Course Material

Name of the Course	:	Product Design & Development
Name of the Unit	:	Unit-I: Introduction
Name of the Topic	:	Introduction to Product Design

- **Objectives:**
  To teach the students about the various stages involved in product design and development.
- **Outcomes:** Upon completion of this unit, Students should be able to Know the various stages involved in product design and development
- **Pre-requisites**: Basic knowledge in Manufacturing
- **Pre-test MCQs:**

1. **The ultimate objective of the product is**
   (A) To provide a new look
   (B) Utilizing existing manpower
   (C) To monopolize the market
   (D) All of the above

2. **In which of the following type the manufacturing cost may go up**
   (A) Standardization
   (B) Simplification
   (C) Diversification
   (D) All of the above

3. The life cycle of a product includes
   a) extraction of natural resources
   b) processing of raw materials
   c) manufacturing of products
   d) all of the mentioned

4. The mechanical properties of good product material are
   a) strength
   b) toughness

c) ductility
d) all of the mentioned

5. The physical properties of good product material are
   a) density
   b) melting point
   c) specific heat
   d) all of the mentioned
6. Characteristics of Successful Product Development are
   a. Product quality
   b. Product cost
   c. development time
   d. all the above.

7. Challenges of the product development are

a. Trade-offs, dynamics

b. Details, time pressure

c. Economics, creation

d. all the above.

Theory behind:

The Product Development Process

A process is a sequence of steps that transforms a set of inputs into a set of outputs. Most people are familiar with the idea of physical processes, such as those used to bake a cake or to assemble an automobile. A *product development process* is the sequence of steps or activities that an enterprise employs to conceive, design, and commercialize a product. Many of these steps and activities are intellectual and organizational rather than physical. Some organizations define and follow a precise and detailed development process, while others may not even be able to describe their process. Furthermore, every organization employs a process at least slightly different from that of every other organization. In fact, the same enterprise may follow different processes for each of several different types of development projects.

A well-defined development process is useful for the following reasons:

• ***Quality assurance:*** A development process specifies the phases a development project will pass through and the checkpoints along the way. When these phases and checkpoints are chosen wisely, following the development process is one way of assuring the quality of the resulting product.

• ***Coordination:*** A clearly articulated development process acts as a master plan that defines the roles of each of the players on the development team. This plan informs the members of the team when their contributions will be needed and with whom they will need to exchange information and materials.

• ***Planning:*** A development process includes milestones corresponding to the completion of each phase. The timing of these milestones anchors the schedule of the overall development project.
• ***Management:*** A development process is a benchmark for assessing the performance of an ongoing development effort. By comparing the actual events to the established process, a manager can identify possible problem areas.
• ***Improvement:*** The careful documentation and ongoing review of an organization's development process and its results may help to identify opportunities for improvement.

The Generic Product Development Process

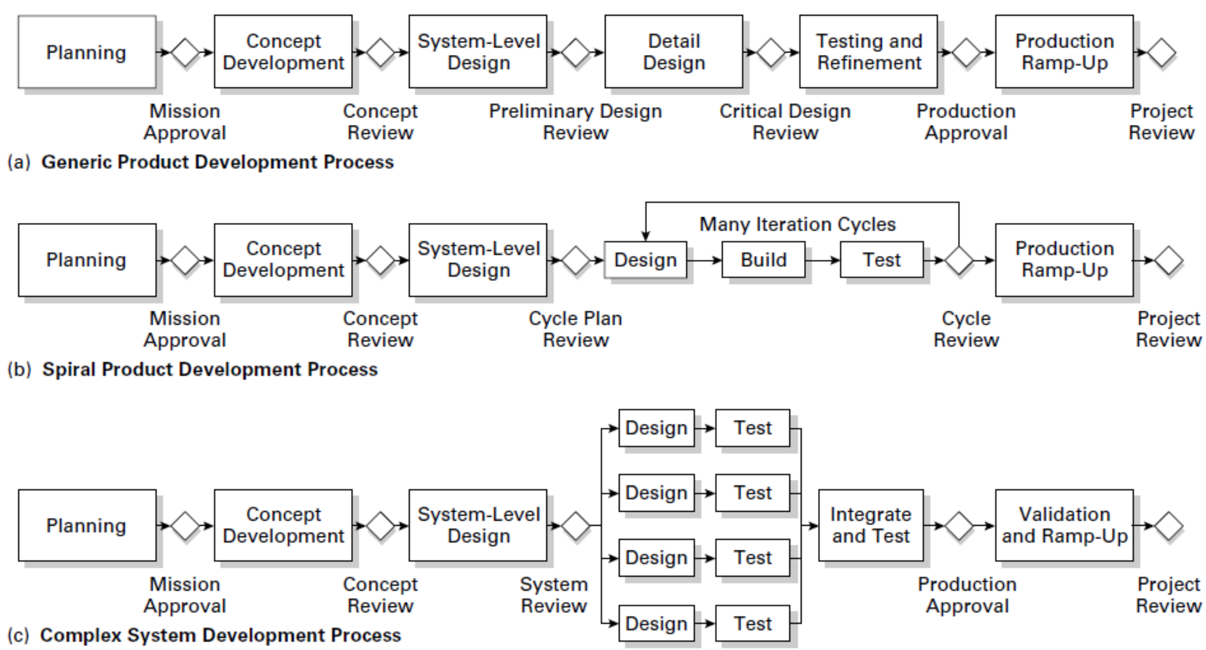
1. Concept development: In the concept development phase, the needs of the target market are identified, alternative product concepts are generated and evaluated, and one or more concepts are selected for further development and testing. A concept is a description of the form, function, and features of a product and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project. This book presents several detailed methods for the concept development phase. We expand this phase into each of its constitutive activities in the next section.

2. ***System-level design:*** The system-level design phase includes the definition of the product architecture, decomposition of the product into subsystems and components, and preliminary design of key components. Initial plans for the production system and final assembly are usually defined during this phase as well. The output of this phase usually includes a geometric layout of the product, a functional specification of each of the product's subsystems, and a preliminary process flow diagram for the final assembly process. Chapter 10, Product Architecture, discusses some of the important activities of systemlevel design.

3. ***Detail design:*** The detail design phase includes the complete specification of the geometry, materials, and tolerances of all of the unique parts in the product and the identification of all of the standard parts to be purchased from suppliers. A process plan is established and tooling is designed for each part to be fabricated within the production system. The output of this phase is the *control documentation* for the product—the drawings or computer files describing the geometry of each part and its production tooling, the specifications of the purchased parts, and the process plans for the fabrication and assembly of the product. Three critical issues that are best considered throughout the product development process, but are finalized in the detail design phase, are: materials selection, production cost, and robust performance. These issues are discussed respectively in Chapter 12, Design for Environment, Chapter 13, Design for Manufacturing, and Chapter 15, Robust Design.

4. ***Testing and refinement:*** The testing and refinement phase involves the construction and evaluation of multiple preproduction versions of the product. Early *(alpha)* prototypes are usually built with *production-intent* parts—parts with the same geometry and material properties as intended for the production version of the product but not necessarily fabricated with the actual processes to be used in production. Alpha prototypes are tested to determine whether the product will work as designed and whether the product satisfies the key customer needs. Later *(beta)* prototypes are usually built with parts supplied by the intended production processes but may not be assembled using the intended final assembly process. Beta prototypes are extensively evaluated internally and are also typically tested by customers in their own use environment. The goal for the beta prototypes is usually to answer questions about performance and reliability in order to identify necessary engineering changes for the final product. Chapter 14, Prototyping, presents a thorough discussion of the nature and use of prototypes.

