PART II
Design Stages 3 - 8
Steps 7 – 12

- Details of the Design
- Testing the Design
- Design Review and Refinement
7. Develop concepts and select the best alternative.

8. Complete the system or parameter level design.

9. Complete the detail (or tolerance level) design for production.

10. Test the effectiveness of system or production design.

11. Review, assess, and evaluate the design results against the objectives at each stage.

12. Iterate: refine and improve based on the evaluations; communicate the results.

Pugh Matrix, Design Concepts, Descriptions, and Drawings (Documents DP-7, DP-7A,B,C)

List of Design Decisions on Selected Concept supported by evaluation of alternatives, research, analyses, and calculations; Bill of Material; Assembly Drawings (Documents DP-8A,B,C)

Design Progress Report (Document DP-8)

Detail Drawings, Production Specifications, and Tolerances (Document DP-9)

Prototype or Production Model Test Plan (Document DP-10)

Design Evaluation Results Report (Document DP-11)

Final Design Project Report (Document DP-12) Presentations and Team Evaluation (Documents DP-12A,B,C)
Step 7: System Level Design Stage

- Seeing the Design as the User Sees It and as the Producer May Build It
  - Consider product and process technologies which will bear on design decisions

- Develop Multiple Design Concepts
  - First of three design levels
  - Based on Design Problem Analysis statement and Design Project Proposal
  - Encourages designers to consider multiple alternatives early in the process
Step 7: System Level Design Stage (2)

- Choose the Best Alternative
  - Compare merits of each concept
  - Merits are determined by how well a design concept meets the project goals (objectives and constraints)

- Don’t Rush the Process!
  - Less time, effort, and cost to make changes on paper early in the process than during prototype and production stages (or worse, through product recalls)
Step 7: System Level Design Stage (3)

• Pugh Method, Round I
  ✓ Each team member invents a complete design concept and presents the concept to the team
  ✓ Emphasis on how well the concept addresses each of the design objectives and constraints
  ✓ Design objectives and constraints used are weighted by importance
  ✓ Use Modified Pugh Matrix to rate each design compared to a baseline (-1, 0, or +1)
  ✓ Baseline can be an existing design or one of the team’s design concepts
Step 7: System Level Design Stage (4)

- Pugh Method, Round II
  - Concept selected as the best now becomes the baseline
  - New competing designs are invented, based on best-rated features of the designs in Round I
  - Use Modified Pugh Matrix again to rate the designs
  - Repeat process as necessary until an approved design is chosen
Step 8: Parameter Level Design Stage

- Optimize the Design with Respect to Performance
  - Goal is for the design product to exhibit “robust” performance
  - Robust means to perform well under the intended conditions of use with relative insensitivity to variations in conditions or types of users
Step 8: Parameter Level Design Stage (2)

- Complete Specification of the Design Product
  - List major decisions to complete parameter level
  - Identify viable alternatives
  - Perform analyses, simulations, or model tests to determine appropriate values of parameters
  - Trade-off analyses for competing parameters
  - Make decisions that optimize the performance of the entire design against all objectives
  - Beware against *sub-optimizing* an aspect of the design
Step 8: Parameter Level Design Stage (3)

• Complete Documentation of All Decisions
  ✓ List of decisions and rationale behind them
  ✓ Construction, layout, or assembly drawings
  ✓ Bills of material for all built or purchased materials, with complete specifications

• Designed Experimentation
  ✓ Understand more complex phenomena of design parameter interplay not available through trade-off analysis or Pugh Matrix
Step 9: Tolerance Level Design Stage

- Detail Design Decisions
  - How much variation around nominal specifications is tolerable for acceptable quality?
  - What is the least precise tolerance that can be applied to a component with acceptable quality?
  - May assembly or construction tolerances be relaxed by a more “fault-tolerant” design?
  - Specify tolerances to avoid tolerance stack-up and ambiguous/conflicting specifications
    - ASME Y14.5M specification standard
Design Evaluation Stage

Step 10: Testing the Design

- State Specific Purposes of the Test
  - Prototype, component, or production model test
  - Design decisions the test will validate or illuminate
  - Objectives of test
  - Step-by-step procedure
  - Outline of expected results
Step 11: Review, Assess, Evaluate

• Do At Each Design Stage
  ✓ Provides opportunities for periodic improvement during design stages
  ✓ The earlier in the process you do it, the less it costs!
Step 12: Iterate, Refine, Improve

- Evaluation and Communication
  - Review of design evaluation results
  - Identification and ranking of potential improvements
  - Communicating the results
    - Use appropriate format for the particular design stage
Step 13: ????

Questions

Your feedback is appreciated!