STANDPOINTS ABOUT THE MANAGEMENT OF PRODUCTS DESIGN

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Abstract

In this paper the engineering design process is defined and the Product Design Specification is detailed. Subjects covered include form design, design for manufacture and assembly, materials and process for powder products selection. In general the simplest solution is the best and all professional engineers seek elegant and simple solutions. Design is not solely the achieving of technical solutions but also creating useful products which satisfy and appeal to their users. So along with the engineering science knowledge used the importance of communication, teamwork an project management cannot be underestimated.

Keywords: products, form design, project management.

1. Introduction

Engineering design is the total activity necessary to establish and define solutions to problems not solved before, or new solutions to problems which have previously been solved in a different way. The engineering designer uses intellectual ability to apply scientific knowledge and ensures the product satisfied an agreed market need and product design specification whilst permitting manufacture by the optimum method. The design activity is not complete until the resulting product is in use providing an acceptable level of performance and with clearly identified methods of disposal.

The main characteristics of engineering design:

- transdisciplinary;
- highly complex;
- iterative.

The cost of a product, particulary in international markets, is only one factor which has a bearing success. Reliability, fitness for purpose, delivery, ease of maintenance and many other factors have a significant influence and many of these are determined by design. Good designe is therefore critical for success both in national and export markets and can only be ensured by adherence to a formal design process. The engineering design process in its simplest form is a general problem solving process which can be applied to any number of classes of problem, not just engineering design. It must be remembered that the design process as outlined will not produce any design solutions. The aim in recommending a design process to adopt is to support the designer by providing a framework or methodology. A systematic approach permits a clear and logical record of development of a design. This is useful if the product undergoes development and redesign. The first and important stage in the design process is the formulation of Product Design Specification (PDS). This is especially important as international trade becomes simpler and competitiveness becomes harder to achieve. Companies must use a logical and comprehensive approach to design if they are to profit from their labours.

2. Engineering design interfaces

As explained earlier the design process begins with a design brief or Product Design Specification. This then is the major trigger which causes the design department to act. Two broad types of communications can be identified, internal and external. Those internal communications with the design department may include defining input parameters for computation, discussion and information transfer with other relevant design groups, informing the drawing office by such means as scheme drawings and materials specifications, gaining approval for proposals from the originator and answering the questions of reviewers at design audit meetings. In detail, the types of communication with other departments and outside are: sales, purchasing, analysis/specialists, manufacturing, development. There is continuous two way communication between the design and sales departments. The sales department supply customer requirements and the design department supplies technical descriptions, performance data and predictions. This is generally one way communication with the design department supplying the technical information essential for the purchasing department to buy in components. Within companies there are many specialists who are often consulted by the design team. These may include standards, materials and stress analysis experts, amongst many others. During all design review meetings at least one representative of manufacturing department will be present to ensure optimum manufacturing methods are beeing specified by the design team. This is part of what has become known as concurrent engineering, which serves to shorten the time taken from initial concept to the production of the first products for sale. In smaller companies design and development form one department which is an indication of how closely linked the two departments are. In the development department tests are carried out on particular aspects of design concepts generally by manufacturing the design and performing accelerated tests or by simulations. The results of these tests are fed back to the design team. As a prelude to writing the PDS much research must be carried out and much information gathered.

3. Product design specification criteria

The five main criterias are: performance requirements, manufacture requirements, acceptance standards, disposal and operation requirements (fig. 1). There may only be a single main function which is to be provided by the product to be designed but this in unusual. More often than not multiple functions can be identified which can be divided into primary and secondary functions.