5. *Production ramp-up:* In the production ramp-up phase, the product is made using the intended production system. The purpose of the ramp-up is to train the workforce and to work out any remaining problems in the production processes. Products produced during production ramp-up are sometimes supplied to preferred customers and are carefully evaluated to identify any remaining flaws. The transition from production ramp-up to ongoing production is usually gradual. At some point in this transition, the product is *launched* and becomes available for widespread distribution. A *postlaunch project review* may occur shortly after the launch. This review includes an assessment of the project from both commercial and technical perspectives and is intended to identify ways to improve the development process for future projects.



<u>Aplications:</u>

1. Understanding the product design process

<u>MCQ – Post test:</u>

1. Establishing the target specifications is a ------------ step process
a) 2 b) 4 c) 5 d) 6

2. How many steps are there in a generic product development process?
a) 2 b) 3 c) 6 d) 5

3. Detail design comes after system level design.

a) True b) False C) Not applicable d) None of these

4. Production ramp-up comes before testing and refinement.

a) True b) False C) Not applicable d) None of these

5. Concept testing takes place before concept generation.

a) True b) False C) Not applicable d) None of these

6. Design-build-test are the steps involved in

a) Generic product development b) Spiral product development c) Complex system development d) None of the above

7. Integrate and test is a step involved in

a) Generic product development b) Spiral product development c) Complex system development d) None of the above

8. Opportunity identification is a ------------- step process

a) 2 b) 3 c) 5 d) 6

9. During product planning process, identifying opportunities is the second step.

a) True b) False C) Not applicable d) None of these

10. Identifying the customer needs is the third stage of a product development process.

a) True b) False C) Not applicable d) None of these

11. Gathering the raw data from customers contains

a) Interviews b) Focus groups c) Observing the product in use d) All the above

12. Defining the physical form of the product to best meet the customer needs is known as

a. design

b. marketing

c. manufacturing

d. none of these.

13. Designing, operating, and/or coordinating the production system in order to produce the product is known as

a. designing

b. manufacturing

c. marketing

d. none of these

14. Challenges of the product development are

a. Trade-offs, dynamics

b. Details, time pressure

c. Economics, creation

d. all the above.

15. A well-defined development process is useful for the following reasons

a. Quality assurance, coordination

b. Planning, management

c. Improvement

d. All the above.

16. The complete specification of the geometry, materials, and tolerances of all of the unique parts in the product and the identification of all of the standard parts to be purchased from suppliers is known as

a. Testing

b. Concept selection

c. detailed design

d. All the above.

17. System must be decomposed into several subsystems and many components in

a. complex systems

b. quick build products

c. high risk products

d. none of the above

18. Under which case, the team begins with a new technology, then finds an appropriate market?
a. Platform products
b. process-intensive products
c. generic products
d. technology push products

19. In opportunity identification process, charters are closely analogous to_________
a. Mission statement
b. Vision statement
c. Objectives
d. none of these

Conclusion

The basics steps involved in product design process and various approaches followed in the product design process are clearly explored.

References

1. Ulrich K.T. and Eppinger S.D., “Product Design and Development” McGraw – Hill International Editions,1999.
2. Belz A., 36-Hour Course: “Product Development” McGraw-Hill, 2010.
3. Rosenthal S., “Effective Product Design and Development”, Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
4. Pugh S., “Total Design – Integrated Methods for successful Product Engineering”, Addison Wesley Publishing, 1991, ISBN 0-202-41639-5.

Assignments

1. Explain the various stages involved in generic product development process.
2. What are the various product development process? Explain in detail.

Course Material

Name of the Course : **Product Design and Development**

Name of the Unit : Unit-II: CONCEPT GENERATION, SELECTION AND TESTING

Name of the Topic : CONCEPT GENERATION, SELECTION AND TESTING

1. **Objectives:**
   To understand the steps involved in concept generation, selection and testing

2. **Outcomes:** Upon completion of this unit, Students should be able to understand the steps involved in concept generation, selection and testing.

3. **Pre-requisites**: Basic knowledge in Manufacturing

4. **Pre-test MCQs:**

   1. **The ultimate objective of the product is**
      (A) To provide a new look
      (B) Utilizing existing manpower
      (C) To monopolize the market
      (D) All of the above

   2. **In which of the following type the manufacturing cost may go up**
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7. Challenges of the product development are

a. Trade-offs, dynamics

b. Details, time pressure

c. Economics, creation

d. all the above.

<u>Theory behind:</u>

A concept is something more than an idea but is not yet a product. The concept is a detailed statement of what the new product will be and what it is designed to do. At this stage of the process, the concept must be examined in terms of the proposed product's strategic fit. That is, in light of company objectives, strengths, weaknesses, resources, new product criteria, and prevailing market and competitive conditions. The concept generation, selection and testing phases of new product development may be thought of as a search for the most profitable solution to a design problem.

Concept generation is an integral part of the new product development process. It is an idea of doing a structured process to generate design concepts is one of the most difficult concepts to teach, where the skill, experience and creativity of design team are used to generate designs which address the identified needs of the clients and the users. Ideas are like prototypes need to be tested to verify they fit customer and client needs.

"Thorough exploration of alternatives early in the development process greatly reduces the likelihood that the team will stumble upon a superior concept late in the development process or that a competitor will introduce a product with dramatically better performance than the product under development.”

The advantage of concept generation is can reduce the likelihood of costly problems later in the development process, because in the early concept generation is a very affordable way of looking at a lot of alternatives.

A good concept design requires the use of intuition, imagination and logic to come up with creative solutions to the, now well-defined, problem. The main difficulty in concept design is sufficiently to come up with original concepts.

Three concept generation methods are: task analysis, product function analysis, and life cycle analysis. Together these methods can be thought of as ways ‘force-generating’ concepts.

Task analysis

Most products are designed to be used, in some way, by people. When examined in detail, the product-user interface for even the simplest of products is often complex and rarely well understood. Consequently, this aspect of product design often provides a rich source of inspiration on concept design. Task analysis exp0lores the interaction the product and the person who uses it by observation and analysis and then uses the results to generate new product concepts. It gives the designer firsthand experience of how customers actually use products. Through this, it stimulates concept generation to improve the user interface and paves the way for the subsequent application of ergonomic or anthropometric design methods.

Product function analysis

Product function analysis is a powerful technique which can be used on its own for concept design or used as the first step in two other design methods, value analysis and failure modes and effects analysis. Product function analysis is a fundamentally customer-oriented technique. Throughout, it presents the functions of the product as perceived by the customer and as ranked in importance by the customer. For products with complex, or not properly understood customer functions, it will have to be based on formal market research.

Life cycle analysis

This technique is used most widely by designers interested in improving the environmental-friendliness of new products but in principle it is applicable to design for all purposes. By mapping out the life cycle of a product from the time it enters the factory as raw materials to the time it is discarded after use by the customer, the designer is forced to think about how well the product is designed for each of these life cycle stages.

