Capability Modeling for Manufacturing System Reconfiguration

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Issues for Sustainable Manufacturing

• Adaptability to Change
  – Short Term vs. Long Term
• Inconsistency of Inertia:
  – Product
  – System, Facility
  – Surrounding Conditions
• How to Close the Gaps?

Various Changes Affecting Manufacturing Systems
Degradation from Optimal Situations

• Product Area:
  – Automobile
  – Electronics
  – Information
  – Machine Tools
  – Plants, etc.
Adaptability to Change

- Product Life Cycle
- Manufacturing System Life Cycle

Inconsistency

Operation

Disposal

Construction

Modification

Facility

Material

Product

Manufacturing System

Flexibility for Change

APS (Adaptive Production System)

(Denso)
Evaluation of Manufacturing System

- Operational Efficiency: Input vs. Output
  - Capability: Maximum, Optimal, etc.
  - Actual Performance during Operation
    - Over Capacity and Idle Resources
  - **Effective Resource Utility** throughout the Total Life Cycle of Manufacturing Systems
    - Never Dispose Value-remaining Resources!

- Time vs. Space Local vs. Global

Total Elimination of Inefficiency
Reasons for Inefficiency

- **Inefficiency**
  - Unit Process
  - System

- **Inconsistency**
  - Product, Market, etc.
  - Surrounding Conditions

- **Bad Life Cycle Management**

Nominal Capability is not enough for System Evaluation.

System/Process Capability

- **Comprehensive Description:**
  - Abstract vs. Real
  - Controllable vs. Uncontrollable
Product and Process Integration

- **Product**
  - Independent of or Dependent on Manufacturing System
  - Total Efficiency
- **Manufacturing System**
  - Independent of or Dependent on Product

- **General Purpose ⇔ Dedicated**

  Dependency between Product and Process

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**Relationship between Product and Resource**

- **Group of Products**
- **Product Family**
- **Corresponding manufacturing resources’ capability**

- a) Maximize product variation with fixed resources
- b) Simplify resources with fixed products
- c) Sensitivity analysis with resource improvements
- d) Maximize reuse
**Goal of Research and Development**

Our goal is to achieve cost-competitive and optimized production system that can flexibly and rapidly meet various changes in product techniques, production engineering and market trends.
Product and Manufacturing System Relationship

Customer Requirements

- Product Design
  - Function/Behavior
  - Embodiment
    - Constraint
    - Component
  - Embodiment Design
    - Elimination of superficial variations
    - Standardization

- Conceptual Design
  - Conceptualization of requirements

- Generic Process Planning
  - Basic process knowledge
  - Standardization

- Detailed Process Planning
  - Existing/planned resource constraints

- Manufacturing Resources
  - Ideal/planned/existing

Suggested Method

1. **Parts description**
   Mapping from function/behavior to embodiment
   Minimize superficial variation

2. **Extract machining portions**
   Mapping to standardized machining processes

3. **Generic process planning**
   Assuming typical machine tool functionality
   Posture & setup constraints

4. **Process planning**
   Actual facility constraints are considered
Test Case: Engine Cylinder Head

Cam shaft: Open & close valves

Intake valve: Let air & gas mixture in

Exhaust valve: Let combustion gas out

Plan A: Process Precedence

- Machining portion/process
- Precedence constraint
- Cam shaft & valve processes
Process Design Data Flow

1. Product Shape Data

2. MFG-Template
   Machining Method & Tool

3. Addition of Posture & Setup Information

4. Addition of Order Restrictions Information

5. Process Template

Transformation from process information to real production system

Process information → Equipment Data → Tool Data → Abstract equipment → Real Production system

- TL
- FTL
- CELL
The system suggests some candidates of process plans, which are mapped to cutting tools and equipments.

System operation assessment under the production fluctuations

(1) System assessment using lifecycle simulation methods

We study the method to simulate product families and production system concerning the various solutions generated in WP2 and WP3 for the propose of production assessment through the total lifecycle.
Comparison Experience

Plan 1: Cell Manufacturing System

- 7 lines with same spec.
- Production system of process consolidating type
- Tact Time: 260sec ~ 270sec
- Attribute for cost calculation:
  - Initial Cost, Fixed costs, Variable costs
- Movable rate: 95%
- Lead Time for Re-Config.: 1 month

Plan 2: Transfer Manufacturing System

- 2 lines
- Production system of mass production type
- Tact Time: 65sec ~ 72sec
- Attribute for cost calculation:
  - Initial Cost, Fixed costs, Variable costs
- Movable rate: 95%
- Lead Time for Re-Config.: 4 month

Operating days per month is 20 days with 7.5 hours per day in 2 shifts operation
Future Research

- **Integration**
  - Horizontal and Vertical Integration

- **Generic Resource Modeling**
  - Abstract vs. Real

- **Simulation and Evaluation**
  - How to evaluate “Excess” Capability

- **Practical Implementation**
  - Necessity for “New” Facility