Automation (21-541)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

Session # 14

Session Schedule

- Computer-Aided Process Planning (CAPP)
  - CAPP integration with CAD
    - Computer-Aided Process Planning based on CAD software solutions

Computer-Aided Process planning (CAPP)

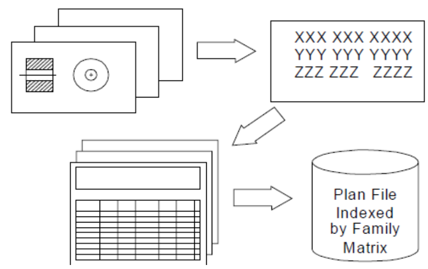
- *Process planning primitives*
  - *Process planning is concerned with determining the sequence of individual manufacturing operations needed to produce a given part or product.*
  - *The resulting operation sequence is documented on a form typically referred to as operation sheet.*
  - *The operation sheet is a listing of the production operations and associated machine tools for a work part or assembly.*
  - *Process planning is an important stage of product development since production tool jigs, fixtures, special tools etc. can be designed only after the process plan is finalize*

Computer-Aided Process planning (CAPP)

- *Process planning primitives*
  - *The current approaches for computer aided process planning can be classified into two groups:*
    - *Variant*
    - *Generative*

Computer-Aided Process planning (CAPP)

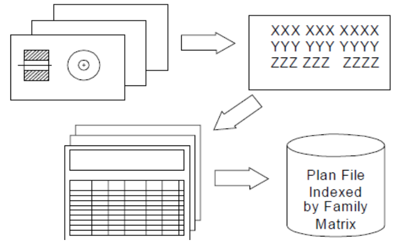
- *Variant Process planning- Group Technology*
  - *A part family is a collection of parts which are similar either because of geometry and size or because similar processing steps are required in their manufacture.*
  - *The parts within a family are different, but their similarities are close enough to merit their identification as members of the part family.*
  - *There are three general methods for solving this problem.*
    - *Visual inspection*
    - *Production flow analysis*
    - *Parts classification and coding system*



Computer-Aided Process planning (CAPP)

- *Variant Process planning- Group Technology*
  - *Part Design Attributes*
    - *Basic (External/Internal) shape* — *Axisymmetric/Prismatic/sheet metal*
    - *Length/diameter ratio* — *Material*
    - *Major dimensions* — *Minor dimensions*
    - *Tolerances* — *Surface finish*
  - *Part Manufacturing Attributes*
    - *Major process of manufacture* — *Surface treatments/coatings*
    - *Machine tool/processing equipment* — *Cutting tools*
    - *Operation sequence* — *Production time*
    - *Batch quantity* — *Production rate*
    - *Fixtures needed*

Computer-Aided Process planning (CAPP)



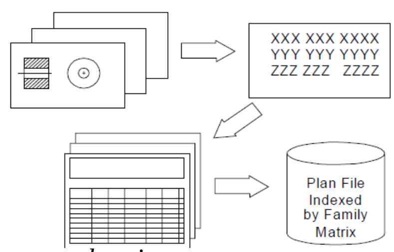
- *Variant Process planning- Coding structures*
  - *A part coding scheme consists of symbols that identify the part's design and/or manufacturing attributes.*

  - *The symbols in the code can be all numeric, all alphabetic, or a combination of both types.*

There are three basic code structures used in group technology applications:

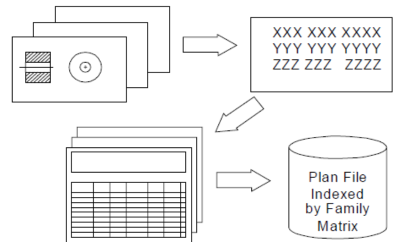
- *Hierarchical structure*
- *Chain type structure*
- *Hybrid structure which is a combination of the above two*

Computer-Aided Process planning (CAPP)