Generation is a divergent process. There are including gather data, study information, define and understand the problem. Besides that, observations, interviews, scenarios, benchmarking is also included. It is focus on creativity and goes for quality.

Five concept generation processes are: clarify the problem, search externally, search internally, explore systematically, and reflect and evaluate.

Step 1: Clarify the problem

Clarify the problem is start with the customer needs analysis and functional specs as inputs. It is focus initial efforts on critical sub problems and decompose a complex problem into simple sub problems if necessary.

Step 2: Search externally

There are five ways to gather information from external sources, which are lead user interviews, expert consultation, patent searches, literature searches and competitive benchmarking.

Step 3: Search internally

Internal search is the use of personal and team knowledge and creativity to generate solution concepts. This is including make analogies, wish and wonder, use related stimuli, use unrelated stimuli, set quantitative goals, and use gallery method.

Step 4: Explore systematically

The team should have a collection of concept fragments so they are able to managing the exploration process. The goal of systematic exploration is to synthesize a complete solution from the concept fragments.

Step 5: Reflect on the results and the process

Reflect on the results and the process is the process continuous improvement.

CONCEPT SELECTION

Following concept generation, the next stage of product development is concept selection. Concept selection is an iterative process closely related to concept generation and testing. It is the narrowing of multiple product concepts to a single, “best” design. A key input to this process is the predicted market performance of a product concept was it to be launched.

Selecting the best product concept is one of critical tasks in product development process. Making decisions at this stage becomes very difficult due to imprecise and uncertain product requirements.

Modern methods of concept selection are due to large extent to pioneering work of Stuart Pugh (1990) at Strathclyde University in Scotland. Pugh developed the notion of controlled convergence on a single selected concept. Concept selection during product development process is an iterative process that narrows the number of concepts quickly and selects the best concept.

After identifying a set of customer needs and target specifications, a product development team will generate a number of product concepts from which the team will select the best one. Concept selection is an iterative process that includes concept screening and concept scoring which is leading to a single concept upon which subsequent development activities will be focused.

Concept Screening

The purpose of concept screening is to narrow the number of product concept quickly and to improve the concept Pugh (1990). There are three possible outcomes resulted from the concept screening which are superior concept, inferior concept and revised or new concept. A superior concept is a concept that is worth considering to be further assessed, while an inferior concept needs to be thrown out since it is not worth considering.

In straightforward, concept screening gives relative score against a known benchmark design. It is fast because using approximate evaluation that produces several viable concepts. And is best used when quantitative comparisons are difficult and useful for eliminating alternatives when there are large number needs to consider.

There are six step of concept screening:

1. Prepare the selection matrix

2. Rate the concepts

3. Rank the concepts

4. Combine and improve concepts

5. Select one or more concepts

6. Reflect on the results and the process

Concept Scoring

After having a set of concept candidates consisting of superior concepts and revised or new concepts, the concept scoring then takes place. At this stage, the product development team weighs the relative weight of the selection criteria and evaluates each product concept with respect to each selection criterion. The concept scores are determined by the weighted sum of the rating. The concept with the highest score is then selected.

Means that concept scoring is used to refine the selection when there are only have a few choices. It is weighted ranking of measurement criteria. It used when only a few alternatives are being considered and just required quantitative comparisons of concepts. Not only that, it can be quite subjective due to choices of weights and ranks.

There are six step of concept scoring:

1. Preparing the selection matrix

2. Rate the Concepts

3. Rank the Concepts

4. Combining and improving is similar to concept screening

5. Select one or more concepts

6. Reflect on the Results

The process screening and scoring is process filter and decides of concept generation by using external decision, product champion, intuition, multi-voting, pros and cons, prototype and test and decision matrices. Almost every team uses some method for decision making.

External decision is the let the customer, client, or someone else to make decide.

Product champion is an influential team member chooses the concept.

Intuition is subjective criteria are used to decide. It just chosen by its “feel”.

Multi-voting is team members vote based upon group opinion and chosen for their favourite.

Pros and Cons is the team list strengths and weaknesses and choose based on group opinions.

Prototype and test is the team builds several unit prototypes and decision is based on the test prototype results.

Decision matrices are team rates each concept against defined selection criteria.

The first round of concept selection ranks the concepts in relation to a series of selection criteria from the opportunity specification. This is done by means of a concept selection matrix in which the concepts are arranged along one axis of the matrix and selection criteria along the other. To make the ranking procedure simple, each concept is judged ‘better than’ (scored as +), ‘worse than’ (scored as -) or ‘the same as’ (scored as 0) a reference concept. This reference concept should be the best current competitor to the proposed new product. The outcome of the ranking process will be a single number expressing the relative merit of each concept. From these ranks, attention focuses on the better concepts. Now comes the concept hybridisation and generation phase. Essentially this sets out to take all the good features from the different concepts and combine them into a single product. At the same time the weak features should be eliminated. So, look closely at the concepts which were strong overall but which scored – on any of the criteria.

Below are the benefits of structured concept selection:

A customer focused approach-concepts are evaluated against customer-oriented criteria, so the selected concept is likely to be focused on the customer.

More competitive designs-concepts are benchmarked against best-in-class designs, designers can push the design to match or exceed their competitors' performance along key dimensions.

Reduced development time-using a structured approach develops a common vision and language for the design, manufacturing, industrial and project manager team.

Better product-process coordination-respect to manufacturing criteria improves the product's manufacturability and helps to match the product with the process capabilities of the firm.

Better group decision making-the decision is more likely to be based on objective criteria and minimizes the likelihood that arbitrary or personal factors influence the product concept.

Documentation-the method provides its own documentation for quickly assessing the impact of changes in the customer needs or in the available alternatives.

Caveats

Concept Scoring and Screening matrices are only used on those few (less than 5) design problems that will make a significant difference in the outcome of project. And don't need the formality of concept scoring and screening for obvious design choices or those that are dictated by the preferred solution.

There are concept selections techniques select the best concept against criteria derived from the opportunity specification. Probably more importantly, they provide a framework for hybridising and expanding the range of concepts generated initially. Concept selection can, therefore, comprise a highly creative and invaluable conclusion to the concept development process.

CONCEPT TESTING

A concept testing is a search for the most profitable solution to a design problem. When allocating resources, developers must balance the cost of testing multiple designs against the potential profits that may result. Means that, concept testing is the attempt to predict the success of a new product idea before it is marketed. It usually involves getting people's reactions to a statement describing the basic idea of the product. As such, it is usually pass or fail, go or no go to selecting the best among alternative concepts. The ultimate goal of concept testing is to allow companies to make informed "go" or "no go" decisions and thus save capital, time and effort.

Concept testing may be thought as a search for the "best" design, positioning, pricing, and manufacturing of a new product. It probably the most valuable and challenging application of qualitative research, but how much budget should be allocated to testing new product concepts? And how many tests should be conducted? "Innovation" through multiple product concepts increases expected profit through the discovery of incrementally better designs, but because concepts are costly to generate and test, the design team must balance costs and benefits to maximize expected profits net of the cost of testing.

Concept testing is an essential tool for managers who must bring new imaging and document technology products to market so designer need to conduct research throughout their development effort to ensure they are developing solutions for relevant problems, understand customer requirements, and are emphasizing valued features.

There is the concept testing process:

Step 1: Define the purpose of the concept test

Concept testing is essentially an experimental activity, and as with any experiment, knowing the purpose of the experiment is essential to designing an effective experimental method.

