Materials Selection Principles

At the completion of this subject

(a) explain what is meant by design;

(b) explain the relationship between design and product/service quality;

(c) explain the concept of total design; and

(d) explain the concept of adding value for the customer and the place of design in this.

IMPORTANT REFERENCES

1- Cross, N. 1986, Engineering Design Methods, Wiley, Chichester, ch. 2, The Design Process, pp. 19-31.

2- Gibson, P. , Greenhalgh, P. & Kerr, R. 1995, Manufacturing Management: Principles & Concepts, Chapman Hall, London, ch. 2, The Concept of Added Value, pp. 21-46.

3- Pugh, S. (1991) Total Design: Integrated Methods for Successful Product Engineering. Addison-Wesley Publishing, Reading, MA.

MATERIALS SELECTION

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The term of MATERIALS SELECTION is very complex and advanced field. It requires an open mind, scientific knowledge, understanding many engineering disciplines, decisions and the most important mentality for design.

Materials Selection enhances our life and directly responsible for the era of TECNOLOGY.

A core issue is whether Iraqi industry is exploiting the growth opportunities or not, still the Materials Selection plays a vital role to cope with worldwide community.

Defining of Materials Selection is not easy especially for the beginner. It does not only understand it by study. It needs highly qualified personals with high experience. By the end of the course we will learn what is meant simply by Materials Selection. It develops everything around us. I mean All Products and All Services. It gives pleasure, easy and even care of our life. Simply, if any one compare for the life style within for

example the last ten years, the responsible for that is only Materials Selection.

It is very important to keep in your mind that Materials Selection is a chin activates. Every chin should be understood separately and collectively to reach to the final Goal.

In this course we try to simplify the issue as possible. The first thing to be not forgetting that there is a highly difference between Materials Selection and Selection of Materials.

Selection of Materials or Selection of Manufacturing process is only part of the Materials Selection.

The most important <u>SYSTEM</u> is the Materials Selection.

THE TERM SYSTEM WILL BE LEARNED IN THE TUTORIAL.

<u>THINKING IN MATERIALS SELECTION</u>

"Every day billions of peoples wake up, they press one or more electric switches. Electric current will produce many activates such as heat, light, sound and picture … etc. The flow of the current will takes place by conductor wire such as copper to obtain the final activity. If the activity is light, it means at least require a bulb contains many engineering materials not less than 13 (will explain later). Within the next two months the weather becomes cold and electric fire will use which contains heat resistance alloys or ceramics to generate heat and light. Every day activates need different functions starting from the home, business, restaurant, travelling, hospital, theater, hotel, workshop, and meeting ….. etc. If you

examine any of these, you will find that infinity millions of products and services are operated. The secrete behind these is successes of Materials Selection. This is the answer why the human life changes dramatically within the last twenty years.

The objectives of the course

- **Improve the student practical experience in the thinking, search, and analysis of solving the problems scientifically.**
- **Provide the student hands-on experiences in materials engineering and manufacturing processing through laboratory experiments.**
- **Enhance the student methodologies for creating a successful project.**
- **Open the student thinking in the network of product and services.**

Philosophy of Materials Selection

The key point is the design. The objective of any particles work dealing with the manufacture of products or services is to produce components that will adequately perform their designated task.

Ideal design is one that will just meet all requirements.

Anything better tends to waste money or materials.

Anything worse leads to fail during manufacturing or service.

Original design starts from a new concept and develops the information necessary to implement it. Evolutionary design (or redesign) starts with an existing product and seeks to change it in ways that increase its performance, reduce its cost, or both.

Original design starts from scratch. It involves a new idea or working principle.
Original design can be stimulated by new materials. Sometimes the new material suggests

the new product. Sometimes instead the new product demands the development of a new material.

Design process is needed to be understood by using the design flow chart.

It covers all the interaction of at least three Ps from the materials selection Ps. It shows the market need (sometimes: a new idea) up to product specification.

It shows also all the stages between the input and the output.

Any scientific design process involves at least three stages:

1- Idea or conceptual design.
2- Embodiment or engineering or functional design.
3- Product or detailed design.

It should be noted that complete these stages does not mean that the materials selection process is finished.

These lead generally to production of prototype. Detailed analyses are needed before final mass production stage.

