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Method and Process used in Engineering Design

Engineering Design requires efficient and careful consideration to solve technical problems related to the satisfaction of human needs. A simple definition of design is to create according to a plan for a particular purpose. Design usually starts with a loosely defined problem for which many possible solutions exist. The engineering design process, which can be viewed as a particular type of problem solving, is an orderly, systematic approach involving iteration and decision making at each step. It can be illustrate by using flow chats or steps. They contain four main phases in order to avoid any risks occurring and help the design process successful. The four main phases are clarification of the task, conceptual design, embodiment design and detail design as shown in fig. 1 and fig. 2. The steps listed below represent one of the many possible ways of subdividing the design process. It is important to emphasize that the solution process is both sequential and highly iterative in nature.

1. Identifying the need
2. Defining the problem
3. Gathering information
4. Determining constraints and setting criteria
5. Generating alternative solutions
6. Analyzing the possibilities
7. Deciding the course of action
8. Specifying and communicating the solution
9. Implementing the decision
10. Verifying and evaluating the result

Identifying the Need

The design process begins with someone identifying a need. Needs may be related to consumer demand for products and services and be driven by private industries desire to produce profits. Alternatively, needs may arise as a consequence of government policy. In any case, it is usually not the designer who initially identifies the need to be satisfied.

Defining the Problem

Once a need is identified, the initial task of the designer is to clarify what the client really wants, which involves understanding and defining the real or root problem. This is essential prior to translating the client's needs into a conceptual form that will ultimately lead to a satisfactory solution subject to design problem constraints. In this phase of the design process it is critical that the designer work with the client to ensure that the needs are truly understood. In practice, defining the problem requires communications involving client, users, and designers.

Gathering Information

This step of the design process involves the gathering and processing of information pertinent to the project. Typically, the client will often have some relevant knowledge of use in solving the problem. It may involve consulting with other people about the problem. Some of the sources of information are readily available include libraries, government documents, professional organizations, journals, catalogs, experts, and the Web. It is important to verify information by cross checking and referencing data, facts, and figures.

Determining constraints and setting criteria

Limits or restrictions on the form of a solution are commonly referred to as problem constraints. Constraints are often associated with limited resources. Typical constraints are listed below:

- Budget
- Time
- Personnel
- Legal
- Material properties and availability
- Off-the-shelf components versus customized design
- Competition
- Manufacturability

Design criteria are attributes or project goals that enable comparison to be made among alternative solutions. Typical design criteria are listed below.

- Cost
- Quality
- Reliability
- Maintainability
- Weight
- Performance
- Human factors
- Aesthetics
- Safety
- Operating environment (temperature, pressure, corrosion)
- Compatibility with other systems
- Effect on environment (e.g. pollution)

Generating alternative solutions

Inherently, idea generation and the search for alternative solutions is a creative process that cannot be accomplished simply by following a prescribed algorithm. Brainstorming is one technique commonly employed by a team to generate a range of possible solutions. It is important to ensure that judgment of any ideas is reserved until the session has been completed. At this point in the process, members of the design team should encourage each other to challenge basic assumptions, consider analogies, identify critical parameters, and, in addition to considering novel alternatives, be imaginative in rearranging, recombining, or eliminating existing components or process steps.

Analyzing the possibilities

At this step, the alternative solutions are analysed to determine the best solution in light of available knowledge and criteria. Analysis involves the use of mathematical and engineering principles, the laws of economics, and common sense to determine performance capability. Judgment must be exercised in selecting the method of analysis, which could range from simple and quick hand calculations to complex, costly and involve computer analyses. More accurate results that take longer to obtain may be meaningless, depending on critical deadlines and milestones in the project schedule. In addition, the reliability of the data and results will often be dependent on the amount of money allotted to the analysis.

Deciding the course of action

In the decision making stage of the design process, information obtained during design analysis is used to identify the best solutions. The need to compromise is what can make reaching a decision so difficult. One approach to identifying the best solutions is to list the advantages and disadvantages of each option. A more quantitative approach is to use an evaluation matrix. Decision making can also be based on more sophisticated optimization methods.

Specifying and communicating the solution

In the specification step, the best solution is conveyed to others in sufficient technical detail to enable construction or implementation. Depending on the project, this may require detailed documentation of cost analysis, materials specifications and any other pertinent standards or specifications concerning. Effective communication is required throughout the whole of the design process. In essence, it involves selling, explaining, clarifying and, when necessary, persuading others of the worthiness of ideas. It may take the form of informal conversation, oral presentations, or formal project reports.

