Imperial College London

Week 7 – Workshop 1: Product Design Specification

EE1-13 Engineering Design and Practice
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TASK:

This hand-out has been compiled in order to help you prepare for the small group workshops taking place next week (Week 7).

Please read through this document and the PPT provided **ahead** of your timetabled workshop session. Once you have read and understood the Product Design Specification:

- highlight the 10 elements you think are the most relevant to the EERover project
- provide a rationale for your decision
- be ready to discuss with your group during the workshop

1. Introduction

The simplified version of Systems Engineering that will be covered during ED&P was introduced in Week 3. It covers the activities between the time the customer provides their requirements (also known as "brief") until the design has been finalised and is ready for manufacture.

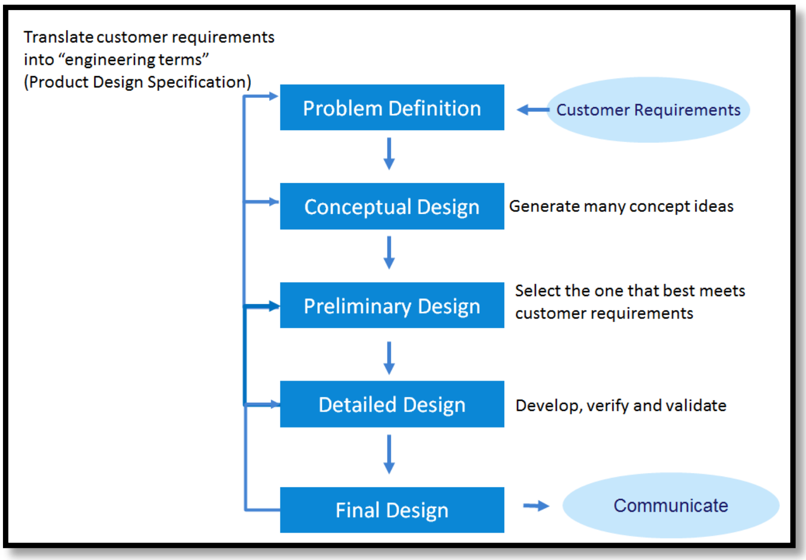

Figure 1

Next week's workshop will cover the Problem Definition phase, with particular emphasis on the Product Design Specification.

2. Problem Definition phase

This is probably the hardest phase of the entire for engineers, particularly if under time constraints. As engineers, our mind-set is to solve problems; however, we have a tendency to start solving the problem without knowing what it really is. In addition, we often believe that we know best (as we have the technical knowledge and know how) and do not involve the customer as much as we should.

Therefore, we might end taking a "Design now, fix it later" approach which will result in increased costs and time delays in the future. But more importantly, might result in a product that no one wants and cannot be sold.

In order to avoid the above scenario, a systematic approach must be used in order to translate the brief into an objective document, also known as Specification.

2.1. Going from "Brief" to "Specification"

The Brief from the client tends to contain the following:

- Errors - incorrect or inaccurate information
- Biases – the problem is perceived from their own limited viewpoint
- Implied solutions - client's (or engineers') idea of how to solve problem and what the ideal solution is

Therefore, the first step in the engineering design process is to translate the brief containing the Customer Requirements into an objective document. This document should contain:

- Operational Requirements: Define the major purpose of the system
- Functional Requirements: Specify what the system has to do to satisfy the Operational Requirements
- Non-Functional Requirements: also known as Constraints. They provide limits to the design space.

One of the many methods to aid in this translation is the Product Design Specification. A comprehensive document that provides unique set of constraints for the particular problem being solved.

2.2. Total Design

Is a methodology formalised by Stuart Pugh (University of Strathclyde) that provides a framework for the creation of innovative products that satisfy the needs of the customer. Based on a core of activities, the engineering design process is presented as systematic and disciplined.

Total design can be defined as "the systematic activity necessary, from the identification of the market/user need, to the selling of the successful product to satisfy that need - an activity that encompasses product, process, people and organisation".

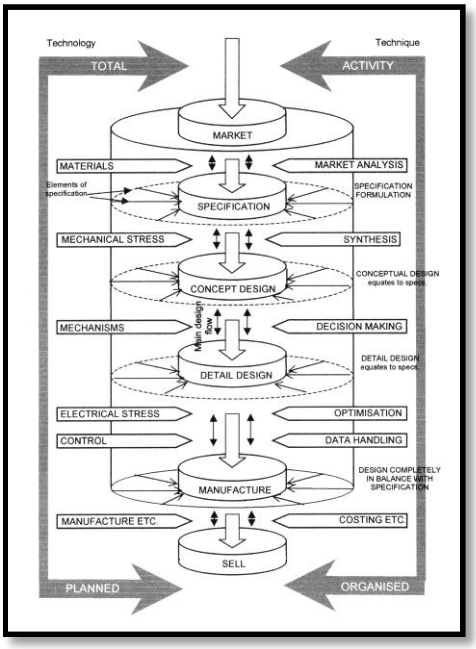

Figure 2

It may be constructed as having a central core of activities, all of which are imperative for any engineering project, irrespective of the domain. This **design core** consists of:

1. user need / market demand
2. product design specification
3. conceptual design
4. detail design
5. manufacture
6. sale

During ED&P we will cover phases 1-4, as detailed in Figure 1.

