

Automation (21-541)

*Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology*

Session # 13



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 finalized.*

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3

Computer-Aided Process planning (CAPP)

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

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4

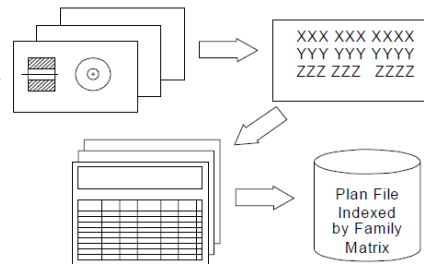
Computer-Aided Process planning (CAPP)

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



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5

Computer-Aided Process planning (CAPP)

Variant Process planning- Group Technology

Part Design Attributes

- Basic (External/Internal) shape
- Length/diameter ratio
- Major dimensions
- Tolerances

Axisymmetric/Prismatic/sheet metal

Material

Minor dimensions

Surface finish

Part Manufacturing Attributes

- Major process of manufacture
- Machine tool/processing equipment
- Operation sequence
- Batch quantity
- Fixtures needed

Surface treatments/coatings

Cutting tools

Production time

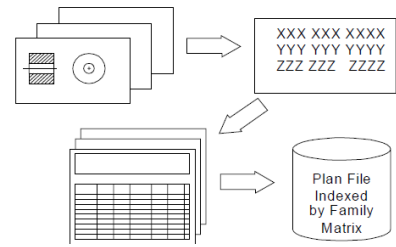
Production rate

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6

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.

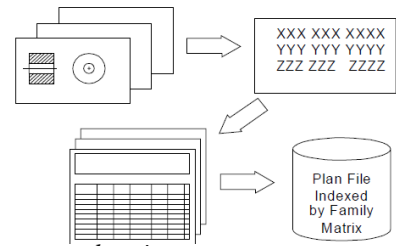
There are three basic code structures used in group technology applications:

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

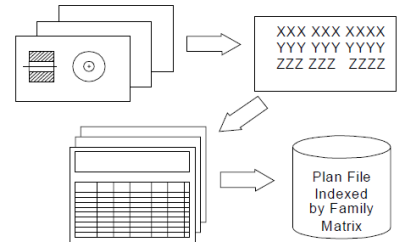
Computer-Aided Process planning (CAPP)

- 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)



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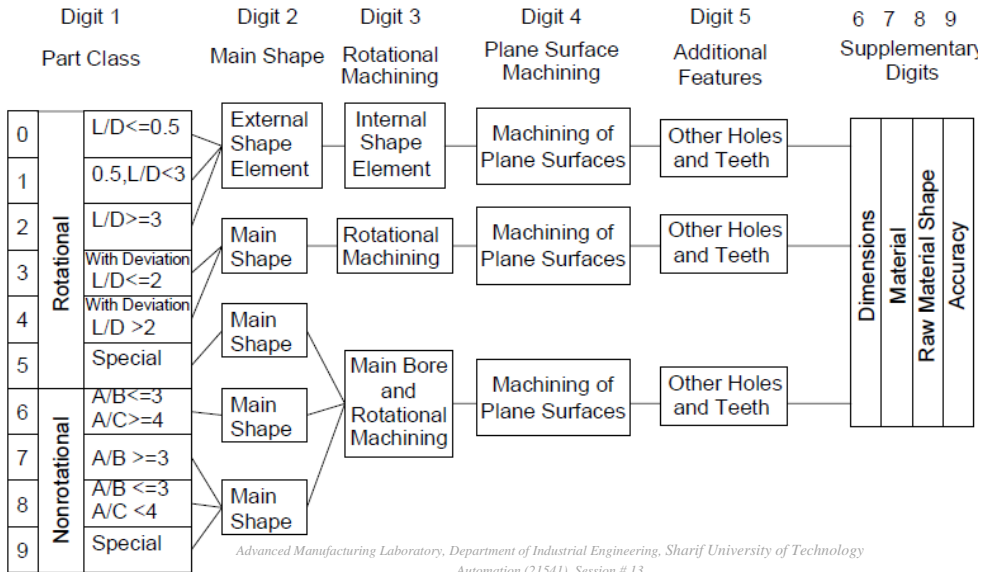


Variant Process planning- Coding structures

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.

