MIT 2.008 Design and Manufacturing II

Spring 2023

Quiz 2 - Part B, Take-Home Component

- All work for CREDIT must be completed in this quiz document
- All work must be completed individually and cannot be discussed with classmates.

Name:

_____

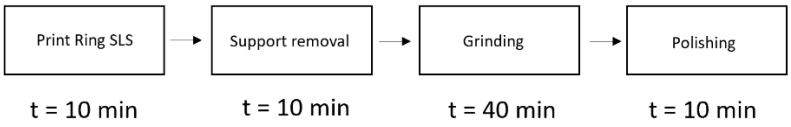
Part A, In-Class Component		
Problem 1		Out of 10 points
Problem 2		Out of 40 points
Part B, Take-Home Component		
Problem 3		Out of 50 points
Total		**100 points**

Problem 3: Manufacturing Systems Analysis

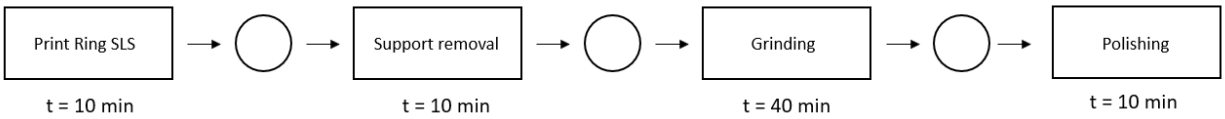
Expanding on the scenario from Part A, to better analyze and improve the SLM brass rat assembly line, you have been asked to perform a more in-depth manufacturing systems analysis. Upon a site visit to the facility, you learn that the manufacturing line used to produce a final Brass Rat is more complex with buffers being used between the major stages in the system. Ever the manufacturing engineer, you also take measurements of machine cycle times, as well as up and down times and compile all your information in the table below.

Your task will be to use this information, as well as some of your MATLAB simulations on Canvas to make a set of informed decisions about the process in the subsequent parts of this exercise.

Original Assembly Line assumed in Part A



Observed Assembly Line for Part B



Station	Tau (hr)	MTTR (hr)	MTTF (hr)	p	r	e
Printing	0.166667	5	20	0.008333	0.033333	0.8
Support Removal	0.166667	2	25	0.006667	0.083333	0.925926
Grinding	0.666667	1	3	0.222222	0.666667	0.75
Polishing	0.166667	1	6	0.027778	0.166667	0.857143

a) If you had the option to place a single infinite buffer in this manufacturing line from part A, where would you place it and why?

Generally, it's best practice to place the buffer before the bottleneck, this ensures that particular machine is never starved or idle for work, if the ones prior to it experience down time. Taking reliability into account, the bottleneck will be the machine with the lowest average production rate e/tau, which in this case is the Grinding operation.

5pts (all or nothing)

b) Let's move on to the "observed assembly line for part B" shown above. You suggest the purchase of an identical grinding machine to improve the line. What's the new effective production rate of the grinding step? How many machines would you have to add for this to no longer be the bottleneck in the process. Note: You can only add a discrete number of machines

First find the average production rate of each of the stages

$$avr\ prod.rate = \frac{e}{\tau} = \frac{1}{\tau} x \frac{MTTF}{MTTF + MTTR}$$

Machine	Average Prod Rate
Print Ring	4.80
Support Removal	5.56
Grinding	1.13
Polishing	10.29

Then calculate how many grinding machines would be needed. This can be done by setting up and solving the following equation.

$$avr\ prod.rate \geq \frac{n}{\tau} x \frac{MTTF}{MTTF + MTTR}$$
$$4.26 \geq n$$

5 machines would be needed to remove grinding step as the bottleneck.

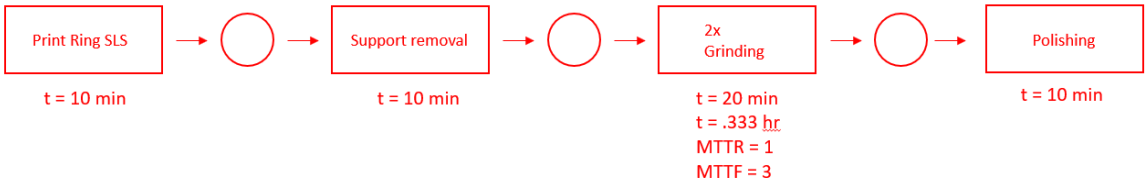
Students who just say 4 did not account for efficiency/ any of the metrics listed in the table and will not receive credit

10 pts

- **5 pts average prod rate of stages**
- **5 pts correct answer**
- **(2 point penalty if efficiency not considered)**

c) What simplifications or assumptions about line B with buffers and the addition of a single grinding machine do you need to make in order to utilize the analytical solutions in MATLAB? Draw this new line and write any new values for tau, MTTR/MTTF under the machine(s)?

