System Physics – solution support

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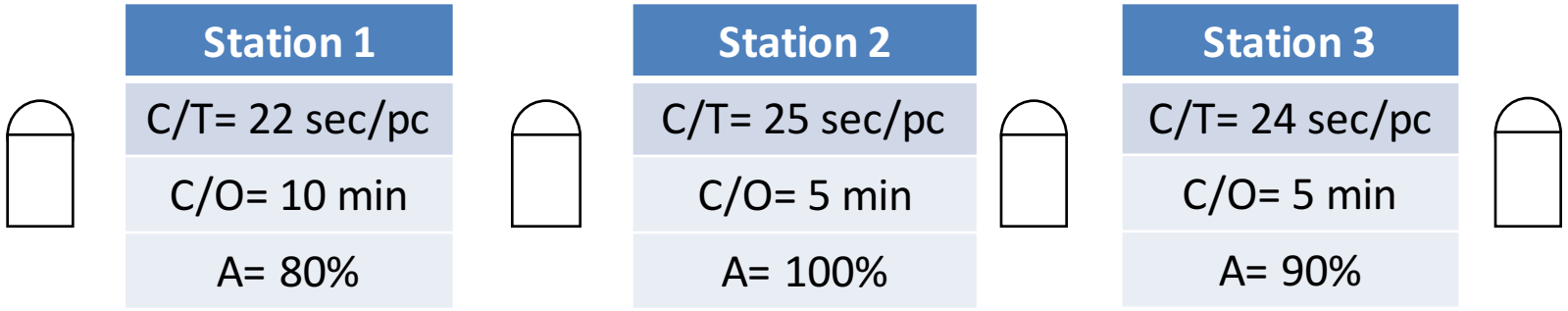
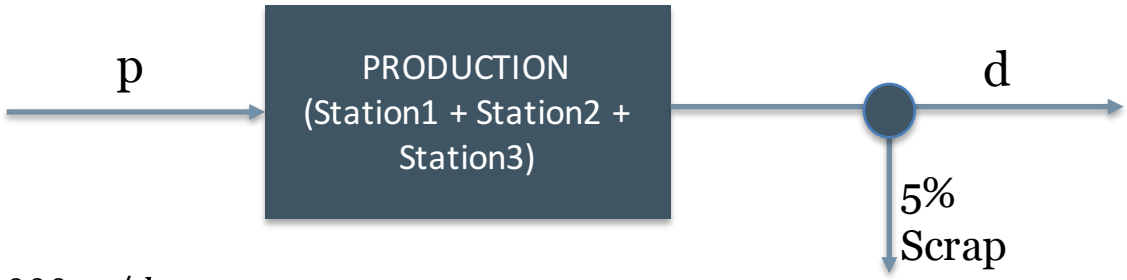
Exercise 1 – Washing Spa

Daily demand (d) = 2000 pc/day
Ta = **21h/day**



Scrap rate (end of line): **5%**



Daily production (p) = $\frac{d}{0,95} = \frac{2000\ pc/day}{0,95}$ = **2105 pc/day**

Exercise 1 – Washing Spa

Q1 - Daily production capacity of a decoupled system

Ta= 21 h/day

Expected output = Daily production capacity = $\frac{Ta * A}{C/T}$

Daily C1: (21*3600 sec) * 0,8/22 = 2749 pc/day

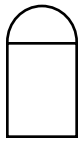
Daily C2: (21*3600 sec) * 1/25 = 3024 pc/day

Daily C3: (21*3600 sec) * 0,9/24= 2835 pc/day

Daily production capacity of Washing Spa: **2749 pc/day**

Exercise 1 – Washing Spa

Q2 - Daily production capacity of a coupled system



Station 1	Station 2	Station 3
C/T= 22 sec/pc	C/T= 25 sec/pc	C/T= 24 sec/pc
C/O= 10 min	C/O= 5 min	C/O= 5 min
A= 80%	A= 100%	A= 90%