Implementing the decision

Typically, this phase begins with the construction of a prototype product, process, or system based on the technical specifications describing the best solution. Results obtained from testing of the prototype are used to refine and finalize the design. The next step may be to implement a full-scale version of the design. At this stage the designer will likely be interacting with engineers about the next stage of the process involved in a variety of business and management functions.

Verifying and evaluating the result

The final step in the engineering design process is to verify and evaluate the solution at the large-scale operating or production level. This generally requires sampling or otherwise testing the product, process, or system to confirm the design specifications are being met in practice. Typically, corrections and further refinement of the design will be required before the optimum design is arrived at. Due to technology changes so rapidly, the closing step of the design process often marks the start of a new design process in search of the next generation of products, processes, and systems. New designs may be motivated by improved manufacturing techniques, substitution of better materials with superior properties, or product designs better able to satisfy the latest market requirements.

References

- Eide, A.R., Jenison, R.D., Mashaw, L.H., and Northrup, L.L.,Engineering Fundamentals and Problem Solving, Second Edition, McGraw-Hill, NY (1986)
- Holtzapple, M.T. and Reece, W.D., Foundations of Engineering, McGraw-Hill, NY (2000)
- Fogler, H.S. and LeBlanc, S.E., Strategies for Creative Problem Solving, Prentice Hall, NJ, (1995)
- Dym C.L. and Little, P., Engineering Design: A Problem-Based Introduction, John Wiley & Sons, NY (2000)

