESIGN



INTEGRATED METHODS FOR SUCCESSFUL PRODUCT ENGINEERING

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No mention has yet been made of technology or science or specific areas of design operation because, to this stage, it has not been necessary to do so.

To enable design to be practised effectively and efficiently, it becomes necessary to utilize techniques, to enable the designer or design team to operate the core activity. These are techniques *directly related* to the design core. They are the designer's tool-kit, the necessary tools to enable design to be done. These are shown as inputs to the core in Figure 1.6. They may be techniques of analysis, synthesis, decision making, modelling, etc., applicable to any product or technology, and are therefore *independent* of discipline or technology.

An engineering course will provide, or have provided, specific discipline-*dependent* techniques and technological knowledge such as stress analysis, thermodynamic analysis, information on materials, electronics, hydraulics and the like. You need these to be able to function as an engineer – they are essential inputs into the design core. The effect of adding these technological aspects to the core is shown in Figure 1.7.

So, we have arrived at a broad design core, always enveloped by the PDS, and with inputs from the two types of tool-kit – that is, discipline/technology dependent and independent. We have now reached the stage where we must refer to, and involve, technology on a wider front, to bring the whole design activity to life. To this point, it is a lifeless, inert activity, and will remain so until it is applied in a context where a need exists in some product or process area.

It is at this point that we 'go live' and need to focus on a product area proper – for example, razor, nuclear power station, building, bridge, dustbin or motor car. Specific techniques and technological information will always form the major part of all engineering degree courses, and it is essential that knowledge, understanding and prowess is gained in their use. Teaching in these areas of partial design should be related to the given model of the total design activity. Thus, teaching in total design will enable you to exercise your own prowess to the full, given the opportunity.

It is essential to consider and understand 'the whole' as the total design package concerned with the creation of products. Place this within the framework of planning and organization, as shown in Figure 1.8, and you will begin to gain some idea of the way products should be designed, and how they fit into a business structure.

If total design in an engineering course adheres to this pattern, as your knowledge and understanding of engineering broadens and expands, this will lead to increased engineering rigour, which will enhance total design rigour.

This book is primarily concerned with technology-independent methods presented in a coherent and visible structure.

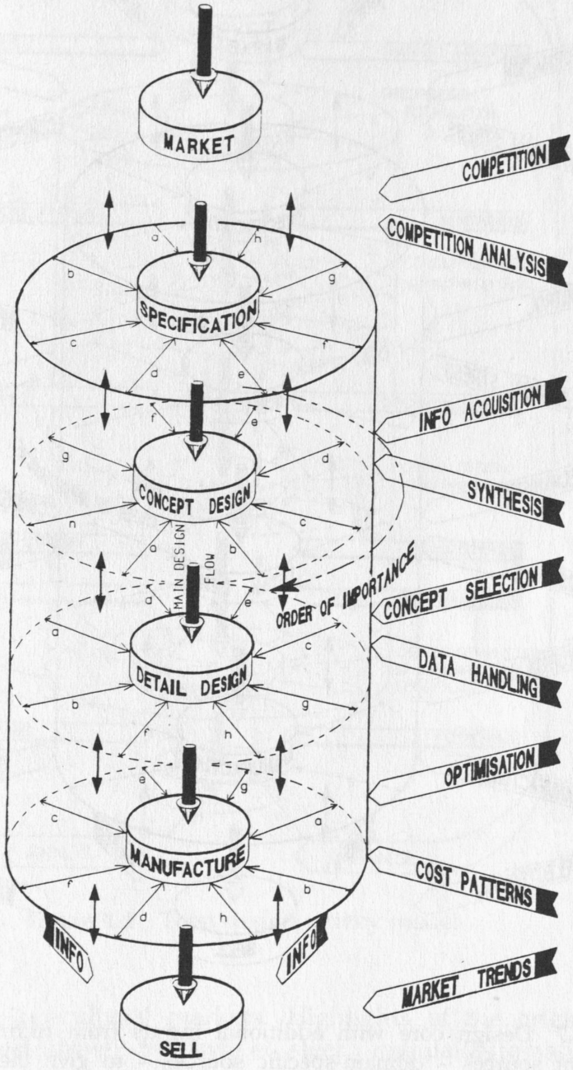

Figure 1.6 Design core with inputs from discipline-independent methods.

stimulates the emergence of new concepts, which might not have emerged by other means.