Step 2: Choose a survey population

Choose a survey population is choose the survey potential customers from the largest segment to do the testing process.

Step 3: Choose a survey format

There are various surveys format can be carry out and it depends partially on the situations and the environments such as by email, phone, post or direct face to face. But it is undeniable that each of the survey format presents risks of sample bias.

Step 4: Communicate the concept

There have several way of communicate which are verbal description, sketch, storyboard, video and simulation. The choice of the survey format is closely linked to the way which the concept will be communicated.

Step 5: Measure customer response

Customer response will be very important because identify customer needs because it is the first step to be carry out in new product implementation.

Step 6: Interpret the results

By using calculation, which $Q = N \times A \times P$

Q = sales in annual

N = number of annual purchases

A = awareness x availability in fractions

P = probability of purchase in surveyed

Step 7: Reflect on the results and the process

Reflect on the outcome and the process will always be the last step and it is very important been carried out to ensure successful product development. The product concept should allow the teams to actually set the specifications so that the product will meet the customer needs and perform competitively.

Aplications:

Development of concepts for various products, its testing and selection.

MCQ – Post test:

Part-A

1. Concept generation is the ___________ stage of the product development process.
a. 2^{nd} b. 3^{rd} c. 4^{th} d. 5^{th}

2. Concept generation is a __________ step process.
a. 3 b. 4 c. 5 d. 6

3. External search contains
a. Interviews b. Consults experts c. search patents d. all the above.

4. Concept selection is the ___________ stage of the product development process.
a. 2^{nd} b. 3^{rd} c. 4^{th} d. 5^{th}

5. Concept screening is a stage in
a. Concept generation
b. Concept testing
c. Concept selection
d. All the above

6. Concept scoring is a __________ step process
a. 3 b. 4 c. 5 d. 6

7. Concept testing is the___________ stage of the product development process.

a. 2^{nd} b. 3^{rd} c. 4^{th} d. 5^{th}

8. Number of steps involved in concept testing process is ___________
   a. 7 b. 4 c. 5 d. 6

9. Which one is not a survey format during concept testing?
   a. Face-to-face interaction
   b. Electronic mail
   c. Telephone
   d. Bench marking

10. What are the ways of communicating the concept?
    a. Verbal description
    b. Storyboard
    c. Models
    d. All the above d

11. The purchase intent scale response contains
    a. Definitely buy
    b. Probably buy
    c. Might or might not buy
    d. All the above
12. During concept selection,
    a. only one concept need to be selected
    b. two or more concepts are to be selected
    c. no concept is to be selected
    d. none of the above.
13. At the time of rating the concept,
    a. + means better, 0 means same, - means worse
    b. - means better, 0 means same, + means worse
    c. 0 means better, + means same, - means worse
    d. None of the above
14. During internal search of concept generation,
    a. Only feasible ideas are to be accepted
    b. Both feasible and infeasible ideas are to be accepted
    c. Only infeasible ideas are to be accepted
    d. None of the above
15. During idea generation of a concept,
    a. Only one idea is to be generated
    b. Two or three ideas are to be generated

c. A lot of ideas are to be generated
d. None of the above

Part-A Answers: 1-b, 2-c, 3-d, 4-c, 5-c, 6-d, 7-d, 8-a, 9-d, 11-d, 12-b, 13-a, 14-b, 15-c

Conclusion

Upon completion of this unit, a clear-cut idea on the concept generation, concept selection and testing are obtained.

References

1. Ulrich K.T. and Eppinger S.D., "Product Design and Development" McGraw – Hill International Editions,1999.
2. Belz A., 36-Hour Course: "Product Development" McGraw-Hill, 2010.
3. Rosenthal S., "Effective Product Design and Development", Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
4. Pugh S., "Total Design – Integrated Methods for successful Product Engineering", Addison Wesley Publishing, 1991, ISBN 0-202-41639-5.

Assignments

1. Explain various steps involved in concept generation.
2. Explain various steps involved in concept selection.

Course Material

Name of the Course : **Product Design and Development**

Name of the Unit : Unit-III: PRODUCT ARCHITECTURE

Name of the Topic : : PRODUCT ARCHITECTURE

Objectives:

To learn about the product architecture and its importance in engineering

Outcomes: Upon completion of this unit, Students should be able to learn about the product architecture and its importance in engineering

Pre-requisites: Basic knowledge in Manufacturing

Pre-test MCQs:

1. **The ultimate objective of the product is**
   (A) To provide a new look
   (B) Utilizing existing manpower
   (C) To monopolize the market
   (D) All of the above

2. **In which of the following type the manufacturing cost may go up**
   (A) Standardization
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3. The life cycle of a product includes
   a) extraction of natural resources
   b) processing of raw materials
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4. The mechanical properties of good product material are
   a) strength
   b) toughness
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5. The physical properties of good product material are
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7. Challenges of the product development are

a. Trade-offs, dynamics

b. Details, time pressure

c. Economics, creation

d. all the above.

Theory behind:

What is product architecture? Chunking or organization of the functional elements of a product is Product architecture. The way the chunks or elements interact is product architecture. It plays an important role in designing, making, selling, and repairing a new product. It also involves a linking system and level design and principles of engineering of the system. In simple terms, it refers to the strategy of mapping the function to form. Product architecture is especially relevant to functions pertaining to the research and development (R & D) of an organization. The decisions are particularly taken during the starting or early stages of the process of innovation where the lead role is played by research and development.

The product architecture diagram is given below:

1. **Basic Steps**

2. **Product Architecture Examples**
3. **Product Design Architecture**
4. **Types of Product Architecture**
5. **Product Architecture Definition**

1) BASIC STEPS INVOLVED ARE:

1. Creation of a schematic for the product.
2. Clustering the schematic elements
3. Drafting of geometric layout
4. Identification of incidental and fundamental interactions.

2) PRODUCT ARCHITECTURE EXAMPLES:

decisions of product architecture relate to planning the product and developing a concept for the same. Some examples are

1. Camera Lenses in compact cameras, copier toner (product change)
2. Computer and automobiles (product variety).
3. Motor, fasteners, and bearing (standardization)
4. Fighter planes, racing bikes (performance)
5. Razors and disk drives (manufacturing cost) etc.

To elaborate the product change example-

- Multiple chunks implement the functional elements or many functions may be implemented by multiple chunks.
- There is a poor definition of interaction between chunks.
- For any specific product model, an increase in performance and a decrease in cost is generally influenced by integral architecture.

3) PRODUCT DESIGN ARCHITECTURE:

- To respond to an environmental necessity, an architect's ability is extended by product design so as to use creative skills with a keen eye for artistic interpretation and planning. To design products, many of the explored and addressed principles can be applied. Fundamental to an architect's toolkit, is a multidisciplinary, board-based approach, that lends itself appropriately to the interest of product design. Architects are most often perfectly suited and willing to take up small scale projects by focusing on details and appreciation for aesthetics that are scalable.
- One practical solution for architects is to design furniture for the newly designed building's needs as it is common to not find the appropriate design of furniture in the market and develop a product that is in alignment with the form, shape, and design of the building. This enables the architect to take control personally over the interior

environment. The enhanced level of the architect and involvement with designing products within the newly designed building has a potential for increasing the cohesive identification of the structure.