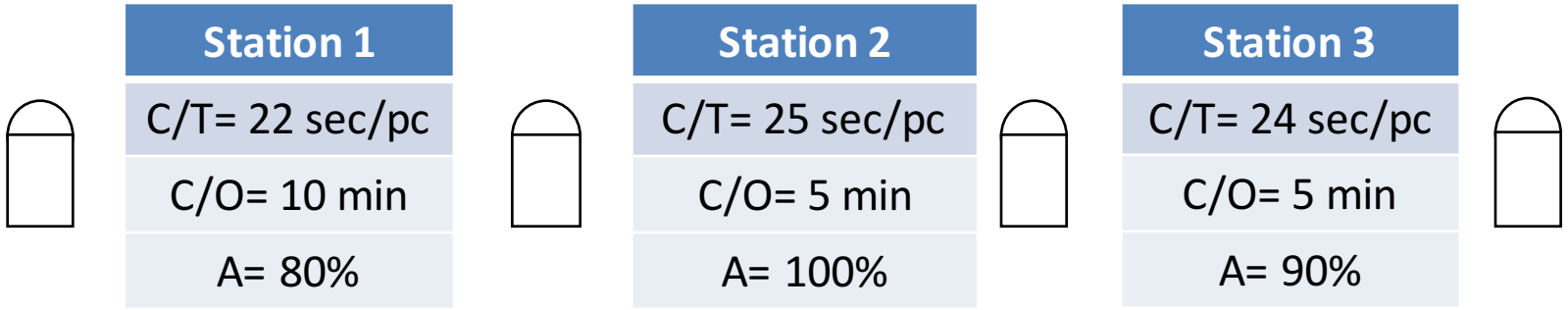
C/T= 25 sec/pc
C/O= 10min
A= 72%

Daily CSystem: (21*3600 sec) * 0,72/25 = **2177** pc/day

As the decoupled system, the coupled system is able to produce what is required daily by the customer.

Δproduction: **-20,8%** compared to the decoupled system

Q3 – Batching in a decoupled system



Each station has its own stocks and therefore they work rather independently one from the other.

Batch size = **60 pc/batch**

#Setups per day = 2105 pc/day/60 pc/batch = **35 setups/day**

Q3 – Batching in a decoupled system

We must verify for each station whether it is possible to satisfy customer requirements within available time.

$$Tp + Tsu \leq Ta$$

Station 1: 22/0,8*2105 + 35*10*60 ≤ 21*3600
78887,5 sec/day > 75600 sec/day ✗

Station 2: 25/1*2105 + 35*5*60 ≤ 21*3600
63125 sec/day < 75600 sec/day ✓

Station 3: 24/0,9*2105 + 35*5*60 ≤ 21*3600
66633,33 sec/day< 75600 sec/day ✓

Q3 – Batching in a decoupled system

The system can work in batches of 60 pieces at phases 2 and 3.

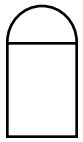
It can not work instead in batches of 60 pieces at phase 1.

What activities would you propose to be able to work with batches of 60 products?

What advantages do you expect from this activity?

Exercise 1 – Washing Spa

Q4 – Maximum setup time in a coupled system



Station 1	Station 2	Station 3
C/T= 22 sec/pc	C/T= 25 sec/pc	C/T= 24 sec/pc
C/O= 10 min	C/O= 5 min	C/O= 5 min
A= 80%	A= 100%	A= 90%

C/T= 25 sec/pc
C/O= 10min
A= 72%

Product range = **15 pc**

Whole product range required daily

#Setups per day = 15

NB: In a coupled system, for each change (setup) in one station, the whole line is stopped (all the other stations are stopped)

Q4 – Maximum setup time in a coupled system

We can verify if we can perform 15 setups per day according to actual conditions

$$Tp + Tsu \leq Ta$$

System: 25/0,72 * 2105+ 15*10*60 ≤ 21 h/day *3600

82090 sec/day > 75600 sec/day ✗

In 1 day, according to actual conditions, it is not possible to produce the entire range in the quantities required by the customer during the available production time.

Q4 – Maximum setup time in a coupled system

We must find the maximum setup time that enable Washing Spa to satisfy customers requests in terms of volume and variety.

$$\boldsymbol{Tp + Tsu \leq Ta}$$

$25/0{,}72 * 2105 + 15*\mathbf{x}*60 \leq 21$ h/day $*3600$

$$x = C/O = \frac{Ta - Tp}{\#Setups\ per\ day} = \mathbf{2,8\ min/setup}$$

The time required to produce the entire range of product in respect of the daily demand is an index of the **system flexibility**.

