Chapter III
Computer-Aided Process Planning and Manufacturing

ABSTRACT

Products and their components are designed to perform certain functions. Design specifications ensure the functionality aspects. The task in manufacturing is then to produce the components that meet the design specifications. The components are in turn assembled into the final products. When computers are used to assist the process planning and manufacturing activities, multiple benefits can be had. The related technologies are known as computer-aided process planning and computer-aided manufacturing. Often, they are not separable and are therefore discussed in tandem in this chapter. It should be emphasized that process planning is not only for metal-cutting processes. We need process planning for many other manufacturing processes such as casting, forging, sheet metal forming, composites and ceramic fabrication. In this chapter, the basic steps of developing a process plan are explained. There are two approaches to carrying out process planning tasks—manual experience-based method and computer-aided process planning method. The focus is on two computer-aided process planning methods, the variant approach, and generative approach. These discussions on process planning have been limited to machining processes. The topic of computer-aided manufacturing, on the other hand, is discussed with a more general point of view. A fictitious CAM plant is presented and some of the key aspects of CAM in a manufacturing system are discussed. A more specific version of CAM (i.e. computer numerical control) will be covered in Chapters VIII and IX.
COMPUTER-AIDED PROCESS PLANNING

Traditionally, process planning tasks are undertaken by manufacturing process experts. These experts use their experience and knowledge to generate instructions for the manufacture of the products based on the design specifications and the available installations and operators. Different process planner may come up with different plans when facing the same problem, leading to inconsistency in process planning and manufacturing. Consistent and correct planning requires knowledge of manufacturing process and experience (Park 2003, Vidal, Alberti, Ciurana & Casadesus, 2005). This has led to the development of computer-aided process planning and manufacturing systems.

The idea of developing process plans using computers was first conceived in the mid-1960’s. The first CAPP system was developed in 1976 under sponsorship of Computer-Aided Manufacturing International (CAM-I) (Cay & Chassapis, 1997). Since then, there has been a great deal of research carried out in the area, which has been documented in a number of articles (Alting & Zhang, 1989, Cay & Chassapis, 1997, Marri, Gunasekaran & Grieve, 1998, Shen, Hao, Yoon & Norrie, 2006, Zhang & Xie, 2007).

Process planning acts as a bridge between design and manufacturing by translating design specifications into manufacturing process details. Therefore, process planning refers to a set of instructions that are used to make a component or a part so that the design specifications are met, or as it is defined by the Society of Manufacturing Engineering (SME) — “process planning is the systematic determination of the methods by which a product is to be manufactured economically and competitively”. The question is what information is required and what activities are involved in transforming a raw part into a finished component, starting with the selection of raw material and ending with completion of the part. The answer to this question essentially defines the information and set of activities required to develop a process plan.

Basic Steps in Developing a Process Plan

The development of a process plan involves a number of activities (Singh, 1996):

- Analysis of part requirements.
- Selection of raw workpiece/material.
- Determination of manufacturing operations and their sequences.
- Selection of machine tools.
- Selection of tools, work-holding devices and inspection equipment.
- Determination of machining conditions (cutting speed, feed and depth of cut) and manufacturing times (setup time, processing time and lead time).

Figure 3.1 illustrates these activities. Note that these activities are not to be considered in a strict linear sequence. They are often intertwined and inter-dependent. Iterations often occur during the entire process planning cycle.

Analysis of Part Requirements

At the engineering design level, the part requirements are expressed through and as the part features, dimensions and tolerance specifications. These, in turn, dictate the processing
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