The 2 grinding machines are combined into an equivalent machine acting in parallel. The MTTR and MTTF times remain the same, but the cycle time, r and p are cut in half.



5 pts

- **2 pts drawing**
- **3 pts updated parameters for combined machine**

d) The factory with the non-dedicated machinery has a size limit of 10 rings in the one allotted buffer for free. What is the production rate in the scenario highlighted in part c? Is this sufficient to meet the production rate of 500 rings in 1 month (assume a 24 hour day and 7 day week, 4 week month)? **Note, it is best to keep at least 4 digits after the decimal for the MATLAB script**

```
% Input parameters:
% Change the values for k, r, p, and N
% Click "Run Script" to calculate prodrate and nbar
k = 4;
r = [.0333 .0833 .3333 .1667];
p = [.0083 .0067 .1111 .0278];
N = [10 10 10];

% Calculate deterministic processing time
[prodrate,nbar] = detlong(k,r,p,N)

```

▶ Run Script

Output

```
prodrate =

    0.6492    0.6492    0.6492


nbar =

    7.2014    7.0332    2.1876
```

500	rings/month	
125	rings/week	
17.8571	rings/day	
0.7440	rings/hr	
0.3333	hr/cycle	tau_max
0.2480	rings/cycle	

This is more than sufficient to meet the production rate

10 pts

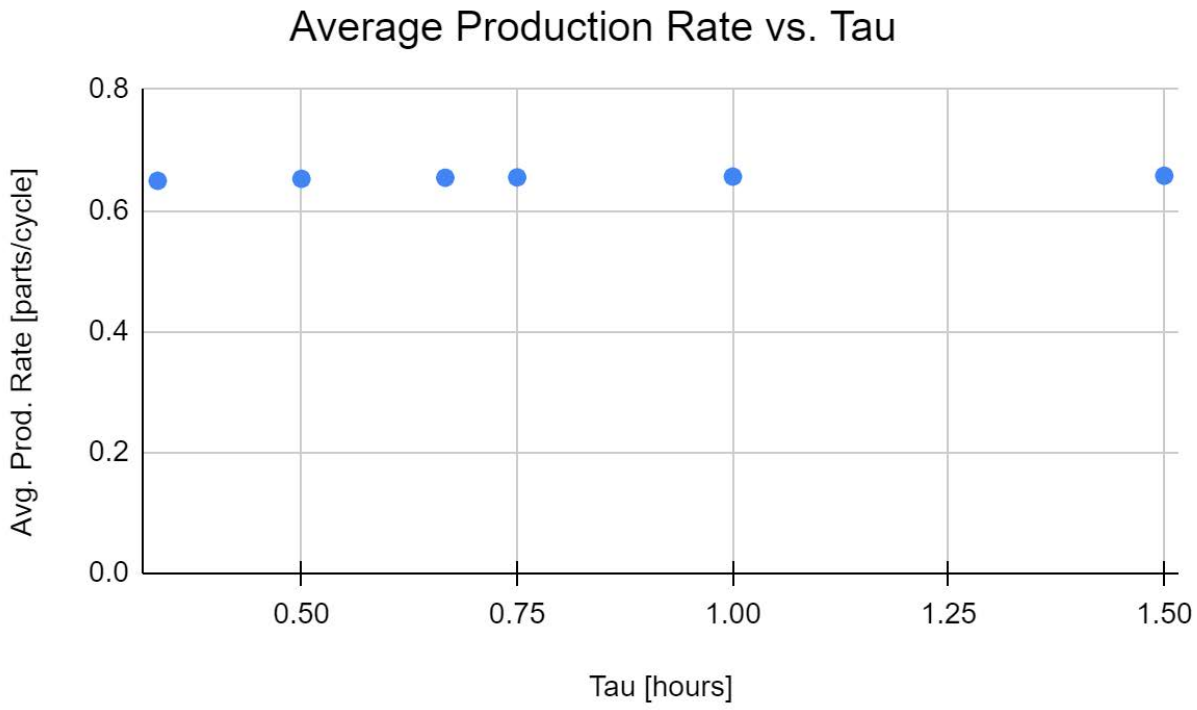
- **5 pts, show work**
- **5 pts, correct answer**