The design environment is discussed further in Chapter 9, in the context of design management.

4.8 Concept Evaluation/Generation

Experience gained over many projects both in industry and associated with industry has led to the conclusion that matrices in general are probably the best way of structuring or representing an evalution procedure, in that they give structure and control to the process. A common facet of all such matrices is the evaluation of alternative solutions against criteria that have been identified as being significant, with the specific purpose of identifying those alternatives that best satisfy the criteria. The type of matrix referred to here is not a mathematical matrix; it is simply a format for expressing ideas and the criteria for the evaluation of these ideas in a visible, user-friendly fashion.

4.8.1 Method of controlled convergence

The purpose of any method of evaluation is to allow design principles to emerge visibly in a context and to be articulated. The method of controlled convergence (Pugh, 1981) has been devised on this basis, out of a necessity to select actual concepts in practice with greater certainty of success, which other methods failed to do. The method utilizes directly one leg of the matrix to express the criteria for selection on the vertical axis. The horizontal axis is used to express the concepts.

A major advantage of controlled convergence over other matrix selection methods is that it allows alternate convergent (analytic) and divergent (synthetic) thinking to occur, since as the reasoning proceeds and a reduction in the number of concepts comes about for rational reasons, new concepts are generated. It is alternately a generative (creative) and a selection process. An essential feature of this approach is the comparison of each alternative concept, in turn, with a *peer* concept in such a manner as to render a fixed viewpoint on any one concept impossible.

The method also makes it difficult for people to push their own ideas for irrational reasons. This variable viewpoint, together with deliberate attempts to eliminate the bad features of some apparently less acceptable concepts in relation to the peer concept, forces the

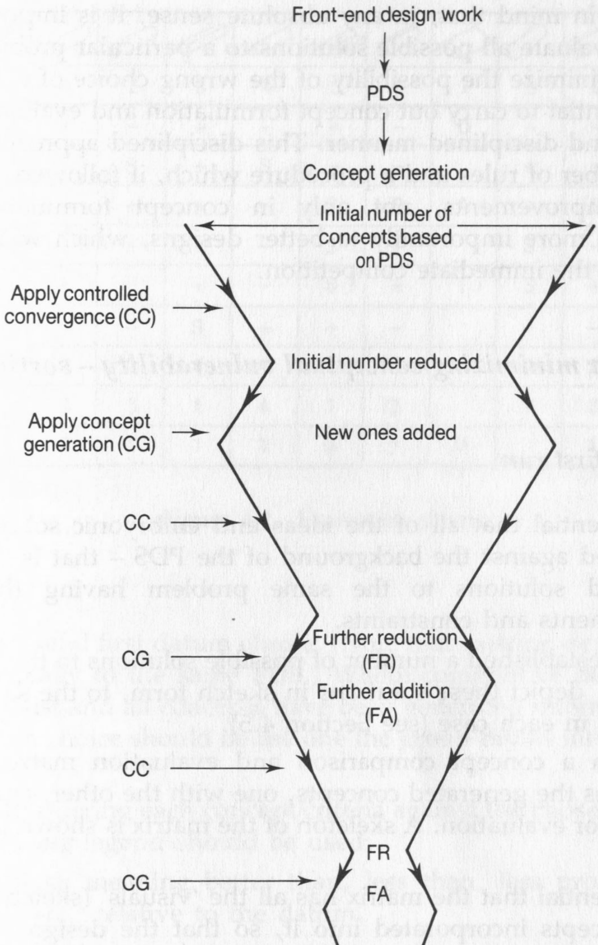

Figure 4.1 Flexible approach to concept generation and selection.

emergence of new concepts in a unique manner. As the method is iterative, continued iteration alternately expands and contracts the matrix until such time as the best concepts emerge, and one has converged on to the concept(s) (Figure 4.1).

A peer concept is the one that is considered the best; that is, the one most likely to meet the constraints of the PDS in the most effective manner.

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