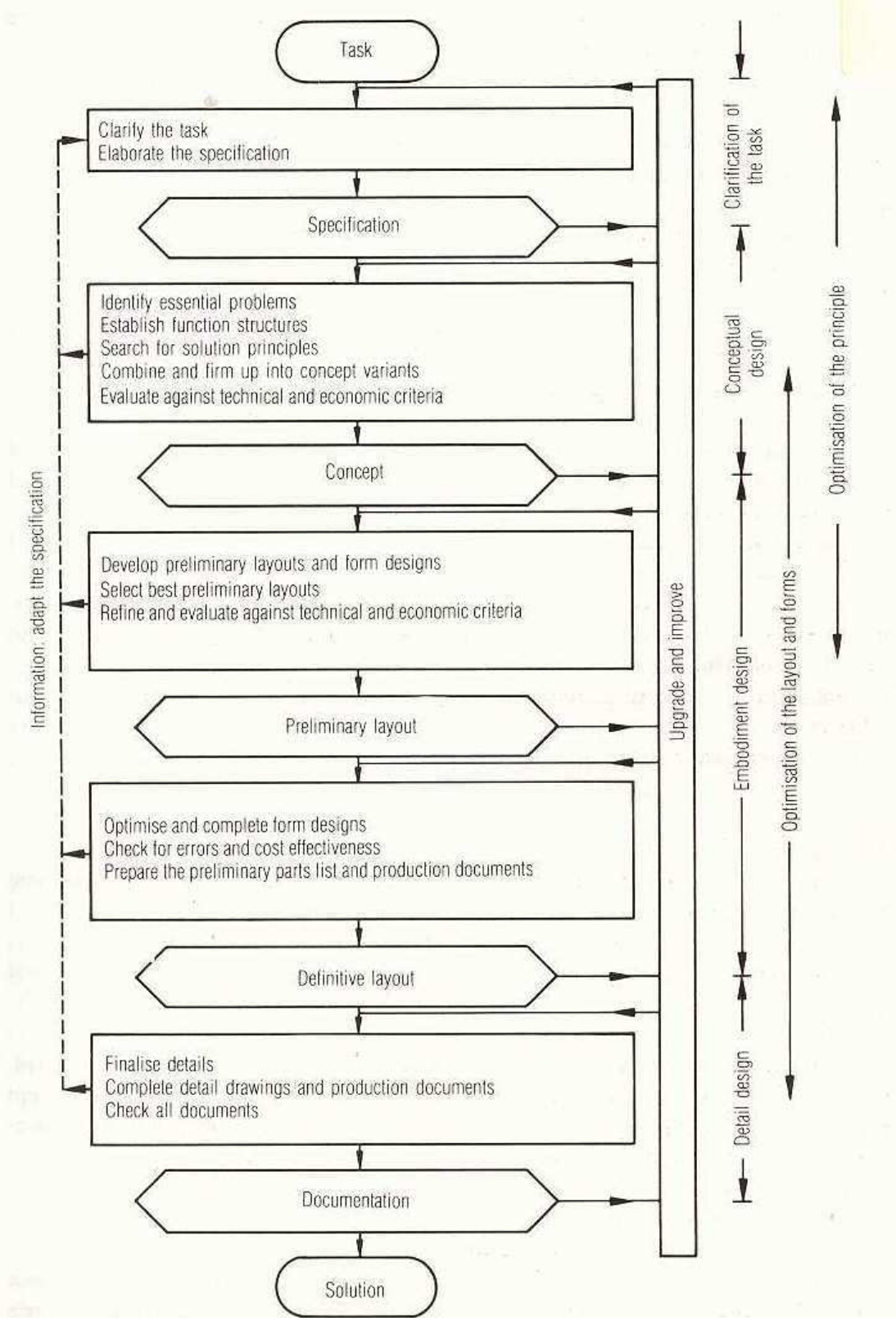

Fig.1 - Steps of the design process

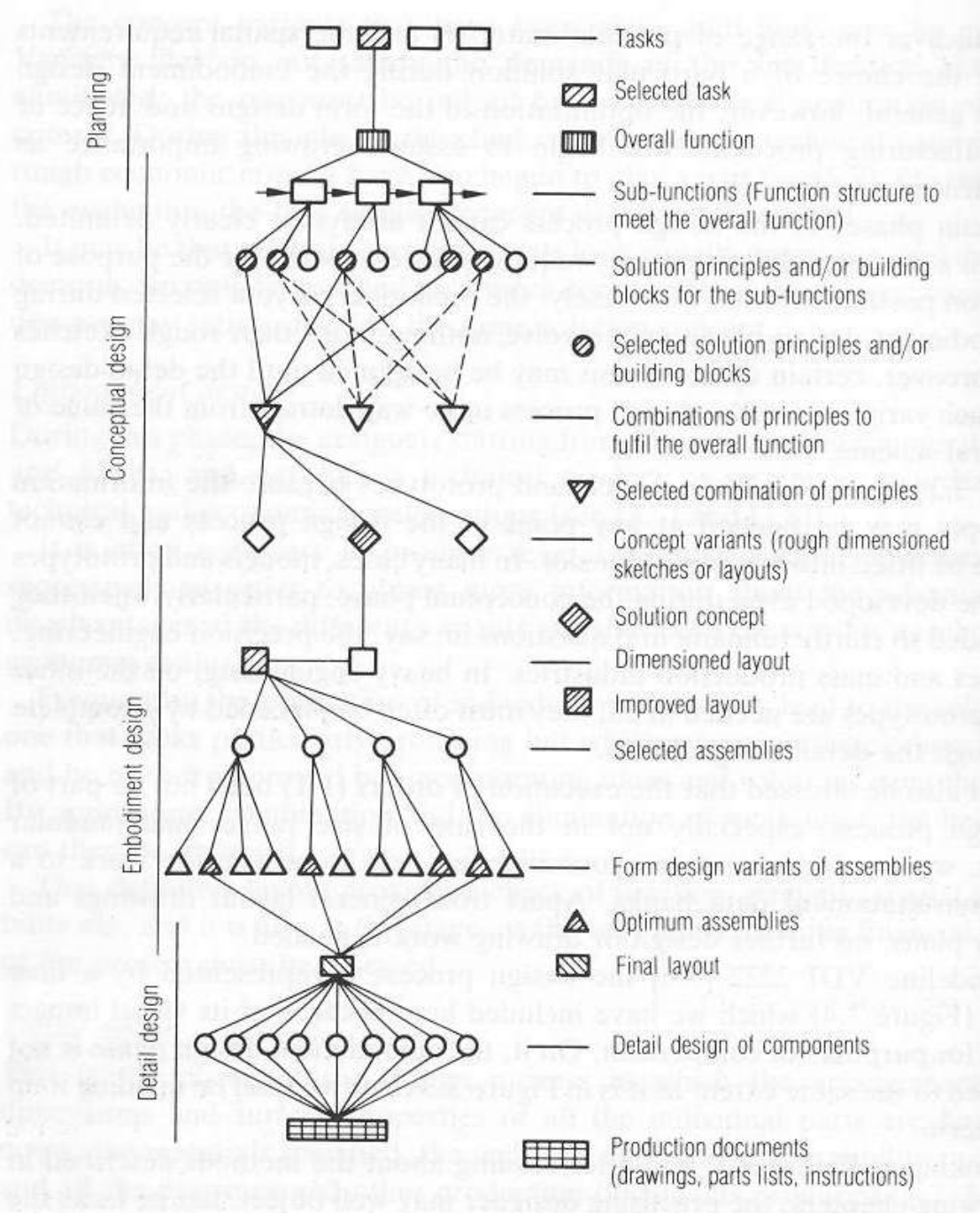

Fig. 2 - Flow diagram of the design process