Assembly Line Designs for High Turnover Environments

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Implications of Labor Turnover

- High labor turnover often cited as a factor for low productivity and competitiveness

- Input costs
  - Replacement costs
  - Training costs

- Output costs
  - Reduction of production per employee
United Technologies Automotive

- **Location:**
  - Plant 158 is located in Cd. Juarez Mexico

- **Product Assembled:**
  - Electrical harnesses for the automotive industry

- **Principal Clients:**
  - GM, Toyota and Nissan amongst others
Self-Balancing Line (Bucket Brigade)

• Recently proposed by Bartholdi and Eisenstein to build more flexible lines
• Each worker carries an item from station to station until interrupted by the subsequent worker
• After the worker has surrendered his part he/she walks back take over the item of his/her predecessor
• Operators sequenced from slowest to fastest
• The assembly line arrives by itself to a point of equilibrium
• No “balancing” of the line is required
Bucket Brigade

Traditional Line Balancing Method

Bucket Brigade Method
Methodology

- Data collection in the assembly line
- Development of simulation models
  - Current method
  - Bucket brigade
- Revalidation of available results
  - Learning curve
  - Tenure Distribution
  - Assembly time distribution
- Verification and Validation of simulation
- Implementation in a pilot application (Toyota Assembly Line 152)
- Final validation (compare simulation vs. pilot line)
Methods

• Simulation Models:
  - Actual system (experienced operators)
  - Actual system with learning curve/rotation
  - Bucket Brigade (experienced operators)
  - Bucket Brigade with learning curve/rotation
Actual Method

• $N$ Operators among $N$ work stations
• Buffer available between stations
• Operator is idle if station is starved
Assumptions

• Experienced Operators
  - 0% rotation
  - Shift: 6:15-15:20
  - Two 25 min. breaks
  - Run simulation one month
  - 30 replications

• Rotation
  - 12% rotation
  - Weibull distribution for operator tenure
  - Shift: 6:15-15:20
  - Two 25 min. breaks
  - One month of warm-up, 1 year run.
Simulation
Results W/ Experienced Operators

- **Actual System**
  - 267.33 parts/shift
  - (260-270 reported)
  - Std. Error = .86 parts
  - Avg. Op. Util. = 71.52%

- **Bucket Brigade**
  - 343.37 parts/shift
  - (previous 347.37)
  - Std. Error = 1.03 parts
  - Avg. Op. Util. = 91.36%
Results with 12% turnover

- **Actual System**
  - 232.89 parts/shift
  - Std. Error = 9.81 parts
  - Avg. Op. Util. = 71.93%

- **Bucket Brigade**
  - 283.54 parts/shift
  - Std. Error = 10.13 parts
  - Avg. Op. Util. = 90.95%
Verification and Validation

- The verification of the simulation was performed by calculating throughput with deterministic times and using print statements.
- The current system was validated by comparing the throughput of the pilot assembly line vs. the one provided by the simulation.
Results Obtained at BB Pilot Line

• Team integration at both shifts
• The weekly production quota being achieved
• Most of the operators prefer to work on the BB line over the pre-existing one
• The group leader prefers BB since it is easier to supervise
• Dramatic reduction of WIP
Production at Line BB

**Weekly production quota achieved**

**1st shift**

**2nd shift**

**BB Meeting**
Operator Comments

• Time goes by faster since the work becomes less monotonous
• We can work as a team!
• It is satisfactory to reach the production goal with good quality
• This method allow us to finish early and to be trained in other areas or machines
Conclusions

• The line reached for the first time ever 300 parts in one shift
• The line consistently reaches and sometimes exceeds the daily production quota even though personnel turnover rate is high.
• Level changes (set up) are quicker since the WIP is lower than with the pre-existing method
• The leader of the line prefers BB since it is easier to supervise the operators and change levels
• The mentality of teamwork is enhanced