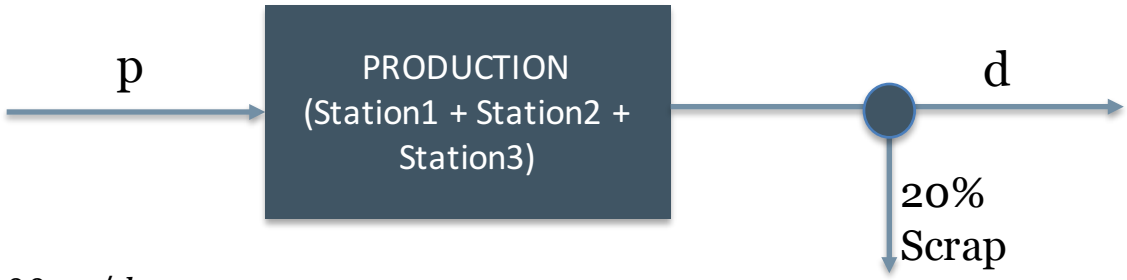
It consists in the calculation of the time required to produce the entire range of varieties in the quantities required by customers.

Exercise 2 – MTCF Spa

Daily demand (d) = **3000 pc/day**
Ta = 7,5h/shifts*2shifts = **900 min/day**

Painting	Assembly	Mounting
C/T= 5 sec/hand	C/T= 9 sec/pc	C/T= 10 sec/pc
C/O= 0 min	C/O= 0 min	C/O= 0 min
A= 90%	A= 80%	A= 85%

Scrap rate (end of line): **20%**



Daily production (p) = $\frac{d}{0,8} = \frac{3000\ pc/day}{0,8}$ = **3750 pc/day**

Q1 – Seek overtime in a decoupled system?

We must verify for each stages whether they are able to fulfil customer demand within the available time.

$$Tp + Tsu \leq Ta$$

Painting: (**2***5)/0,9*3750 ≤ 900 min/day *60
41667 ≤ 54000 ✓

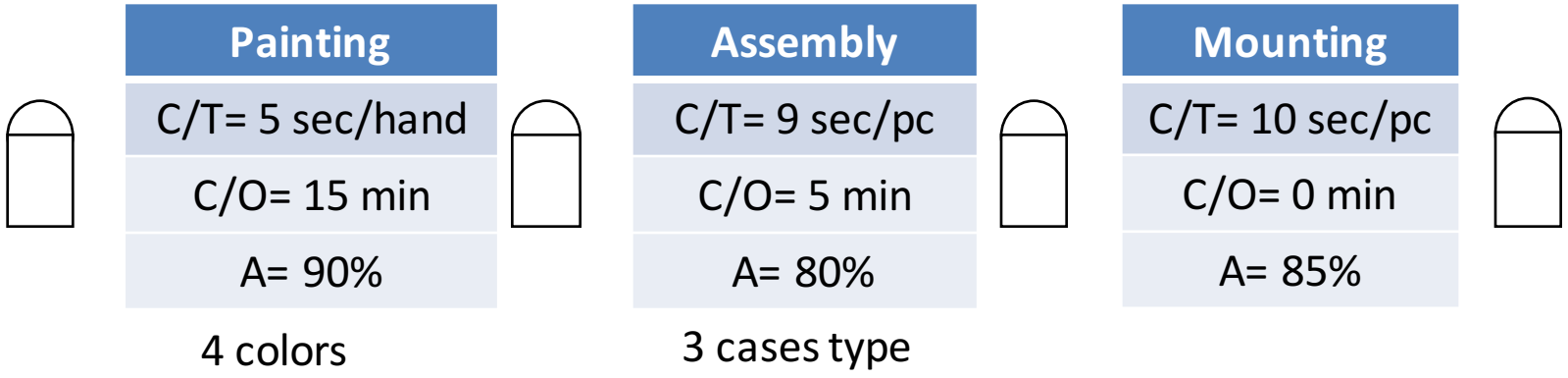
Assembly: 9/0,8*3750 ≤ 900 min/day*60
42187,5 ≤ 54000 ✓

Mounting: 10/0,85*3750 ≤ 900 min/day*60
44118 ≤ 54000 ✓

No Overtime needed

Q2 – Batching in a decoupled system

Total range = 4 colors * 3 cases type = **12 products**



The system is decoupled:

- Each phase is then "free" and is unaffected by other phases.
- Each phase has its **own batching** only depending on the setup of the phase itself.
- Phase 3, having a setup time equal to 0, can always produce a different watch without doing any batching.

