CHAPTER-4

PROCESS PLANNING AND SCHEDULING METHODOLOGY

4.1 Introduction to Computer Aided Process planning

Currently, latest advances in the information and communication technology systems have forced industrial activities to use sophisticated computers in all phases of the manufacturing processes. Hence, the Computer Aided Process Planning is one of the most important advances in the area of manufacturing engineering industries concerned, particularly in automobile manufacturing, tool room, dies and moulds, aerospace, navy and defense applications etc., Once the Process planning activity is ordered, machining operational task sequences able to transform raw material into a final part or product assembly under economical and competitive conditions in the manufacturing shop floor. The major process planning activities are interpretation of product design data, selection of machining processes, determination of datum surfaces, selection of the required jigs and fixtures, accessories, sequencing of operations, determination of production tolerances, determination of the cutting condition parameters, estimation of production times and generation of CNC machines programming data. Therefore job of the Process Planning has a strong impact on manufacturability, product variety and related quality, production cost and delivery dates.

The main disadvantage of manual process planning is very time-consuming and the result depends on the person doing the planning activities. Whereas computerized process planning systems can help to reduce the manufacturing time and related cost from design to manufacturing stages. Therefore it is a bridge between design and manufacturing in a computer-integrated manufacturing (CIM) environment. The methodology on process planning model (PP model) that has three parts: the Features Framework, the Precedence-Relations-Net and the Sequencing Mathematical Model and can be illustrated Fig4. 1
Two major methods are used in computer aided process planning, the variant CAPP method and the generative CAPP method

### 4.1.1 Variant CAPP

In variant CAPP approach, a process plan for a new part is created by copying, identifying, retrieving and editing an existing process plan of old part for a similar part and making necessary modifications for the new part to be machined. Sometimes, the process plans are developed for parts representing a family of parts called 'master parts'. The similarities in design attributes and manufacturing methods are exploited for the purpose of formation of part families. A number of methods have been
developed for part family formation using coding and classification schemes of group technology (GT).

The variant process planning approach can be realized as a four step process.

1. Definition of coding scheme.
2. Grouping parts into part families.
4. Retrieval and modification of standard process plan.

4.1.2 Generative CAPP

The next stage of evolution is towards generative CAPP. In the generative CAPP, process plans are generated by means of decision logic, formulas, Artificial Intelligence technology algorithms and part geometry based data to perform uniquely many processing decisions for converting part from raw material to final shape. There are two major components of generative CAPP; geometry based coding scheme and process knowledge in form of decision logic data. The geometry based coding scheme defines all geometric features for process related surfaces together with feature dimensions, locations, tolerances and the surface finish desired on the features. The level of detail is much greater in a generative system than a variant system. For example, details such as rough and finished states of the parts and process capability of machine tools to transform these parts to the desired states are provided. Process knowledge in the form of decision logic and data matches the part geometry requirements with the manufacturing capabilities using knowledge base. It includes selection of processes, machine tools, jigs or fixtures, tools, inspection equipment and sequencing operations. Development of manufacturing knowledge base is backbone of generative CAPP. The tools that are widely used in development of this database are flow-charts, decision tables, decision trees, iterative algorithms, concept of unit machined surfaces, pattern recognition techniques and artificial intelligence techniques such as expert system shells.
4.2 Integrated CAPP functions

There are number of difficulties in achieving the goal of complete integration between various functional areas such as design, manufacturing, process planning, inspection and testing. For example, each functional area has its own stand-alone relational database and associated database management system. The software and hardware capabilities among these systems pose difficulties in full integration. There is a need to develop single database technology to address these difficulties. Other challenges include automated translation of design dimensions and tolerances into manufacturing dimensions and tolerances considering process capabilities and dimensional chains, automatic recognition of features and making CAPP systems affordable to the small and medium scale manufacturing companies having following advantages.

- Reduced process planning and production lead-times
- Faster response to engineering changes in the product
- Greater process plan accuracy and consistency
- Inclusion of up-to-date information in a central database
- Improved cost estimating procedures and fewer calculation errors
- More complete and detailed process plans
- Improved production scheduling and capacity utilization

Improved ability to introduce new manufacturing technology and rapidly update process plans to utilize the improved technology

4.3 Introduction to Scheduling

Scheduling is the processes of running the manufacturing resource activities in the shop floor as per process plan engineer developed processes sheets based on due dates which is promised to the customer. Generally, scheduling problem can be approached in two steps; in the first step sequence of operations is planned. In the second step, planning of start time and perhaps the completion time of each task is performed. In a scheduling process, the type and amount of time spend by each resource should be known so that accomplishing of tasks can be feasibly determined.
Boundary of scheduling problem can be efficiently determined if resources are specified. In addition, each task is described in terms of such information as its resource requirement, its duration, the earliest time at which it may start and the time at which it is due to complete.

4.4 Importance of Scheduling in Manufacturing Shop floor

In the shop floor, resources are usually called machine tools and tasks are called jobs. Sometimes, jobs may consist of several elementary subtasks are called operations. This environment of scheduling the problem is called the job shop or simply the machine shop. The general problem is to determine the time for allocating tasks, while recognizing the capability of the resources with given tasks and resources together with available information. This problem usually arises within a decision making hierarchy in which scheduling follows some earlier basic decisions. In industries, analogous decisions are usually said to be part of the planning functions. Among existing things, the planning functions describe the design of a company’s products and the technology available for making and testing the required parts for the volumes to be produced.

