
by

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Outline

1. Introduction
2. Concept of Product-Process Hierarchy Integration
3. Manufacturing Development based on Product-Process Hierarchical Model
4. More Discussion
5. Conclusion
1. Introduction

1.0 Current Status Review

- My Industry Experience
  - 5 vehicles assembly development
  - 5+2 new vehicle launches

- Observation on Assembly Development
  - Experience based
  - Carryover from previous models
  - Disconnection with new methods

- Impression on Industry Practices
  - Intuitive and working
  - Not systematic/optimal

- Challenges
1. Introduction

1.1 Product Hierarchy

- Passenger Car (Example)
- Uni-body Architecture
1. Introduction

1.2 Assembly Process Hierarchy

- Typical Vehicle Body Assembly

![Diagram of typical vehicle body assembly process hierarchy]

- Bodyside Inner
- Bodyside Outer
- Front Structure
- Mid Floor
- Rear Structure
- Bodyside Inner
- Bodyside Outer
- Roof
- Bodyside LH
- Underbody
- Body Framing
- Roof Framing
2. Product-Process Hierarchy Integration

Product Hierarchy + Process Hierarchy

= Product-Process Integration
3. Manufacturing Development based on P-P Model

3.1 3-Step Development based on the Model

1. System Flow

2. Assembly Lines

3. Workstations/Processes
3. Manufacturing Development based on P-P Model

3.2 Step 1 - To Plan Overall Assembly Flow

- Product (a Body Side as an Example)
- Corresponding Hierarchy
3. Manufacturing Development based on P-P Model

3.2 Step 1 - To Plan Overall Assembly Flow

- Assembly Flow
3. Manufacturing Development based on P-P Model

3.2 Step 1 - To Plan Overall Assembly Flow

- Assembly Flow
3. Manufacturing Development based on P-P Model

3.3 Step 2 - To Configure Subassembly Lines

System Flow

Line Configuration
4. More Discussion

4.1 Evaluation of Assembly Systems Developed

- **Evaluation Criteria**
  - Process Feasibility (F), Initial and Operating Costs (C), and System Reliability (R), etc.
  - At the Levels of Workstation and Assembly Line
    
    \[
    F_{\text{line 1}} = \prod_{s=1}^{8} F_s \quad C_{\text{line 1}} = \sum_{s=1}^{8} C_s \quad R_{\text{line 1}} = \prod_{s=1}^{8} R_s
    \]

- **Individual Influencing Factors**
  
  \[
  \tilde{F} = \left\{ \begin{array}{l} F_{\text{difficulty}} \\ F_{\text{auto/manual}} \\ F_{\text{safety/ergo}} \end{array} \right\}, \quad \tilde{C} = \left\{ \begin{array}{l} C_{\text{acquisition}} \\ C_{\text{direct}} \\ C_{\text{indirect}} \end{array} \right\}, \quad \tilde{R} = \left\{ \begin{array}{l} T_{\text{cycle time}} \\ T_{\text{MTBF}} \\ T_{\text{MTTR}} \end{array} \right\}, \quad \tilde{Q} = \left\{ \begin{array}{l} Q_{\text{scrap}} \\ Q_{\text{repair}} \\ Q_{\text{reprocess}} \end{array} \right\}, \ldots
  \]
4. More Discussion

4.2 Product-Process Modularization

- Improved Modular Design

- Integrated Model and System
5. Conclusion

• Established a new product-process hierarchical modeling and method
• To guide the assembly system and process development of complex products
• Beneficial to product variety and modularity for DFM and manufacturing system optimization
• Further studies on alternative assembly designs, comparison of different system scenarios, and detailed evaluations
Thank You!

Questions and Comments?

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New Books in Manufacturing Assembly (SAE 2017)

- **Automotive Vehicle Assembly Processes and Operations Management**
  - He (Herman) Tang
  - [Link](https://www.sae.org/publications/books/content/r-456/)

- **Manufacturing System and Process Development for Vehicle Assembly**
  - He (Herman) Tang
  - ISBN: 978-0-7680-8351-4
  - [Link](https://www.sae.org/publications/books/content/r-457/)