1 A production cell is producing under the following conditions: 5p

Work hours: 3-shifts, Sunday 21:00 to Friday 21:00

Shift hours: Night shift, 22:00 – 06:12, Sunday nights start at 21:00
Morning shift, 06:00 – 14:12
Afternoon shift, 14:00 – 22:12, Friday afternoons stop at 21:00

Breaks: 30 minutes lunch-/coffee break each shift, with no production.

Maintenance: Preventive maintenance is performed daily during the shift exchange at 14:00 – 14:12
Also preventive maintenance is performed every Sunday night 21:00 – 21:30.
On Fridays the cell is cleaned 19:30 – 21:00. This cleaning is to be considered as preventive maintenance as well.

Production: The machine has a bought cycle time of 72 seconds per item type A and 36 seconds per item type B.

True outcome during one week:

Breakdowns:
Mon. 08:30 – 10:00
Tue. 02:30 – 04:00
Thur. 16:00 – 20:00
Fri. 14:30 – 16:00

Set-up changed from type A to type B on Tuesday at 10:06 – 11:06

Production: 1177 type A produced from Sunday 21:30 to Tuesday 10:06, of which 17 were defect.
6019 type B produced from Tuesday 11:06 to Friday 19:30, of which 19 were defect.

A: Calculate PfOEE and OEE for the production cell during the described week (3p)
B: Which type of loss should be focused on in order to increase the OEE. Motivate (2p)

2a.

A component with exponentially distributed time to failure has a failure rate of 0.00031 [faults/hour]. Calculate the MTBF, and the reliability at time 1420 hours.

(2p)

2b.

How many of these specific components do you need in a parallel system in order for the system reliability to be >0.993 at time 1420 hours.

(1p)

3:

A milling machine that is run in dayshift, 8h/day, 220 days/year, is usually repaired 8 times/year. A repairman is leased from another company every time the machine fails to operate. It takes the repairman about 1 hour of travel to make it to the milling machine and roughly 4 hours to repair it. Further, the paperwork takes an additional 30 minutes. Except for the repair work, the machine gets preventive maintenance performed 4 times per year. Each preventive maintenance takes about 8 hours.

Calculate the inherent, achieved, and operational availability of the milling machine.

(5p)

Solutions:

Scheduled working time	3h + 4x24h + 21h =	120h	
Planning related stops	3x5x0.5h + 5x0.2h + 0.5h + 1.5h =	10.5h	
Planning factor (Pf)	(120 – 10.5) / 120 =	0.9125	Pf = 91.25%
Planned production time	120 – 10.5 =	109.5h	
Unplanned stop time	1.5 + 1.5 + 4 + 1.5 + 1 =	9.5 h	
Availability (A)	(109.5 – 9.5) / 109.5 =	0.913	A = 91.3%
Available operative time	109.5h – 9.5h =	100 h	
Bought cycletime A	72 sec. / 3600 =	0.02h	
Produced items A	1177		
Bought cycletime B	36 sec. / 3600 =	0.01h	
Produced items B	6019		
Performance rate	((0.02x1177) + (0.01x6019)) / 100 =	0.837	P = 83.7%
Defects/scrap	17 + 19 =	36	
Quality rate (Q)	(1177 + 6019 –36) / (1177 + 6019)	0.995	Q = 99.5%
PfOEE	0.9125 x 0.913 x 0.837 x 0.995	0.694	PfOEE = 69.4%
OEE	0.913 x 0.837 x 0.995	0.76	OEE = 76.0%

2

MTBF = 1/0.00031 = 3225.8 h
$R_{1420} = e^{-0.00031x1420} = 0.6439$
$R_{1420} > 0.993 = 1-(1-0.6439)^x$
$0.007 < 0.3561^x$
x = 5

3

Total time = 220 x 8 = 1760 h
Repair time = 8 x 4 = 32 h
Waiting time = 8 x (1 + 0.5) = 12 h
PM time = 4 x 8 = 32 h
Total down time = 76 h
Total Up-time = 1760 – 76 = 1684 h
MTBF = 1684 / 8 = 210.5 h
MTTR = 4 h
MTBM = 1684 / 12 = 140.3
M(dash) = (32 + 32) / 12 = 5.3 h
MDT = 76 / 12 = 6.3

Ai = 210.5 / (210.5 + 4) = 0.981
Aa = 140.3 / (140.3 + 5.3) = 0.964
Ao = 140.3 / (140.3 + 6.3) = 0.957