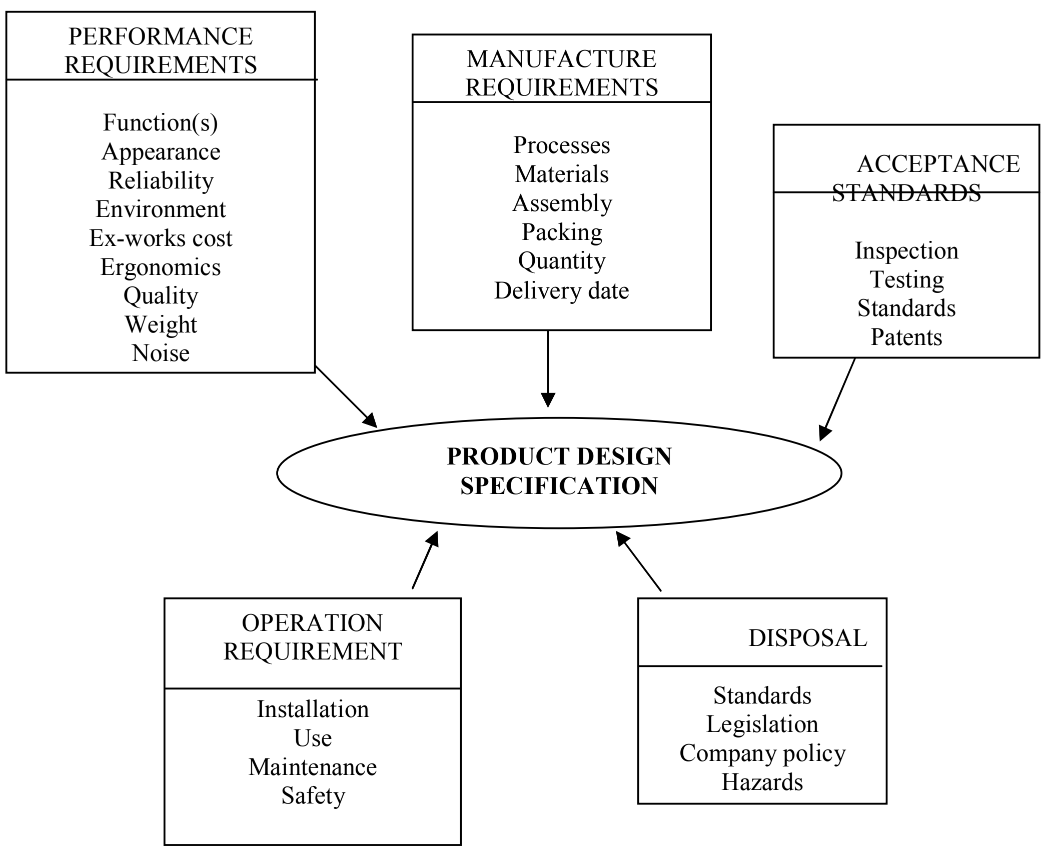


Fig. 1. Product Design Specification criteria

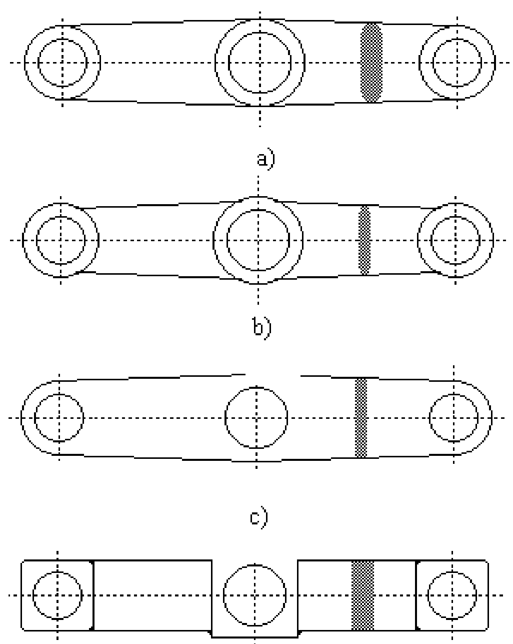
These can vary in nature from mechanical, electrical, optical, thermal, magnetic and acoustic functions. In some instance this is not important, particularly where the device or the structure is not seen. However, for many consumer products or structures a pleasing elegant design is required and colour, shape, form and texture should be specified. The required design life, taking due account of routine maintenance, must be specified. This is usually done by specifying the number of operating cycles rather than in units of time. Within this number of cycles an acceptable level (%) of random failures or breakdowns is also specified.

These include the temperature range, pressure range, magnetic and chemical environmental conditions to which the product will be exposed. It is important to consider manufacture, store and transport environmental conditions along with the more obvious operating conditions. Companies sell products for the maximum price the market will stand which often bears little relation to the cost of producing that product. Hence, the maximum cost specified in the PDS and which the design team must work to, should be the production cost and not the selling price. If a product is intended for human use then accountmust be taken of the characteristics of those users. The design of the product and the tasks required of the product and the users must reflect their respective capabilities. The quality of the product should meet market requirements and the quality of all components should consistent. All workmanship must be in accordance with the best commercial practices. All materials and components shall be new and free from defects. In some industries, such as aerospace, this is the most critical constraint. However, this is not always the case and weight is not always required to be a minimum. The many criteria which must be consideres are corrosion and wear resistance, flammability, density, hardness, texture, colour, aesthetics and recyclability. There are also many regulations governing the use of hazardous materials which must be included in the specification if relevant. The maximum size and weight for convenient transportation must be specified. Shapecan also be important since stacking products together can reduce transport costs substantially. The cost of packing and shipment must be added to the ex-works cost to ensure that the product remains competitive wherever it is used. The projected quantity of a product which will be sold can have a effect on the manufacturing methods and materials used. This particularly influences the appropriate levels of tooling, with large quantities justifying expensive tooling. It is important that realistic timescales are set for each stage of the design and production process. This is particularly important when a delivery date has been agreed with a customer and costly penalties for late delivery are built into the contract. Hence, the date by which each stage of the process is to be completed must be specified at the outset. The PDS of a single complex system which is to be designed and produced to an agreed contract will state dates by which the design, manufacture, erection, testing, commissioning and hand over of the fully working installation are to be completed.

The degree of conformance to standards must be specified in accordance with relevant legislation and the objectives set in the PDS. The degree of conformance required to tolerances as stated within the rest of the specification must also be specified. The methods of verification for the product should be specified along with the timescales for carrying out the necessary tests. It is usual on completion that acceptance tests are carried out in the presence of the customer. Individual country or international standards for disposal of products and materials must be listed in the PDS.

