Assembly Line Designs for High Turnover Environments

J. René Villalobos and Luis F. Muñoz

Department of Industrial Engineering

Arizona State University

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
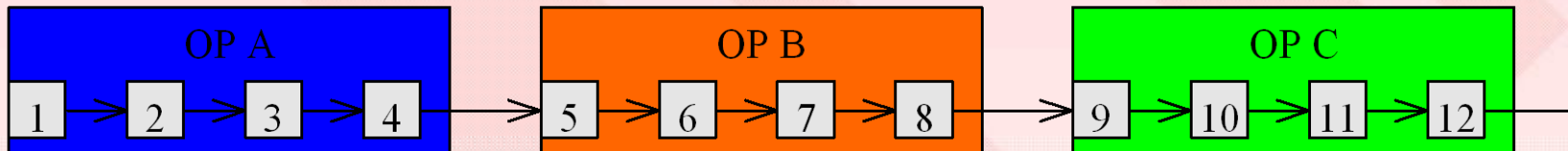
United Technologies Automotive

- 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
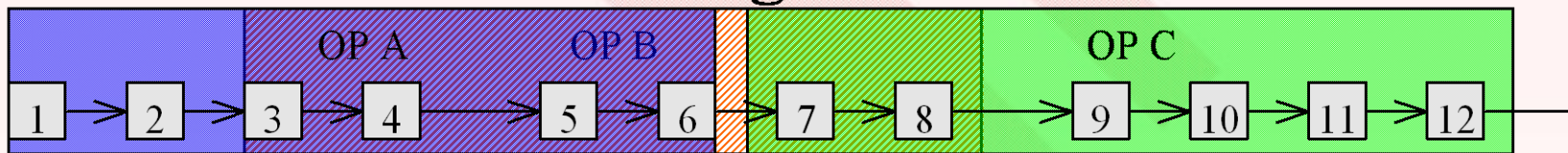
Self-Balancing Line (Bucket Brigade)

- 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

OP A	OP B	OP C
1 → 2 → 3 → 4	5 → 6 → 7 → 8	9 → 10 → 11 → 12

Bucket Brigade Method

OP A   OP B   OP C

1 → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 → 11 → 12

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
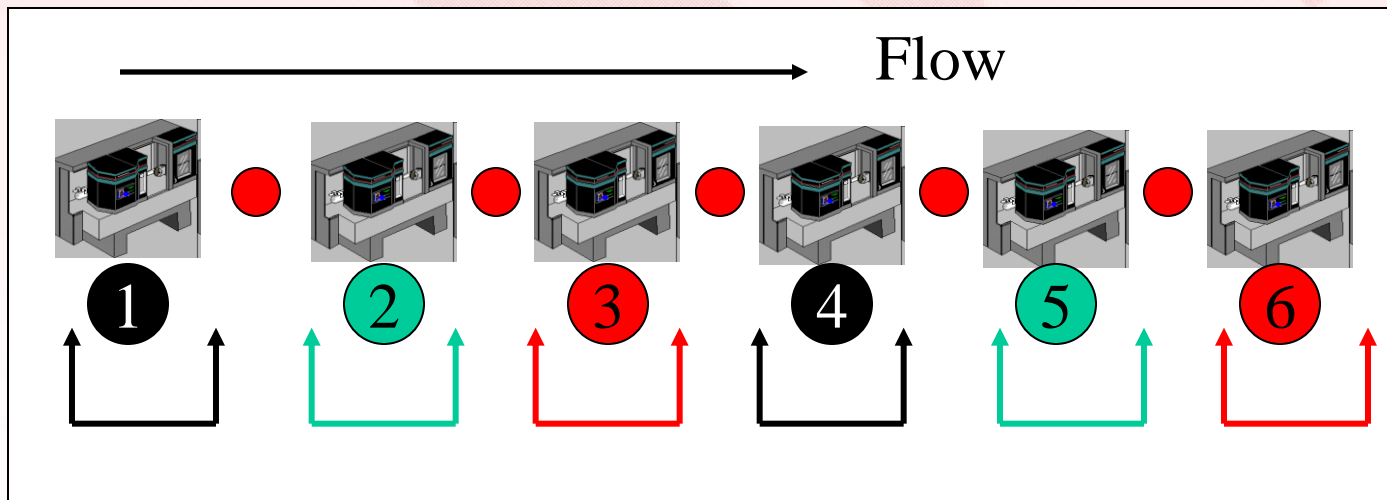
Assumptions