It requires the input from people of many disciplines, both engineering and non-engineering, working in cross functional teams, in a mix that is almost unique to the product or system under consideration.

3. The Product Design Specification

From the statement of need, a document called the **Product Design Specification** or **PDS** must be formulated. This document embodies the voice of the costumer, its defines a product that does not yet exist (still needs to be designed). Therefore, it specifies a problem, not a solution, as it does not predict an outcome to the design process.

All 32 elements must be considered, even if they overlap with each other or do not apply to your particular project. When completing the PDS, we must be meticulous and thorough. Try to quantify parameters for each of the elements as early as possible in the project. But, rather than making assumptions, leave the relevant elements as “To be defined”; you can add the relevant information once it becomes available.

The PDS document can be real or virtual, depending on your team logistics and company policy. Just like the project plan, it is a dynamic document that you should update it whenever new information is available. By the time the project is finished, you will have multiple versions of the PDS.

Allocate a document and version number, and a date to the original PDS. The version number should be updated whenever any changes are made. Keep copies of all superseded versions, because sometimes the PDS can be a contractual document.

Any changes must be clearly documented and communicated to the rest of the team, as it is the reference for everybody working on the project.

When completing the elements of the PDS, remain concise, clear, factual and objective. Aim to write at most a short paragraph for each element in order for it to remain user friendly and easy to update.

3.1. The Contents of a Product Design Specification

There are 32 elements to the PDS, each of which will be addressed in turn:

3.1.1 Performance

What is the product / system supposed to do?

Performance should be fully defined, e.g., how fast, how slow, how often, continuously vs. discontinuous, energy requirements- electrical, hydraulic, pneumatic, tolerances, etc.

A common failing in specifying performance is to ask for the ultimate, rather than which is obtainable from economical point of view. In practice the client is often amazed that the product emerging from their specifications cost much more than they anticipated.

Beware of "over-specification" of performance, as it will result in compromises in other elements of the PDS. Bear in mind that performance is but one component of the PDS.

2.3.2 Environment

All aspects of the product's likely operating environment should be considered and investigated.

For example:

- temperature range
- pressure range (altitude)
- humidity
- shock loading (gravity forces)
- dirt or dust - how dirty? - how clean?
- noise levers
- insects
- vibration
- type of labour or person who will use the equipment (and maintain it)
- likely degree of abuse or misuse

2.3.3 Life in Service (performance)

How long do you expect the product / system to remain operational?

Against which element(s) of the PDS is (or should) the product life be asserted?

One year on full performance, 24 hours a day, seven days a week or what?

2.3.4 Maintenance

What maintenance does the product / system have to undergo?

How often? Will the user be able to carry out the maintenance or will they need specialised personnel?

Is regular maintenance available or desirable?

Is the market used to maintaining equipment once it purchased?

The following points are relevant:

- Specify easy access to the parts that are likely to require maintenance. It is no good calling for regular maintenance if it takes 10 days to reach the part.
- What is the maintenance and spares philosophy of the company and market?
- What is the likely need and desirability of special tools for maintenance?

2.3.5 Target Product Cost

Target production costs should be established from the outset and checked against existing or like products.

Invariably, all target costs are on the low side, and in many cases they are unattainable within the constraints of the PDS.

If a whole-life costing attitude is being adopted by the company or market area into which you are entering, then this should be considered, with particular reference to maintenance trade-off and down time.

2.3.6 Competition

Which other products / systems are currently available which perform the same function / meet the same need as yours?

A thorough analysis of competition must be carried out, including comprehensive literature search, patents and product literature search relating not only to the proposed product area, but also to analogous product areas.

2.3.7 Shipping

It is necessary to determine how the product will be delivered from the manufacturing plant, to the retailer and to the customer:

- By land, sea or air?
- How will you maintain competitiveness of the product when is shipped overseas.

2.3.8 Packing

Depending on the type of product being designed, some form of packaging may be necessary for the protection, transportation, storage, display, etc.

The cost of packaging will add to the product cost and volume. Should the packaging protect against environmental effects of shipping such as salt water, corrosion, shock-loading, etc.?

2.3.9 Quantity

How many products to be made in one run? How often?

If you are making a one-off it will require very little tooling; however, large production runs may require permanent, expensive tooling. This has considerable effect on the supportive investment required and the plant already existing in-house.

2.3.10 Manufacturing Facilities

What facilities are available within the company for the manufacturing and assembly of the product / system?

Would we need to outsource? Would we need to set up a new facility?

Make-in or buy-out policy: is the product constrained to techniques with which the company is familiar?

2.3.11 Size

Are there any restrictions on the size of the product?

It is acceptable to give a range to begin with, but try to quantify as far as possible.

2.3.12 Weight

What is the desirable weight? Give a range of weight if the exact figure is not yet known.