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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		0		0	
1		0.5 < L/D < 3		1		1		1	
2		L/D > 3		2		2		2	
3				3		3		3	
4	Non rotational Parts			4		4		4	
5				5		5		5	
6				6		6		6	
7				7		7		7	
8				8		8		8	
9			9		9		9		

11

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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.

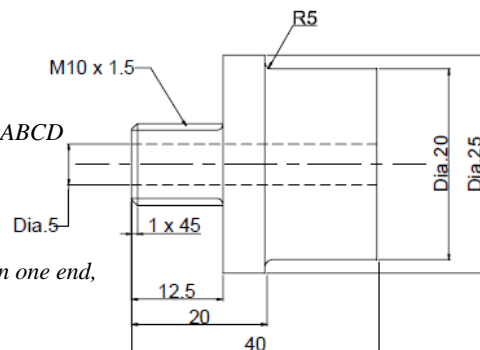
The part is stepped on both ends with a screw thread on one end, so the second digit code would be 5

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.

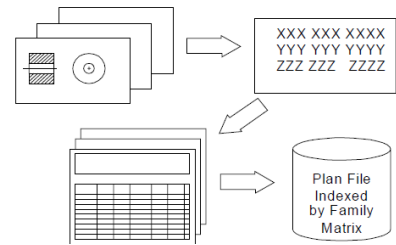
The complete form code in the OPITZ system is "15100".

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



12

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

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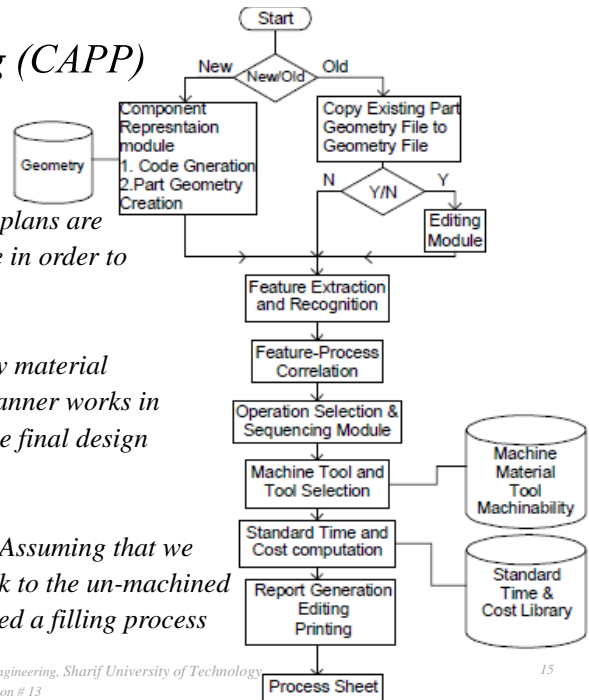
▪ Generative Process planning

- 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



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Automation (21541), Session # 13

15

Computer-Aided Process planning (CAPP)

Generative Process planning

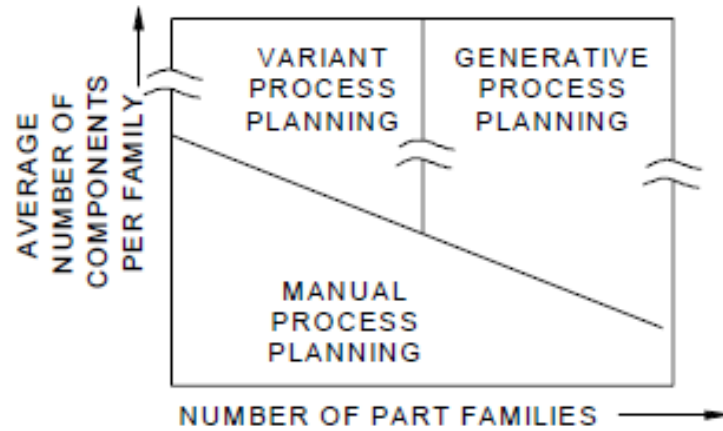
- Decision logic
 - The decision logic determines how a process or processes are selected. The major function of the decision logic is to match the process capabilities with the design specification.
 - The different techniques in decision logic are: Decision trees; Decision tables
- Artificial Intelligence (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).

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16

Computer-Aided Process planning (CAPP)

- *Implementation consideration*



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17