4) TYPES OF PRODUCT ARCHITECTURE:

What are product architecture and its types? Product architecture is mainly concerned with the way a product is arranged into physical parts which are components and assemblies. A number of sub-functions are identified after the comprehensive function of the product is reviewed for achieving the overall function. Hence, to carry out sub-functions and subsequently whole functions, parts and assemblies should be assigned.

Product architecture is of two fundamental types-Modular and Integral.

Modular Product Architecture: Well defined components functionally interface with self-contained modules in the modular type. For development and completion of a specific function, a product is organized into many modules. The overall purpose of the product is carried out by the interaction between these modules. The advantages of this type of architecture includes outsourcing and task allocation. Advantages of modular architecture also includes standardization/reuse for the development of new products, scale economies, maintenance and mass customization.

The second type is integral product architecture. In this type, physical elements share the functions. Mapping between functions and components involve greater complexity. However, to make it easier to optimize overall system, components are adapted or designed for specific products.

5) PRODUCT ARCHITECTURE DEFINITION

Product architecture is mainly concerned with the way a product is arranged into physical parts which are components and assemblies. A number of sub-functions are identified after the comprehensive function of the product is reviewed for achieving the overall function.

Modular versus Integral Product Architecture: the arrangement where functions of the product are done by an array of parts that need not be organized or arranged in assemblies are described by the integral design whereas in the modular design particular functions necessary for achieving the overall purpose of the product are identified. The product in integral type is arranged as a small structured and logical framework than in the modular type. The integral design has more advantages than the modular design. Parts and a group of parts are less interchangeable in the modular design whereas product development is done independently and separately in the integral design. There are cost implications for servicing and maintenance.

Product architectural design is the process of collecting and defining software and hardware components and the interfaces for establishing a framework for developing a computer system. A number of architectural styles can be exhibited in software that is built for computer-based systems. In order to represent a software design, software needs an architectural design.

A system category will be described by each style consisting of:

- A group of components that can perform a required function for the system (example: computational modules, database).
- Connectors- Cooperation, connection, and communication between the components will be helped by a set of connectors.
- Conditions which show that in order to form a system, integration of components can be done.
- Semantic models assist the designer in understanding the overall characteristics of the system.

<u>Aplications:</u>

Understanding the various architecture for product design

<u>MCQ – Post test:</u>

1. The assignment of the functional elements of a product to the physical building blocks of the product is known as __________
   a. Design
   b. Concept testing
   c. Product architecture
   d. None of these c

2. Types of architecture are
   a. Modular, integral
   b. Modular, united
   c. Integral, united
   d. None of these a

3. Which of these is a type of modular architecture?
    a. Slot modular
    b. Bus modular
    c. Sectional modular
    d. All the above d

4. The physical elements of a product are typically organized into several major physical building blocks, which are called as_________
    a. Products
    b. Chunks
    c. Modules
    d. None of these b

5. An architecture in which, each of the interfaces between chunks is of a different type from the others, so that the various chunks in the product cannot be interchanged is known as ___________________
    a. Slot modular architecture
    b. Bus modular architecture
    c. Sectional modular architecture
    d. None of these a

6. In a ______________architecture, there is a common bus to which the other chunks connect via the same type of interface.
    a. Slot modular architecture
    b. Bus modular architecture
    c. Sectional modular architecture
    d. None of these b

7. In a ______________ architecture, all interfaces are of the same type, but there is no single element to which all the other chunks attach.
    a. Slot modular architecture
    b. Bus modular architecture
    c. Sectional modular architecture
    d. None of these c

8. Establishing the product architecture is a _________ step process.
    a. 2
    b. 3
    c. 4
    d. 5 c

9. A ___________ is a diagram representing the team's understanding of the constituent elements of the product.
    a. Schematic
    b. Function

c. Block
d. None of these a

10. A ______________ can be created in two or three dimensions, using drawings, computer models, or physical models.
a. Chunk
b. Block
c. Geometric layout
d. None of these c

11. During product architecture, the first step is _____________
a. Create a schematic
b. Cluster the elements
c. Create a rough geometric layout
d. Identify the fundamental and incidental interactions. A

12. During product architecture, creating a rough geometric layout comes after clustering the elements.
a. True
b. False
c. Not applicable
d. None of these a

13. During product architecture, clustering the elements comes after creating the schematic.
a. True
b. False
c. Not applicable
d. None of these a

14. Identify the fundamental and incidental interactions is the final stage of product architecture.
a. True
b. False
c. Not applicable
d. None of these a

15. Creating the schematic the final stage of product architecture.
a. True
b. False
c. Not applicable
d. None of these b

Conclusion

product architecture is essential for designing and introducing new and customized products that can increase sales and at the same time be cost-efficient. For achieving overall function and responding to environmental necessities, product design has become an integral part of the architectural world be it software or hardware.

References

1. Ulrich K.T. and Eppinger S.D., "Product Design and Development" McGraw – Hill International Editions,1999.
2. Belz A., 36-Hour Course: "Product Development" McGraw-Hill, 2010.
3. Rosenthal S., "Effective Product Design and Development", Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
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Assignments

1. Explain the steps involved in product architecture with suitable example.
2. Classify product architecture.

Course Material

Name of the Course : **Product Design and Development**

Name of the Unit : Unit-IV: INDUSTRIAL DESIGN

Name of the Topic : INDUSTRIAL DESIGN

Objectives:

To understand the industrial design process including robust design, CAD, CAM, CAE etc.

Outcomes: Upon completion of this unit, Students should be able to understand the industrial design process including robust design, CAD, CAM, CAE etc

Pre-requisites: Basic knowledge in Manufacturing

Pre-test MCQs:

1. **The ultimate objective of the product is**
   (A) To provide a new look
   (B) Utilizing existing manpower
   (C) To monopolize the market
   (D) All of the above

2. **In which of the following type the manufacturing cost may go up**
   (A) Standardization
   (B) Simplification
   (C) Diversification
   (D) All of the above

3. The life cycle of a product includes
   a) extraction of natural resources
   b) processing of raw materials
   c) manufacturing of products
   d) all of the mentioned

4. The mechanical properties of good product material are
   a) strength
   b) toughness
   c) ductility
   d) all of the mentioned
5. The physical properties of good product material are
   a) density
   b) melting point
   c) specific heat
   d) all of the mentioned
6. Characteristics of Successful Product Development are
   a. Product quality
   b. Product cost
   c. development time
   d. all the above.

7. Challenges of the product development are

a. Trade-offs, dynamics

b. Details, time pressure

c. Economics, creation

d. all the above.

Theory behind:

Industrial design is a process of design applied to products that are to be manufactured by mass production. It is the creative act of determining and defining a product's form and features, which takes place in advance of the making of a product. In contrast, manufacture consists purely of repeated, often automated, replication This distinguishes industrial design from craft-based design, where the form of the product is determined by the product's creator largely concurrent with the act of its creation.

All manufactured products are the result of a design process, but the nature of this process can take many forms. It can be conducted by an individual or a team, and such a team could include people with varied expertise (e.g. industrial designers, engineers, business experts, etc.). It can emphasize intuitive creativity or calculated scientific decision-making, and often emphasizes both. It can be influenced by factors as varied as materials, production processes, business strategy, and prevailing social, commercial, or aesthetic attitudes. Industrial design, as an applied art, most often focuses on a combination of aesthetics and user-focused considerations,[6] but also often provides solutions for problems of form, function, physical ergonomics, marketing, brand development, sustainability, and sales.