2.3.13 Aesthetics, Appearance and Finish

The appearance of a product is a difficult thing to specify. Colour, shape, form and texture of finish should always be considered from the outset. However, more details will become available as the project progresses.

The first interaction any user has with a product or system is through their eyes. Therefore, visual performance will always precede functional performance (you only get one chance to make a first impression)

2.3.14 Materials

The choice of materials for a particular product might be dictated by standards or other regulations (for example, medical devices). On other occasions it might be determined by the manufacturing processes available at the time.

Try to provide as much detail as possible.

2.3.15 Product Life Span

Some indication of the life of a product is a marketable entity. Is it likely to remain in production for 2 or 5 years? Do we want to build in obsolescence so that the user changes or upgrades every so often (mobile phones)?

The answer is critical as it can affect the design approach, as well as influencing 2.3.6. Competition, 2.3.10 Manufacturing facility and many others

2.3.16 Standards and Specifications

Is the product to be designed to current international or American Standards 9this will depend on the destination market for the product)? If so, then these should be specified and copies obtained, e.g., OSHA standards, ISO 9000, etc.

2.3.17 Ergonomics

According to the Merriam- Webster dictionary, ergonomics is “an applied science concerned with designing and arranging things people use, so that the people and things interact most efficiently and safely”

Factors to consider are: height, reach, forces and operating torques are acceptable to the user. Postures and lighting should be considered.

Our aim is for the user to be delighted to use or interact with our product. It is essential that potential users are consulted at every stage of the process.

2.3.18 Customer

Who is your intended user? Define age range, height, strength, etc.

Remember that we need to be very clear on who are customers are in order to provide a product or system they actually want to use.

2.3.19 Quality and Reliability

A company must ensure adequate feedback of any failure analysis to the design team. Mean time before failure (MTBF) and mean time before repair (MTBR) are familiar expressions in this field.

2.3.20 Shelf Life (Storage)

What is the maximum time that the product can remain operational while in storage?

Shelf life must be specified at the outset and the means to combat decay considered, otherwise rusty gearboxes, perished rubber components, seized bearings, defective linings, corrosion and general decay will occur.

2.3.21 Processes

If special processes are to be used during manufacture, they should be defined - for example, plating specifications, wiring specifications.

2.3.22 Time-scale

What is the time-scale for the project as a whole? How long do you have between receiving the client brief and the product being commercialised?

This is one of the most important drivers of any project and one of the most rigid constraints, as delivery dates cannot easily be moved.

2.3.23 Testing

Most products require some form of testing after manufacture in order to ensure they are functional and safe. This can be carried out either in the factory, on site or both.

A testing protocol must be written and signed off.

2.3.24 Safety

The safety aspects of the proposed design and its place in the market must be considered. There may be legislation on product liability. Labelling should give adequate warnings. Likely degree of abuse, whether obvious or not, should also be considered. Definitive operating instructions must be prepared.

2.3.25 Company Constraints

These include manufacturing facility constraints, financial and investment constraints, and company philosophy constraints.

2.3.26 Market Constraints

There are different constraints depending on the geographical market of the product (cultural, legal, etc.)

Feedback from the market place should be considered. Otherwise, during the course of the project the market may disappear.

2.3.27 Patents, Literature and Product Data

All areas of likely useful information should be investigated and researched and in particular possible patent clashing should be known about as soon as possible.

It is pointless to design something for sale in ignorance of someone else's patent.

2.3.28 Political and Social Implications

Typical factors include the effect of consumer movements, the stability of the market, and the avoidance of product features that can create social unrest and upset.

2.3.29 Legal

It is essential to consider legal aspects of a design at the PDS stage. Legislation has been adopted for product defects and failure. What would be the legal consequences?

2.3.30 Installation

Many products must interface with other products or be assembled into large products (buildings). Installation therefore must be considered in the PDS. This include fixing holes and lugs, access, the volume available for the product, system compatibility, power compatibility, etc.

How many people will be needed for the assembly? What is their level of expertise?

2.3.31 Documentation

Product documentation is always important in terms of instructions to the user or those responsible for maintenance. For smaller products, it can take the form an instruction leaflet; for more complicated ones, a user manual.

2.3.32 Disposal

How will the product be disposed of after service? Can it be recycled? Can it be dismantled into smaller components that will be reused or recycled (Design for Disassembly)?

If the product contains hazardous or toxic parts, or indeed parts worth reclaiming, these should be considered at the PDS stage.

4. Conclusion

- The PDS is part of the Total Design Methodology
- Defines a product that does not yet exist
- Lists all 32 conditions the product must meet
- Dynamic, concise and user friendly document
- Should be the reference for everybody working on the project

Bibliography

Stuart Pugh, *"Total Design: Integrated Methods for Successful Product Engineering",* Addison Wesley Publishing Company.

Miguel A. Torres "Everything you wanted to know about Design Methodology, but you were afraid to ask", course notes, Centre for Continuous Improvement, University of Puerto Rico at Mayagüez