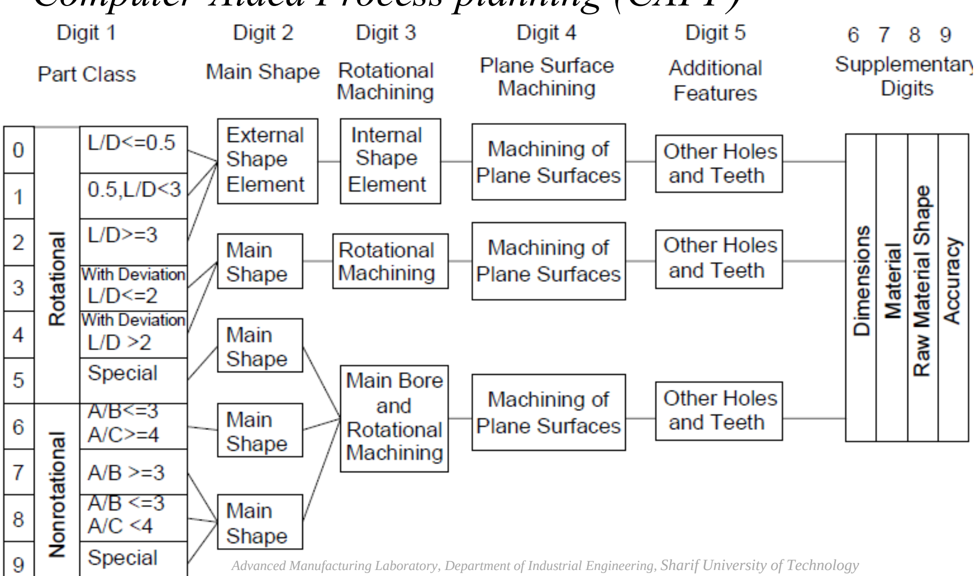
- *Variant Process planning- Coding structures*
  - *Coding systems that have been successfully implemented in process planning:*
    - *OPITZ system*
    - *The CODE system*
    - *The KK-3 system*
    - *The MICLASS system*
    - *DCLASS system*
    - *COFORM (coding for machining)*

Computer-Aided Process planning (CAPP)



- *Variant Process planning- Coding structures*
  - *OPITZ classification system:*
    - *The OPITZ coding system digit sequence: 12345 6789 ABCD*
    - *The first nine digits are intended to convey both design and manufacturing data.*
    - *The first five digits, 12345, are called the "form code" and describe the primary design attributes of the part.*
    - *The next four digits, 6789, constitute the "supplementary code". It indicates some of the attributes that would be of use to manufacturing (work material, raw work piece shape, and accuracy).*
    - *The extra four digits, "ABCD", are referred to as the "secondary code" and are intended to identify the production operation type and sequence.*

Computer-Aided Process planning (CAPP)

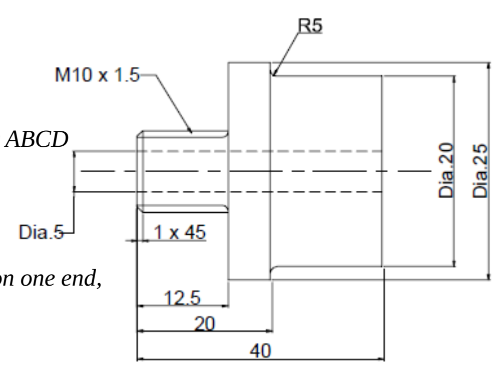


Computer-Aided Process planning (CAPP)

DIGIT 1			DIGIT 2			DIGIT 3			DIGIT 4		DIGIT 5	
PART CLASS			External shape External Shape Elements			Internal Shape Internal Shape Elements			Plane Surface Machining		Auxiliary Holes and Gear Teeth	
0	Rotational Parts	L/D <=0.5	0	Smoothing Shape Elements		0	No Hole, No Break Through		0	No Surface Machining	0	No Auxiliary Holes
1		0.5<L/D<3	1	Stepped one end or Smooth	No Shape Elements	1	Smooth or Stepped on One End	No Shape Elements	1	Surface Plane/ Curved	1	Axial, Not on Pitch Circle Dia
2		L/D > 3	2		Thread	2		Thread	2	External Plane Surface, Circular Graduation	2	Axial on Pitch Circle Diameter
3			3		Groove	3		Groove	3	External Groove and/or Slot	3	Radial, Not on Pitch circle Dia.
4			4	Stepped Both Ends	No Shape Elements	4	Stepped Both Ends	No Shape Elements	4	External Spline (Polygon)	4	Radial, on Pitch Circle Dia.
5	Non rotational Parts		5		Thread	5		Thread	5	External Plane Surface/Slot Spline	5	Axial and/ Radial and/ other Direction
6			6		Groove	6		Groove	6	Internal Plane Surface or Slot	6	Spur Gear Teeth
7			7	Functional Cone		7	Functional Cone		7	Internal Spline (Polygon)	7	Bevel Gear Teeth
8			8	Operating Speed		8	Operating Speed		8	Internal or Slot/ External Polygon	8	Other Gear Teeth
9			9	All Others		9	All Others		9	All Others	9	All Others