Industrial design studies function and form—and the connection between product, user, and environment. Generally, industrial design professionals work in small scale design, rather than overall design of complex systems such as buildings or ships. Industrial designers don't usually design motors, electrical circuits, or gearing that make machines move, but they may affect technical aspects through usability design and form relationships. Usually, they work with other professionals such as engineers who focus on the mechanical and other functional aspects of the product, assuring functionality and manufacturability, and with marketers to identify and fulfill customer needs and expectations.

Industrial design (ID) is the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer.

Design, itself, is often difficult to describe to non-designers, because the meaning accepted by the design community is not made of words. Instead, the definition is created as a result of acquiring a critical framework for the analysis and creation of artifacts. One of the many accepted (but intentionally unspecific) definitions of design originates from Carnegie Mellon's School of Design, "Design is the process of taking something from its existing state and moving it to a preferred state" (Simon, Herbert A. "The sciences of the artificial." Cambridge, MA (1969, 1981, 1996)). This applies to new artifacts, whose existing state is undefined, and previously created artifacts, whose state stands to be improved.

Industrial design can overlap significantly with engineering design, and in different countries the boundaries of the two concepts can vary, but in general engineering focuses principally on functionality or utility of products, whereas industrial design focuses principally on aesthetic and user-interface aspects of products. In many jurisdictions this distinction is effectively defined by credentials and/or licensure required to engage in the practice of engineering. "Industrial design" as such does not overlap much with the engineering sub-discipline of industrial engineering, except for the latter's sub-specialty of ergonomics.

Although the process of design may be considered 'creative,' many analytical processes also take place. In fact, many industrial designers often use various design methodologies in their creative process. Some of the processes that are commonly used are user research, sketching, comparative product research, model making, prototyping and testing. These processes are best defined by the industrial designers and/or other team members. Industrial designers often utilize 3D software, computer-aided industrial design and CAD programs to move from concept to production. They may also build a prototype first and then use industrial CT scanning to test for interior defects and generate a CAD model. From this the manufacturing process may be modified to improve the product.

Product characteristics specified by industrial designers may include the overall form of the object, the location of details with respect to one another, colors, texture, form, and aspects concerning the use of the product. Additionally they may specify aspects concerning the production process, choice of materials and the way the product is presented to the consumer at the point of sale. The inclusion of industrial designers in a product development process may lead to added value by improving usability, lowering production costs and developing more appealing products.

Industrial design may also focus on technical concepts, products, and processes. In addition to aesthetics, usability, and ergonomics, it can also encompass engineering, usefulness, market placement, and other concerns—such as psychology, desire, and the emotional attachment of the user. These values and accompanying aspects that form the basis of industrial design can vary—between different schools of thought, and among practicing designers.

Aplications:

Understanding the importance of industrial design

MCQ – Post test:

1. The professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer is known as ______________
   a. Manufacturing
   b. Production
   c. Industrial design
   d. None of these c

2. Which are the goals of industrial designers?
   a. Utility
   b. Ease of maintenance
   c. Appearance
   d. All the above. d

3. _____________ is a one of the goal of industrial designers.
   a. Low cost
   b. High cost
   c. Medium cost
   d. None of these a

4. Product designs should communicate the corporate design philosophy and mission through the visual qualities of the products.
   a. True
   b. False
   c. Not applicable
   d. None of these a

5. Form, line, proportion, and color which are used to integrate the product into a pleasing whole is known as _______________
   a. Communication
   b. Costing
   c. Appearance
   d. None of the these c

6. Products must be designed to communicate how they are to be maintained and repaired. This is said to be ______________
   a. Ease of maintenance
   b. Communication
   c. Costing
   d. None of these a

7. The term ____________ is used to encompass all aspects of a product that relate to its human interfaces.
   a. Ergonomics
   b. Capability
   c. Aesthetics
   d. None of these a

8. Ergonomic need includes_____________
   a. Ease of use
   b. Ease of maintenance
   c. User interaction needs
   d. All the above d

9. Aesthetic needs includes_____________
   a. Is visual product differentiation required?
   b. How important are pride of ownership, image, and fashion?
   c. Will an aesthetic product motivate the team?
   d. All the above d

10. The cost of industrial design includes
    a. Manufacturing cost
    b. Direct cost
    c. Time cost
    d. All the above d

11. ____________ cost is the expense incurred to implement the product details created through industrial design.
    a. Manufacturing
    b. Direct
    c. Time
    d. None of these a

12. ___________ cost is the penalty associated with extended lead time.
    a. Manufacturing
    b. Direct
    c. Time
    d. None of these c

13. ___________ cost is the cost of the industrial design services.
    a. Manufacturing
    b. Direct
    c. Time
    d. None of these b

14. Industrial design is a _________ step process.
    a. 2
    b. 4
    c. 6
    d. 8 c

15. Investigation of customer needs is the first step of industrial design process.
    a. Yes
    b. No
    c. Not applicable
    d. None of these a

Conclusion

Industrial design helps an industrial engineer to properly analyse the complications that arises during the design process.

References

1. Ulrich K.T. and Eppinger S.D., “Product Design and Development” McGraw – Hill International Editions,1999.
2. Belz A., 36-Hour Course: “Product Development” McGraw-Hill, 2010.
3. Rosenthal S., “Effective Product Design and Development”, Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
4. Pugh S., “Total Design – Integrated Methods for successful Product Engineering”, Addison Wesley Publishing, 1991, ISBN 0-202-41639-5.

Assignments

1. Explain the various steps involved in industrial design process.
2. With a suitable case study, explain the industrial design process.

Course Material

Name of the Course : **Product Design and Development**

Name of the Unit : Unit-IV: DESIGN FOR MANUFACTURING AND PRODUCT DEVELOPMENT

Name of the Topic : DESIGN FOR MANUFACTURING AND PRODUCT DEVELOPMENT

Objectives:

To know about the principles of design for manufacturing and product development.

Outcomes: Upon completion of this unit, Students should be able to know about the principles of design for manufacturing and product development

Pre-requisites: Basic knowledge in Manufacturing

Pre-test MCQs:

1. **The ultimate objective of the product is**
   (A) To provide a new look
   (B) Utilizing existing manpower
   (C) To monopolize the market
   (D) All of the above

2. **In which of the following type the manufacturing cost may go up**
   (A) Standardization
   (B) Simplification
   (C) Diversification
   (D) All of the above

3. The life cycle of a product includes
   a) extraction of natural resources
   b) processing of raw materials
   c) manufacturing of products
   d) all of the mentioned

4. The mechanical properties of good product material are
a) strength
b) toughness
c) ductility
d) all of the mentioned

5. The physical properties of good product material are
a) density
b) melting point
c) specific heat
d) all of the mentioned

6. Characteristics of Successful Product Development are
a. Product quality
b. Product cost
c. development time
d. all the above.

7. Challenges of the product development are

a. Trade-offs, dynamics

b. Details, time pressure

c. Economics, creation

d. all the above.

