Chapter Five

TOOLING

INTRODUCTION

Costs of tooling have their own distinct CCDR category. In this chapter, we describe the different aspects of tooling and some of the advances in tooling concepts relevant to lean production. Improvements in product design and tooling flexibility have the potential to lower costs and ease the manufacturing process. The CCDR definition for tooling can be found in Appendix C.

TOOLING IN THE CCDR

The tooling CCDR cost category is divided into two groups, design and fabrication. Tooling also has recurring and nonrecurring aspects. Tooling in the CCDR sense refers to the special tools and equipment unique to a particular weapons system. General-purpose tooling (cranes, autoclaves) usable for different products is normally accounted for in the factory overhead category. Nonrecurring tooling refers to the initial tool design and in-house fabrication or purchases, as well as subsequent buys for replacement or to increase manufacturing rates. Recurring tooling captures costs for maintenance and repair of tooling unique to manufacturing a particular weapon system as well as wear parts, such as drill bits.

Note that lean principles hold engineering and tooling to be intrinsically related. Designing for lean manufacturing involves careful attention to minimizing all tooling costs. For example, parts that self-locate minimize the need for jigs and other tools that hold parts in the proper position for assembly. Flexible tooling that can be used for more than one part decreases the overall investment in tools.

Organizing manufacturing lines according to lean principles should enable output to be increased in any given line, thereby reducing the costs of procuring additional tooling. The same techniques and design concepts, coupled with attention to costs, that reduce assembly hours can also be applied to reduce tooling costs.

ADVANCES IN TOOLING

Self-Locating Parts

One mechanism to reduce tooling is to design and fabricate parts with devices that properly align them in the next higher assembly or to adjoining parts. For example, small tabs or tongue-and-groove features in adjoining parts can help locate them in the proper position during final joining, whether using fasteners, adhesives, or some other assembly method. This can dramatically reduce the number of dedicated assembly tools required to hold different parts and subassemblies in place as they are joined.

Flexible Tooling

Another technological advance that contributes to lean is flexible tooling. Flexible tools can be used in the fabrication or assembly of multiple parts rather than being dedicated to a particular part or a small family of parts. Ideally, they should also have very low setup times. Tools that can make many different parts can be used to fill in and reduce bottlenecks by allowing for the manufacturing of whatever subassemblies are needed to continue the flow of aircraft through the plant. They can also help reduce total investment in nonrecurring tooling, because fewer tools dedicated to particular parts are needed. For example, "pogo beds" are holding devices consisting of a grid of small rods with suction devices at the end. The rods can be individually raised and lowered so that parts of different shapes can be placed on the beds that have been programmed to match the shape of a part or subassembly. The vacuum applied by each suction device holds the parts tightly in place during processing by machine tools.

Another classic example of flexible tooling is offered by optical laser ply alignment of composites. Rather than using hard templates in the shape of each ply to mark out where to locate the actual ply on the lay-up tool, laser ply alignment involves an outline of laser light projected onto the tool to guide the mechanics in placing each ply of composite material onto the previous plies. Benefits include lower labor hours, elimination of the design and purchase or manufacture of templates, faster fabrication (ply laying), and elimination of storage space and maintenance of the templates. Costs include the purchase and programming of the laser. (The costs of programming the laser are not significant if a translator program is used with the digital data from the design database.) One company estimated that overall, laser ply alignment systems save as much as 67 percent in nonrecurring tooling costs. In one case, hard template tooling took an average of 70 hours to fabricate. The N/C programming required for laser ply alignment took only 22 hours.

Other New Tooling Technologies

Other new technologies improve productivity and quality and reduce cost. For example, high-speed machine tools offer many contributions to leanness. One company listed the following benefits: design optimization/learning, span time reductions, reduced assembly requirements, improved part finishes and tolerances, ability to accommodate all part families and unitized structures, producibility for high angularity parts, and burr reduction.

These new technologies may or may not be used in a lean way—e.g., to improve flow of the value through the plant. A new high-speed machine tool located in a traditional machine shop will certainly process batches more quickly. In this capacity it contributes to a reduction of overall value-added cycle time, but the overall part or product cycle time may not be decreased measurably if the part is fabricated and then is placed in a holding area awaiting the next operation. However, high-speed machines can contribute to lean production in many other ways by taking advantage of their capabilities in the design process to develop unitized structures.

SUMMARY DISCUSSION OF LEAN TOOLING

Several of the companies participating in this study provided interesting examples of how they planned to reduce the tooling required on future programs. These included both design features (e.g., self-locating parts) and new tooling technologies and concepts. In one case, analyzing product flow through the plant led to an estimate that rate tooling could be reduced by one full assembly line. Lean implementation does have a potentially significant effect on tooling costs in the manufacture of military aircraft, but there is as yet little actual data from full-rate production in a lean environment.