15.760: National Cranberry Case

1. Admin: Webvan case; UHS case
2. What are the sources of variability in the NCC case?
3. What are the problems NCC is experiencing that should be addressed?
5. Assess possible options for relieving truck waiting.
6. How would you assess converting some dry bins to wet?
7. How would you assess whether you can begin at 8 am?
8. How would you assess labor cost impacts?
9. How would you deal with the distribution of wet/dry and volume over the days of the season?
10. Can you eliminate/reduce demand peaks?
National Cranberry Process Flow Diagram

unload 5-10 min/truck

weighed/graded ▸ tested/sampled ▸ destone ▸ dechaff

1500 bbls/hr

1-16
Dry 250 bbls = 4000 bbls

both 17-24
Dry 250 bbls = 2000 bbls

wet 25-27

3x400 bbls = 1200 bbls

1500 bbls/hr

destone

2 x 1500 bbls/hr

Bulk Truck 2000 bbl/hr

Bulk Bins 800 bbl/hr

Freeze

3 x 200 bbls/hr

3 x 400 bbls/hr

dechaff

2 x 1500 bbls/hr

667 bbl/hr

Bag

Freeze

Separation

Dry

Wet
Wet Cranberry Inventory Buildup

Assume: buildup $18000 \times 70\%$ wet $= 12600$ bbl/day

$12600/12 = 1050$ bbls/hr; Plant begins operations at 11:00;

Drying bottleneck @ 600 bbl/hr

Truck waiting =

$7500$

$6000$

$4500$

$3000$

$1500$

$4200$

$7800$

$16.67$ hrs x $(4600/2)/75$

$= 511$ hours

$3200/1050$

$= trucks$ begin waiting at 10:03 am

$4600/600$

$= 7.67$ hrs

$= 2:40$ am

No more trucks

Plant is empty after $7800/600 = 13$ hours after 19:00 or 8 am the next morning

Total run time $= 12600/600 = 21$ hours
Wet Cranberry Inventory Buildup

Assume: buildup 18000 x 70% wet =12600 bbl/day
12600/12 = 1050 bbls/hr; Plant begins operations at 7:00;
Drying bottleneck @ 600 bbl/hr

Plant is empty after 5400/600 = 9 hours after 19:00 or 4 am the next morning
Total run time = 12600/600 = 21 hours
**Wet Cranberry Inventory Buildup**

Assume: buildup 18000 x 70% wet = 12600 bbl/day

12600/12 = 1050 bbls/hr; Plant begins operations at 7:00;

Drying bottleneck @ 800 bbl/hr

Truck waiting = 0 !!

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Plant is empty after 3000/800 = 3.75 hours after 19:00 or 20:45 the next morning

Total run time = 12600/800 = 15.75 hours; dry berry processing drops to 400/hr
15.760
Basic Concepts in Queueing

System Performance = f(System parameters)

- Arrival rate \( \lambda \)
- Service rate \( \mu \)
- Service time \( M \)
- Number of servers \( S \)
- Queue/Buffer capacity \( R \)
- Capacity or Server utilization \( \rho \)
- Probability that Queue is full \( P_{\text{full}} \)
- Number of Service classes \( K \)

Output/throughput rate
Inventory Level/Queue Size/
Line length
Waiting Time/Cycle Time
Capacity or Server utilization
Probability that Queue is full

Customers or jobs arrive → Queue or waiting line → server or service facility → Finished work
Kiwanee Dumpers: Capacity Analysis

Busy Day: Arrival rate = 18,000 bbl/day = 1500 bbl/hr = 20 trucks/hr

\[ L = \frac{\rho^2}{(1-\rho)} \]

\[ W = \frac{\rho^2}{\lambda(1-\rho)} \]
Basic Concepts in Queueing: Nonlinearities in Congestion in Stochastic Systems

If service times and interarrival times have exponential distributions, then

$L = \frac{\rho^2}{1-\rho}$

$W = \frac{\rho^2}{\lambda(1-\rho)}$

(Arrival Rate / Service Rate = $\rho$) = “congestion”
Management of Queues

The Physics of Waiting Lines

- Number and type of servers
- Waiting time, service time, and system time
- Queue discipline
- Number of people in queue
- System utilization

![Graph showing Total time in the queue vs Congestion](image1)

![Graph showing Cost vs Congestion](image2)
Management of Queues

The Psychology of Waiting Lines

Propositions

1. Unoccupied time feels longer than occupied time
2. Process waits feel longer than in process waits
3. Anxiety makes waits seem longer
4. Uncertain waits seem longer than known, finite waits
5. Unexplained waits are longer than explained
6. Unfair waits are longer than equitable waits
7. The more valuable the service, the longer the customer will wait
8. Solo waits feel longer than group waits