Theory behind:

Introduction to Design for Manufacturing / Assembly (DFM/DFA)

The last few decades have brought several new challenges for manufacturing companies. Technology and improvements in transportation of goods has enabled companies to source parts globally. This has also resulted in more manufacturers having entered the market place. Competition for business is fierce. Manufacturing companies in the developing world market are able to offer products at lower prices. In an effort to maintain business and achieve growth many manufacturers are continually developing new products to widen their customer base. They must be quick to market with a high quality product or be left behind. Properly planned and implemented Design for Manufacturing and Assembly (DFMA, DFM/A or DFM/DFA) processes are enabling companies to develop high quality products in less time at lower production costs. Higher quality at a lower cost usually means more sales and greater customer loyalty.

What is Design for Manufacturing / Assembly (DFM/DFA)

DFMA is a combination of two methodologies, Design for Manufacturing (DFM) and Design for Assembly (DFA). This combination enables a product design to be efficiently manufactured and easily assembled with minimum labor cost. Through the use of DFM/A, a company can prevent, detect, quantify and eliminate waste and manufacturing inefficiency within a product design. DFM/A is a break from tradition. With DFM/A, the Design and Manufacturing Engineers work together as a team in developing the product's manufacturing and assembly methods simultaneously with the design. Conventionally, the design engineer designs the product then hands the drawings to manufacturing who then determine the manufacturing and assembly processes. Many engineers automatically separate the two into DFM and DFA since they have been defined separately for several years. For effective application of DFM/A the two activities must work in unison to gain the greatest benefit.

Why Perform Design for Manufacturing / Assembly (DFM/DFA)

The DFMA methodology allows for new or improved products to be designed, manufactured and offered to the consumer in a shorter amount of time. DFM/DFA helps eliminate multiple revisions and design changes that cause program delays and increased cost. With DFM/A the design is often more comprehensive, efficient to produce and meets the customer requirements the first time. A shorter total time to market frequently results in lower development costs. The application of the DFMA method results in shorter assembly time, lower assembly cost, elimination of process waste and increased product reliability.

How to Perform Design for Manufacturing / Assembly (DFM/DFA)

Many companies today are integrating the DFM and DFA practices through design and manufacturing teamwork. The Design for Manufacturing (DFM) and Design for Assembly (DFA) techniques are two different classifications. DFM techniques are focused on individual parts and components with a goal of reducing or eliminating expensive, complex or unnecessary features which would make them difficult to manufacture. DFA techniques focus on reduction and standardization of parts, sub-assemblies and assemblies. The goal is reduce the assembly time and cost. But if you think about it, they must be integrated to prevent one from causing negative effects on the other. The designer may seek to combine parts to reduce assembly steps, quantity of parts and hardware. If the resulting parts are difficult or expensive to manufacture then you have gained nothing. We must work together to accomplish both goals. The principle goals for simultaneous DFM/A are detailed below.

Reduce Quantity of Component Parts and Simplify Part Design

The designer should review the assembly design part by part and determine if any part can be eliminated or combined with another part. The designer should determine the theoretical minimum quantity of parts required for the assembly. One method for determining minimum part quantities is to first list out all the components in your assembly, including hardware. Then ask the following questions:

- Can the part be manufactured using the same material as other parts?
- How does the part in question move in relation to other moving parts?
- Can the parts be combined without need for any special process or tooling?
- If combined with another part how does that impact ease of possible disassembly?
- If combined with other parts how would it impact ease of manufacture?

Through reduction of component part quantities you also reduce the amount of hardware and the number of assembly steps required. The likelihood of assembly errors are subsequently reduced in relation to the reduction in assembly steps.

Design Parts for Ease of Fabrication

The designer should consider the method of fabrication that may be used for producing the parts, the required material specifications and required production volumes. Some particular guidelines to review are as follows:

- Specify materials that are commonly used and compatible with existing production processes that will minimize processing time and will meet all functional requirements
- Review the part and eliminate unnecessary features that could result in additional process steps, extra effort and complex or expensive tooling
- Design reviews with members of process engineering, quality control and the fabrication team are beneficial when possible. In most cases the meetings result in a few changes to the design that increase utilization of existing tools or improve machine utilization, preventing the need for capital expenses for special tools. In addition, the meetings improve knowledge transfer of design intent to all levels of the organization.

Design Within Known Process Capabilities and Avoid Tight Tolerances

The designer should become familiar with the process capabilities of any equipment required for the manufacture of the part. In addition, review current process controls to assure that any Special Characteristics (KCCs or KPCs) can be monitored. Avoid tight tolerances beyond the proven capability of the manufacturing processes. Determine if improved process capabilities are required early in the design or program schedule to allow time for any process improvement activities and the establishment of proper process controls. In addition, the designer should evaluate any interactions between component parts to avoid tolerance “stack-up” issues. Parts should be dimensioned in the center of the tolerance range to allow for the greatest variance and still remain a functional conforming part. In addition, avoid one sided tolerances and use surface finish callouts only when required, as that may result in unneeded additional part cost. Chamfered or radius corners should both be allowed if it will not change the function of the part. This will permit production control to route the part to different machines based upon demand.

Utilize Common Parts and Materials

Whenever possible the design should incorporate common parts and materials, including parts already in use in other similar products or assemblies. Common parts and materials help minimize inventory levels and will result in lower cost and higher quality. One of the most successful new product introductions Quality-One has been a part of incorporated 50% carry over / common parts from a similar product. The new content of the design was greatly reduced therefore the design risk was reduced. In addition, the learning curve of the assembly team members was reduced.

Mistake Proof Product Design and Assembly (Poka Yoke)

Designers should look for ways to mistake proof their designs, making the proper assembly of mating parts instantly recognizable and impossible to assemble incorrectly. By the addition of tabs and slots, asymmetrical holes and interference features the parts can be made difficult or impossible to assemble in reverse or oriented improperly. The designer should also avoid the need for any special adjustments or alignments in the assembly process. With enough thought put into the design of an assembly many of the parts can be made mistake proof. The designer should also consider how the part or assembly could be inspected for quality purposes. For some parts, conformance to design requirements may be verified with basic go / no-go tools. In other cases the parts may need to be measured and the designer should indicate any key or critical to quality dimensions or features.

Handling Requirements and Part Orientation

The design engineer should consider how the parts are going to be handled and oriented during the manufacturing and assembly processes. If this is not done, the impact could range from non-value added motion and part movement to possible operator safety issues or requirements for special fixtures or lifting devices. There are several basic principles that can be applied to improve parts handling and orientation. A few examples can be found below:

- Drawings should consistently indicate the proper origination when fed into a process. An example would be how parts are oriented into a brake press for either bend up or bend down operations.
- The designer should avoid use of parts that can easily become tangled in the container or that are difficult to pick up and handle. This slows production and can increase waste due to damaged, dropped or lost parts.
- When possible design parts that are symmetrical along both axis. This allows for ease of fabrication and correct assembly.
- Parts should be designed so that they may be easily grasped, oriented and placed in an assembly or weld fixture. Examples would be parts with flat, parallel surfaces that are easily picked-up and assembled by the operator. Another instance to think about could be if the part is picked up by a suction or magnetic gripping device when used in a “pick and place robot” application.

- Always avoid parts with sharp edges, burrs or points. Use radii and chamfers when possible to reduce chance of operator injury.
- Avoid heavy or oversized parts that will require lifting devices or may increase worker fatigue and risk of injury. Always consider assembler and operator safety in all designs.
- When designing a workstation it is good practice to plan for minimum worker travel time. Minimize the distance to access and move a part or assembly. A good rule of thumb is that most components should be within two steps from the point of assembly and common hardware and tools within easy reach.