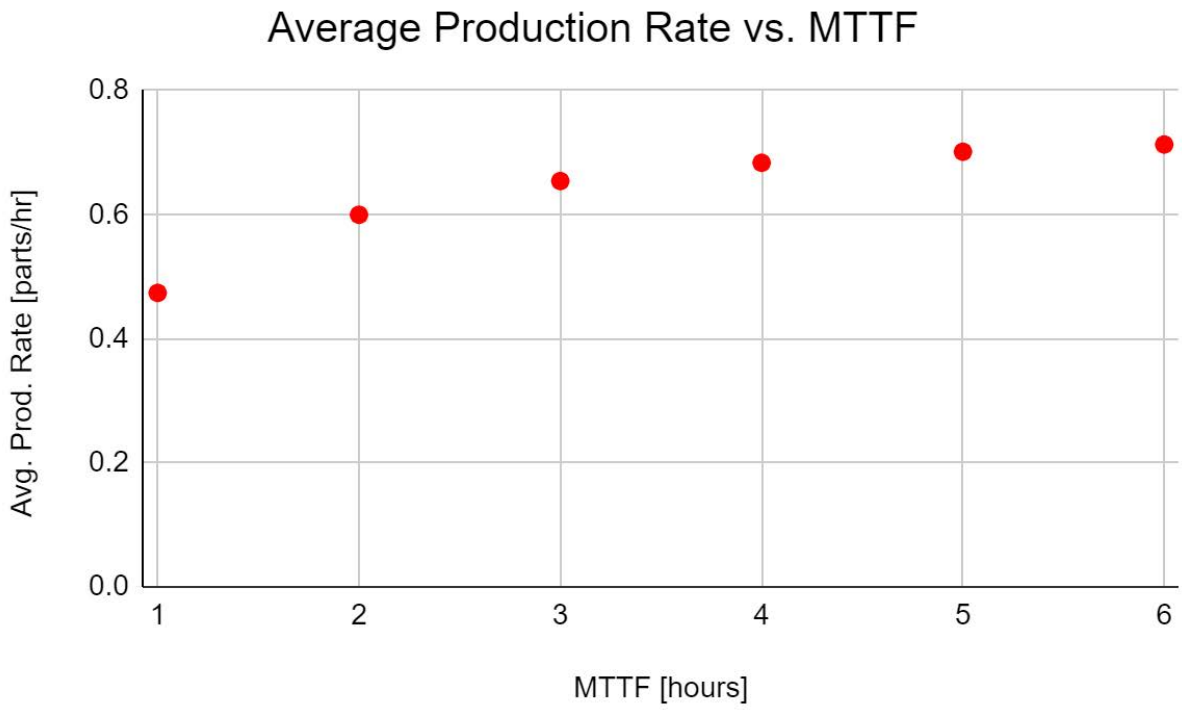
e) Is it more effective to improve the reliability of the bottleneck (MTTF increase) or the cycle time (Tau decrease) in order to increase production rate. **Using the MATLAB script collect at least 5 data points for each independent scenario and sketch two plots, one of MTTF vs average production rate, and Tau vs average production rate to help you answer this question.** Be sure to state the parameters you use and label your plots. You may use Excel or Google Sheets to help with your plots if desired.

What students should find is that in order to improve production rate it is more effective to improve the reliability of the machine rather than decrease the cycle time (assuming N = 10 for all buffers and decrease of tau from the 2 machine scenario, not by adding extra machines).

Other assumptions however may have changed this response. The opposite response was accepted without penalty as long as the student stated their assumptions and explained which parameters they used, ran two independent experiments with the matlab script, plotted the results and had an interpretation of data that matched what their plots showed. (N <10, N of diff values etc are a few examples of assumptions that could have led to another conclusion)

Spreadsheet here:
https://docs.google.com/spreadsheets/d/1RhwIGuhGeODOw5jfU4_sjQ5EI53u8YILfpW9pLMhPHU/edit?usp=sharing





20 pts

- **5 pts (state the parameters being used to do this analysis)**
- **10 pts (5 for each plot, with 5 data points)**
- **5 pts (interpretation of data collection)**

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