In practice, the number of containers is an integer. In order that the bottleneck would work all the time, the container-count n must be rounded to the closest integer larger than n. In this case some queue would form in front of the bottleneck machine.

4.6.2 EVALUATING PERFORMANCE OF CONWIP CONTROL. An important issue in CONWIP system implementation is performance evaluation. The approach of pull systems is, "Set WIP and measure throughput," and CONWIP is no exception. For planning, the operational performance measures must be determined. A common measure is mean throughput, because it allows us to calculate completion times and set realistic due dates. CONWIP is a closed production system: When a container reaches the end of the line, the finished goods are removed and the container is sent to the beginning of the line. By Little's Law, when selecting a WIP level there is a trade-off between flowtime and throughput. Setting a high level of WIP results in a higher throughput for a given flowtime. A low level of WIP results in lower throughput for a given flowtime. As noted, CONWIP is a closed production system and can be described in terms of a closed queueing network. There are many robust analytical models and approximations for performance evaluation of closed queueing networks. We give a simple algorithm, called mean value analysis (MVA) first introduced by Reiser and Lavenberg (1980). Let

i = index of workstations ($i = 1, 2, \ldots, m$)
l = number of containers ($l = 1, 2, \ldots, n$)
$W(l)$ = system relative throughput as a function of the number of containers l ($0 < W(l) \leq 1$)
$N_i(l)$ = number of containers at workstation i as a function of the number of containers l
$F_i(l)$ = flowtime at workstation i as a function of the number of containers l
μ_i = average processing rate at workstation i

$N_i(l)$ and $F_i(l)$ are actually random variables. Therefore, computations are performed on expected values. Assuming a single product line,

1. Set $E[N_i(0)] = 0, i = 1, 2, \ldots, m$.
2. For $l = 1, 2, \ldots, n$, calculate

$$E[F_i(l)] = \frac{E[N_i(l-1)] + 1}{\mu_i} \qquad i = 1, 2, ..., m$$

$$W(l) = l / \sum_{i=0}^{m} \{E[F_i(l)]\}$$

$$E[N_i(l)] = W(l) E[F_i(l)] \qquad i = 1, 2, ..., m$$

3. Stop.

MVA is theoretically correct only for exponentially distributed processing times.

Example 10-3. Baer FAX assembly. Baer, Inc., has a CONWIP-controlled assembly line for FAX machines with five stations, 1, 2, 3, 4, and 5. The process is sequential, with FAX machines arriving one at a time by conveyor. Times at each station are exponential with means