Robust Designs of Serial Assembly Lines
Working under Labor Turnover

By
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Agenda

- Proposed Approach
- Previous Results
- Current Research
- Questions
Simulation Approach

• Cross verification with analytical models of small instances

• Due to the complexity of analytical models the analysis of large instances will not be feasible without simulation

• Flexibility in the design of prospective models of direct use in real world systems
Proposed Approach

• Develop production systems that combine characteristics of current dynamic work allocation methods, such as work sharing and bucket brigades, to mitigate the effects of labor turnover.
Previous Results

• Bucket Brigade implementation at Lear Co.

• Recent research by Muñoz
Bucket Brigades at Lear Co.

- Serial assembly line
- Six work stations
- Assembly of Toyota Camry left door wire harness
Bucket Brigades at Lear Co.

By following these rules WIP goes from this:
Bucket Brigades at Lear Co.

To this:
Bucket Brigades at Lear Co.

<table>
<thead>
<tr>
<th>Comparison Criterion</th>
<th>Bucket Brigades</th>
<th>Traditional Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Historical Daily Line Production</td>
<td>301 harnesses</td>
<td>280 harnesses</td>
</tr>
<tr>
<td>Average Daily Line Production</td>
<td>279 harnesses</td>
<td>245 harnesses</td>
</tr>
<tr>
<td>Max. Line Historical Efficiency</td>
<td>91.56%</td>
<td>85.17%</td>
</tr>
<tr>
<td>Average Daily Efficiency</td>
<td>84.87%</td>
<td>74.53%</td>
</tr>
<tr>
<td>Work In Process Inventory</td>
<td>6 harnesses</td>
<td>24 harnesses</td>
</tr>
</tbody>
</table>
Recent Research by Muñoz

• Phase I: Small instances of assembly lines
  – Three workstations
  – Three types of work allocation
    • Traditional
    • Bucket Brigades
    • Unbalanced (High-Med-Slow)
  – DOE with three factors: Method, Learning Curve and Level of Turnover
  – Analytical and simulation models (Promodel®)
Recent Research by Muñoz

• Phase II: More realistic assembly lines
  – Six workstations
  – Two assembly methods: Bucket Brigades Vs. Traditional
  – Total assembly work divided in assembly elements
  – DOE with three factors: Method, Learning Curve and Level of Turnover

• Simulation models (Promodel®)
Results Phase II

The chart shows the throughput results for various scenarios. The x-axis represents different scenarios labeled as B80/0, B85/0, B90/0, T80/0, T85/0, T90/0, B80/6, B80/12, T80/6, T80/12, B85/6, B85/12, T85/6, T85/12, B90/6, B90/12, T90/6, and T90/12. The y-axis represents the throughput values ranging from 400 to 700. The bars indicate the throughput for each scenario, with error bars showing the variability.
Results Phase II

Throughput vs. Departures

- **Throughput**
  - 300
  - 400
  - 500
  - 600

- **Periods**
  - 1
  - 82
  - 163
  - 244
  - 325
  - 406
  - 487
  - 568
  - 649

- **Operator Quits**
  - Quits
  - BB_TH
  - T_TH

- **Legend**
  - Quits
  - BB_TH
  - T_TH
Current Research

• Implementation of Dynamic work allocation Method (Bucket Brigades Islands) at TRW Occupant Restraint Plant, Chihuahua Mexico.
• Assembly line manufactures passenger airbag for Ford Trucks
• Sewing operation
Current Research

- Project divided in three phases
  - Phase I: Data gathering (completed)
  - Phase II: Simulation modeling of alternatives (validation stage)
  - Phase III: Implementation of dynamic work allocation method (11/26/01)
Preliminary Results

• Phase I: Data gathering
  – Learning curve
  – Tenure distribution
  – Thorough process description (current method)
Preliminary Results

• Phase I: Learning Curve

\[ y = 117.48x^{-0.3848} \]

\[ R^2 = 0.9088 \]

Asymptote at 8 sec

Day 30

Cumulative production

Time in seconds
Preliminary Results

- Phase I: Tenure Distribution

[Histogram for days]

<table>
<thead>
<tr>
<th>Days (X 1000)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>
Preliminary Results

• Phase I: Tenure Distribution
  – $W(0.658, 256.29)$ days (5.6 % Labor turnover/month)
Preliminary Results

• Phase II: Simulation Modeling
  – Current production method (13 people sewing)
  – Dynamic work allocation method (11 people sewing)
Preliminary Results

• Phase II: Current production method
Preliminary Results

• Phase II: Proposed production method
Preliminary Results

• Throughput BB Islands Vs Current
Preliminary Results

• Throughput BB Islands Vs Current

<table>
<thead>
<tr>
<th>Method</th>
<th>Average throughput</th>
<th>Stdev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Method</td>
<td>498.6554622</td>
<td>113.2911681</td>
</tr>
<tr>
<td>Dynamic Work Allocation Method</td>
<td>537.4789916</td>
<td>32.80989122</td>
</tr>
</tbody>
</table>
Phase III: Implementation

• Pilot line implementation in three shifts
• Implementation will include training of operators, line supervisor and engineers
• Break through change, change from sitting standing/walking position
• Phase III is expected to be completed by the end of November, following a supervision period
Questions