Product Planning & Development (21-423)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session #11

Course Description

- Instructor
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- Recommended prerequisite
  - Manufacturing process I (21-418)
- Class time
  - Sunday-Tuesday 18:00-19:30
- Course evaluation
  - Mid-term (25%)
  - Final exam (40%)
  - Quiz (5%)
  - Exercise (Manufacturing Lab.) (30%)

Session reference

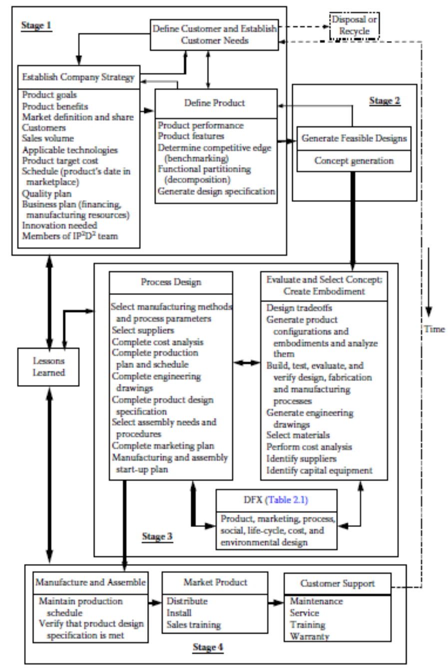
- *Reference:*
  - *Edward B., "Integrated product and process design and development : the product realization process", CRC Press, 2010*
  - *John Priest, Jose Sanchez; "Product Development and Design for Manufacturing: A Collaborative Approach to Producibility and Reliability, Second Edition", CRC Press, 2001*
  - *Mital et al. , "Product Development A Structured Approach to Consumer Product Development, Design, and Manufacture", Butterworth-Heinemann, 2008*

Course Description *(Continued..)*

- ***Contents:***
- *Product development in the changing Global world*
- *Stages of Product Development*
- *The Structure of the Product Design Process*
- *Early design: Requirement definition and conceptual Design*
- *Trade-off analyses: Optimization using cost and utility Metrics*
- *Detailed design: Analysis and Modeling*
- *Design Review: Designing to Ensure Quality*
- *Production System; Strategies, planning, and methodologies*
- *Production System Development*
- *Planning and Preparation for Efficient Development*
- *Supply chain: Logistics, packaging, supply chain, and the environment*

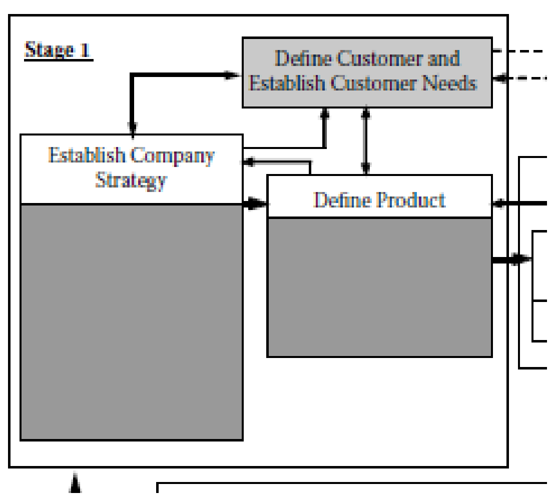
Trade-off analyses: Optimization using cost and *[cut off]*

- *Early Design:*



Product Functional Requirements and Functional Decomposition

- *Functional modeling*



Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach*
  - *AD gives a means of clarifying and focusing both the product's functions and the objectives that the design should meet.*
  - *the axiomatic approach provides a compact visual way of expressing the design intent and the overall design objective.*
  - *Functional requirements are defined as the minimum no unique set of independent mandatory requirements that completely characterize the design objectives for a specific need.*
    - *If possible, they must be independent of each other at every level in the design hierarchy.*

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach*
  - *AD gives a means of clarifying and focusing both the product's functions and the objectives that the design should meet.*
  - *The axiomatic approach provides a compact visual way of expressing the design intent and the overall design objective.*
  - *(FRs) Functional Requirements are defined as the minimum no unique set of independent mandatory requirements that completely characterize the design objectives for a specific need.*
    - *If possible, they must be independent of each other at every level in the design hierarchy.*

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach*
  - *Design parameters (DPs) denote the physical entities that will be created by the design process to fulfill the FRs.*
    - *In other words, the functional requirement describes what action or series of actions is required to satisfy the customer needs, and the design parameter is the physical entity (component/module/unit) that has to be created to satisfy its functional requirement.*
  - *The creation of the DP requires that a concept (specific principle, method, or means) be selected.*

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach*
  - *The functional requirements are subject to constraints.*
  - *In the context of the axiomatic method, constraints differ from FRs in that they do not have to be independent of other FRs or other constraints.*
  - *The effect of constraints on the outcome of the design process cannot be overstated.*