Design for Ease of Assembly

There are many methods to design for ease of assembly. When designing for assembly, remember the simpler the design the easier it is to assemble. The designer should consider where the assembly is going to be performed and the tools or equipment that will be available. For example, if the product is sold as a kit and assembled in the field by the customer, it is different than if it will be assembled on an assembly line or in a work cell. There are many guidelines for ease of assembly. The following list contains some examples:

- Incorporate simple patterns of movement in your assembly process and minimize steps. If that is not possible, consider breaking it down into logical sub-assemblies.
- Avoid multiple set-ups or re-orientation during the assembly process. This creates wasted movement and time.
- Parts should incorporate lead-in features and chamfers. This allows for easier insertion of pins or bolts.
- Design the product so it may be assembled from the bottom up using gravity to your advantage.
- Always allow for adequate tool clearance and assure the operator can see what they are assembling, with no hidden interfaces or attachment points.
- Limit the variety of hardware sizes and configurations in an assembly. This will help prevent incorrect hardware being used or used in the wrong location.
    - Example: One design recently observed utilized one size and type of self-tapping screw for every sub-assembly and the parent assembly. Only one type of hardware was required in the production cell.

Reduce / Eliminate Flexible Parts and Interconnections

The designer must consider the usage and environment in which the product will operate. Many product failures are due to the component parts not being robust to the application. Let’s look at one example. There was a display system that operated a piece of equipment used outdoors which has inherent vibration during operation and experiences heavy usage. The displays were failing due to a fragile ribbon cable that became brittle over time and would break. It was also found that the cable connectors did not lock into place and would sometimes vibrate out, breaking the connection. The product was redesigned to include a locking connector attached to a temperature resistant cable robust to the operating environment. Here are a few ideas to think about:

- Design for use of robust connectors and connection points
- Avoid flimsy flexible cables, tubing and gaskets when possible
- Minimize the use of wire harnesses – instead design boards that stack and /or plug directly to one another when possible
- Utilize direct drive instead of pulleys and belts
- When harnesses are used, error proof the connectors by using unique connectors that cannot be attached in the wrong orientation or to the incorrect mating connection

Incorporate Easy and Efficient Fastening Methods

Threaded bolts, washers and nuts are time consuming to assemble. If they are required, consider weld nuts or nuts that are captured in the part. The designer must look at alternative methods of attachment.

- Minimize the variety of hardware required for assembly
- Consider the use of connections integrated into the parts such as snap fit or tab and slot
- Evaluate other bonding techniques with adhesives
- Match fastening techniques to materials and product functional requirements
- Consider ease of disassembly for service and repairs

Modular Product Design

Modular design is becoming more prevalent in many industries. It has various advantages for the manufacturer, the dealer and the customers. Some of the advantages to modular design are listed below:

- Modules help minimize cost by reducing the number of different parts within a family of products
- Modules may result in shorter learning curves when new employees require training on the assembly of the products
- In some cases it allows the manufacturer to balance production throughout the year based on projected seasonal sales
- In addition, the dealer can stock most sold items for fast delivery to customer. Customized combinations of the modules can be delivered to the site and installed quickly.
- Modules allow for greater outsourcing of parts and assembly modules, freeing-up manufacturing capacity and increasing the number of products delivered on time
- Modules provide for easy and quick installation of products at the site saving labor and time
- Modules improve servicing and maintenance of products as well as reduces the number of service parts that need to be stocked at the dealer
- Modular assemblies can also be improved with minimal effect on the rest of the product

Design for Automation

There are many obvious advantages to designing products or parts for automation. A few of them are listed below:

- Increased process throughput or efficiency.
- Improved quality or more predictable process results.
- Consistency in the process output.
- Reduced operator labor costs and indirect labor costs

Something else to consider is the fact that automated production can require less flexibility in design than manual production. The product must be designed so that it can be handled with automated equipment like gripping or magnetic lifting and placement equipment. Avoid any requirements for gripper / tool change. You must also use self-locating parts, simple parts-presentation devices and avoid the need for clamping or securing parts during assembly or processing.

Design for Manufacturing and Design for Assembly are both important and often interwoven and referred to simply as DFM/A. The primary goal is to design a product and process to be as efficient as possible. Whether a product is assembled by machines or by operators, the designer and the mechanical engineer should work together to ensure that labor cost, overhead and materials are reduced as much as possible. We should always strive to produce a quality product the first time and every time and Design for Manufacturing and Assembly can help! When DFM/A is applied, your company can run at higher profit margins, with higher quality and at a greater level of efficiency.

<u>Aplications:</u>

Understanding the importance of design for X and prototyping methods.

<u>MCQ – Post test:</u>

1. Design for manufacturing is a _______ step process.
   a. 2
   b. 3
   c. 4
   d. 5 d
2. DFM stands for ____________
   a. Design for machinery
   b. Design for machine tools
   c. Design for manufacturing
   d. Design for mechanics c
3. Estimating the manufacturing cost is the first step of DFM technique.

a. True
b. False
c. Not applicable
d. None of these a

4. While looking up the DFM process, the following are to be considered
   a. Reduce the cost of components
   b. Reduce the cost of assembly
   c. Reduce the cost of supporting production
   d. All the above d
5. While estimating the manufacturing cost, the following are to be considered
   a. Component costs
   b. Assembly costs
   c. Overhead costs
   d. All the above d
6. Labour, equipment and tooling cost comes under
   a. Assembly cost
   b. Component cost
   c. Overhead cost
   d. None of these a
7. Supporting and indirect allocation costs comes under
   a. Assembly cost
   b. Component cost
   c. Overhead cost
   d. None of these c
8. Raw material, processing and tooling costs are known as
   a. Standard cost
   b. Custom cost
   c. General cost
   d. None of these b
9. During cost analysis in DFM process, BOM stands for____________
   a. Board of members
   b. Bill of materials
   c. Born of Mumbai
   d. None of these b
10. Tooling for casting, machine tools and fixtures comes under
    a. Fixed cost
    b. Variable cost
    c. Unit cost
    d. None of these a
11. DFA stands for ____________

a. Direct fixed assembly
b. Design fixed animation
c. Design for assembly
d. Design for animation c

12. DFA index is directly proportional to ___________
    a. Theoretical minimum number of parts
    b. Estimated total assembly time
    c. Efficiency
    d. None of these a
13. ____________ is a philosophy followed in DFM technique.
    a. Minimize the ease of assembly
    b. Maximize the ease of assembly
    c. Do nothing on assembly
    d. None of these b
14. Increasing the self-aligning parts will ______________ ease of assembly
    a. Enhances
    b. Diminishes
    c. Do nothing on
    d. None of these a
15. During the process of DFM, product complexity must be___________
    a. Maximized
    b. Minimized
    c. Not applicable
    d. None of these b

Conclusion

Design for X is an important stage in the product development process. It helps to avoid mistakes during design.

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3. Rosenthal S., “Effective Product Design and Development”, Business One Orwin, Homewood, 1992, ISBN 1-55623-603-4.
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Assignments

1. Explain the design for manufacturing process with suitable example.
2. Explain any two prototyping methods with neat sketches.