4. Form design

Once some shape and body begins to emerge then the modelling, analysis and synthesis process can begin. It is important that, during this phase, some provisional thought centres on the likely manufacturing and assembly processes. Consider the design of a lever which must have a central pivot and two guide holes at its extremities. The likely manufacturing processes to be considered are casting, die forging, hammer forging and welding. Fig. 2. indicates how the cross section and overall shape would be influenced by each process.



a) – cast iron

b) – die forged steel

c) - hammer forged steel

d) - welded steel

Fig. 2. Alternative manufacturing processes for lever

Cast iron is not as strong in tension and bending as steel so more material is required and the cross section must be much ticker. Die forged steel will use the least material of all.

The decision as to which manufacturing process to choose is always significantly influenced by the quantities to be manufactured. A graph of manufacturing cost against quantity is gevin in fig. 3. Clearly for large quantities die forging using dies is the cheapest quantities then a welded construction is problably best. Load paths have a great influence on the shape and forme of components. The ideal is often to try and design so that components are subjected to pure tension and compression.

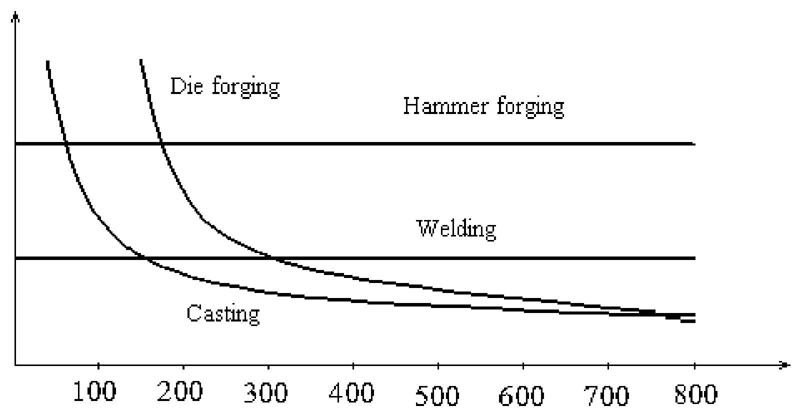


Fig. 3. Influence of quantity on cost

For example, one very common design of a component for translating reciprocating horizontal motion into reciprocating vertical motion is the rocking lever. However, as ilustrated in Fig. 4 (a), this design has to be reletively thick to prevent defection due to bending. The alternative in Fig. 4 (b), which at first sight look wrong because we do not commonly see designs like it, can involve 50% less material because bending is almost completely designed out. Material and process selection is an integral part of the engineering design decision-making processes. The proper use of materials leads to increased product performance, greater efficiency and reduced costs, resulting in increased competitiveness for companies. Engineering ceramics continue to replace more traditional engineering materials in a wide range of applications. This is due mainly to their excellent corrosion resistance at both high and low temperatures. An example is silicon carbide which is being used for the pump bearings, providing prolonged life and reducing the need for lubrication. Over the last five years the reliable strength of ceramics has doubled, plastics can be made fire resistant and cast metals can be processed to have the properties of forgings. At the limits of science and technology, materials are being developed for specific tasks. These are specialized materials with little general applicability. In such circumstances the material the designer must employ in the solution would form one of the constraints in the specification. If the specification is thorough and complete, the selection of material and process should be clearly constrained.

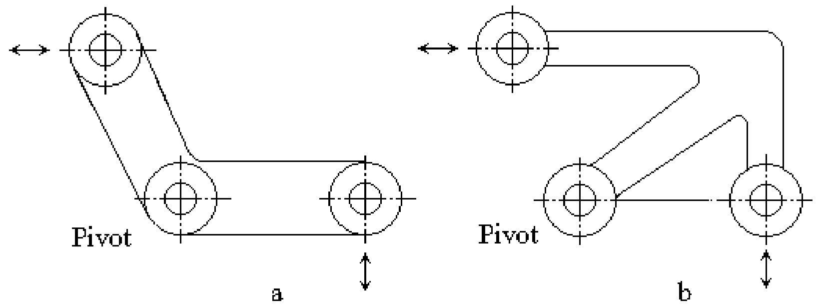


Fig. 4. Modern rocking lever:
a) – thick to prevent bending
b) – little or no bending

However, their use has been restricted due to high production costs. As alternative production methods to hand lay up, such as resin transfer moulding and sheet moulding compound reduce the production cost so the use of composite materials will extend beyond specialized components. As an example, composite leaf springs are now quite common since they are much lighter than steel ones, are inherently corrosion resistant, have a better fatigue life and a gradual rather than sudden failure mode.

5. Conclusions

Identify the optimun manufacturing method at the earliest possible stage taking of quantities to be manufactured, strength requirements, weight restrictions and any other relevant factors. Take careful note of the size of components and design shape and form to suit. When a new product is launched there are many uncertainties and will be a brave designer who will experiment with a new or unfamiliar material or who will push the material to the limit of its performance.

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