The Engineering Design Process –Function before Form

For our purposes, the engineering design process seeks to define the materials and geometry which make up a product. Importantly, engineering design emphasizes product function over its form. Hence engineering design is not styling first, rather styling second. In other words, while styling may influence the design it does not dictate the design. A good design will function well and be esthetically pleasing.

During the past decade, a wide range of textbooks has appeared which address the methodology of design with each author attempting to reveal guidelines that can be used for all design problems. The result is a comprehensive set of charts, approaches, and exercises, that at first glance, appears daunting. One author breaks the process down into several subprocesses (Hubka, 1987) which fall into one of the following three categories: conceptual design, lay-out design and detail design. Activities associated with these stages were extracted from several sources (Eder, 1989, Hubka, 1987, Hubka, et al., 1988, Ulrich and Eppinger, 1995) and include the following:

_ identify customer need
_ establish project specifications
_ generate concepts (search for solutions by examination of competing products, brainstorming, iteration, etc.)
_ select concept (evaluate possible solutions and decide on the most promising)
_ determine the life-cycle of the part (design for assembly/disassembly/recycle)
_ understand relevant legal issues
_ incorporate business considerations (cost-effective, market-analysis, etc.)
_ incorporate effects of manufacturing (design for manufacture)
_ perform calculations and verify performance (use standards, codes, and current accepted practices)
_ consider effects of variability (set appropriate tolerances)
_ validate performance (prototype testing)
_ communicate design (graphically represent design)
_ report final design

Each design may require emphasis on a different activity. For example, some designs deal with more environmental or legal issues whereas others may focus on reducing manufacturing costs. Regardless of the focus, each design will begin with identifying the problem and developing key factors for the solution. For example, let's consider problem statement 3 from page 1. What is the customer need?

Exercise 1. List ten features you think the customer may want or need for the hammock attachment system. Be prepared to discuss these in class.

1. rope length for a range of tree distances	6.
2. ________________________________	7.
3. ________________________________	8.
4. ________________________________	9.
5. ________________________________	10.

Look over your list and devise a set of criteria, or the method for which you will establish the criteria, to meet the design need. For example, the first item on the list reflects a variability in customer need— namely, the distance between trees (or posts). We could limit the total rope length to 4 feet. If we do, we will have to provide a hook that can be bored into the tree trunk as there will not be sufficient rope to wrap around trees. You can quickly see how complicated this process becomes. But have we thought of everything? What if the market area has no trees? As a design engineer, your task will be to consider as many design ideas as possible and then develop the most promising ideas in full detail. Identifying the specifications, assumptions and limitations are integral parts of the report which communicate your final detailed design.

The design stage which involves analysis and calculation must be performed with current, accepted practices. This means that standards must be used where appropriate (refer to the appendix on standards). Good resources are handbooks related to the discipline, e.g., Marks' Standard Handbook for Mechanical Engineers, Civil Engineering Handbook, or the SAE (Society of Automotive Engineers) Handbook. Designs that involve human interaction require information on population data, or an understanding of ergonomic issues. For such instances refer to the Handbook of Industrial Engineering, Handbook of Human Factors and Ergonomic Design, or Human Factors in Engineering and Design. References that focus on specific materials can be found in the appendix on materials. A book of formulas (Blake, 1982, and Roark and Young, 1975) supplements the theoretical developments in a strength of materials text by including solutions for various fundamental models. Computer-aided-engineering (CAE) tools continue to evolve to support the repetitive calculations associated with design. The practice of using CAE is becoming more accepted; however, as with reference handbooks, the tool can only be applied successfully with a solid understanding of the relevant theory. Importantly, al resources used to create the design must be recorded and referenced.

Once the design is finalized, it must be communicated accurately in a report. Usually, the communication is multistage. A preliminary report is developed which shows the proposed design with detailed sketches. Sometimes a prototype is created from the preliminary layout. Modifications are usually made as a result of refining a specification, determining appropriate tolerances, or adjusting a component for a specific manufacturing or assembly process. Finally, the detailed drawing is prepared according to current accepted practices.

Design practices, beginning with identifying the customer need, up through the preliminary layout communication stage will be considered in this course. Recall that each design problem will have a unique set of demands and that formulating the problem into a tractable form will be one of the initial challenges. To help with that stage, a review of modeling supports and load will be presented.