Product Functional Requirements and Functional Decomposition

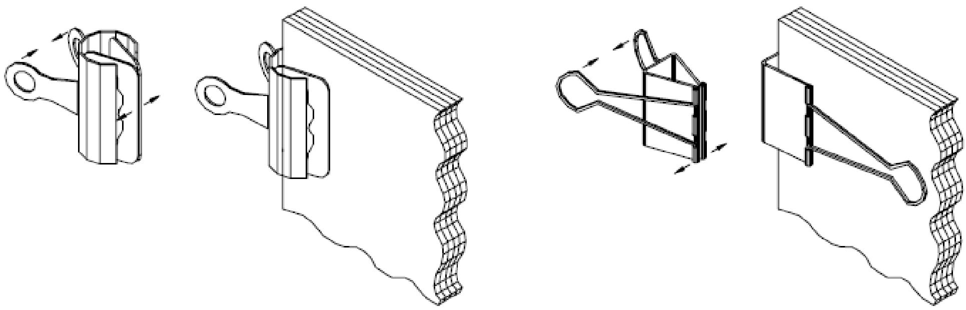
- *Functional Decomposition and the Axiomatic Approach*
  - *The functional requirements for both bicycles are the same: support rider, manually propel bicycle, steer, and stop*
  - *The touring bicycle constraints will be directed to high speed on smooth riding surfaces.*
  - *For the mountain bicycle, the constraints will be directed toward maneuverability and climbing ability on a wide variety of unpaved surfaces.*

Product Functional Requirements and Functional Decomposition

- *Functional Requirement*
  - *A manufacturer's requirements that must be satisfied by its all-wheel drive (AWD) system:*
  - *Torque transfer up to 2,400 Nm.*
  - *Built-in torque transfer limitation.*
  - *Full function in reverse.*
  - *Instant activation on differential speed.*
  - *Fully integrates with brake systems and stability systems.*
  - *Can be deactivated in less than 60 ms.*
  - *No wind-up during tight cornering and parking.*
  - *No functional problems when towing with one axle lifted.*
  - *Transparent actuation.*

Product Functional Requirements and Functional Decomposition

- *Functional Requirement*



Product Functional Requirements and Functional Decomposition

- *Functional Requirement*

Goal	Representative Product
High acceleration	Corvette
High fuel economy	Prius
No emissions	Tesla roadster
Luxury	Maybach
Sporty	BMW Z4
Family friendly	Odyssey
Lowest purchase price	Aveo
Small size	Smart, Polo

Product Functional Requirements and Functional Decomposition

- *Functional Requirement*
  - *Design is the creation of synthesized solutions (products, processes, systems) that satisfy perceived needs through the mapping between the FRs (in function space) and the DPs (in the physical domain)*

through the proper selection of the DPs that satisfy the FRs.

  - *If the FRs change, then the solution changes*
  - *Design involves the continuous interplay between what we want to achieve (the FRs) and how we want to achieve it (the DPs) so that the final design cannot be better than the set of FRs and their constraints that it was created to satisfy.*

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach: Two Axioms*
  - *There are two design axioms that have been proposed as a means of evaluating a good design.*
  - *Axiom 1. The Independence Axiom*

Maintain the independence of the FRs.

  - *Axiom 2. The Information Axiom*

Minimize the information content of the design

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach: Two Axioms*
  - *Axiom 1 deals with the relationship between functions and physical variables.*
  - *It states that during the design process, as one goes from DPs to FRs the mapping must be such that a perturbation in a particular DP only affects its referent FR.*

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach: Two Axioms*
  - *Axiom 2 deals with the complexity of the design.*
  - *It states that among all designs that satisfy Axiom 1, the one with the minimum information content is the best.*
  - *The designs that integrate parts while preserving their functional independence, designs that use standard and interchangeable parts, and designs that use symmetry as much as possible will result in designs that have reduced information content.*

Product Functional Requirements and Functional Decomposition

- Functional Decomposition and the Axiomatic Approach: Two Axioms

Product Functional Requirements and Functional Decomposition

- Functional Decomposition and the Axiomatic Approach: Two Axioms

$$\{FR\} = \begin{Bmatrix} (FR)_1 \\ \vdots \\ (FR)_n \end{Bmatrix} \quad \text{and} \quad \{DP\} = \begin{Bmatrix} (DP)_1 \\ \vdots \\ (DP)_n \end{Bmatrix}$$

$$\{FR\} = [A]\{DP\}$$

$$[A] = \begin{bmatrix} A_{11} & A_{12} & \dots & A_{1n} \\ A_{21} & A_{22} & \dots & A_{2n} \\ . & . & \dots & . \\ A_{n1} & A_{n2} & \dots & A_{nn} \end{bmatrix}$$

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach: Two Axioms*

$$\begin{Bmatrix} (FR)_1 \\ (FR)_2 \\ (FR)_3 \end{Bmatrix} = \begin{bmatrix} A_{11} & 0 & 0 \\ 0 & A_{22} & 0 \\ 0 & 0 & A_{33} \end{bmatrix} \begin{Bmatrix} (DP)_1 \\ (DP)_2 \\ (DP)_3 \end{Bmatrix}$$

Product Functional Requirements and Functional Decomposition

- *Functional Decomposition and the Axiomatic Approach: Two Axioms*

$$\begin{Bmatrix} (FR)_1 \\ (FR)_2 \\ (FR)_3 \end{Bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \begin{Bmatrix} (DP)_1 \\ (DP)_2 \\ (DP)_3 \end{Bmatrix}$$

Project

- *Product Functional Decomposition*