

Design of Bucket Brigade Production Lines

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Definitions

- A bucket brigade consists of workers and stations. There are less workers than there are stations.
- Workers carry a batch of work from station to station.
- Workers maintain their sequence along the line.
- If a worker arrives at a busy station, then they must wait until the station is available. The worker may not bypass the station or seek other work.
- When the last worker finishes his batch on the last station, s/he takes over the work of the preceding worker, and so on until the first worker starts a new batch at the first station.

Production Rate

- The maximum production rate of a bucket brigade with n standard workers and with p_{max} as the largest percentage of processing time at any station.
- The time unit is the amount of time required for a standard worker to complete one item.
- The maximum production rate is $\min\{n, 1/p_{max}\}$.

Production Rate Cases

- If $n < p_{max}$, queuing eventually ceases at all machines.
- If $n > p_{max}$, queuing will always exist at machines that do p_{max} work.
- If $n = p_{max}$, the result holds trivially.

Bucket Size

- If batch size is small, workers may lose time to moving among stations. If batch size is large, workers may lose time to material handling within a station.
- If the batch size is 1, the worker never needs an item buffer, so the total wasted time is the time required to walk forward and back between stations and the time to hand off work.
- If the batch size is more than 1, the worker needs an in-buffer and an out-buffer. Time is wasted by:
 - Placing the batch in the in-buffer and removing it from the out-buffer.
 - Getting an item from the in-buffer and placing it in the out-buffer.
 - Moving from the out-buffer back to the in-buffer.
 - This is an underestimate since it neglects time spent moving.

Bucket Size Results

- If time wasted due to movement is small compared to time wasted due to material handling, it is better for the batch size to be 1.
- Otherwise, the batch size should be greater than 1. Cannot be more specific because the model breaks for very large batch sizes.
 - Material handling can change for very large batches.
 - Costs from work-in-progress, holding costs, loss of flexibility, risk of quality problems, etc.

Bucket Brigade Setup

- The number of workers n should not exceed $1/p_{max}$, otherwise workers are wasted. Usually, it is better to keep n smaller than $1/p_{max}$ to avoid queuing.
- Smaller teams tend to perform better.
- If task times vary greatly, using a large batch size can smooth out the variance.
- Once a good line setup is found, just duplicate the line to get the target production rate.

Conclusions

- No special material handling required.
- The line is self-balancing.
- Protocol is simple and identical for each worker.
- Applicable when:
 - Work must be balanced among workers
 - Work is mostly variation on a single skill
 - Workers can easily take over work at a station
 - Work stations are inexpensive compared to labor costs
 - Demand varies significantly