Design for Assembly

A common roadblock to the manufacturing industry is the ability of a design to be manufactured. Industrial designers play the leading role in determining a product's form and appearance. What these designers sometimes fail to realize is that their designs also affect the way in which a product will be manufactured and assembled.

Traditionally, it was expected that engineering students should take "shop" courses in addition to courses in machine design. The idea was that a competent designer should be familiar with manufacturing processes to avoid adding unnecessarily to the manufacturing costs during design. Unfortunately, in the 1960s, shop courses disappeared from university curricula in the U.S.; they were not considered suitable for academic credit by the new breed of engineering theoreticians (Boothroyd, Dewhurst, and Knight 1994, p. 1).

This lack of practical "know-how" has hurt the design of manufactured goods. "If the designer creates forms on paper using pencil or marker, there is a danger that he or she is not only removed from an understanding of what the manufacturing ramifications are but is another step removed from dimensional reality and material behavior. It takes a real-world understanding of materials and manufacturing methods to create successful products" (Lesko 1999, p. 3).

To counter the growing effects of the removal of design from real-world application, a detailed system for product design for assembly was necessary. Geoffrey Boothroyd and Peter Dewhurst led the development of design-for-assembly (DFA) systems, starting in 1977 with funding from the U.S. National Science Foundation (Huang 1996, p. 21). Design for Manufacture and Assembly (DFMA, a trademark of Boothroyd Dewhurst, Inc.) is a computer-based system where savings in both manufacturing and assembly costs can be achieved through parts reduction. "In order to give guidance to the designer in reducing the part count, the DFMA methodology provides three criteria against which each part must be examined as it is added to the product during assembly" (Boothroyd, Dewhurst, and Knight 1994, p. 5):

- During operation of the product, does the part move relative to all other parts already assembled? Only gross motion is considered—small motions that can be accommodated by integral elastic elements, for example, are not sufficient for a positive answer.

- Must the part be of a different material than, or be isolated from, all other parts already assembled? Only fundamental reasons concerned with material properties are acceptable.

- Must the part be separate from all other parts already assembled because otherwise necessary assembly or disassembly of the separate parts would be impossible?

The answers to these basic design questions lead to the establishment of the critical parts necessary for the assembly. In addition, these parts form the baseline for manufacturing and assembly evaluation. Mathematical formulas involving theoretical part counts and design efficiencies help put a quantifiable cost on various designs. In fact, Boothroyd and Dewhurst's system establishes the systematic procedure for analyzing a design prior to assembly and manufacture (see Figure 2.8).

The DFMA system has been a documented success in many industries including automotive, electronics, and aviation. The DFMA system has also been applied on low–assembly cost and low-volume operations with the same success as high–assembly cost, high-volume operations.

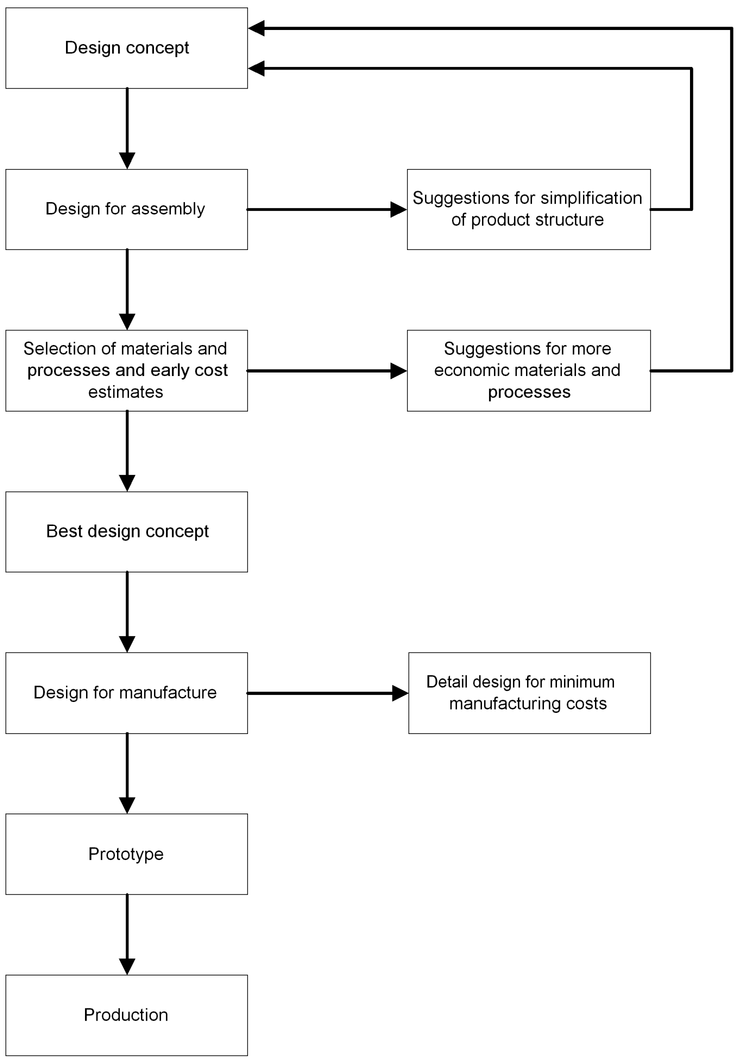

Figure 2.8: Typical steps in a design for manufacture and assembly study.

The construction industry has already instituted a technique similar to the manufacturing industry's design for assembly. It is called "value engineering" (VE). VE is a technique by which a project's value is increased. Since value is a function of worth divided by cost, VE attempts to increase a project's worth while decreasing a project's cost. In the same manner, DFMA attempts to increase the value of a product by decreasing cost and increasing product quality (a form of worth). However, the major difference between DFMA and VE is the stage in the product design-production cycle at which the process is applied. VE is usually applied in construction after the design stage, whereas DFMA in manufacturing is applied as part of the design phase. DFMA can be successfully applied in construction if used during the design phase, similar to the manufacturing industry. Outputs from the DFMA process could help reduce project duration, reduce project costs, and increase project quality. Current potential systems that could greatly benefit from a DFMA analysis in residential construction include foundations, wall systems, roof systems, and plumbing systems. Tremendous monetary savings could be generated and passed on to homeowners if these systems could be designed around manufacturing and assembly.

CONCLUSION

Construction has been a conservative industry. Potential liabilities, personal resistance to change, and contentious project relationships have limited the development of construction production methodology. However, the manufacturing industry has shown that industrialization in information management, production management tools, and assembly techniques can change not only a company but an entire industry.

The construction industry must first assess the potential idea transfers from the manufacturing industry leaders. This section has identified several high-potential manufacturing techniques that can be applied to construction: JIT manufacturing, supply chain management, material/resource planning systems, and DFA systems.

In particular, there is a need to focus the construction industry on three thrust areas: enterprise-wide business-support systems (IT), process and production management tools, and assembly industrialization techniques. The results of efforts in these three areas will bring reduced project costs, increased productivity, and increased project quality by improving information management, resource utilization, and assembly techniques, all of which both consumers and the industry desire. These techniques have the potential to become the vehicle for integration of the residential construction industry. Concepts and methods of integration will be discussed in the next chapter.