Computer-Aided Process planning (CAPP)

- *Variant Process planning- Coding structures*
  - *OPITZ classification system:*
    - *The OPITZ coding system digit sequence: 12345 6789 ABCD*

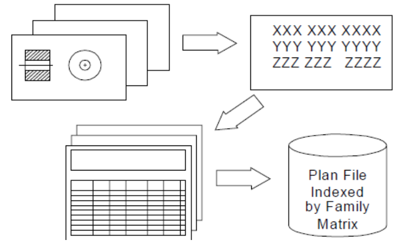


    - *The overall length/diameter ratio, L/D = 1.6,*

  so the first code = 1.
    - *The part is stepped on both ends with a screw thread on one end,*

  so the second digit code would be 5
    - *The third digit code is 1 because of the through hole.*
    - *The fourth and fifth digits are both 0, since no surface machining is required and there are no auxiliary holes or gear teeth on the part.*
    - *The complete form code in the OPITZ system is "15100".*
    - *To add the supplementary code, we would have to properly code the sixth through ninth digits with data on dimensions, material, starting work piece shape, and accuracy*

Computer-Aided Process planning (CAPP)

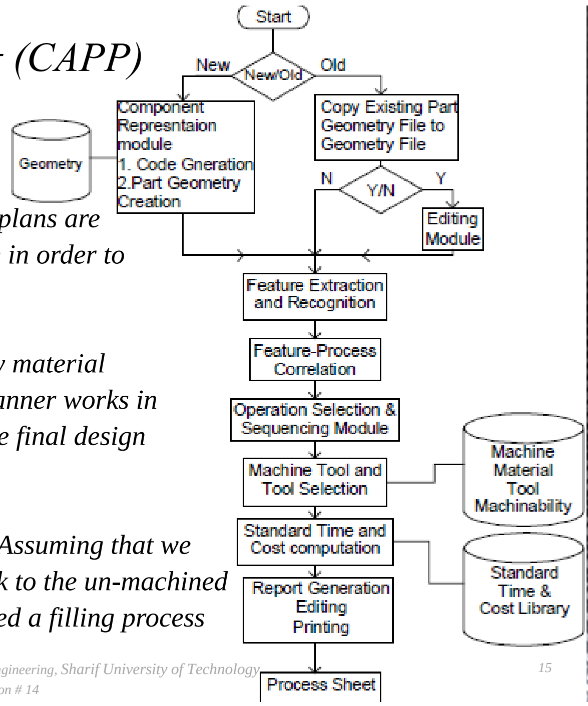


- *Variant Process planning*
  - *The following are the sequences in the design of a variant process planning system:*
    - *Family formation*
    - *Data base structure design*
    - *Search algorithm development and implementation*
    - *Plan editing*
    - *Process parameter selection/updating*

Computer-Aided Process planning (CAPP)

- *Generative Process planning*
  - *Generative process planning is a system that synthesizes process information in order to create a process plan for a new component automatically.*
  - *Knowledge of manufacturing must be captured and encoded into efficient software. By applying decision logic, a process planner's decision making can be imitated.*
  - *The generative planning has the following advantages:*
    - *It can generate consistent process plans rapidly.*
    - *New process plans can be created as easily as retrieving the plans of existing components.*
    - *It can be interfaced with an automated manufacturing facility to provide detailed and up-to-date control information.*

Computer-Aided Process planning (CAPP)



- *Generative Process planning*
  - *In generative process planning, when process plans are generated, the system must define an initial state in order to reach the final state (goal).*
  - *In forward planning, the initial state is the raw material and the final state is the component design. A planner works in modifying the raw work piece until it takes on the final design qualities.*
  - *Backward planning uses a reverse procedure. Assuming that we have a finished component, the goal is to go back to the un-machined Work piece. Each machining process is considered a filling process*

Computer-Aided Process planning (CAPP)

- *Generative Process planning*
  - *Decision logic*
    - *The decision logic determines how a process or processes are selected. The major function of the decision logic is to match the process capabilities with the design specification.*
    - *The different techniques in decision logic are: Decision trees; Decision tables*
  - *Artificial Intelligence (AI)*
    - *There are two types of knowledge involved in process planning systems: Component knowledge, and process knowledge. The component knowledge defines the current state of the problem to be solved (declarative knowledge). On the other hand, the knowledge of processes defines how the component can be changed by processes (procedural knowledge).*

Computer-Aided Process planning (CAPP)

- *Implementation consideration*