- **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
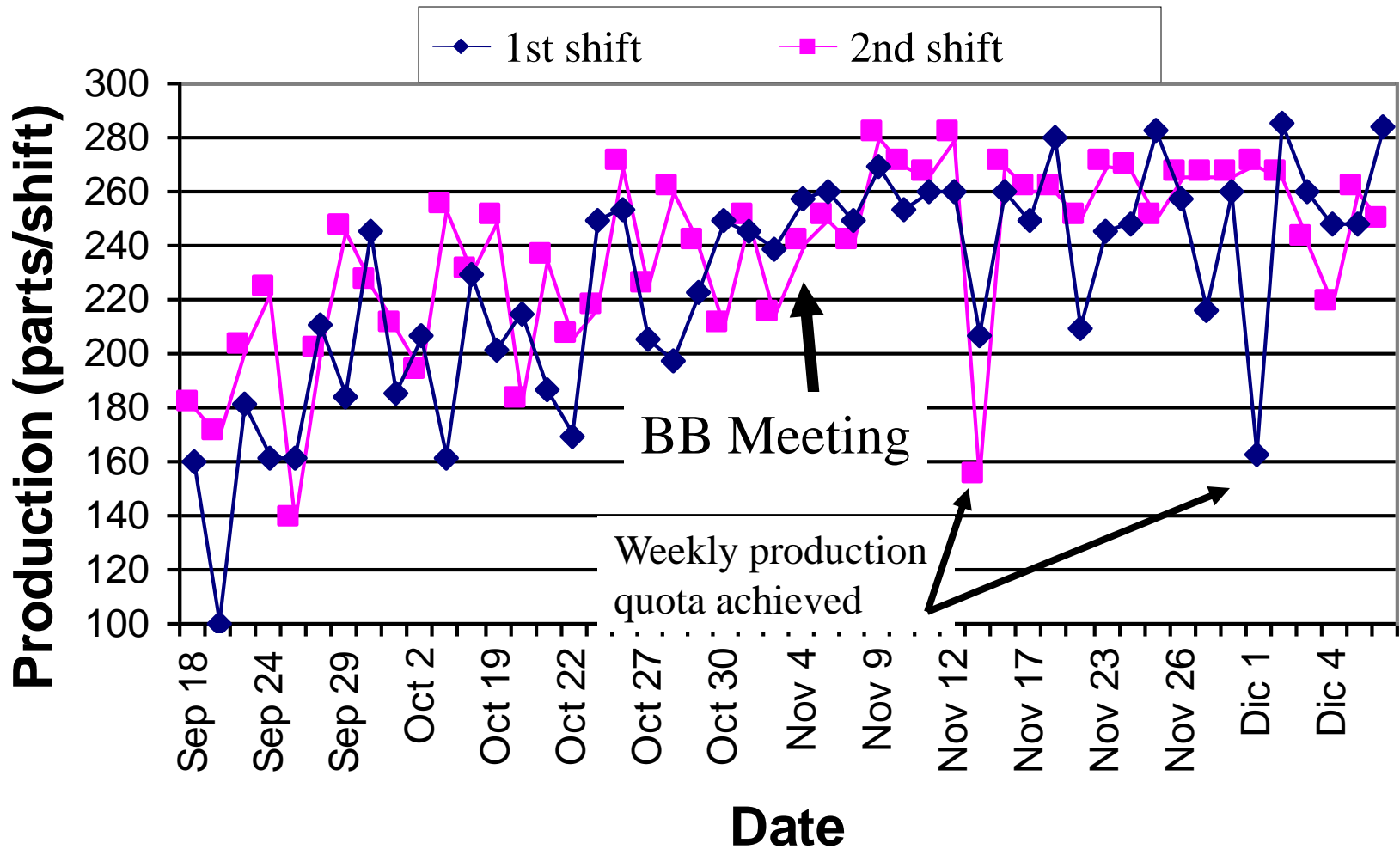
Operator Comments

- 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