At the conceptual design stage, all options are open, the designer considers alternative concepts (ideas) and the ways in which these might be separated or combined.

The next stage, embodiment, takes the promising concepts and seeks to analyze their operation at an approximate level. This involves sizing the components and a preliminary selection of materials and processes, examining the implications for performance and cost.

The embodiment stage ends with a feasible layout, which becomes the input to the detailed design stage.

In final stage of design (Product design) the specifications and dimensions for each component are drawn up. Critical components may be subjected to precise mechanical or thermal analysis. Optimization methods are applied to components and groups of components to maximize performance, minimize cost and ensure safety. A final choice of geometry and material is made, and the methods of production are analyzed and determine the cost. The stage ends with a detailed product specification.

The useful way to look for materials selection activites is using Tetrahedron.

Principles

Product **Properties**

Processes

The most important in Materials Selection is the interrelationship between Four P_s $(P_1P_2P_3P_4)$

In any design (product) the interdependence between material and their processings must be recognized.

Improper Processing of a well-chosen material is likely to result in a defective product.

Improvements in processes often dicate a reevaluation of the materials being processed. Like wise, a change in material may well require a change in manufacturing process.

There are four aspects to the use of materials in manufacturing (materials selection).

- The design of a product to meet a specific need.
- The selection of materials with the right properties.
- The choice of a suitable manufacturing process.
- The main principles underlying the response of a material to its environment.

Design may define as the creation of synthesized solutions in the form of products, processes or systems that satisfy human needs through mapping between Functional Requirements and Design Parameters through the proper selection of Design Parameters that satisfy Functional Parameters.

This mapping process is non-unique in that more than one design may ensue from the generation of Design Parameters that satisfy the Functional Requirements. In other words, the actual outcome depends on a designer individual creative process. The creative process is thus an important element of the design process and in addressing the challenge of managing the process, it is important to be aware of the attributes of a creative person. These are identified as the following:

- tends to be a risk taker who is willing to accept failures;
- has good memory;
- possesses vast store of knowledge rooted in many fields;

- knows how to use data and interpolate from known applications to new situations;
- reduces complex array of facts and data points to limited number of critical sets of variables; and
- combines known facts to create new solutions.

Ingredients in successfully competing in world markets for manufactured goods

The points below encapsulate some ideas about this:

- Better products that meet customer requirements.
- Cuts in product time to market.
- Raising quality to world class levels.
- Cutting time to ramp up to full production.
- Action on systematic problems, viz:

+ Immature designs going into production.
+ Excessive design changes.
+ Poor vendor quality.
+ Excessive defects.
+ Recurring waivers and deviations.
+ High rework and scrap.
+ Low manufacturing yields.
+ Delinquent deliveries.
+ Cost growth.

Design - what is it?

Design, may consider as the product sence, as the final of the goal of engineering, facilitates the creation of new products, services, processes, software, systems and organisations by which engineering contributes to society by satisfying its needs and aspirations.

Design is involving four distinct aspects of engineering and scientific, namely:
problem definition from a fuzzy array of facts and myths into a coherent statement or question;

creative process of devising a proposed physical embodiment of solutions;

analytical process of determining whether the proposed solution is correct or rational; and

ultimate check of fidelity of the design of the product to the originally perceived needs.

Design is an activity that today is widely recognized as crucial to the success of business enterprises, particularly in today's climate of high technology and high consumer expectations.

Design has a direct impact on the company's bottom line. It determines not only the functional performance and reliability of products and services, but also their cost.

Most **inventive** processes are hit or miss affairs, requiring much **trial** and **error** as well as being an astute observer.

From Experience, study and literature, it will be evident that there is no universally acclaimed sequence of steps that lead to a workable design.

It can be a top-down or bottom-up process, or a hybrid of the two processes.

Different Designer have defined the process in as few as 3 steps or as many as 25 steps.

Methods for approaching design

1- Case-history method

2- Modification of an existing product

3- Development of an entirely new product

Requirements of materials selection

1- Shape or geometry considerations

2- Property requirements

3- Manufacturing Concerns

1- Shape or geometry considerations

1- What is the relative size of the components?
2- How complex is its shape? Are there axes or planes of symmetry? Uniform cross sections? Do you want consider making it in more than one piece?
3- How many dimensions must be specified?
4- How precise must these dimensions be? Are all precise? How many are restrictive and which ones?
5- How does the component interact with other components?
6- What surface characteristics are needed? Which surfaces need to be smooth? Hard? Which need to be f finished? Which do not?
7- How much can a dimension change by wear or corrosion and the part still perform adequately?
8- Could a minor change in the shape significantly improve the suitability of the part (increase strength, reliability, fracture resistance etc.)?

