CHAPTER 10: CONCLUDING CONCEPTUAL DESIGN: MOVING TOWARD DETAILED DESIGN

Chapter outline

- Bill of materials
- Considerations in detailed design

In freshman engineering, you will concentrate on conceptual design. That is, your projects will culminate in the presentation of a design concept that solves the client's problem and addresses user needs. To test that concept and demonstrate it to your client, you will have to move part way into the second major phase: detailed design. In EDC, that phase will consist of producing a prototype that embodies key features of your design. You will need to figure out exactly where certain components will connect, how far apart holes must be drilled, what kinds of fasteners to use, and other such problems.

In a few cases, your detailed design might include a fully functional "looks like/works like" prototype. This most often occurs if you are creating a "one off"—a unique design for a single user, such as a toy for disabled children at Children's Memorial Hospital or a wheelchair ramp for a specific client's front entrance. In completing a detailed design, you will produce a bill of materials and dimensioned drawings that depict all components of the system. The bill of materials and other considerations that go into detailed design are discussed below.

10.1 BILL OF MATERIALS

The bill of materials (BOM) is a comprehensive listing of every item that goes into a finished product. For each item, the BOM includes the description, quantity, part number, unit cost, and total cost. The BOM tells the client exactly how much the design costs and eases the process of ordering parts if the client decides to manufacture it.

Here is a small portion of the BOM from a project to design swimming goggles for people with spinal cord injuries:

Example 10.1: Portion of a bill of materials

Item	Description	Qty	Source	Part #	Unit Cost	Total Cost
Dive mask	U.S. Divers Admiral Mask	1	Sports Authority	2173701	$29.99	$29.99
Aluminum plates	Corrosion-resistant aluminum (alloy 5052), 1/8" thick, 1" width, 12" length	1	McMaster Carr	9135K111	$8.01	$8.01
Polypropylene rib	Polypropylene strip, 1/16" thick, 1/2" wide, 12" long	1	McMaster Carr	8742K131	$0.15	$0.15

10.2 CONSIDERATIONS IN DETAILED DESIGN

When a client wants to mass-produce the product, detailed design becomes much more complex than in the case of a one off—and beyond the scope of EDC. But because detailed design for production is such a crucial aspect of the work you will do as an engineer, you should have a general understanding of what it involves. Here is a partial list of considerations that typically go into detailed design for production:

- Materials: What will each component of the product be made of? If there are 18 components in your design, then you must specify the material of each one. It isn't enough to say that the material will be plastic, since there are many kinds of plastic. If you go to the website of McMaster-Carr, a large industrial supplier, you will find that they carry 21 different categories of plastic, ranging from ABS to Garolite to Ultem. Within those 21 categories, there are sub-categories, and each one has specific properties, uses, and costs. You need to research materials to specify those that best suit the requirements of your design.
- Manufacturing processes: How will components be produced? If you are designing a plastic component for production, will it be manufactured by injection molding, blow molding, rotational molding, compression molding, or some other process? Your decision will affect what features you incorporate into the part and its manufacturing costs.
- Assembly: How will the various components be joined in the final product? In their book, *Engineering Design: A Project-Based Introduction* (2000), Clive Dym and Patrick Little give this example:

  > [A]ssembling a ball point pen might require that the ink-holding unit be inserted into the tube that forms the handgrip, and that caps be attached to each end. The assembly process can be done in a number of ways, and the designer needs to consider approaches that will make

> it possible for the manufacturer to reduce the costs of assembly while maintaining high quality in the finished product. (p. 202)

- Reliability: What is the probability that each component in the design will fail to function within a given period of time (or number of uses, miles, etc.)? It is a given in engineering that all components fail. Detailed design requires that you consider the causes that contribute to failure (stress, heat, corrosion, etc.), the means of counteracting those causes, and methods of dealing with failure when it does occur (for instance, designing redundancy into the system so that when one component fails, another allows the system to keep functioning until a repair can be performed).
- Maintenance: How can the product be designed to make maintenance and repair as easy and practical as possible? Dym and Little (2000) explain the role of engineers in this aspect of detailed design:

> Designing for maintainability requires that the designer take an active role in setting goals for maintenance (such as times to repair), and in determining the specifications for maintenance and repair activities in order to realize these goals. This can take a number of forms, including selecting parts that are easily accessed and repaired, providing redundancy so that systems can be operated while maintenance continues, specifying preventive or predictive maintenance procedures, and indicating the number and type of spare parts that should be held in inventories in order to reduce downtime when systems fail. (p. 214)

These and other considerations are important to good detailed design for production. Clearly, no one engineer can master them all. That's partly why companies assemble cross-disciplinary teams to work on design projects. The point is, however, that no designer can afford to overlook these considerations in completing a project.

10.3 REFERENCES

Dym, C. & Little, P. (2000). *Engineering design: a project-based introduction*. New York: John Wiley and Sons.

Foley, P., Kanesathasan, A., Schuster, D. & Willer, M. (2008). *Tap-tight goggles:tap on, tap off*. Engineering Design and Communication, Northwestern University.