Q2 – Batching in a decoupled system

We need to compute for each stage the minimum batch size that enable MTCF Spa to avoid overtime.

$$Tp + Tsu \leq Ta$$

x= #Setups = $\frac{Ta - Tp}{C/O}$

Minimum Batch size (MBS) = daily prod./#Setups

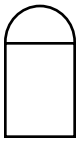
Painting: (2*5)/0,9*3750 + **x***15*60 ≤ 900 min/day *60
X= 13,7 setups/day
MBS= 3750/13,7 = **274 pc/batch → MBS of MTCF**

Assembly: 9/0,8*3750 + **x***5*60 ≤ 900 min/day*60
X= 39,38 setups/day
MBS = 3750/39,38 = **95 pc/ batch**

If the variants requested everyday by the customer are 12, MTCF will use an average batch size of 312,5 pc → 3750/12.
If the variants requested per day increase the batch size is constrained by the **MBS**

Exercise 2 – MTCF Spa

Q3 - Seek overtime in a coupled system?

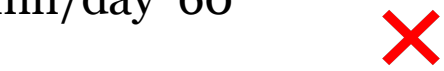


Painting	Assembly	Mounting
C/T= 5sec/hand	C/T= 9sec/pc	C/T= 10sec/pc
A= 90%	A= 80%	A= 85%

C/T= 10 sec/pc
A= 61,2%

$$Tp + Tsu \leq Ta$$

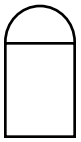
System: 10/0,612*3750 ≤ 900 min/day*60
61274 ≤ 54000



Overtime is needed to satisfy average demand volume

Overtime needed = around 2 hours

Q4 – Batching in a coupled system



Painting	Assembly	Mounting
C/T= 5sec/hand	C/T= 9sec/pc	C/T= 10sec/pc
C/O= 15 min	C/O= 5 min	C/O= 0
A= 90%	A= 90%	A= 90%

C/T= 10 sec/pc
C/O= 8,3 min
A= 72,9%

For understanding whether overtime is needed, we must compute the maximum production capacity of our system and to compare it with customer requirements and setup time.

System

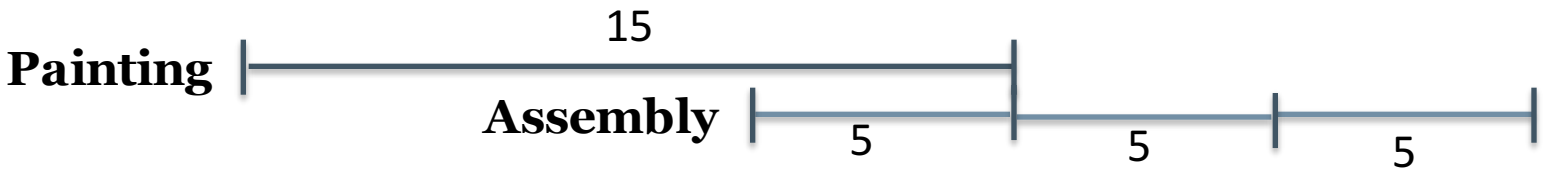
900*(0,729/10*60) = 3936 pc/day ≥ daily required capacity (3750 pc/day) ✓

Q4 – Batching in a coupled system

Since the previous condition was verified, we need to understand whether MTCF Spa is able to satisfy also the range requirements of the clients (12 range).

At system level:

- 4 setups at stage 1
- 3 setups at phase 2
- Each time the system changes the color of the hands, hands of the same color must be assembled on 3 kinds of different cases.
- How much is the stop time for the line because of sets up?



Total time of stop for the line to make setups per each day= 4* (15 + 5 + 5) = **100 min**
#Setups per day = 12
Average C/O= 100 min/12 setups = **8,33 min/setup**

Q4 – Batching in a coupled system

$$Tp + Tsu \leq Ta$$

System:
3750*10/(0,729) + 100*60 ≤ 900 min/day *60
57440 ≤ 54000 ✗

Overtime = 57440 – 54000 = 3440 sec/day = **57,33min/day**

Batching
Average C/O = Tsu /range = 100/12 = 8,33 min/setup
10/0,729*3750 + x*8,33*60 = 900min/day * 60

x= #Setups = $\frac{Ta - Tp}{C/O}$ = 5,12 setup/day

Minimum Batch size (MBS) = p/#Setups = **732 pc/batch**

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