2- Property requirements

2.1 Mechanical Properties

1- What are the needs with regard to static strength?

2- If overloaded is the component more likely to fail by deformation or fracture? Do you have preference?

3- Can you envision impact loadings? If so of what type and magnitude?

4- Can you envision cyclic loadings? If so what type, magnitude and frequency?

5- Is wear resistance needed? Where? How much? How deep?

6- Over what temperature range must these properties be present?

7- How much can the material deflect, stretch or compress and still function properly?

2.2 Physical Properties

1- Are there any electrical property requirements?

2- Are any magnetic properties desired?

3- Are thermal properties significant? Thermal conductivity? Change of dimensions which change of temperature?

4- Are there any optical requirements?

5- Is weight a significant factor?

6- What about appearance?

2.3 **Service environment**

1- What is the lowest, highest and normal operating temperature for the component and how fast is temperature likely to change?

2- Are all of the desired properties required over this range of temperatures?

3- What is the most severe environment anticipated as far as corrosion or deterioration of material properties is considered?

4- What is the desired service lifetime of the product?

5- What is the anticipated maintenance for this component?

6- What is the potential liability if the product should fail?

7- Should the product be manufactured with recycling in mind?

3- Method of manufacture

1- Have standard components and sizes been specified wherever possible?

2- Has the design addressed the requirements that will facilitate case of manufacture? Machinability? Weldability? Formability? Hardenability? Castability?

3- How many components are to be made? At what rate?

4- What are the maximum and minimum section thicknesses?

5- What is the desired level of quality compared to that of similar products on the markets?

6- What are the anticipated quality control and inspection requirements?

7- Are there and assembly concerns, relationships to mating parts and so on that should be noted?

General notes on Materials selection

1- Materials selection is field of PHILOSOPHY
2- Don't hesitate to take any DECESION; many times this is the way for successful
3- Materials selection trained you that for every thing there is a VALUE
4- Selection of materials is COMPLETELY DIFFERENT than materials selection
5- Standard of LIVING of any nation is closely related to materials selection
6- It is a field of STUDY, SCIENCE, EXPERIENCE, EXPERTISE, CREATIVE, INNOVATIVE and ENGINEERING
7- It takes the DECESION to select a given material from up to 150 000 MATERIALS
8- It let you to take the DECESIONS to select a given process from up to 1000 PROCESSES
9- Design is the main CORE of the materials selection
10- Any Idea even is NOT PRACTICAL, IMAGINARY or SOUND should be considered and paid attention

11- Numerous DECISIONS have to be made imaginary

12- Understanding the SYSTEM is very necessary and consider the materials selection as an important system

13- Knowing the product design specification (PDS) and product design requirements (PDR) are VITAL to help to be on the field

14- Knowing the FIRST STEPS in any materials selection should clearly understand

15- Materials selection is ONLY the engineering field to develop the materials, processing, ideas and even the principles

16- Be specialist in materials selection is the PIN POINT to be SUCCESSFUL engineer

17- It requires TIME SPENT to be familiar with the field

18- Simple engineering OVERSIGHTS may lead to failure in materials selection

19- Two types of requirements should be selected carefully namely ABSOLUTE and RELATIVE

20- Spent a CONSIDERABLE time to understand and take decision to use many forced Aid of materials selection

21- Pay attention to COST but without forget the performance and reliability

22- It is the field to training you to take the vital and important decision not even in the field of industry but also in the life

23- Don't forget the MISUSE for every goods and services

24- Always satisfy all the CUSTOMER's wants and needs

25- It requires all the requirements of PRODUCTION, MANUFACTURING and SERVICES SYSTEMS

26- Bay attestation to ASSEMBLY

27- Concentrate on materials engineering EDUCATION

28- Understanding clearly ASSEMBLY, SUBASSEMBLY, COMPONENT and IN-PROCESS STRUCTURES

29- Always take in consideration the SUSTAINABILITY means