In short, the planning functions determine the resources available for production and the tasks to be scheduled. The present industrial environment is characterized by competitive markets, where customer requirements and expectations are increasingly high in terms of quality, cost and delivery times. This evolution is made stronger by rapid development of new information and communication technologies which provide a direct connection between industries and customers.

To achieve the targets, an organization relies on the implementation of a number of functions together with scheduling which also plays a very important role. Indeed, the scheduling function is intended for the organization of human and technological resource used in company workshops which satisfy the customer’s requirements or demands issued from a production plans prepared by the company process planning engineer or production manager.

Scheduling derives its importance from the two different considerations:

(i) Ineffective scheduling results in deprived utilization of available resources.
(ii) Poor scheduling normally create delays in the flow of some orders through the systems. Thus calls for advance measures that again increase cost.

4.5 Types of scheduling

(1) Flow Shop Scheduling: In many manufacturing and assembly facilities a number of operations have to be done on every job. Often, these operations have to be done on all jobs in the same order, which implies that the jobs have to follow the same routes. The machines are assumed set-up in series and the environment is referred to as flow shop. In a flow shop with machines in series, each job has to be processed on each one of the machines. Usually all jobs are assumed to follow the first in first out (FIFO) discipline.

(2) Flexible Flow Shop: A flexible flow shop is a generalization of the flow shop and the parallel machine environments. Instead of machines in series, there are stages in series with a number of machines in parallel at each stage. A stage functions is a bank of parallel machines, at each stage job requires only one machine and usually, any machine can process any job. The jobs between the various stages usually operate under the FIFO discipline.

(3) Open Shop Scheduling: In open shop each machine performs each job again that job has to be processed on another machines. However, some of these processing times may be zero. There are no restrictions with regard to the routing of each job through the machine environment. The scheduler is allowed to determine the route of each job, and different jobs may have different routes.

(4) Job Shop Scheduling: Job Shop Scheduling is a combinatorial problem of considerable industrial importance. In job shop, each job has its own route to follow. In job shops, a job may visit a machine more than once. The job shop-scheduling problem consists in broad sense, of assigning over the time resources of finite capacity to operations, while complying with various constraints like capacity constraints, precedence constraints, temporal constraints, preemption constraints, etc.
4.6 Heuristic procedure for scheduling

Heuristic algorithms can be broadly classified as dispatching rules, constructive and improvement heuristics. Constructive heuristics build a schedule from scratch by making a series of passes through a list of unscheduled jobs where at each pass one or more jobs are selected and added to the schedule. Contrary to constructive heuristics, improvement heuristics start from an existing solution and apply some improvement procedure. In constructive heuristics, once a sequence is obtained, it is fixed and cannot be altered whereas in improvement heuristics, an initial solution is iteratively improved upon.

4.7 Significance of interlinking CAPP and scheduling modules

Process planning and scheduling are the two most important sub-systems in a manufacturing system. A process plan specifies the raw materials or components needed to produce a product, the processes and operations, which are necessary to transform the raw materials to a final product. The outcome of process planning includes the identification of machines, tools and fixtures suitable for a job and the arrangement of operations. A job may have one or more alternative process plans.

Process planning is the bridge of product design and manufacturing. With the process plans of jobs as inputs, a scheduling task is to schedule the operations of all the jobs on machines while precedence relationships in the process plans are satisfied. Scheduling is the link of the two production steps, which includes the preparing processes and putting them into action. Although there is a close relationship between process planning and scheduling, there is integration of still a challenge in both research and applications. In traditional approaches, process planning and scheduling were carried out in a sequential way, where scheduling was conducted separately after the process plans have been generated. Hence, Process plans and production schedules play important roles in achieving high productivity and low manufacturing cost. Obtaining a proper plan that simultaneously accomplishes process planning and the scheduling objectives is not easy because their optimality can frequently conflict. The quality of the process plan can decrease when the quality of the production scheduling is
preferred; on the other hand, the quality of the production schedule can be corrupted as the process plan is prioritized. It is difficult to obtain a proper process plan and a production schedule under such tight conditions. Using traditional planning methods, the process plan optimization and production scheduling are determined sequentially. New planning methods to integrate process planning and production scheduling have been proposed to resolve such dilemma state by process planning and scheduling needs. For example, Chryssolouris and Chan (1985) and Zijm (1995) introduced process plan alternatives and changed the process plan when the scheduling results are not feasible. Palmer (1996) used simulated annealing techniques to integrate process planning and scheduling. Sadeh (1996) attempted to implement communication functions between a process planning module and a production scheduling module to integrate them. However, because most of these methods repeat separated optimizations, they sometimes encountered problems by which the solutions do not converge but are instead periodic. A method that simultaneously forms process plans and production schedules using a genetic algorithm (GA) based method was proposed by Morad and Zalzala (1999). The proposed method can reportedly obtain a good solution to fulfill both objective functions of process planning and scheduling. Nevertheless, it remains difficult for the method to adapt to environmental changes such as altered production requirements. A method that is adaptable to environmental changes must be developed because market demands often cause turbulent fluctuations. Thereby, it can accomplish simultaneous process planning and scheduling as a result of local interactions among machines. It is desired that the proposed method be adaptable to environmental changes through re-learning performed by each machine after environmental changes.

4.8 Summary

In this chapter, introduction and significance of CAPP in the manufacturing shop floor and its approaches are discussed. Benefits with the integration of process planning and scheduling are enlightened. Introduction, types of scheduling and its importance in shop floor have been reviewed. Types of heuristic procedures, various authors’ research contributions are discussed.