Computer Aided Process Planning

Date: 2/27/03
Room: MSE Computer Lab

Presenters:
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Agenda

- Background of Process Planning
- Manual vs Automated Process Planning
- CAPP & CAD/CAM
- Group Technology, Coding & Classification
- Variant vs. Generative Approach
- CAPP Software Packages
  - Advantages/Disadvantages
- Future Development
  - Conceptual Process Planning
Process planning is the function within a manufacturing facility that establishes which processes and parameters are to be used (as well as those machines capable of performing these processes) to convert a part from its initial form to a final form predetermined (usually by a designed engineer) in an engineering drawing.

- Chang, Wysk, & Wang
What is CAPP?

- **Formal Definition:**
  - Computer Aided Process Planning is the systematic determination of manufacturing methods and operation details by which parts can be produced economically and efficiently from raw materials to finished products.
    - Cornelius T. Leondes

- Plays a significant role in dealing with dynamics activities & time dependent problems from design to shop floor manufacturing.
Aspirations for CAPP

- Must provide multiple decisions & alternative information transfer from design to various manufacturing functions.
- Must be capable of coordinating, harmonizing and integrating production activities such as design, production planning, resource planning, shop floor manufacturing, and control.
- Must be able to integrate with Manufacturing Execution System and other related manufacturing software applications such as CAD/CAM and MRP/ERP.
- To date, most CAPP packages have not gained anticipated computing support and flexible planning functions and tools to meet all the criteria mentioned.
Process Planning Synonyms

- Manufacturing Planning
- Process Engineering
- Machine Routing
- Process Engineer
- Process Planner
Manual Process Planning

- Is done by a Process Planner

Knowledge Required:
  - Interpreting engineer drawing
  - Familiarity with and understand relative costs of manufacturing processes & practice, tooling & fixture, & raw materials
  - Know what resources are available in shop such as reference books & machining handbooks
  - Computing machining time & cost
Manual Process Planning (Cont.)

Preparation:
- Study overall shape, classify part, & determined type of workstation needed.
- Identify all manufacturing features & notes.
- Determine best raw material shape or raw stock to use.
- Identify datum surface for setup.
- Select machines for each setup.
- Determine rough sequence of operations to create features for each setup.
- Sequence the operations in the previous step.
- Select tools for each operation.
- Select or design fixtures for each setup.
- Evaluate the overall plan generated & modify if necessary.
- Select cutting parameters for each operation.
- Prepare the final process-plan document.
Manual Process Planning

Engineering Drawing

Process Planner
- Retrieves PP Document
- Modifies PP to Match a Specific Part
- Make a Copy for Part Programmer
- Filed New PP Document

Part Programmer
- Retrieves PP Document
- Modifies PP to Match a Specific Part
- Make a Copy for Part Programmer
- Filed New PP Document

NC Program

Filed Process Planning
Based on Coding & Classification of Parts
Semi-Automated Process Planning

1. Engineering Drawing
2. Process Planner
3. Coding or Other Form of Input
4. Process Planning System
5. Process
   - Production Planner
     - Scheduling
     - MRP
6. Industrial Engineer
   - Time Standard
   - Operation Instruction
   - Layout
7. Part Programmer
8. NC Processor and Post-processor
9. NC Program
Fully Automated Process Planning

- Classification Module
- Parameter Optimization Module
- Machinability DB
- Standard Time DB
- Standard Cost DB

- Surface Identification Module
- Material Selection Module
- Process Selection Module
- Machine Selection Module
- Tool Selection Module
- Fixture Selection Module
- End Effector Selection Module
- Cutter Path Generation Module
- Intermediate Surface Generation Module

- CAD DB
- Process Capability DB
- Machine DB
- Tool DB
- Material DB
- Fixture DB
- End Effector DB
- Process Plan DB

- System Maintenance Module
Process Planning & CAD/CAM

CIM

Engineering Design
  CAD

CAPP

 Manufacturing
  CAM
Group Technology

- Group technology is the realization that many problems are similar, and that by grouping similar problems, a single solution can be found to a set of problems thus saving time and effort.

- Chang, Wysk, Wang
Coding & Classification

- Coding & Classification are 2 elements of Group Technology.
- Coding is a means of quantifying the geometry and material content of a part.
- Classification is a separation process in which items are separated into groups based on the existence or absence of characteristic attributes.
Variant Process Planning

- Uses similarity among components to retrieve process plan.
- Standard process plan can be used for a family of components.
- No limitation to the detail that a standard plan can have.
- A standard plan must contain at least a sequence of fabrication steps or operations.
- Certain degree of modification is usually necessary on a new component.
- Logic for retrieval of a standard plan is predicated on the grouping of parts into families (index by Family Matrix).
Variant Process Planning (Cont.)

- There are 2 operational stages:
  - Preparatory stage
  - Production stage
Variant PP – Preparatory Stage

Engineering Drawing

Family Code

Family Formation

Process Plan

Standard Plan File (Index by Family Matrix)
Variant PP – Production Stage

Engineering Drawing → Coding → Family Search → Standard Plan Retrieval

Family Code

Process Plan

Editing

Standard Plan File (Index by Family Matrix)
Generative Approach To Process Planning

- Defined as a system that synthesizes process information in order to create a process plan for a new component automatically and effectively eliminate the preparatory phase.
- Process plan is created from information available in a manufacturing database without human intervention.
- Knowledge of manufacturing must be captured and encoded into efficient software.
- Other planning functions: machine selection, tool selection, and process optimization are also automated.
Implementation of Generative Approach

- Process planning knowledge must be identified and capture.
- Must have a 3-D model of the part produced, group technology code, materials code, etc. in computer readable format.
- Planning knowledge and part description data must be incorporated into a unified manufacturing database.
CAPP System - Implementation Considerations

- Manufacturing System Components
  - Capabilities
- Production Volume/Batch
  - Special purposed machine vs general purposed machine
- Number of Different Families & Production Families
  - Variant PP vs Generative PP
Conceptual Process Planning

Product Design

Customer Requirements

Functional Decomposition

Conceptual Design

Detailed Design

Process Design

Conceptual Process Planning

Message

Design Rationale

Manufacturability

Objects

Detailed Process Planning
References

- Manufacturing Planning and Execution Software Interfaces, Shaw C. Feng, Manufacturing Systems Integration Div., MEL at NIST, Gaithersburg, Maryland, USA, 2000 (http://www.mel.nist.gov/msidlibrary/doc/v19n1a1.pdf)
- Conceptual Process Planning – A Definition and Functional Decomposition, Shaw C. Feng, Y. Zhang, Manufacturing Engineering Laboratory, NIST, 1999 (http://www.mel.nist.gov/msidstaff/feng.shaw.html)